COMPETENCY BASED EDUCATION
KENYA CERTIFICATE OF BASIC EDUCATION
SENIOR SCHOOL CURRICULUM

GRADE 11
GEOGRAPHY NOTES

GEOGRAPHY

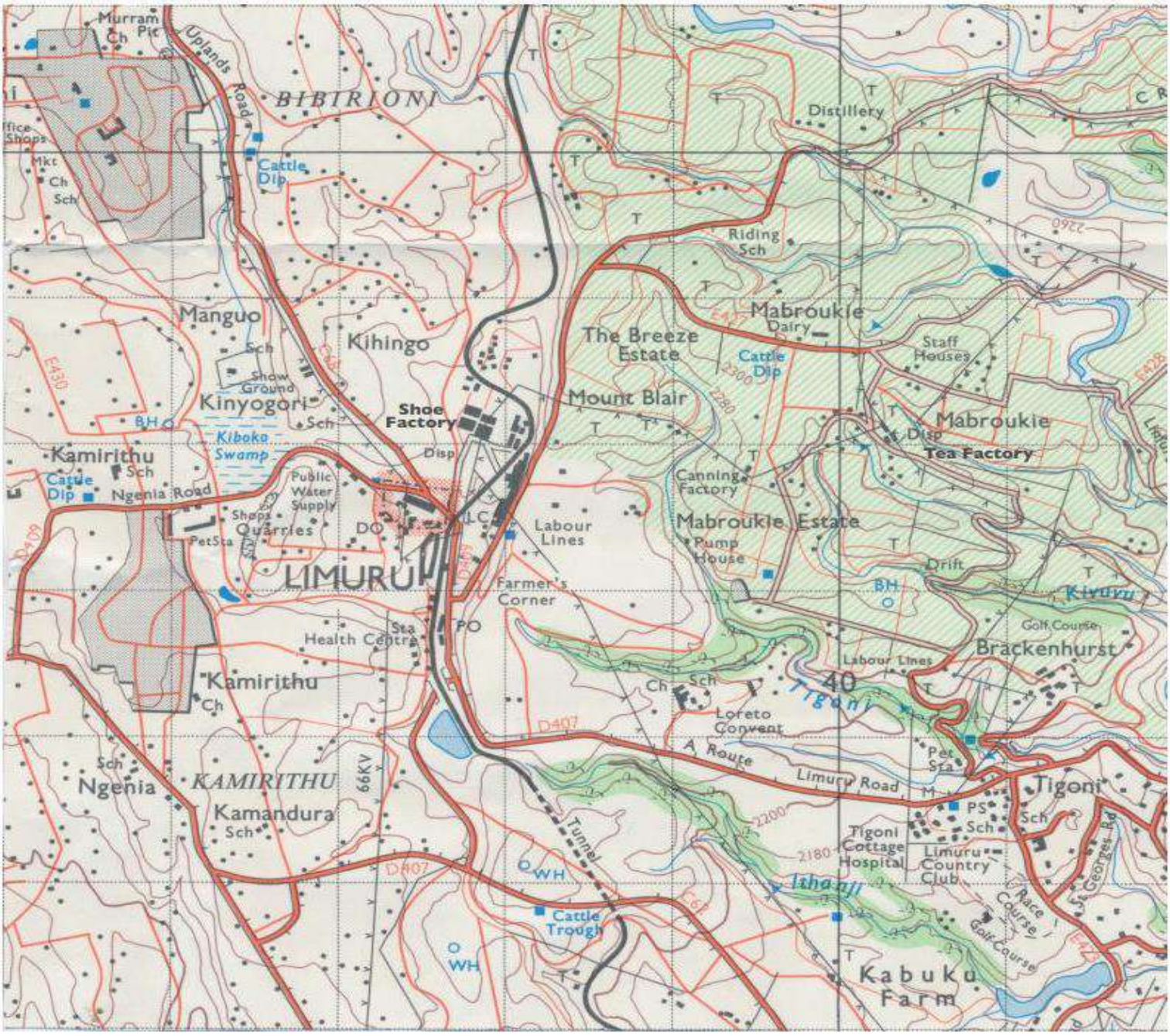


AUTHOR: COMPETENCE GROUP

STRAND: PRACTICAL GEOGRAPHY

SUBSTRAND: MAP READING AND INTERPRETATION





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km

N

Key

- town or area with permanent buildings
- other populated area, houses
- A12 Road Number — all-weather road – bound surface
- all-weather road – loose surface
- main track (motorable)
- other track and footpath
- Sta LC — railway, station, level crossing
- power line
- plantation

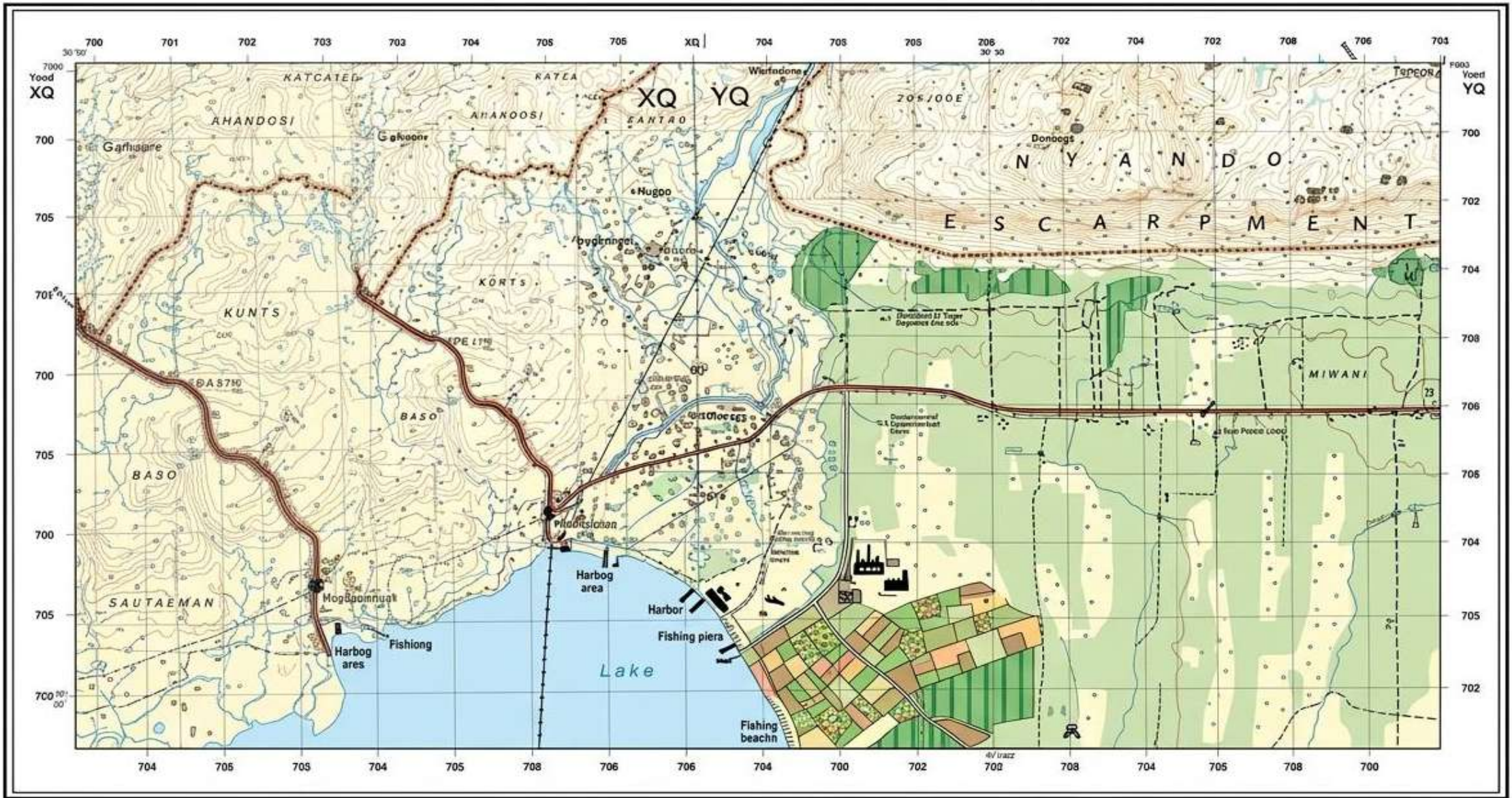
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EAST AFRICA 1:50,000 (KENYA)

KISUMU EAST

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SCALE 1:50,000

20 75 10 0 100 200 300 Kilometers

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0 5 10 200 Reference

N W E S

- Nucleated cane boundary (squalst squares and social serviices)
- Linear settlements
- Structured fornest

N Declination

LEGEND

- Contours
- River
- Main road
- Track
- Nucleated settlement
- Linear settlement
- Forest
- Cultivation
- Cultivation
- Police post
- Hospital

STRAND 1.0: PRACTICAL GEOGRAPHY

SUB-STRAND 1.1: MAP READING AND INTERPRETATION

1.0 INTRODUCTION TO MAP READING AND INTERPRETATION

Map reading and interpretation is the process of examining a map to identify, describe, analyse and explain the geographical features and activities represented on it.

A topographical map is a detailed representation of a section of the earth's surface drawn to scale using conventional signs, symbols, colours, lines and other forms of representation.

Topographical maps provide information about both physical and human features of an area.

Examples of information obtained from topographical maps include:

1. Location and distribution of settlements.
2. Transport and communication networks.
3. Agricultural activities.
4. Industrial activities.
5. Mining and quarrying activities.
6. Trade and commercial activities.
7. Fishing activities.
8. Forestry and wildlife conservation.
9. Tourism and recreational activities.
10. Social and administrative services.
11. Relief and drainage features.
12. Land use and economic development.

1.1 Importance of reading and interpreting topographical maps

Topographical maps are important because they help people to:

1. Identify the location of geographical features.
2. Determine the distribution of human activities.
3. Understand how people use land and other natural resources.
4. Identify transport and communication networks.
5. Locate important social amenities such as schools and hospitals.
6. Identify areas suitable for agriculture and settlement.
7. Plan the construction of roads, railways, bridges and buildings.
8. Identify areas with potential mineral resources.
9. Support environmental conservation and management.
10. Guide government and private-sector development projects.
11. Identify suitable locations for industries and commercial centres.
12. Understand the relationship between human activities and the physical environment.

2.0 CONVENTIONAL SIGNS AND SYMBOLS ON TOPOGRAPHICAL MAPS

2.1 Meaning of conventional signs and symbols

Conventional signs and symbols are standardised signs, colours, letters, shapes and patterns used on maps to represent different geographical features.

They enable map users to understand the information represented without having to write the full names of all the features.

For example:

- A blue line may represent a river.
- A black line may represent a railway.
- A red line may represent a major road.
- A green area may represent forest or vegetation.
- A small square may represent a building.

The symbols used on topographical maps are usually explained in a section called the **key or legend**.

2.2 Importance of conventional signs and symbols

1. They simplify the representation of geographical features.
2. They save space on maps.
3. They make maps easier to read and interpret.
4. They enable map users to identify features quickly.
5. They provide a common method of representing geographical information.
6. They make it possible to represent many features on a single map.
7. They help distinguish between different geographical features.
8. They facilitate communication among map users.

2.3 Main categories of symbols on topographical maps

Conventional symbols can be classified into the following categories:

1. Point symbols.
2. Line symbols.
3. Area symbols.
4. Colour symbols.
5. Letter and numerical symbols.
6. Pictorial symbols.

A. Point symbols

These are symbols used to represent geographical features that occupy relatively small areas on a map.

Examples include:

Symbol representation	Feature represented

●	Town or settlement centre, depending on map key
□	Building or structure
✚	Church or religious building, depending on map key
Mosque symbol	Mosque
School symbol	School
H	Hospital
Well symbol	Well
Triangulation pillar symbol	Trigonometrical station
Mine symbol	Mine
Monument symbol	Monument

Note: Exact shapes vary between map series. Always consult the map key.

B. Line symbols

These are symbols used to represent geographical features that have considerable length compared to their width.

Examples include:

Line representation	**Feature represented**
Blue continuous line	River or stream
Blue broken line	Seasonal or intermittent stream
Black continuous line	Railway line or other mapped linear feature
Red continuous line	Major road
Red broken line	Minor road or track, depending on the map key
Black broken line	Footpath or track, depending on the map key
Double parallel lines	Railway or major road, depending on the key
Dashed boundary line	Administrative or other boundary

Dotted line	Footpath or boundary, depending on the key

C. Area symbols

These are symbols used to represent geographical features that cover relatively large areas.

Examples include:

Map representation	**Feature represented**
Green shading	Forest or woodland
Blue shading	Water bodies
Closely spaced tree symbols	Woodland or forest
Repeated marsh symbols	Swamp or marsh
Sand or stippled pattern	Sandy area
Repeated building symbols	Built-up area
Plantation pattern	Plantation
Grass symbols	Grassland
Quarry pattern	Quarrying area
Cultivated land pattern	Agricultural land

D. Colour symbols

Different colours are used to distinguish geographical features on topographical maps.

Colour	**Common representation**
Blue	Rivers, lakes, dams, swamps and other water features
Green	Forests, woodlands and vegetation
Brown	Contour lines and some relief information
Red	Major roads and selected important features
Black	Buildings, settlements, boundaries and many man-made features

Yellow	Cultivated or open land in some map series
Purple	Additional information or revisions on certain map series

Important: Colours are not universal for every topographical map. Their meanings should always be confirmed using the map legend.

3.0 SYMBOLS REPRESENTING HUMAN ACTIVITIES ON TOPOGRAPHICAL MAPS

Human activities are economic, social and cultural activities carried out by people to satisfy their needs and improve their living standards.

Topographical maps represent these activities using different conventional signs, symbols, letters, names, lines and patterns.

The main human activities represented on topographical maps include:

1. Settlement.
2. Transport and communication.
3. Trade and commerce.
4. Industry.
5. Agriculture.
6. Fishing.
7. Forestry.
8. Wildlife conservation.
9. Tourism.
10. Social services.
11. Mining and quarrying.

4.0 SETTLEMENT ACTIVITIES

4.1 Meaning of settlement

A settlement is a place where people establish homes and other structures for living, working and carrying out social and economic activities.

Settlements may be rural or urban.

Topographical maps show the location, distribution, pattern and nature of settlements through buildings, roads, names and other conventional symbols.

4.2 Symbols representing settlement features

Symbol or map evidence	**Feature represented**
Small black squares or rectangles	Individual buildings
Clusters of building symbols	Dense settlement

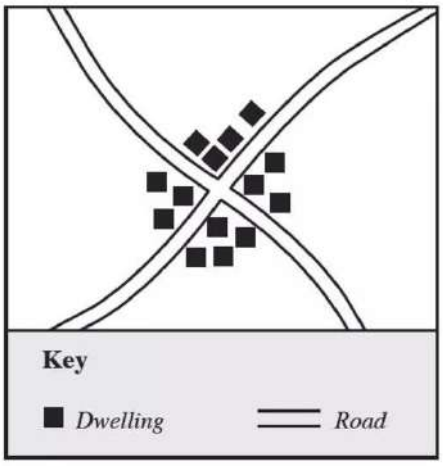
Scattered building symbols	Dispersed settlement
Numerous buildings along a road	Linear settlement
Closely packed buildings	Urban or densely populated settlement
Large groups of buildings	Town or urban centre
Small groups of buildings	Village or rural settlement
Named town	Urban centre
Named village	Rural settlement
Market symbol	Market centre
Administrative buildings	Administrative settlement functions
Residential estate names	Residential areas
Industrial buildings	Industrial settlement functions

4.3 Types of settlement patterns

A settlement pattern refers to the arrangement or distribution of buildings and other human structures in an area.

There are three main settlement patterns.

A. Nucleated settlement pattern



This is a settlement pattern in which buildings are concentrated close together in one particular area.

Characteristics:

1. Buildings are closely grouped together.
2. Houses are concentrated around a common centre.

3. Roads may converge towards the settlement.
4. Social amenities may be concentrated within the settlement.
5. The settlement may develop around a market, water source or transport junction.

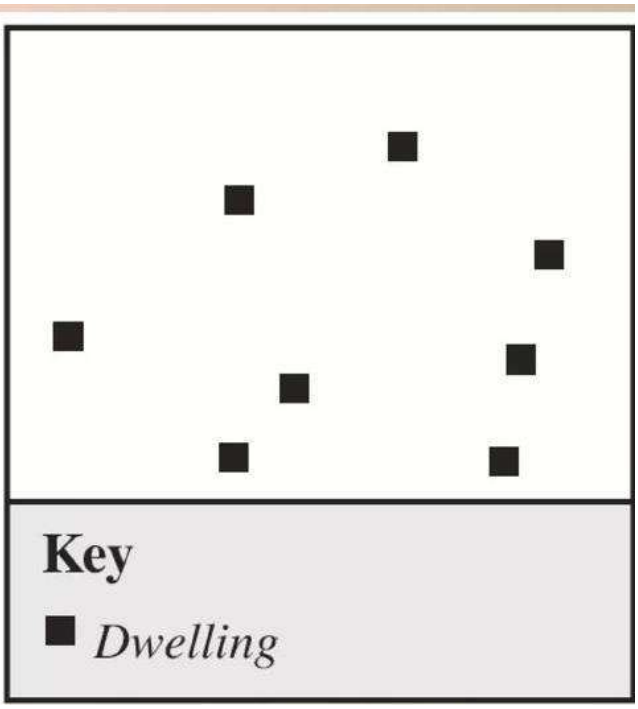
Evidence on a topographical map:

- Closely packed building symbols.
- A concentration of roads and tracks.
- Presence of schools, churches, markets and other services.
- A named village or town.

Factors encouraging nucleated settlements:

1. Availability of water.
2. Security considerations.
3. Presence of fertile agricultural land.
4. Availability of social amenities.
5. Development of trade and markets.
6. Availability of employment opportunities.

B. Dispersed settlement pattern



This is a settlement pattern in which buildings are scattered over a wide geographical area.

Characteristics:

1. Houses are widely separated.
2. Individual homesteads are surrounded by farms or grazing land.
3. Roads and tracks connect individual homesteads.
4. Social amenities may be far apart.

5. It is common in extensive agricultural areas.

Evidence on a topographical map:

- Scattered building symbols.
- Widely spaced homesteads.
- Farms surrounding individual buildings.
- Long distances between settlement centres.

Factors encouraging dispersed settlements:

1. Large individual land holdings.
2. Extensive farming.
3. Availability of land.
4. Low population density.
5. Ownership of large farms.
6. Poor accessibility to central settlement areas.

C. Linear settlement pattern



This is a settlement pattern in which buildings are arranged in a line along a particular geographical feature.

Characteristics:

1. Buildings are arranged along roads, rivers or railway lines.
2. The settlement is elongated.

3. Houses are located close to the main transport route.
4. Economic activities may develop along the route.

Evidence on a topographical map:

- Buildings arranged along roads.
- Buildings following a river valley.
- Houses concentrated along a railway line.
- Elongated settlement distribution.

Factors encouraging linear settlements:

1. Availability of transport routes.
2. Availability of water along rivers.
3. Presence of valleys and narrow strips of suitable land.
4. Commercial development along roads.
5. Availability of fertile land along river valleys.

4.4 Other ways of describing settlement distribution

When interpreting settlements, a learner should examine:

- **Density:** Whether buildings are closely packed or widely scattered.
- **Distribution:** Whether buildings are concentrated in one place or spread over a wide area.
- **Pattern:** Whether settlements are nucleated, dispersed or linear.
- **Size:** Whether the settlement is a hamlet, village, town or city.
- **Function:** Whether the settlement is residential, commercial, industrial, administrative or mixed.
- **Location:** Whether the settlement is found along a river, road, railway, valley or on a plateau.
- **Growth:** Whether the settlement appears to be expanding based on the extent of built-up areas and transport networks.

4.5 Factors influencing settlement distribution

1. Relief – flat land encourages settlement because it is suitable for construction.
2. Climate – favourable climatic conditions attract settlement.
3. Water supply – people settle near reliable water sources.
4. Soil fertility – fertile soils attract agricultural communities.
5. Transport – accessible areas attract settlement.
6. Security – secure areas encourage permanent settlement.
7. Employment – industrial and commercial centres attract people.
8. Social amenities – schools, hospitals and markets attract settlement.
9. Government policy – planned settlement schemes encourage population concentration.
10. Historical factors – historical trading centres and administrative centres may develop into towns.

5.0 TRANSPORT AND COMMUNICATION ACTIVITIES

5.1 Meaning of transport

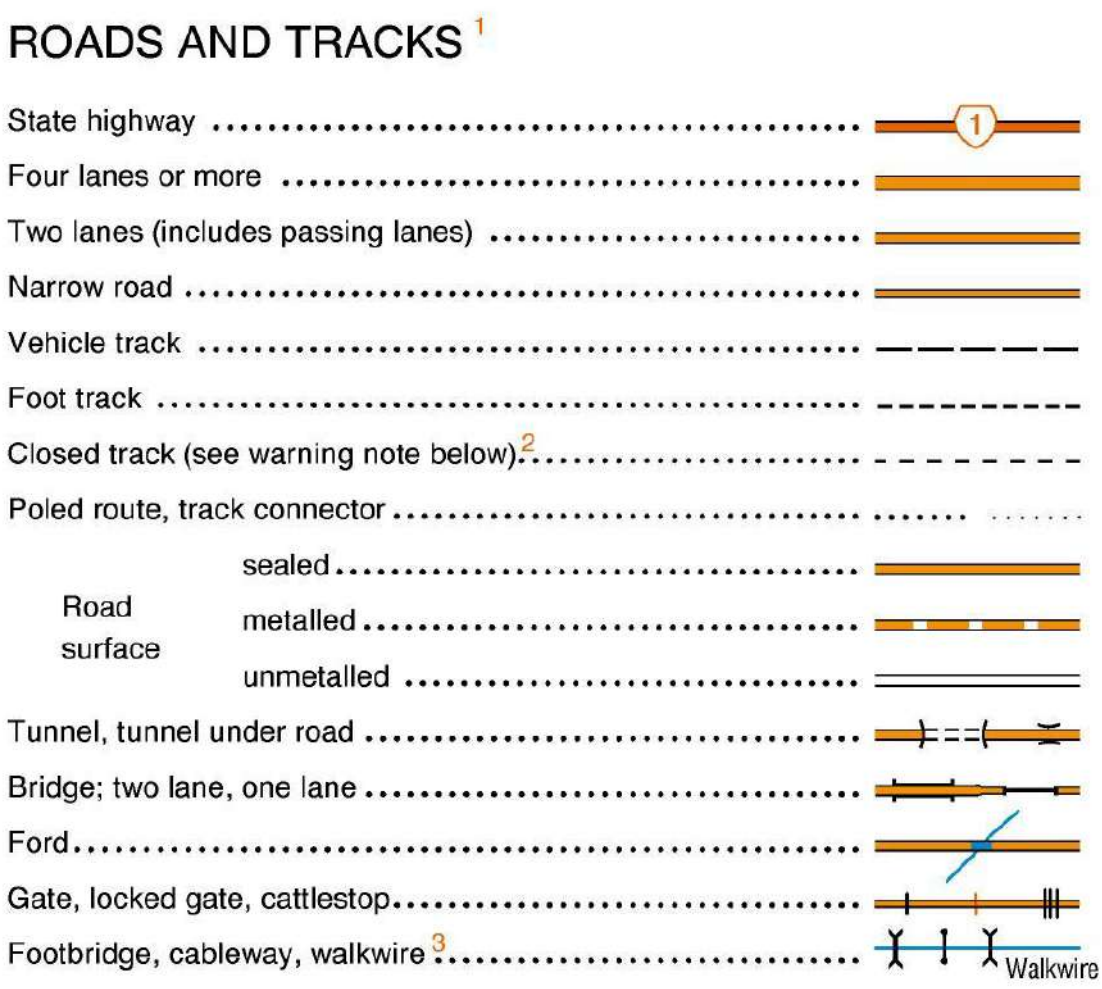
Transport refers to the movement of people, goods and services from one place to another using different means.

Communication refers to the transmission of information from one person or place to another.

Topographical maps represent transport and communication networks through lines, symbols, names and other conventional signs.

5.2 Transport features represented on topographical maps

A. Roads



Roads are routes constructed for the movement of vehicles, bicycles, pedestrians and other forms of road transport.

Common road categories:

Road category	Representation or evidence
Main road	Prominent road symbol, often a thicker or coloured line
Secondary road	Thinner road line

Minor road	Narrow or less prominent line
Motorable track	Track symbol shown in the legend
Footpath	Narrow dotted or broken line
All-weather road	Road identified as usable throughout the year, where indicated
Seasonal road	Road indicated as impassable or difficult during certain seasons, where shown

Interpretation of road networks:

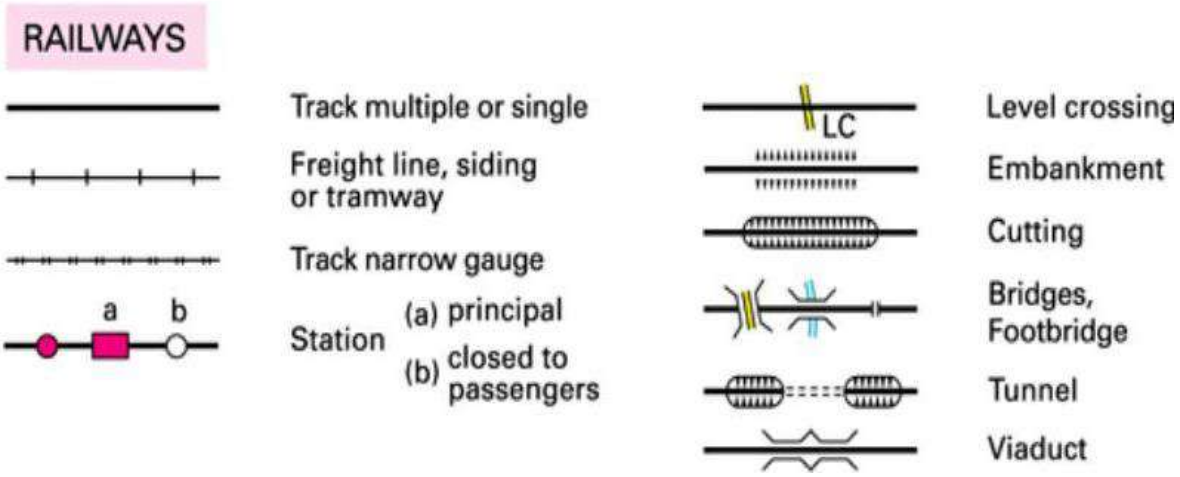
A learner should examine:

1. Number of roads in the area.
2. Types and classes of roads.
3. Length and direction of roads.
4. Distribution of roads.
5. Road density.
6. Condition of roads, where indicated.
7. Connectivity between settlements.
8. Presence of road junctions.
9. Roads connecting towns and markets.
10. Roads crossing rivers and valleys.

What a dense road network may indicate:

- High population concentration.
- High levels of economic activity.
- Advanced infrastructure development.
- Extensive settlement.
- High demand for transport services.

B. Railway lines



Railway transport involves the movement of passengers and goods using trains along railway tracks.

Symbols and features:

Map evidence	**Interpretation**
Parallel railway lines with crossbars	Railway line
Railway station symbol	Railway station
Railway siding	Additional railway track
Railway yard	Area for arranging and storing railway wagons
Railway bridge	Railway crossing over a river or valley
Railway tunnel	Railway passing beneath a hill or other obstacle

Interpretation of railway networks:

1. Identify the railway route.
2. Identify railway stations.
3. Establish the direction of the railway line.
4. Identify settlements connected by railway.
5. Identify railway bridges and tunnels.
6. Examine the relationship between railway lines and industrial centres.
7. Determine the accessibility of the area by rail.

C. Bridges and ferries



- **Bridge:** A structure constructed across a river, valley or other obstacle to facilitate movement.
- **Ford:** A shallow section of a river where people and vehicles can cross.
- **Ferry:** A water transport service used to carry people and vehicles across a water body.

Map evidence:

- Bridge symbols.
- Road or railway lines crossing rivers.
- Names of bridges.
- Ferry symbols.
- Ford symbols.

Interpretation:

- Bridges indicate improved accessibility.
- Ferries suggest the use of water transport.
- Fords indicate crossing points in shallow rivers.
- Numerous bridges may indicate an extensive transport network or the presence of many river crossings.

5.3 Communication features

Communication infrastructure facilitates the exchange of information.

Examples represented on topographical maps include:

Map evidence or symbol	**Feature**

Post office symbol or abbreviation	Post office
Telephone symbol or abbreviation	Telephone facility
Radio mast symbol	Radio transmission station
Television transmitter	Television broadcasting station
Telegraph office	Telegraph communication facility
Communication mast	Telecommunications infrastructure
Named communication facility	Communication service centre

Interpretation:

1. Presence of communication facilities indicates access to communication services.
2. Radio and television masts suggest broadcasting activities.
3. Telephone facilities indicate availability of telecommunications infrastructure.
4. A concentration of communication facilities may indicate an urban or administrative centre.

5.4 Importance of transport and communication

1. They facilitate movement of people and goods.
2. They promote trade and commerce.
3. They encourage industrial development.
4. They improve access to education and healthcare.
5. They facilitate agricultural marketing.
6. They promote tourism.
7. They improve communication and information sharing.
8. They encourage settlement expansion.
9. They create employment opportunities.
10. They promote regional integration.

6.0 TRADE AND COMMERCIAL ACTIVITIES

6.1 Meaning of trade

Trade is the buying and selling of goods and services between individuals, businesses and organisations.

Commercial activities refer to activities involved in the distribution, exchange and sale of goods and services.

6.2 Features representing trade on topographical maps

Symbol or map evidence	**Feature represented**

Market symbol	Market
Named market	Trading centre
Shops	Retail businesses
Shopping centre	Commercial centre
Wholesale market	Wholesale trading activity
Petrol station symbol	Fuel-selling facility
Hotel symbol	Hospitality business
Bank symbol or abbreviation	Banking facility
Post office	Postal services
Commercial buildings	Business premises
Named town centre	Concentration of commercial activities
Bus station	Passenger transport and related commercial services

6.3 How to identify and interpret trade on a topographical map

A learner should examine:

1. Distribution of markets.
2. Number of shops and commercial buildings.
3. Presence of petrol stations.
4. Location of banks and financial institutions.
5. Presence of hotels and restaurants.
6. Location of shopping centres.
7. Relationship between markets and roads.
8. Relationship between markets and agricultural areas.
9. Presence of bus stations and transport terminals.
10. Concentration of commercial facilities in urban centres.

6.4 Factors influencing trade

1. Good transport networks.
2. High population density.

3. Availability of goods for sale.
4. Presence of markets.
5. Availability of purchasing power.
6. Good communication networks.
7. Security.
8. Availability of banking services.
9. Location of trading centres.
10. Availability of storage facilities.

6.5 Interpretation of commercial activities

- Numerous shops and markets indicate active commercial activities.
- Markets located at road junctions suggest accessibility and exchange of goods.
- A concentration of commercial buildings indicates an important trading centre.
- Petrol stations along major roads indicate transport-related commercial activities.
- Hotels and restaurants may indicate commercial, hospitality and tourism activities.

7.0 INDUSTRIAL ACTIVITIES

7.1 Meaning of industry

An industry is an economic activity involving the processing of raw materials into finished or semi-finished products, or the provision of industrial services.

Industries may be classified into primary, secondary and tertiary industries.

A. Primary industries

These involve the extraction or production of raw materials from the natural environment.

Examples:

1. Mining.
2. Fishing.
3. Forestry.
4. Crop farming.
5. Livestock farming.

B. Secondary industries

These involve the processing of raw materials into finished or semi-finished products.

Examples:

1. Food processing.
2. Textile manufacturing.
3. Cement manufacturing.
4. Sugar processing.

5. Dairy processing.
6. Oil refining.
7. Timber processing.

C. Tertiary industries

These involve the provision of services to individuals and other businesses.

Examples:

1. Banking.
2. Transport.
3. Communication.
4. Tourism.
5. Retail trade.
6. Insurance.

7.2 Symbols and evidence of industries on topographical maps

Map evidence	**Industrial feature**
Factory symbol	Manufacturing industry
Industrial buildings	Industrial establishment
Saw mill	Timber processing industry
Flour mill	Food-processing industry
Sugar factory	Sugar-processing industry
Dairy factory	Dairy-processing industry
Tea factory	Tea-processing industry
Coffee factory	Coffee-processing industry
Oil mill	Oil-processing industry
Cement works	Cement manufacturing
Power station	Electricity generation
Quarry	Extraction of building materials

Abattoir	Meat-processing facility
Grain mill	Grain-processing industry

The exact symbols used depend on the map legend. Some industrial features are identified through written labels rather than special symbols.

7.3 How to interpret industrial activities

Examine the following:

1. Number of factories.
2. Types of industries.
3. Distribution of industrial establishments.
4. Location of industries in relation to settlements.
5. Accessibility through roads and railways.
6. Proximity to raw materials.
7. Availability of water sources.
8. Presence of electricity infrastructure.
9. Presence of warehouses and storage facilities.
10. Relationship between industries and commercial centres.

7.4 Factors influencing the location of industries

1. Availability of raw materials.
2. Availability of water.
3. Reliable energy supply.
4. Availability of labour.
5. Good transport networks.
6. Proximity to markets.
7. Availability of land.
8. Government policies.
9. Availability of capital.
10. Security and suitable environmental conditions.

8.0 AGRICULTURAL ACTIVITIES

8.1 Meaning of agriculture

Agriculture refers to the cultivation of crops and the rearing of animals for food, raw materials, income and other economic purposes.

Agriculture is one of the major human activities represented on topographical maps, particularly in rural areas.

8.2 Types of agricultural activities

A. Crop farming

Crop farming involves the cultivation of plants for food, commercial purposes and industrial raw materials.

Examples include:

- Maize farming.
- Wheat farming.
- Tea growing.
- Coffee growing.
- Sugarcane farming.
- Rice cultivation.
- Horticulture.
- Vegetable farming.
- Fruit farming.
- Flower farming.







Map evidence of crop farming:

Map evidence	Interpretation
Tea plantation label or symbol	Commercial tea growing

Coffee plantation label	Coffee cultivation
Sugarcane plantation label	Sugarcane growing
Irrigation canals	Irrigated crop farming
Cultivated land patterns	Crop cultivation
Rice scheme label	Rice farming
Orchards	Fruit growing
Greenhouse structures	Controlled-environment crop production
Farm buildings	Agricultural activities
Large cultivated blocks	Extensive crop cultivation

B. Livestock farming

Livestock farming involves keeping domestic animals for food, income, transport, manure and other products.

Examples:

1. Cattle keeping.
2. Sheep rearing.
3. Goat keeping.
4. Poultry farming.
5. Pig farming.
6. Dairy farming.
7. Beekeeping.
8. Camel keeping.







Map evidence of livestock farming:

Map evidence	**Interpretation**
Grazing land	Livestock keeping
Ranch label	Commercial livestock ranching
Cattle dip	Cattle disease-control facility
Veterinary centre	Livestock health services
Abattoir	Slaughtering and meat processing
Dairy factory	Milk processing
Livestock market	Buying and selling of animals
Water trough	Livestock watering facility
Fenced grazing areas	Managed livestock production

Sheep or cattle ranch	Commercial livestock farming

C. Mixed farming

Mixed farming is the practice of growing crops and keeping livestock on the same farm.

Map evidence:

1. Cultivated fields.
2. Grazing areas.
3. Farmhouses.
4. Cattle dips.
5. Farm tracks.
6. Barns and other farm buildings.

D. Plantation agriculture

Plantation agriculture is the large-scale cultivation of a single commercial crop, usually for sale or industrial processing.

Examples:

- Tea plantations.
- Coffee plantations.
- Sugarcane plantations.
- Sisal plantations.

Map evidence:

- Large areas labelled with plantation crop names.
- Regularly arranged cultivated blocks.
- Processing factories near plantations.
- Estate roads.
- Workers' settlements.

E. Irrigation farming

Irrigation farming involves supplying water artificially to crops to supplement or replace rainfall.



Map evidence:

1. Irrigation canals.
2. Dams and reservoirs.
3. Water pumping stations.
4. Irrigation schemes.
5. Water distribution channels.
6. Irrigated agricultural fields.

Interpretation:

- Irrigation canals indicate artificial water supply for farming.
- Dams and reservoirs may provide water for irrigation.
- Irrigation schemes indicate organised agricultural development.

8.3 Factors influencing agricultural activities

1. Climate.
2. Soil fertility.
3. Relief.
4. Availability of water.
5. Availability of labour.
6. Transport facilities.
7. Availability of markets.

8. Land ownership and size.
9. Government agricultural policies.
10. Access to agricultural technology.
11. Availability of capital.
12. Availability of veterinary and extension services.

8.4 How to interpret agricultural activities on topographical maps

A learner should:

1. Identify the types of crops grown.
2. Identify livestock-keeping areas.
3. Identify plantations and irrigation schemes.
4. Examine the distribution of cultivated land.
5. Identify agricultural processing industries.
6. Locate cattle dips and veterinary facilities.
7. Examine the relationship between farms and transport networks.
8. Identify water sources used for agricultural purposes.
9. Identify grazing areas and ranches.
10. Explain factors influencing agricultural activities.

9.0 FISHING ACTIVITIES

9.1 Meaning of fishing

Fishing is the activity of catching fish and other aquatic organisms from natural water bodies or rearing them in controlled environments for food and commercial purposes.

Fishing may be carried out in:

1. Oceans.
2. Seas.
3. Lakes.
4. Rivers.
5. Dams.
6. Fish ponds.







9.2 Symbols and map evidence representing fishing

Map evidence	**Feature represented**
Fish landing beach	Fish landing site
Fishing harbour	Fishing port
Boat symbol	Water transport or fishing boats
Fish pond	Aquaculture
Fish farm	Fish farming
Fish processing factory	Fish processing industry
Fishing village	Settlement associated with fishing
Named landing site	Fishing activity
Cold storage facility	Fish preservation

Jetty	Landing or docking facility

9.3 How to identify fishing activities on topographical maps

1. Look for fish landing sites along lakes, rivers or the coastline.
2. Identify fishing harbours.
3. Identify fish ponds and fish farms.
4. Locate fish-processing factories.
5. Examine the presence of settlements along water bodies.
6. Identify transport routes connecting fishing centres to markets.
7. Examine the presence of jetties and boat facilities.

9.4 Factors influencing fishing activities

1. Availability of fish.
2. Presence of lakes, rivers and oceans.
3. Availability of fishing equipment.
4. Market demand.
5. Availability of transport.
6. Presence of fish-processing facilities.
7. Availability of skilled labour.
8. Government regulations.
9. Suitable water conditions.
10. Availability of storage and preservation facilities.

9.5 Interpretation of fishing activities

- Fish landing sites indicate commercial or subsistence fishing.
- Fish ponds indicate aquaculture.
- Fish-processing factories indicate value addition.
- Fishing harbours indicate organised fishing and water transport.
- Fishing settlements near lakes suggest dependence on aquatic resources.

10.0 FORESTRY ACTIVITIES

10.1 Meaning of forestry

Forestry refers to the management, conservation, planting, harvesting and utilisation of trees and forest resources.

Forestry may involve natural forests and planted forests.







10.2 Symbols and map evidence representing forestry

Map evidence	**Feature represented**
Green shading	Forested area
Tree symbols	Trees or woodland
Dense tree patterns	Thick forest
Forest boundary	Extent of forest
Forest station	Forest management facility
Tree nursery	Tree seedling production
Saw mill	Timber processing
Forest plantation label	Planted forest
Forest road	Access route within forest

Forest reserve label	Protected forest area
Timber yard	Timber storage or processing

10.3 Types of forests

A. Natural forests

These are forests that develop naturally without being deliberately planted by humans.

Examples in Kenya include:

- Mau Forest Complex.
- Kakamega Forest.
- Arabuko-Sokoke Forest.
- Mount Kenya Forest.
- Cherangani Forest.

B. Plantation forests

These are forests established by planting trees for commercial, environmental or other purposes.

Examples include plantations of:

- Cypress.
- Pine.
- Eucalyptus.

10.4 How to interpret forestry activities

1. Identify forested areas.
2. Determine the size and distribution of forests.
3. Identify natural forests and plantation forests where labelled.
4. Locate sawmills and timber-processing facilities.
5. Identify forest roads and management stations.
6. Identify forest reserves and protected areas.
7. Examine the relationship between forests and settlements.
8. Identify areas suitable for afforestation.

10.5 Importance of forestry

1. Provides timber for construction and furniture.
2. Provides fuelwood and charcoal.
3. Creates employment.
4. Protects water catchment areas.
5. Prevents soil erosion.
6. Provides habitats for wildlife.

7. Promotes tourism.
8. Absorbs carbon dioxide.
9. Helps regulate local climate.
10. Provides raw materials for industries.

11.0 WILDLIFE CONSERVATION ACTIVITIES

11.1 Meaning of wildlife

Wildlife refers to animals and other organisms that exist naturally in their habitats without being domesticated.

Wildlife conservation involves protecting wild animals, plants and their natural habitats.







11.2 Symbols and map evidence representing wildlife conservation

Map evidence	**Feature represented**
National park boundary	Protected wildlife area
Game reserve boundary	Wildlife conservation area
Wildlife sanctuary	Protected wildlife habitat
Game ranch	Wildlife management area
Game lodge	Wildlife tourism facility
Safari camp	Tourist accommodation
Wildlife viewing point	Wildlife observation area
Ranger station	Wildlife protection facility
Watering point	Water source for wildlife

Salt lick	Wildlife feeding site
Named national park	Wildlife conservation area

11.3 How to identify wildlife activities on topographical maps

1. Look for national park boundaries.
2. Identify game reserves and sanctuaries.
3. Locate game lodges and tourist camps.
4. Identify wildlife viewing points.
5. Examine the distribution of vegetation and water sources.
6. Identify access roads into protected areas.
7. Locate ranger stations and other conservation facilities.
8. Identify the relationship between wildlife areas and nearby settlements.

11.4 Importance of wildlife conservation

1. Protects endangered species.
2. Promotes tourism.
3. Generates government revenue.
4. Creates employment opportunities.
5. Maintains ecological balance.
6. Promotes scientific research.
7. Protects biodiversity.
8. Preserves natural heritage.
9. Supports local community development.
10. Promotes environmental education.

12.0 TOURISM AND RECREATIONAL ACTIVITIES

12.1 Meaning of tourism

Tourism refers to the movement of people from their usual places of residence to other places for leisure, business, education, adventure or other purposes.

Recreation refers to activities carried out during leisure time for enjoyment, relaxation and physical fitness.







12.2 Symbols and map evidence representing tourism

Map evidence	Feature represented

Hotel symbol	Hotel accommodation
Tourist lodge	Tourist accommodation
Camping site	Camping facility
Picnic site	Recreational facility
National park	Wildlife tourism attraction
Game reserve	Wildlife tourism attraction
Viewpoint	Scenic viewing area
Waterfall	Natural tourist attraction
Hot spring	Natural tourist attraction
Cave	Tourist attraction
Museum	Cultural tourism attraction
Historical monument	Heritage attraction
Beach	Coastal tourism and recreation
Golf course	Recreational facility
Stadium	Sports and recreational facility
Swimming pool	Recreational facility
Mountain peak	Mountain tourism attraction
Nature trail	Walking and nature tourism route

12.3 How to interpret tourism activities

1. Identify tourist attractions.
2. Locate hotels and lodges.
3. Identify camping and picnic sites.
4. Locate national parks and game reserves.
5. Identify beaches, waterfalls and caves.

6. Examine roads leading to tourist attractions.
7. Identify recreational facilities.
8. Determine the accessibility of tourist attractions.
9. Examine the relationship between tourism and settlements.
10. Identify the concentration of tourist facilities.

12.4 Factors influencing tourism

1. Presence of attractive physical features.
2. Availability of wildlife.
3. Good transport networks.
4. Political stability.
5. Availability of accommodation.
6. Security.
7. Availability of recreational facilities.
8. Good communication networks.
9. Government promotion of tourism.
10. Availability of tourist services.

13.0 SOCIAL SERVICES AND ADMINISTRATIVE ACTIVITIES

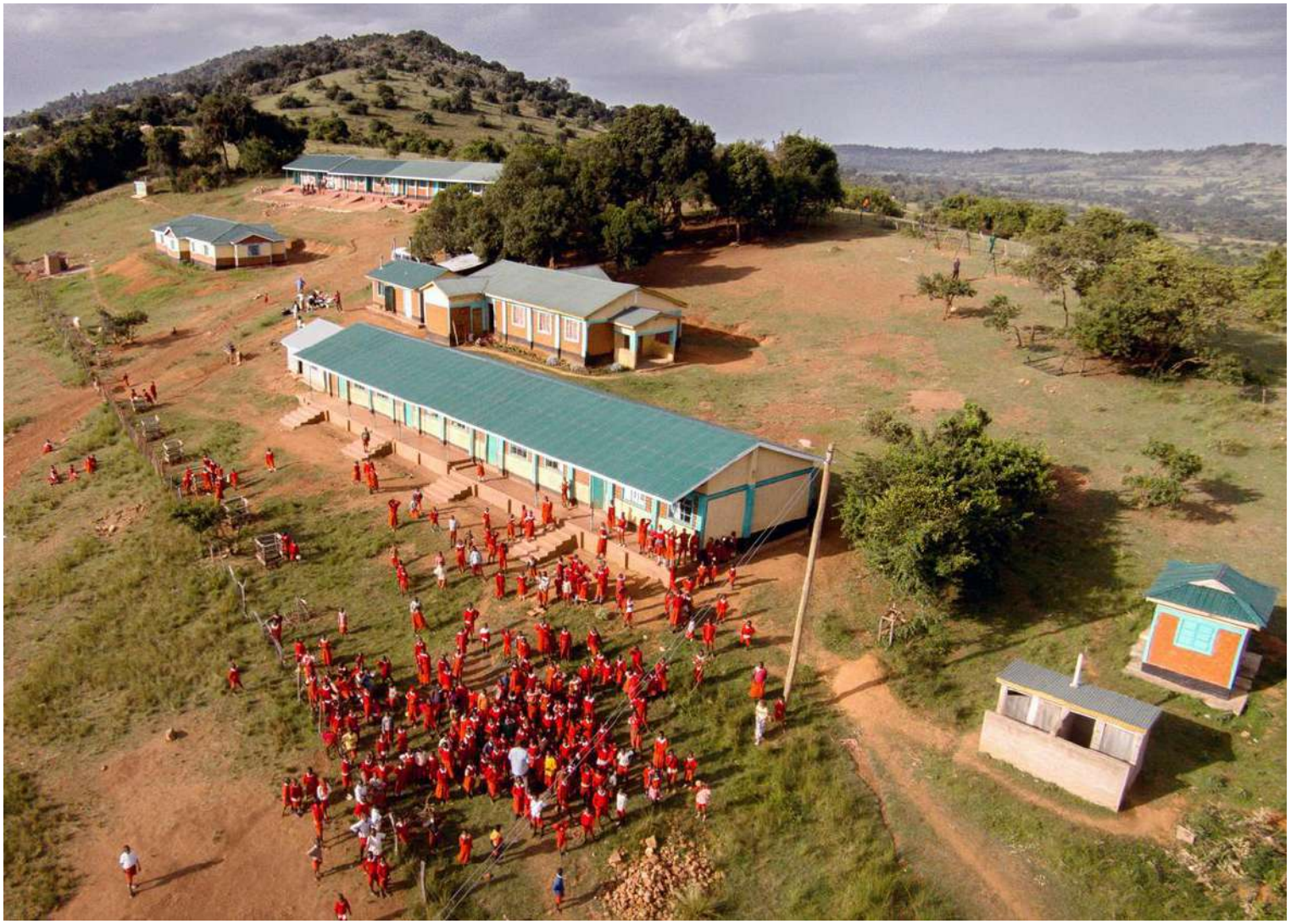
13.1 Meaning of social services

Social services are facilities and activities provided to improve the welfare and quality of life of individuals and communities.

They include education, healthcare, security, religious services, water supply and administrative services.

13.2 Educational facilities

Educational facilities provide teaching and learning services.



Map symbols and evidence:

Map evidence	**Feature represented**
School symbol	School
Primary school label	Primary school
Secondary school label	Secondary school
College label	College
University label	University
Technical institute label	Technical training institution
Teachers' training college	Teacher training institution
School playing field	Recreational facility within a school

Interpretation:

- Numerous schools indicate access to educational services.
- A concentration of schools may indicate a densely populated area.
- Colleges and universities suggest higher educational services.
- Schools located in remote areas may indicate efforts to provide education to rural communities.

13.3 Healthcare facilities

Healthcare facilities provide medical services to individuals and communities.



Map symbols and evidence:

Map evidence	**Feature represented**
H	Hospital, where indicated by the map key
Hospital symbol	Hospital
Dispensary symbol	Dispensary
Health centre label	Health centre
Maternity facility	Maternity services
Clinic	Medical clinic
Veterinary clinic	Animal health services

Interpretation:

1. Hospitals indicate access to advanced healthcare.
2. Dispensaries indicate provision of basic medical services.
3. Health centres indicate local healthcare provision.
4. A concentration of medical facilities may indicate a major urban or administrative centre.
5. The distribution of health facilities helps establish accessibility to healthcare.

13.4 Religious facilities

Religious facilities are buildings or places used for worship and other religious activities.



Map evidence:

Map evidence	Feature represented
Church symbol	Church
Mosque symbol	Mosque
Temple symbol	Temple
Mission station	Religious mission centre
Religious centre	Place of worship
Cemetery	Burial ground

Interpretation:

- Churches, mosques and temples indicate the presence of religious services.
- Mission stations may indicate historical religious activities.
- Cemeteries indicate designated burial areas.

13.5 Security facilities

Security facilities are establishments responsible for maintaining law and order and protecting people and property.

Map evidence:

Map evidence	Feature represented
Police station symbol	Police station
Police post	Police post
Prison symbol	Prison
Military camp	Military installation
Army barracks	Military accommodation
Border post	Border security facility
Fire station	Fire and emergency services

Interpretation:

- Police stations indicate provision of security services.
- Military camps may indicate strategic security installations.
- Fire stations indicate availability of emergency response services.

13.6 Administrative facilities

Administrative facilities are buildings and institutions used to manage government and public affairs.

Map evidence:

1. Chief's office.
2. Assistant chief's office.
3. County government offices.
4. District or sub-county headquarters.
5. Government administrative buildings.
6. Law courts.
7. Registration offices.

8. County assembly buildings.

Interpretation:

- Administrative offices indicate centres of government operations.
- A concentration of government buildings suggests an administrative centre.
- Courts indicate the provision of judicial services.

13.7 Water and sanitation services

These are facilities used to provide clean water and maintain proper sanitation.

Map evidence:

Map evidence	**Feature represented**
Water tank	Water storage facility
Water tower	Elevated water storage
Water pipeline	Water distribution network
Water treatment works	Water purification facility
Dam	Water storage
Borehole	Underground water source
Well	Water source
Spring	Natural water source
Sewerage works	Wastewater treatment
Public toilet	Sanitation facility

Interpretation:

1. Boreholes and wells indicate access to groundwater.
2. Water pipelines indicate water distribution infrastructure.
3. Dams and reservoirs indicate water storage.
4. Water treatment works indicate water purification.
5. Sewerage facilities indicate organised wastewater management.

14.0 MINING AND QUARRYING ACTIVITIES

14.1 Meaning of mining

Mining is the extraction of valuable minerals and other geological materials from the earth for economic purposes.

Examples of minerals include:

- Gold.
- Soda ash.
- Limestone.
- Fluorspar.
- Copper.
- Iron ore.
- Diatomite.
- Gemstones.
- Titanium minerals.

14.2 Meaning of quarrying

Quarrying is the extraction of building materials such as stones, sand, gravel and limestone from the earth's surface.







14.3 Symbols and map evidence representing mining and quarrying

Map evidence	Feature represented
Mine symbol	Mining site
Named mine	Mineral extraction site
Quarry symbol	Quarry
Open excavation	Open-cast mine or quarry
Mining shaft	Underground mine entrance
Mineral processing plant	Mineral processing facility
Tailings area	Mining waste disposal area
Stone quarry	Stone extraction site
Gravel pit	Gravel extraction site
Sand pit	Sand extraction site
Railway siding near a mine	Mineral transportation facility
Mining settlement	Settlement associated with mining

14.4 How to interpret mining activities

1. Identify the location of mines and quarries.
2. Identify the types of minerals extracted where labelled.
3. Determine whether extraction is surface or underground.
4. Locate mineral-processing industries.
5. Examine the transport routes serving mining areas.
6. Identify settlements associated with mining.
7. Examine the relationship between mining areas and water sources.
8. Identify the distribution of quarries and excavation sites.

14.5 Factors influencing mining activities

1. Presence of mineral deposits.
2. Availability of capital.
3. Availability of skilled labour.
4. Good transport facilities.

5. Availability of energy.
6. Availability of water.
7. Government policies.
8. Market demand.
9. Availability of mining technology.
10. Suitable geological conditions.

14.6 Effects of mining

Positive effects:

1. Creates employment opportunities.
2. Provides raw materials for industries.
3. Generates government revenue.
4. Promotes infrastructure development.
5. Encourages growth of settlements.
6. Earns foreign exchange through mineral exports.

Negative effects:

1. Causes land degradation.
2. May lead to water pollution.
3. Destroys natural vegetation.
4. May cause soil erosion.
5. Can displace communities.
6. May destroy wildlife habitats.
7. Can expose workers to occupational hazards.

15.0 METHODS OF READING AND INTERPRETING HUMAN ACTIVITIES ON TOPOGRAPHICAL MAPS

Map interpretation involves more than identifying symbols. A learner must examine the geographical evidence, establish relationships and make logical conclusions.

15.1 General procedure for interpreting human activities

Step 1: Study the map title

The title identifies the geographical area represented.

Step 2: Examine the key or legend

Identify the conventional signs and symbols used to represent human activities.

Step 3: Study the scale

Determine the relationship between map distance and actual ground distance.

Step 4: Examine the distribution of features

Identify where human activities are concentrated and where they are absent.

Step 5: Identify the dominant human activities

Determine the most common economic and social activities.

Step 6: Examine the relationship between human activities and physical features

For example:

- Agriculture in areas with fertile soils.
- Settlements near water sources.
- Fishing along lakes and rivers.
- Tourism in areas with attractive scenery.
- Mining in areas with mineral deposits.

Step 7: Examine the transport network

Identify how roads, railways and other routes support human activities.

Step 8: Make geographical deductions

Use the evidence to explain the possible reasons for the distribution of activities.

Step 9: Support conclusions with map evidence

Always mention specific features observed on the map.

16.0 HOW TO ANSWER TOPOGRAPHICAL MAP INTERPRETATION QUESTIONS

Learners are often asked questions requiring identification, description, explanation and evidence.

It is important to understand the meaning of common instruction words.

Instruction word	What the learner should do
Identify	Give the name of the feature or activity
State	Give a brief factual answer
List	Give several answers without lengthy explanations
Describe	Give the characteristics or appearance of a feature
Explain	Give reasons or show how something happens
Compare	Show similarities and differences
Account for	Give reasons for an observed pattern
Locate	Give the position of a feature
Outline	Give the main points

Distinguish	Show how two features differ
Illustrate	Give examples or use a suitable diagram
Interpret	Explain the geographical meaning of map evidence

16.1 How to describe settlement distribution

When asked to describe settlement distribution, consider:

1. Whether settlements are concentrated or scattered.
2. Whether they are nucleated, linear or dispersed.
3. Whether settlements are located along roads.
4. Whether settlements are found near rivers.
5. Whether settlements are concentrated on flat land.
6. Whether settlements are evenly or unevenly distributed.
7. Whether settlements are concentrated around trading centres.

Example question:

Describe the settlement pattern shown on a topographical map.

Model answer:

- The settlement is mainly nucleated, as shown by the concentration of buildings around the trading centre.
- Some dispersed settlements are found in the surrounding agricultural areas.
- A linear settlement pattern is also evident along the main road.

16.2 How to identify the dominant economic activity

Examine the number and distribution of features representing different activities.

Example:

If the map shows:

- Extensive tea plantations.
- Tea factories.
- Farmhouses.
- Estate roads.

The dominant economic activity is likely to be commercial tea farming.

16.3 How to explain the relationship between human activities and physical features

Use evidence from the map to establish how natural features influence human activities.

Examples:

Physical feature	**Human activity encouraged**

Fertile soils	Crop farming
Flat land	Settlement and transport development
Rivers	Fishing, irrigation and water supply
Lakes	Fishing and tourism
Forests	Forestry and tourism
Mountains	Tourism and some forms of farming
Mineral deposits	Mining
Natural grasslands	Livestock farming
Coastal areas	Fishing, tourism and port activities
Valleys	Settlement, farming and transport routes

17.0 ENLARGEMENT AND REDUCTION OF TOPOGRAPHICAL MAPS

17.1 Meaning of map enlargement

Map enlargement is the process of increasing the size of a map or a selected section of a map while maintaining the original shape and proportions of the features.

17.2 Meaning of map reduction

Map reduction is the process of decreasing the size of a map or part of a map while maintaining the original shape and proportions of the features.

17.3 Reasons for enlarging maps

1. To study geographical features in greater detail.
2. To make small symbols easier to identify.
3. To analyse settlement patterns.
4. To study transport networks.
5. To identify land-use patterns.
6. To prepare detailed sketch maps.
7. To support urban and rural planning.
8. To make map interpretation easier.

17.4 Reasons for reducing maps

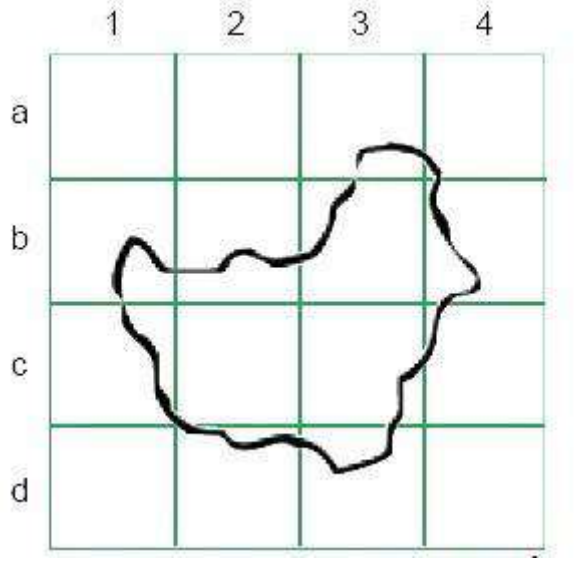
1. To fit maps into books and reports.
2. To compare different geographical areas.

3. To prepare maps covering larger geographical areas.
4. To save printing space.
5. To simplify the presentation of geographical information.
6. To prepare maps for reports and presentations.

17.5 Methods of enlarging and reducing topographical maps

A. Grid square method

This is a method in which a map is divided into equal squares to make it easier to enlarge or reduce.



Procedure for enlarging a map using the grid square method:

1. Select the section of the map to be enlarged.
2. Draw a grid of equal squares over the original map.
3. Number the horizontal and vertical grid lines.
4. Draw another grid with larger squares on a separate sheet.
5. Maintain the same number of squares.
6. Transfer the geographical features from each original square into the corresponding enlarged square.
7. Ensure that the features maintain their original shapes and positions.
8. Add all important symbols and labels.
9. Include the title, key and scale where necessary.
10. Check that the enlarged map is accurate.

Example:

If the original grid squares measure 2 cm by 2 cm and the new grid squares measure 4 cm by 4 cm:

Enlargement factor=4/2=2

The map is enlarged by a factor of 2.

B. Square or rectangle method

This method involves dividing the original map into equal rectangles and reproducing the rectangles at a larger or smaller size.

Procedure:

1. Draw rectangles over the original map.
2. Number the rectangles.
3. Draw corresponding larger or smaller rectangles.
4. Transfer the features from each rectangle.
5. Maintain the correct relative positions of features.
6. Label the reproduced features.

C. Photographic or digital method

This involves using photocopiers, scanners or computer software to enlarge or reduce a map.

Examples of software include:

- Microsoft Word.
- Microsoft PowerPoint.
- Adobe Photoshop.
- Geographic Information Systems (GIS).
- Image editing software.

Procedure:

1. Scan or photograph the map.
2. Open the map image using suitable software.
3. Select the required section.
4. Adjust the image dimensions proportionally.
5. Ensure that the width and height are adjusted using the same enlargement or reduction factor.
6. Save or print the resulting map.

17.6 Calculating the enlargement factor

The enlargement factor is the number of times the original map dimensions have been increased.

Enlargement factor=New lengthOriginal lengthEnlargement factor=Original lengthNew length

Example 1

A section of a topographical map measures 5 cm. It is enlarged to 15 cm. Calculate the enlargement factor.

Solution:

=15/5=3

Therefore, the map has been enlarged by a factor of 3.

17.7 Calculating the reduction factor

Reduction factor=New lengthOriginal lengthReduction factor=Original lengthNew length

Example 2

A map measuring 20 cm is reduced to 10 cm. Calculate the reduction factor.

Solution:

=10/20 =0.5

Therefore, the map has been reduced to half its original linear dimensions.

17.8 Calculating new map dimensions

Example 3

A rectangular map measures 12 cm by 8 cm. It is enlarged by a factor of 2. Calculate the new dimensions.

Solution:

New length:

12×2=24 cm

New width:

8×2=16 cm

New dimensions are 24 cm by 16 cm.

17.9 Relationship between enlargement and map scale

When a map is enlarged, its representative fraction becomes smaller because the same ground distance is represented by a longer distance on the map.

When a map is reduced, its representative fraction becomes larger because the same ground distance is represented by a shorter distance on the map.

Example:

An original map has a scale of 1:50,000. It is enlarged by a factor of 2.

New scale:

=1:50,000/2=1:50,000

The new scale is 1:25,000.

If the same map is reduced to half its original linear size:

50,000×2=100,000

The new scale is 1:100,000.

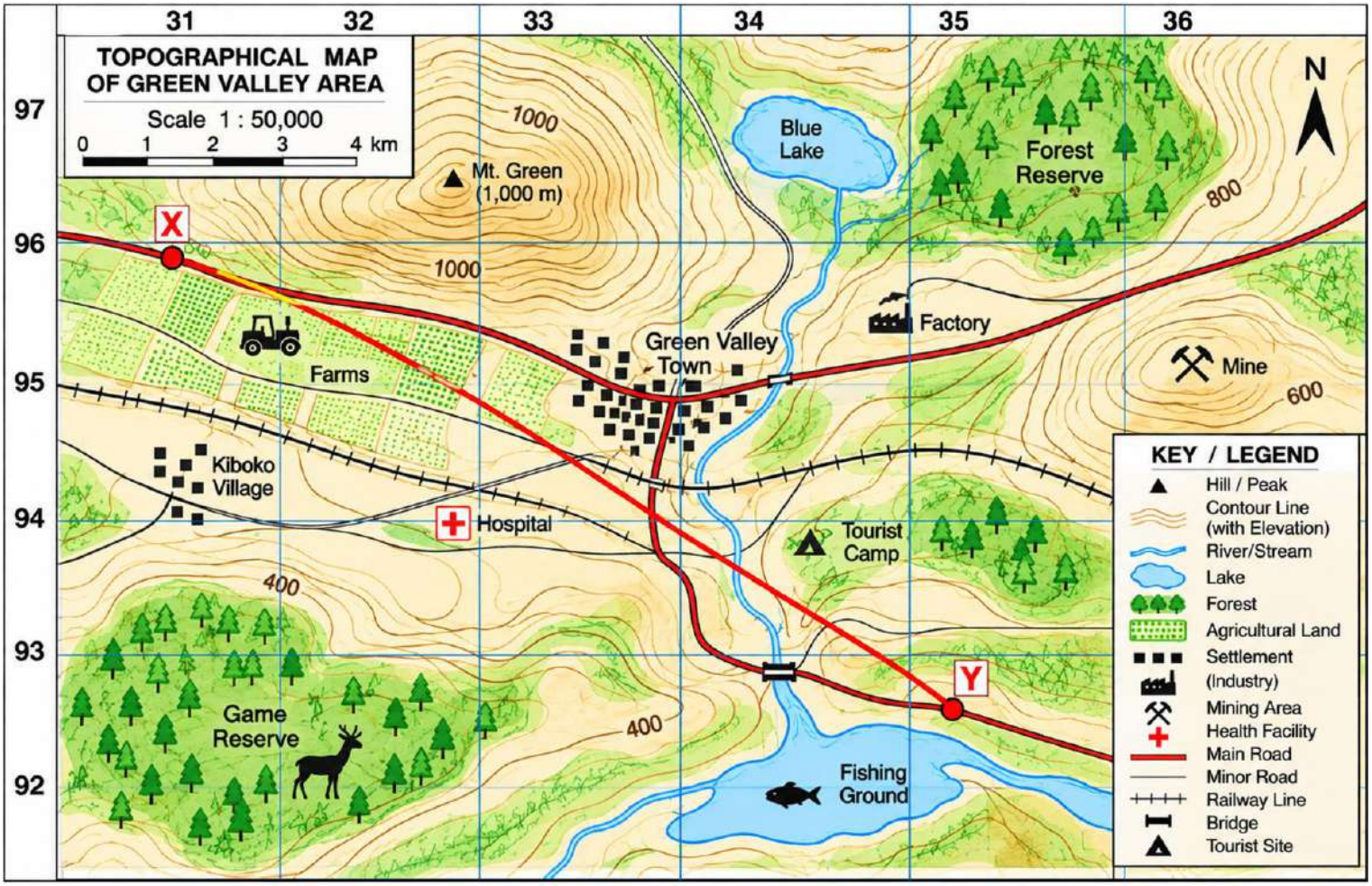
18.0 SKETCH MAPS OF ENLARGED OR REDUCED SECTIONS

18.1 Meaning of a sketch map

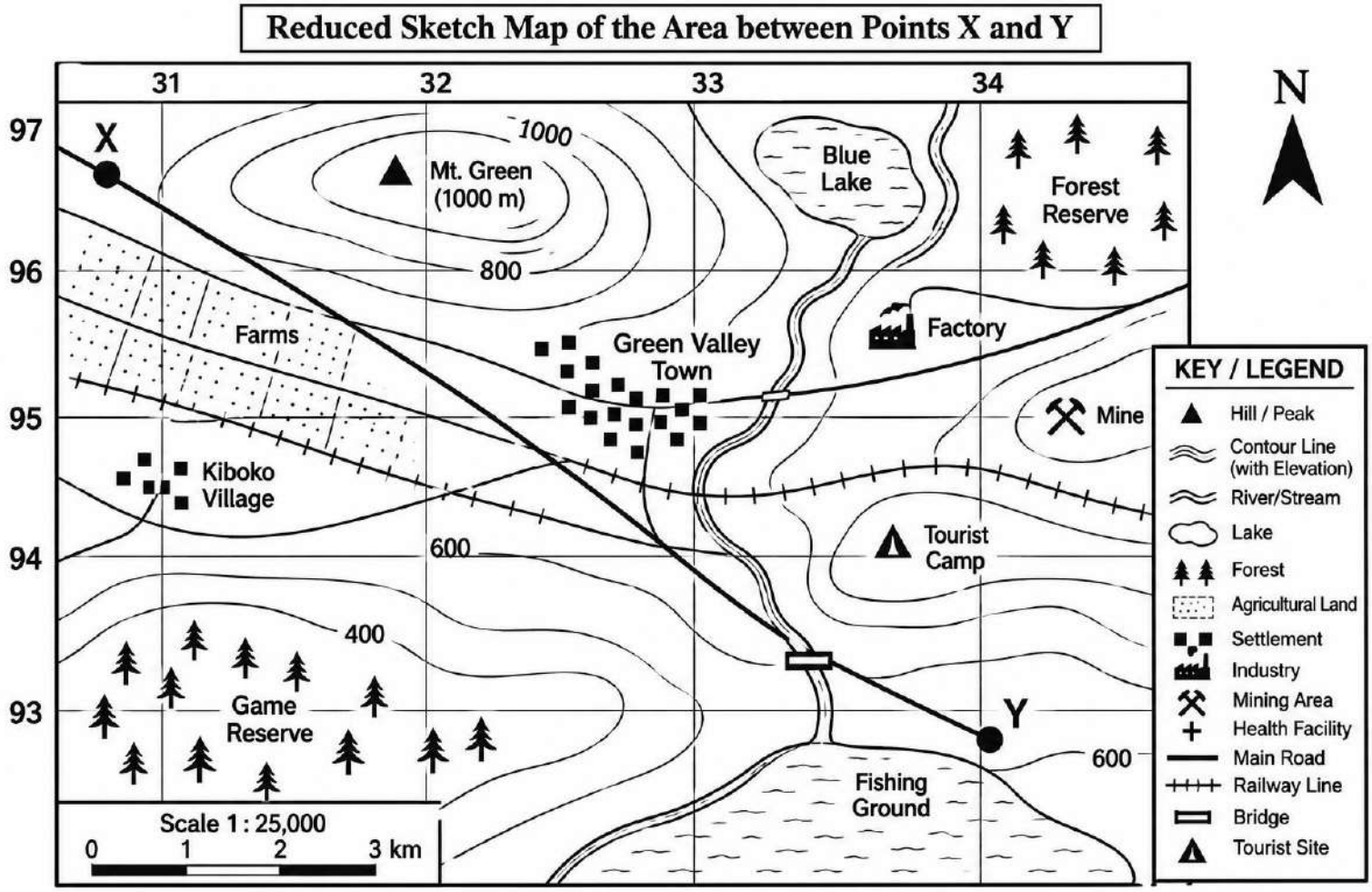
A sketch map is a simplified drawing of a geographical area showing the main features and their relative positions.

It may be drawn from a topographical map to emphasise particular geographical features.

Drawing a sketch map from topographical map

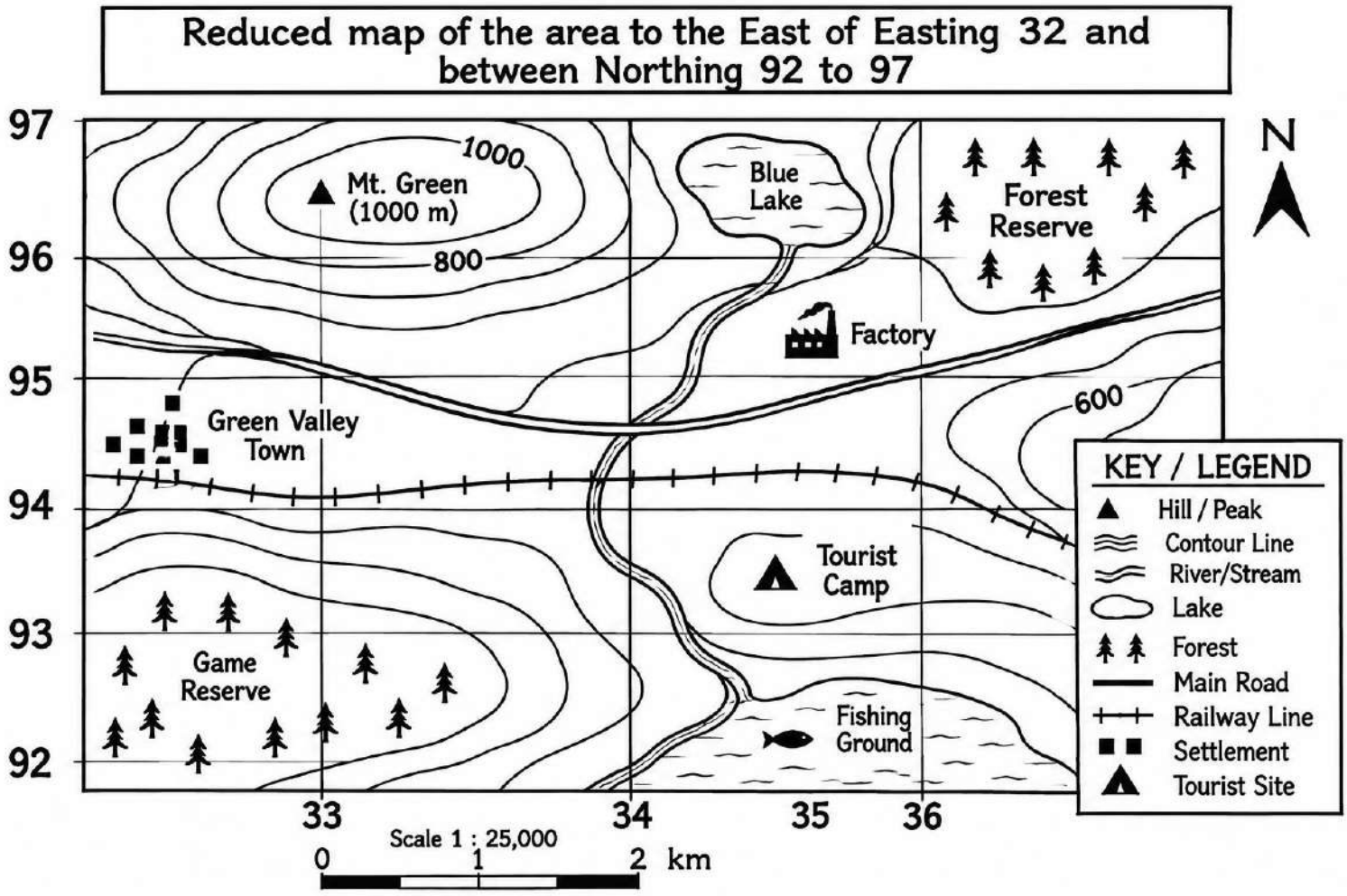


Using the topographical map of Green Valley Area provided, reduce the section x and y by a scale factor of ½. Draw a sketch map of the reduced area, showing and labelling the main physical and human features.



Drawing a sketch map from topographical map

Using the topographical map of Green Valley Area provided, reduce the section of the map lying east of Easting 32 and between Northings 92 and 97 by a scale factor of ½. Draw a sketch map of the reduced area, showing and labelling the main physical and human features.



The sketch map covers the requested area:

- East of Easting 32.
- Between Northings 92 and 97.
- Reduced by a factor of two.
- Grid lines and grid references included.
- Main physical and human features simplified.
- North arrow, scale and key/legend included.

QUESTION

Study the map of Mumias 1:50,000 (Sheet 101/2) provided and answer the following questions.

a.i. Identify two types of scales that have been used in the map extract. (2 marks)

ii. What was the magnetic declination of Mumias as at January 1965? (2 mks)

iii. Name three districts covered by the map of Mumias. (2 mks)

iv. Measure the length of the dry weather road from the junction at grid reference 6028 up to the bridge at grid reference 6434. Give your answer in KM (2 mks)

b.i. Reduce by two, the area to the East of Easting 50 and enclosed by Northing 30 to 40.(2 marks)

On it mark and name;

1. River Nzoia (1mark)
2. All weather road loose surface (1mark)
3. District boundary (1mark)
4. Seasonal swamp (1mark)

ii. Calculate the scale of the reduced area (2marks)

c. Describe the drainage of the area covered by the map. (5 marks)

d. Citing evidence from the map, identify two economic activities carried out in the area covered by the map. (4 marks)

Marking Scheme Answer

a.i.

1. Representative fraction/ Ratio scale
2. Linear scale

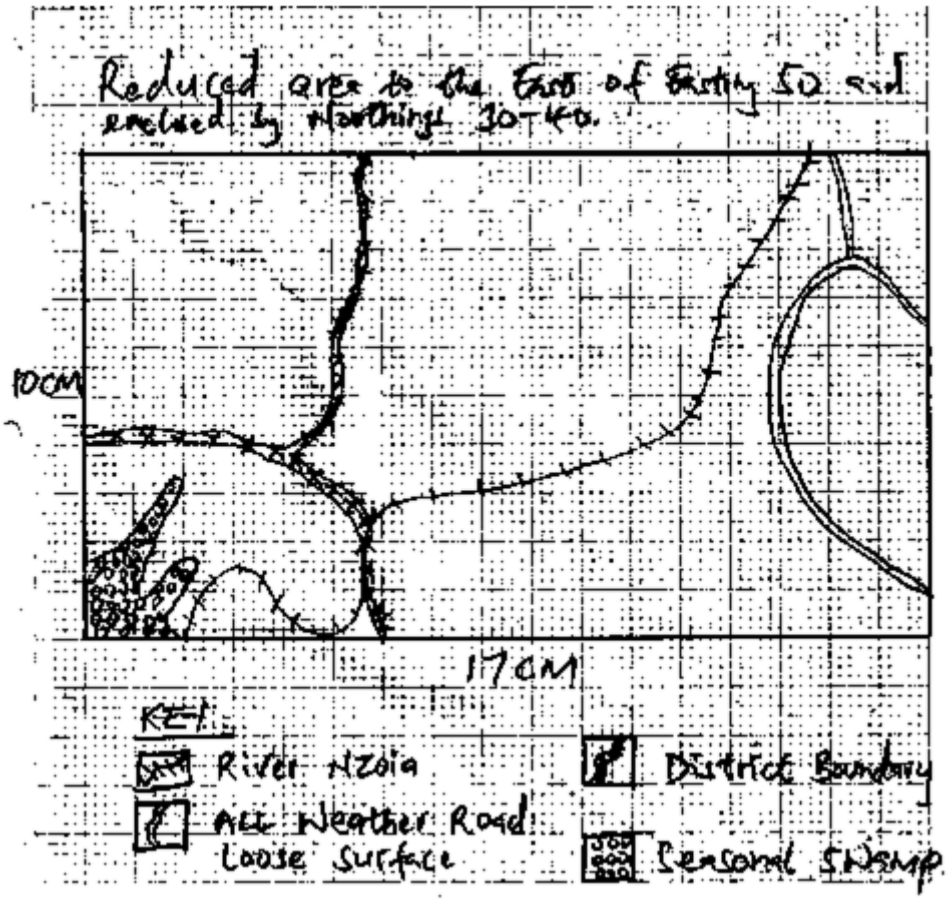
ii. 2° 19'

iii.

1. Busia District
2. Kakamega District
3. Bungoma District
4. Siaya District

iv. 6.8 km ±0.1 (6.7 – 6.9 km)

b.i.



ii. New scale: 1:50,000 ′2 = 1:100,000

c.

1. There are many permanent rivers in the area
2. The main river is River Nzoia
3. River Nzoia flows towards the South Western side of the area covered by the map.
4. There are several seasonal/papyrus swamps in the area covered by the map
5. There are disappearing rivers in the area covered by the map
6. Some rivers form dendritic drainage patterns with their tributaries.
7. There are dams at Bumala, Buhuyi

d.

1. Trade as evidenced by markets
2. Transport as evidenced by many roads

18.2 Characteristics of a good sketch map

1. It should have a clear and appropriate title.
2. It should show the main geographical features.
3. It should have accurate relative positions of features.
4. It should be neat and clearly labelled.
5. It should have a key where necessary.
6. It should have a north direction where appropriate.
7. It should show the important roads and rivers.
8. It should be proportional to the original map if enlargement or reduction is required.
9. It should avoid unnecessary details.
10. It should be easy to interpret.

18.3 Features that may be included in sketch maps

- Roads.
- Rivers.
- Settlements.
- Schools.
- Hospitals.
- Markets.
- Railway lines.
- Bridges.
- Forests.
- Farms.
- Mines.
- Tourist attractions.
- Industrial centres.
- Administrative offices.

18.4 Importance of sketch maps

1. They simplify complex geographical information.
2. They highlight important geographical features.
3. They make geographical interpretation easier.
4. They assist in explaining spatial relationships.
5. They support planning and decision-making.
6. They are useful in geographical fieldwork.

7. They facilitate communication of geographical information.

19.0 USES OF TOPOGRAPHICAL MAPS IN PLANNING

Topographical maps are important tools used by individuals, governments, organisations and professionals in planning and development.

19.1 Settlement and urban planning

Topographical maps help planners to:

1. Identify suitable sites for residential areas.
2. Identify areas suitable for commercial development.
3. Plan roads and streets.
4. Identify areas prone to flooding.
5. Locate suitable sites for public facilities.
6. Plan the expansion of towns.
7. Identify existing land-use patterns.
8. Avoid unsuitable construction areas such as steep slopes and wetlands.

19.2 Agricultural planning

Topographical maps help agricultural planners to:

1. Identify areas suitable for crop farming.
2. Identify suitable grazing areas.
3. Locate water sources for irrigation.
4. Plan irrigation canals.
5. Identify agricultural access roads.
6. Locate suitable sites for farm buildings.
7. Identify areas susceptible to soil erosion.
8. Plan agricultural settlements.

19.3 Transport planning

They help transport planners to:

1. Identify suitable routes for roads.
2. Plan railway lines.
3. Identify suitable bridge construction sites.
4. Locate suitable sites for bus stations.
5. Identify obstacles such as hills and valleys.
6. Plan routes that reduce construction costs.
7. Identify areas requiring improved transport networks.

19.4 Industrial planning

Topographical maps help industrial planners to:

1. Identify suitable industrial sites.
2. Locate industries near raw materials.
3. Identify sources of water.
4. Identify available transport networks.
5. Locate suitable sites for warehouses.
6. Identify areas with adequate space for expansion.
7. Avoid environmentally sensitive areas.

19.5 Environmental planning

Topographical maps help environmental planners to:

1. Identify forests requiring protection.
2. Locate wetlands and water catchment areas.
3. Identify areas susceptible to soil erosion.
4. Plan afforestation projects.
5. Identify areas prone to flooding.
6. Plan wildlife conservation areas.
7. Identify human activities that may threaten the environment.

19.6 Tourism planning

Topographical maps help tourism planners to:

1. Locate tourist attractions.
2. Identify suitable sites for hotels and lodges.
3. Plan tourist routes.
4. Identify camping sites.
5. Locate scenic viewpoints.
6. Identify accessible recreational areas.
7. Plan facilities within tourist destinations.

19.7 Disaster management

Topographical maps assist in:

1. Identifying flood-prone areas.
2. Identifying steep slopes susceptible to landslides.
3. Planning evacuation routes.
4. Identifying safe locations for emergency shelters.
5. Locating hospitals and emergency facilities.
6. Planning responses to natural disasters.

7. Identifying communities at risk.

19.8 Military and security planning

Topographical maps help in:

1. Identifying strategic locations.
2. Understanding terrain characteristics.
3. Planning movement routes.
4. Locating water sources.
5. Identifying natural barriers.
6. Supporting emergency and security operations.

20.0 COMMON CHALLENGES IN READING AND INTERPRETING TOPOGRAPHICAL MAPS

1. Unfamiliarity with conventional symbols.
2. Difficulty interpreting contour lines.
3. Small and unclear map symbols.
4. Inaccurate measurement of distances.
5. Difficulty identifying settlement patterns.
6. Difficulty relating human activities to physical features.
7. Outdated information on some maps.
8. Difficulty interpreting abbreviations.
9. Differences in symbols between map series.
10. Poor map reproduction or printing quality.

20.1 Ways of overcoming these challenges

1. Study the map key carefully.
2. Practise identifying conventional signs.
3. Use appropriate measuring instruments.
4. Study the map title and marginal information.
5. Practise interpreting different topographical maps.
6. Relate map features to real-life geographical experiences.
7. Use updated maps where available.
8. Consult reliable geographical reference materials.
9. Work collaboratively with other learners.
10. Use digital mapping tools where appropriate.

21.0 SUMMARY OF HUMAN ACTIVITIES AND THEIR MAP EVIDENCE

This table provides a useful revision reference when interpreting human activities on topographical maps.

Human activity	Main map evidence
Settlement	Buildings, villages, towns, residential areas
Road transport	Main roads, minor roads, tracks, bridges
Railway transport	Railway lines, stations, sidings
Communication	Post offices, telephone facilities, radio masts
Trade	Markets, shops, banks, petrol stations
Industry	Factories, mills, processing plants, power stations
Crop farming	Plantations, cultivated land, irrigation canals
Livestock farming	Ranches, cattle dips, grazing land, livestock markets
Fishing	Fish landing sites, fish ponds, fishing harbours
Forestry	Forests, tree plantations, sawmills, forest stations
Wildlife	National parks, game reserves, sanctuaries, game lodges
Tourism	Hotels, lodges, campsites, waterfalls, viewpoints
Education	Schools, colleges, universities
Healthcare	Hospitals, dispensaries, health centres
Religion	Churches, mosques, temples, mission stations
Security	Police stations, prisons, military camps
Administration	Chief's offices, government offices, courts
Mining	Mines, mineral-processing plants, mining shafts
Quarrying	Quarries, sand pits, gravel pits, stone extraction sites
Water supply	Dams, boreholes, wells, water tanks, pipelines
Recreation	Stadiums, golf courses, picnic sites, swimming pools

22.0 PRACTICAL APPROACH TO INTERPRETING HUMAN ACTIVITIES

Consider a hypothetical topographical map showing the following features:

- A large town in the central part.
- Several villages in the surrounding countryside.
- A major road passing through the town.
- A railway line passing near the town.
- Extensive tea plantations in the northern part.
- A tea factory near the plantations.
- A river passing through the southern part.
- A forest reserve in the western part.
- A hospital and several schools.

- A market and several shops.

22.1 Questions and model answers

1. Identify the dominant agricultural activity.

Tea growing, as indicated by the extensive tea plantations.

2. Identify the main settlement pattern in the central part.

Nucleated settlement, as shown by the concentration of buildings in the town.

3. State two transport facilities shown on the map.

- Major road.
- Railway line.

4. Give two pieces of evidence of commercial activities.

- Market.
- Shops.

5. State two social services provided in the area.

- Education, as indicated by schools.
- Healthcare, as indicated by the hospital.

6. Explain two factors favouring the location of the tea factory.

- Proximity to tea plantations reduces the cost of transporting raw tea leaves.
- Availability of transport facilitates the movement of processed tea to markets.

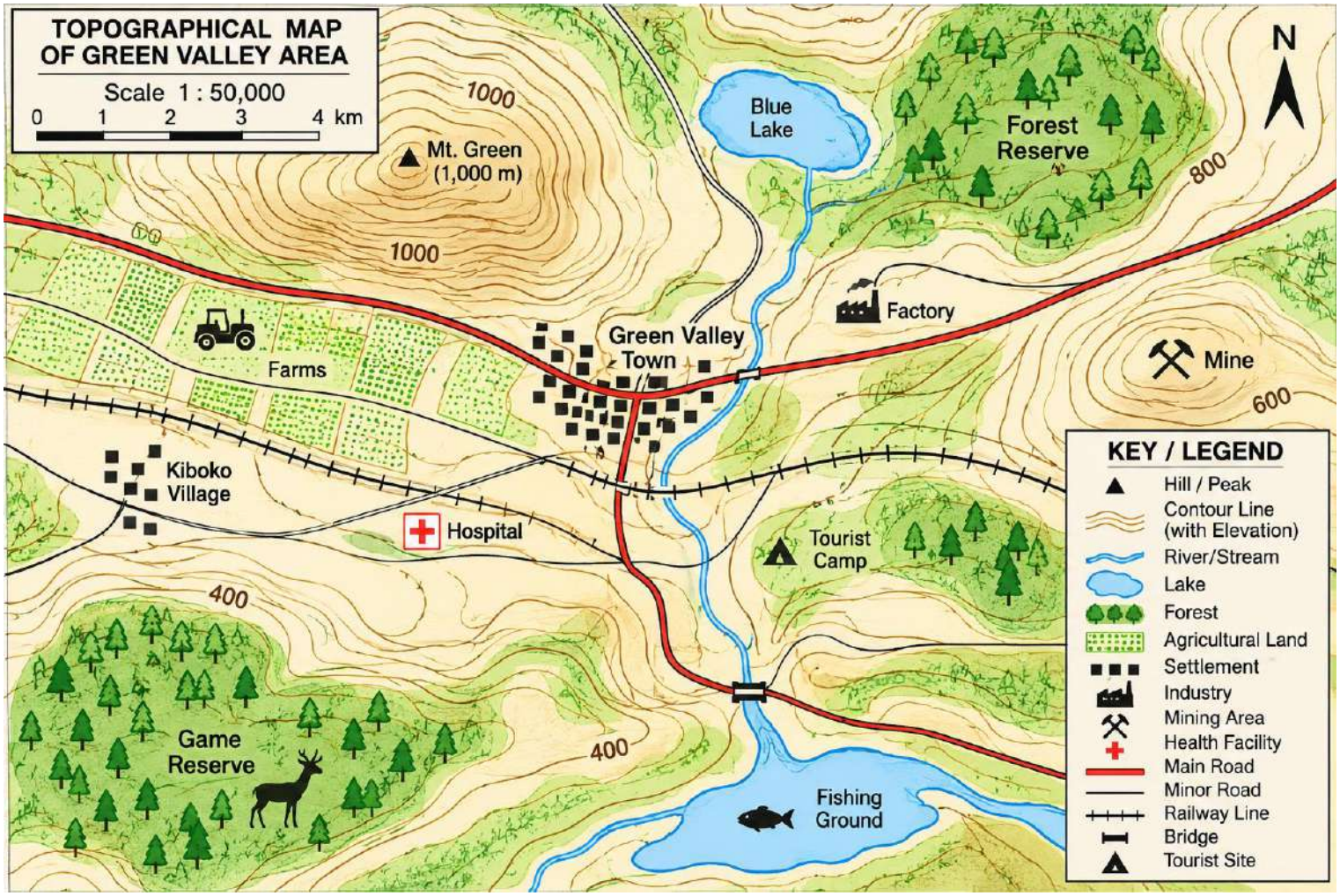
7. State two benefits of the forest reserve.

- It protects biodiversity.
- It helps conserve water catchment areas.

8. Explain how transport facilities encourage economic development in the area.

- They facilitate the movement of agricultural produce to markets.
- They encourage the establishment of industries and commercial activities.
- They improve access to social services.
- They promote trade and employment creation.

ILLUSTRATIONS



EVIDENCE OF HUMAN ACTIVITIES AND CONVENTIONAL SYMBOLS FROM THE TOPOGRAPHICAL MAP OF GREEN VALLEY

1. Introduction

A topographical map is a representation of an area showing both physical and human-made features using conventional signs and symbols.

The topographical map of Green Valley provides evidence of various human activities, settlement patterns, transport networks, economic activities, social services and physical features.

The evidence is obtained by identifying the features shown on the map, interpreting their locations and explaining the activities associated with them.

The following are the major human activities and physical features identified on the map, together with their evidence, explanations and examples.

2. Settlement patterns

Meaning: Settlement refers to the distribution and arrangement of buildings and human populations in an area.

Evidence from the map:

1. Green Valley Town is shown near the centre of the map, with many buildings concentrated together.
2. Kiboko Village is shown in the western part of the map, with buildings arranged in a cluster.
3. The buildings in Green Valley Town are more concentrated than those in Kiboko Village.

Explanation:

- Green Valley Town displays a nucleated settlement pattern because buildings are concentrated in one area.
- Kiboko Village also displays a clustered settlement pattern because houses are located close to one another.
- The concentration of buildings in Green Valley Town suggests the availability of social amenities, employment and transport facilities.

Examples of activities associated with settlements:

- Trading in shops and markets.
- Residential activities.
- Provision of education and healthcare.
- Administrative activities.
- Small-scale businesses.

3. Transport and communication

Meaning: Transport refers to the movement of people and goods from one place to another.

Evidence from the map:

1. A main road is shown passing through Green Valley Town and connecting different parts of the area.
2. Minor roads are shown connecting settlements and other economic activity areas.
3. A railway line crosses the area, passing near the settlements.
4. Bridges are shown where transport routes cross the river.
5. The main road connects Green Valley Town with other parts of Green Valley.

Explanation:

- Main roads facilitate the movement of people and bulky goods.
- Minor roads provide access to farms, villages and other facilities.
- The railway line provides an alternative means of transporting passengers and goods.
- Bridges enable vehicles and railway transport to cross rivers safely.
- The transport network promotes trade and regional development.

Examples:

- Farmers transporting agricultural produce to Green Valley Town.
- Movement of factory products to markets.
- Transportation of minerals from the mining area.
- Movement of tourists to the tourist camp and game reserve.

4. Agriculture

Meaning: Agriculture refers to the cultivation of crops and rearing of animals for food, raw materials and income.

Evidence from the map:

1. Agricultural land is shown in the western part of the map.
2. The farms are located near Kiboko Village.
3. The agricultural fields are divided into separate rectangular plots.
4. A tractor symbol is shown within the farming area.
5. The farms are relatively close to the road network.

Explanation:

- The rectangular plots indicate organised farming activities.
- The tractor suggests the use of mechanised farming methods.
- The presence of roads facilitates transportation of farm inputs and produce.
- The proximity of farms to Kiboko Village suggests that the local population may provide agricultural labour.
- The cultivated land indicates that crop production is an important economic activity.

Examples of agricultural activities:

- Growing maize, beans and vegetables.
- Commercial crop farming.
- Ploughing using tractors.
- Harvesting and transportation of farm produce.
- Keeping livestock.

5. Industrial activities

Meaning: Industry refers to activities involving the processing of raw materials into finished or semi-finished products.

Evidence from the map:

1. A factory is shown in the northern part of Green Valley Town.
2. The factory is represented by an industrial symbol.
3. The factory is located near the main road.
4. It is also relatively close to the settlement of Green Valley Town.

Explanation:

- The factory indicates the presence of manufacturing or processing activities.
- Its location near the road facilitates the transportation of raw materials and finished products.
- The factory may provide employment opportunities to residents of Green Valley Town.
- The factory may use agricultural products from the nearby farms as raw materials.

Examples:

- Processing maize into flour.
- Processing milk into dairy products.
- Manufacturing agricultural equipment.

- Packaging farm produce.
- Processing timber into furniture.

6. Mining activities

Meaning: Mining refers to the extraction of valuable minerals from the earth's surface or underground.

Evidence from the map:

1. A mining site is shown in the eastern part of Green Valley.
2. The mining area is represented by crossed pickaxes.
3. The mining site is located on elevated terrain near the 600-metre contour.
4. The mining site is accessible through the road network.

Explanation:

- The crossed pickaxes are conventional symbols representing mining activities.
- The location indicates that mineral deposits may occur in the surrounding rocks.
- The presence of a road facilitates the transportation of extracted minerals.
- Mining may provide employment and revenue to the local community.
- Minerals extracted may be transported to industries for processing.

Examples:

- Extraction of gold.
- Mining of limestone.
- Extraction of iron ore.
- Quarrying of building stones.
- Extraction of sand and gravel.

7. Fishing activities

Meaning: Fishing refers to the catching of fish from natural or artificial water bodies for food and commercial purposes.

Evidence from the map:

1. A fishing ground is shown in the south-eastern part of the map.
2. The fishing ground is represented by a fish symbol.
3. The fishing ground is located within a large water body.
4. A river flows through the area and drains towards the fishing ground.
5. Blue Lake is also shown in the northern part of the map.

Explanation:

- The fish symbol indicates fishing activities in the area.
- The presence of a large water body provides a suitable habitat for fish.
- The river may supply water and support aquatic life.

- Fishing provides food and income to the local population.
- Fish may be transported to Green Valley Town for sale.

Examples:

- Catching tilapia and catfish.
- Selling fresh fish in local markets.
- Fish preservation through smoking and drying.
- Fish transportation to hotels and restaurants.
- Small-scale commercial fishing.

8. Forestry activities

Meaning: Forestry refers to the management, conservation and utilisation of forests and forest resources.

Evidence from the map:

1. A forest reserve is shown in the north-eastern part of the map.
2. The forest is represented by numerous tree symbols.
3. Another forested area is shown around the game reserve in the south-western part.
4. The forest reserve occupies a relatively large area.

Explanation:

- The tree symbols indicate areas covered by natural or planted vegetation.
- The forest reserve suggests that the area is protected for conservation and sustainable utilisation.
- Forests provide timber, firewood, medicinal plants and other forest products.
- Forests help to conserve water catchment areas and prevent soil erosion.
- The forest may attract tourists interested in nature and wildlife.

Examples:

- Harvesting timber under controlled conditions.
- Collecting medicinal plants.
- Beekeeping.
- Ecotourism.
- Forest conservation and tree planting.

9. Wildlife conservation

Meaning: Wildlife conservation involves protecting wild animals and their natural habitats.

Evidence from the map:

1. A game reserve is shown in the south-western part of Green Valley.
2. The game reserve is represented by numerous tree symbols.
3. An animal symbol is shown inside the game reserve.
4. The game reserve occupies a large area covered by natural vegetation.

Explanation:

- The animal symbol indicates the presence of wildlife.
- The vegetation provides food and shelter for wild animals.
- The game reserve suggests that wildlife is protected from uncontrolled hunting and habitat destruction.
- Wildlife conservation promotes tourism and generates income.
- The reserve may provide employment opportunities for game wardens and tour guides.

Examples:

- Protection of antelopes, zebras and giraffes.
- Wildlife photography.
- Game drives.
- Guided nature walks.
- Wildlife research and conservation.

10. Tourism activities

Meaning: Tourism refers to travelling to places for leisure, recreation, education, adventure or business.

Evidence from the map:

1. A tourist camp is shown in the south-eastern part of Green Valley.
2. The tourist camp is represented by a triangular tourist-site symbol.
3. The camp is located near a forested area.
4. The camp is also relatively close to the river.
5. A game reserve is found in the south-western part of the area.

Explanation:

- The tourist camp provides accommodation or camping facilities for visitors.
- The nearby forest offers opportunities for nature exploration.
- The game reserve attracts tourists interested in wildlife.
- The river and surrounding physical features provide opportunities for outdoor recreation.
- Tourism creates employment and generates income for the local community.

Examples:

- Camping.
- Wildlife viewing.
- Bird watching.
- Nature walks.
- Photography.
- Guided tours.

11. Social services and healthcare

Meaning: Social services are facilities provided to improve people's welfare and quality of life.

Evidence from the map:

1. A hospital is shown in the central-western part of Green Valley.
2. The hospital is represented by a red cross symbol.
3. The hospital is located near Green Valley Town.
4. The hospital is accessible through the road network.

Explanation:

- The hospital indicates the availability of healthcare services.
- Its location near the town makes healthcare more accessible to the surrounding population.
- The hospital provides treatment for sick and injured people.
- The facility may also provide maternal and child healthcare services.
- Its accessibility by road facilitates the transportation of patients.

Examples of social services:

- Medical treatment.
- Immunisation.
- Maternity services.
- Emergency healthcare.
- Laboratory services.
- Health education.

12. Physical features of Green Valley

Physical features are natural features of the earth's surface that have not been created by human beings.

(a) Hills and mountains

Evidence from the map:

1. Mt. Green is shown in the north-western part of the map.
2. It is marked by a triangular peak symbol.
3. Its elevation is indicated as 1,000 metres.
4. Closely spaced concentric contour lines surround Mt. Green.
5. Another elevated area is shown in the eastern part of the map around the mining site.

Explanation:

- Mt. Green is a mountain or highland feature rising to 1,000 metres.
- The concentric contour lines indicate changes in elevation.
- Closely spaced contour lines indicate steep slopes.
- The eastern elevated area is indicated by contour lines around the mining site.

- Mountainous areas may influence rainfall, drainage and human activities.

Examples of human activities associated with highlands:

- Forestry.
- Tourism.
- Mining.
- Livestock keeping.
- Crop cultivation on suitable slopes.

(b) Rivers and streams

Evidence from the map:

1. A blue river is shown flowing from Blue Lake.
2. The river flows southwards through Green Valley.
3. It passes near Green Valley Town.
4. It continues towards the fishing ground in the southern part of the map.
5. The river is represented by a blue winding line.

Explanation:

- The blue winding line represents a river or stream.
- The river provides water for domestic and agricultural use.
- It may support fishing activities.
- It provides water for livestock.
- The river may support tourism and recreational activities.
- The river valley may have fertile soils suitable for crop cultivation.

Examples:

- Irrigation farming.
- Fishing.
- Livestock watering.
- Domestic water supply.
- Recreation.

(c) Lakes

Evidence from the map:

1. Blue Lake is shown in the northern part of Green Valley.
2. It is represented by a blue shaded area.
3. A river or stream flows out of Blue Lake towards the south.
4. Another large water body is shown in the southern part of the map around the fishing ground.

Explanation:

- Blue Lake is a natural water feature.
- The water body may support aquatic life.
- It provides water for domestic and economic activities.
- The lake and surrounding environment may attract tourists.
- The lake may support fishing activities where fish are available.

Examples:

- Fishing.
- Tourism.
- Water supply.
- Recreation.
- Watering livestock.

(d) Contour lines

Evidence from the map:

1. Brown contour lines are distributed across the entire map.
2. The contour lines are labelled 400, 600, 800 and 1,000 metres.
3. The 1,000-metre contour is shown around Mt. Green.
4. The 800-metre contour is shown in the north-eastern part.
5. The 600-metre contour is shown around the eastern mining area.
6. The 400-metre contour is shown in the southern and south-western parts.

Explanation:

Contour lines are lines drawn on a map joining places with equal height above sea level.

They are used to interpret relief and slope characteristics.

- Closely spaced contour lines indicate steep slopes.
- Widely spaced contour lines indicate gentle slopes.
- Concentric contour lines with increasing values towards the centre indicate a hill or mountain.
- Contour lines forming V-shapes across valleys indicate the direction of river valleys, with the V generally pointing upstream.

Examples of uses of contour lines:

- Identifying suitable sites for building.
- Planning roads and railway lines.
- Identifying steep and gentle slopes.
- Determining areas suitable for agriculture.
- Identifying highlands and lowlands.

13. Summary table: Evidence of human activities from the map

The following table summarises the features, their locations and the evidence used to identify the different human activities.

Human activity	Evidence from the map	Location
Settlement	Buildings represented by black squares	Green Valley Town and Kiboko Village
Transport	Main roads, minor roads, railway and bridges	Across the map
Agriculture	Cultivated land and tractor symbol	Western part
Industry	Factory symbol	North of Green Valley Town
Mining	Crossed pickaxes symbol	Eastern part
Fishing	Fish symbol and water body	South-eastern part
Forestry	Tree symbols	North-east and south-west
Wildlife conservation	Animal symbol and game reserve	South-west
Tourism	Tourist camp symbol	South-eastern part
Healthcare	Red cross and hospital label	Central-western part

14. Summary of conventional symbols used on the map

Conventional symbol or colour	Feature represented	Interpretation
▲	Hill/Peak	Indicates elevated land or a mountain peak.
Brown curved lines	Contour lines	Show height and shape of the land.
Blue winding line	River/Stream	Indicates flowing water.
Blue shaded area	Lake	Represents a water body.
Green tree symbols	Forest	Indicates forest vegetation.
Green patterned rectangles	Agricultural land	Represents cultivated fields.
Black squares	Settlement	Represents buildings and residential areas.
Factory symbol	Industry	Indicates manufacturing or processing activities.
Crossed pickaxes	Mining	Indicates mineral extraction.
Red cross	Health facility	Represents a hospital or medical facility.
Red line	Main road	Shows the major transport route.
Thin black line	Minor road	Shows smaller access roads.
Black line with short perpendicular marks	Railway	Represents a railway line.

Bridge symbol	Bridge	Indicates a crossing over a river or valley.
Tourist-site triangle	Tourist site	Indicates a tourist attraction or facility.

15. Other geographical interpretations from the map

These are additional observations that can be made when studying the map.

A. Evidence of economic development

- The presence of a factory indicates industrial development.
- The presence of a mine indicates mineral exploitation.
- Cultivated fields indicate agricultural production.
- The fishing ground indicates exploitation of aquatic resources.
- The tourist camp indicates tourism development.

B. Evidence of accessibility

- The main road passes through Green Valley Town.
- Minor roads connect different parts of the area.
- The railway provides an alternative means of transport.
- Bridges facilitate crossing of the river.
- The hospital and factory are accessible through the transport network.

C. Evidence of environmental conservation

- The forest reserve indicates forest protection.
- The game reserve indicates wildlife conservation.
- The presence of natural vegetation indicates areas that may support biodiversity.
- The lake and river provide important natural water resources.

D. Evidence of relief variation

- Mt. Green rises to approximately 1,000 metres.
- The eastern part contains elevated land around the mining site.
- Contour lines marked 800, 600 and 400 metres show variations in elevation.
- The river valley indicates relatively lower land compared with the surrounding highlands.

16. Important examination questions based on the map

These questions can be used to assess learners' ability to interpret the topographical map.

1. Identify two settlement centres shown on the map.
2. State the settlement pattern displayed by Green Valley Town.
3. Identify three means of transport shown on the map.
4. Give two pieces of evidence indicating agricultural activities in Green Valley.
5. Identify the location of the factory.
6. State two pieces of evidence indicating mining activities.

7. Identify the area where fishing activities are carried out.
8. Give two pieces of evidence indicating forestry activities.
9. Identify the location of the game reserve.
10. State two factors that may attract tourists to Green Valley.
11. Identify the social service facility shown on the map.
12. Name the highest relief feature shown on the map.
13. State the height of Mt. Green.
14. Identify two water bodies shown on the map.
15. Explain two ways in which the river benefits the residents of Green Valley.
16. State two uses of contour lines in map interpretation.
17. Explain how the transport network promotes economic development in Green Valley.
18. Give three economic activities that may provide employment to the residents of Green Valley.

Important note for learners: Always distinguish between evidence and explanation when answering topographical map questions.

- Evidence means the actual feature or symbol observed on the map.
- Explanation means what the observed feature indicates or how it relates to human activities.
- Example means a practical activity associated with the feature.

For instance:

Question: Give evidence of agricultural activities in Green Valley.

- Evidence: Cultivated fields are shown in the western part of the map.
- Explanation: This indicates that land is being used for crop production.
- Example: Growing maize, beans and vegetables.

This approach helps learners provide accurate, well-supported answers in Grade 11 Geography examinations.

REVISION QUESTIONS

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Instructions: Answer all questions. Choose the correct answer from the alternatives A, B, C and D.

1. What is the main purpose of conventional signs and symbols on a topographical map?

A. To decorate the map
B. To represent geographical features in a simplified manner
C. To increase the size of the map
D. To indicate the age of the map

2. Which of the following is an example of a point symbol?

A. River
B. Railway line
C. School
D. Forest

3. A concentration of buildings around a central market indicates which settlement pattern?

A. Dispersed
B. Linear
C. Nucleated
D. Scattered

4. Which of the following map features provides evidence of railway transport?

A. Contour lines
B. Railway station
C. Forest boundary
D. River valley

5. The presence of extensive tea plantations and tea factories indicates:

A. Fishing
B. Commercial crop farming
C. Wildlife conservation
D. Mining

6. Which feature provides evidence of livestock farming?

A. Cattle dip
B. Railway station
C. Lighthouse
D. Quarry

7. A fish landing site is evidence of:

A. Forestry
B. Fishing
C. Mining
D. Manufacturing

8. Which of the following features is associated with forestry?

A. Fish pond
B. Saw mill
C. Railway siding
D. Airstrip

9. The presence of national parks and game reserves indicates:

A. Commercial fishing
B. Wildlife conservation

C. Industrial processing
D. Urban settlement

10. Which of the following is a tourist attraction?

A. Waterfall
B. Cattle dip
C. Grain silo
D. Police station

11. A concentration of shops, banks and markets indicates:

A. Mining activities
B. Commercial activities
C. Forestry activities
D. Fishing activities

12. Which of the following is an example of a social service?

A. Quarry
B. Hospital
C. Mine
D. Factory

13. A large open excavation shown on a topographical map may represent:

A. A plantation
B. A quarry
C. A school
D. A settlement

14. What is the main purpose of a map key?

A. To indicate the direction of the map
B. To explain the symbols used on the map
C. To show the age of the map
D. To determine the height of buildings

15. Which settlement pattern is characterised by houses arranged along a road?

A. Nucleated
B. Dispersed
C. Linear
D. Random

16. The presence of irrigation canals on a topographical map suggests:

A. Fishing activities
B. Irrigated agriculture
C. Mining activities
D. Wildlife conservation

17. Which feature indicates the provision of security services?

A. Police station
B. Tea factory
C. Fish pond
D. Waterfall

18. A map showing a high concentration of roads and buildings is likely to represent:

A. A densely settled area
B. An uninhabited desert
C. A remote forest
D. An isolated mountain

19. What happens to the representative fraction when a map is enlarged?

A. The denominator increases
B. The denominator decreases
C. The scale remains unchanged
D. The scale disappears

20. Which method involves dividing a map into equal squares before reproducing it?

A. Contouring method
B. Grid square method
C. Compass method
D. Direction method

21. A map measuring 5 cm is enlarged to 20 cm. What is the enlargement factor?

A. 2
B. 3
C. 4
D. 5

22. Which of the following is an example of an administrative facility?

A. Chief's office
B. Fish landing beach
C. Tea plantation
D. Quarry

23. A map showing numerous hotels and tourist lodges may indicate:

A. Intensive mining
B. Tourism development
C. Subsistence farming
D. Commercial forestry

24. Which factor is most likely to encourage the development of nucleated settlements?

A. Lack of water
B. Availability of social amenities
C. Extremely steep slopes
D. Poor security

25. Which of the following is a major use of topographical maps in planning?

A. Predicting individual examination results
B. Selecting suitable sites for development projects
C. Determining people's personal income
D. Establishing political opinions

26. A forest reserve is represented on a topographical map mainly to indicate:

A. Industrial development
B. Forest conservation

C. Urban expansion
D. Commercial fishing

27. Which feature is most closely associated with water supply?

A. Borehole
B. Railway station
C. Stadium
D. Market

28. A topographical map showing a mine, railway siding and processing factory indicates:

A. An agricultural region
B. An industrial and mining region
C. A fishing region
D. A recreational region

29. Which of the following is the most appropriate way of supporting an interpretation of a topographical map?

A. Giving unsupported opinions
B. Using evidence from mapped features
C. Ignoring the map key
D. Guessing the activities

30. Why are topographical maps important in environmental planning?

A. They eliminate all environmental problems
B. They help identify sensitive areas and plan conservation activities
C. They prevent all human settlement
D. They replace all environmental laws

SECTION B: STRUCTURED QUESTIONS

31.

a) Define the term topographical map. (2 marks)

b) State four importance of conventional signs and symbols on topographical maps. (4 marks)

c) Distinguish between point symbols and line symbols, giving two examples of each. (4 marks)

32.

a) Identify three main settlement patterns represented on topographical maps. (3 marks)

b) Describe the characteristics of each of the settlement patterns identified in (a). (6 marks)

c) Explain three factors influencing settlement distribution. (6 marks)

33.

a) State five features that provide evidence of transport and communication activities on topographical maps. (5 marks)

b) Explain five ways in which transport and communication networks promote economic development. (5 marks)

34.

a) Identify five agricultural activities that may be represented on topographical maps. (5 marks)

b) Explain five factors influencing the distribution of agricultural activities. (5 marks)

35.

a) State five features that provide evidence of tourism and wildlife conservation activities on topographical maps. (5 marks)

b) Explain five importance of tourism and wildlife conservation to Kenya's economy. (5 marks)

36.

a) Distinguish between map enlargement and map reduction. (4 marks)

b) A section of a topographical map measures 6 cm by 4 cm. It is enlarged by a factor of 3. Calculate the new dimensions. (2 marks)

c) Explain four ways in which topographical maps are useful in development planning. (4 marks)

37. Study the map of Nyeri 1:50,000 (sheet 120/4) provided and answer the following questions.

a.

i. Give the longitudinal extent of the area covered by the map. (2 marks)

ii. Give the six figure grid reference of the trigonometric station at Nyeri Hill Forest. (2 marks)

iii. Calculate the area of Nyeri Forest. Give your answer in square kilometers. (2 marks)

b.

i. What is the bearing of The Ark Lodge from trigonometric station 120 UT 16. (2 marks)

ii. Identify three man-made features in grid square 7263. (3 marks)

iii. Give three drainage features found in the area covered by the map. (3 marks)

c. Describe the relief of the area covered by the map. (5 marks)

d. Citing evidence from the map, identify three social services offered in Nyeri Township. (6 marks)

38.Study the map of Kijabe (1:50000) sheet 134/3 provided and answer the questions that follow

a.

i. What type map of is Kijabe extract? (1mk)

ii. Convert the map scale into statement scale (2mks)

b.

i. Measure the length of the railway line to the west of Easting 30 in kilometres. (2mks)

ii. Give **six** digit grid reference of the forest guard post. (2mks)

c. Draw a square measuring 10cm by 10cm to represent the area enclosed by easting 30 and 40 and northings 90 and 00. (2mks)
On it mark and label;

i. Thicket vegetation (1mk)

ii. Railway line (1mk)\

iii. Bore hole (1mk)

iv. River upper Ewaso Kedong (1mk)

d. Describe the relief of the area shown by the map (5mks)

e.

i. Explain **two** factors influencing dairy farming in the area covered by the map (4marks)

ii. Citing evidence from the map, state three functions of Kijabe town (3mks)

MARKING SCHEME – REVISION QUESTIONS

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Question	Answer	Correct option
1	B	Represent geographical features in a simplified manner
2	C	School

3	C	Nucleated
4	B	Railway station
5	B	Commercial crop farming
6	A	Cattle dip
7	B	Fishing
8	B	Saw mill
9	B	Wildlife conservation
10	A	Waterfall
11	B	Commercial activities
12	B	Hospital
13	B	Quarry
14	B	To explain the symbols used on the map
15	C	Linear
16	B	Irrigated agriculture
17	A	Police station
18	A	A densely settled area
19	B	The denominator decreases
20	B	Grid square method
21	C	4
22	A	Chief's office
23	B	Tourism development
24	B	Availability of social amenities
25	B	Selecting suitable sites for development projects
26	B	Forest conservation
27	A	Borehole
28	B	An industrial and mining region
29	B	Using evidence from mapped features
30	B	They help identify sensitive areas and plan conservation activities

SECTION B: STRUCTURED QUESTIONS (50 MARKS)

31.

a) Define the term topographical map. (2 marks)

A topographical map is a detailed representation of a section of the earth's surface showing both natural and human-made features, including relief, drainage, vegetation, settlements and transport networks.

b) State four importance of conventional signs and symbols on topographical maps. (4 marks)

Award 1 mark each.

1. They represent geographical features in a simplified manner.
2. They make maps easy to read and interpret.
3. They save space on maps.
4. They provide a standard way of representing geographical features.
5. They make it possible to represent features that cannot be drawn to their actual sizes.
6. They reduce congestion on maps.

c) Distinguish between point symbols and line symbols, giving two examples of each. (4 marks)

- Point symbols: Symbols used to represent geographical features whose sizes are too small to be represented by their actual dimensions on a map.

- Examples: School, hospital, church, borehole or police station.

- Line symbols: Symbols used to represent geographical features that have a linear arrangement or extend over a distance.

- Examples: Rivers, roads, railway lines or pipelines.

32.

a) Identify three main settlement patterns represented on topographical maps. (3 marks)

1. Nucleated settlement.
2. Linear settlement.
3. Dispersed settlement.

b) Describe the characteristics of each of the settlement patterns identified in (a). (6 marks)

Award 2 marks for each well-described pattern.

1. Nucleated settlement

- Buildings are concentrated close together in one area.
- Houses are clustered around a central point such as a market, trading centre or water source.

2. Linear settlement

- Buildings are arranged in a line.
- Houses are commonly found along roads, rivers, railway lines or coastlines.

3. Dispersed settlement

- Buildings are scattered over a wide area.
- Houses are separated by large distances, with farms or open land between them.

c) Explain three factors influencing settlement distribution. (6 marks)

Award 2 marks for each well-explained factor.

1. Relief: Flat and gently sloping areas encourage settlement because they are easier to construct buildings and roads on.

2. Climate: Areas with favourable temperatures and adequate rainfall attract more people than areas experiencing extreme climatic conditions.
3. Water supply: Areas with reliable water sources attract settlements for domestic, agricultural and industrial use.
4. Soil fertility: Areas with fertile soils attract people because they support agricultural activities.
5. Transport and communication: Areas with good transport networks attract settlements because they facilitate movement and trade.
6. Security: Areas with good security attract people because they provide a safe environment for living and economic activities.
7. Social amenities: Availability of schools, hospitals and markets encourages settlement development.

33.

a) State five features that provide evidence of transport and communication activities on topographical maps. (5 marks)

Award 1 mark each.

1. Roads.
2. Railway lines.
3. Railway stations.
4. Airports or airstrips.
5. Bridges.
6. Communication masts.
7. Harbours and ports.
8. Telephone lines.
9. Railway sidings.

b) Explain five ways in which transport and communication networks promote economic development. (5 marks)

Award 1 mark for each explanation.

1. Facilitate trade: They enable the movement of goods and services from producers to consumers.
2. Promote agriculture: They enable farmers to transport agricultural produce to markets.
3. Create employment: They provide job opportunities in transport, logistics and communication sectors.
4. Promote industrial development: They facilitate the transportation of raw materials to factories and finished products to markets.
5. Promote tourism: They enable tourists to access tourist attractions.
6. Attract investment: Good transport and communication networks encourage investors to establish businesses.
7. Facilitate information exchange: Communication networks enable people to access and share information easily.

34.

a) Identify five agricultural activities that may be represented on topographical maps. (5 marks)

Award 1 mark each.

1. Crop farming.
2. Livestock farming.
3. Dairy farming.
4. Irrigated agriculture.
5. Plantation farming.
6. Mixed farming.
7. Horticultural farming.
8. Poultry farming.
9. Fishing and fish farming.

b) Explain five factors influencing the distribution of agricultural activities. (5 marks)

Award 1 mark for each explanation.

1. Climate: Temperature and rainfall determine the types of crops and livestock that can be kept in an area.
2. Soil fertility: Fertile soils support crop growth and encourage agricultural activities.
3. Relief: Flat and gently sloping areas favour mechanised farming, while steep slopes limit agricultural activities.
4. Water availability: Areas with adequate water support irrigation, livestock keeping and crop production.
5. Market availability: Areas near markets encourage commercial farming because farmers can easily sell their produce.
6. Labour availability: Areas with adequate labour encourage agricultural production.
7. Transport: Good roads and railway networks facilitate the transportation of farm inputs and produce.
8. Technology: Availability of modern farming equipment and irrigation technology promotes agricultural activities.

35.

a) State five features that provide evidence of tourism and wildlife conservation activities on topographical maps. (5 marks)

Award 1 mark each.

1. National parks.
2. Game reserves.
3. Game sanctuaries.
4. Hotels.
5. Tourist lodges.
6. Campsites.

7. Wildlife viewing points.
8. Museums.
9. Waterfalls.
10. Game parks.

b) Explain five importance of tourism and wildlife conservation to Kenya's economy. (5 marks)

Award 1 mark for each explanation.

1. Foreign exchange earnings: Tourism earns the country foreign currency through spending by international visitors.
2. Employment creation: It provides jobs in hotels, tour companies, national parks and other tourism-related businesses.
3. Government revenue: The government collects revenue through park entry fees, taxes and licences.
4. Infrastructure development: Tourism encourages the construction and improvement of roads, airports, hotels and other facilities.
5. Conservation of wildlife: Wildlife conservation protects endangered species and their natural habitats.
6. Promotion of cultural heritage: Tourism promotes Kenyan cultural practices, traditions and historical sites.
7. Development of local businesses: Tourism creates markets for locally produced goods and services.
8. Regional development: It promotes economic growth in areas surrounding tourist attractions.

36.

a) Distinguish between map enlargement and map reduction. (4 marks)

- Map enlargement: This is the process of reproducing a map or part of it at a larger size than the original map while maintaining its relative proportions and features. (2 marks)

- Map reduction: This is the process of reproducing a map or part of it at a smaller size than the original map while maintaining its relative proportions and features. (2 marks)

b) A section of a topographical map measures 6 cm by 4 cm. It is enlarged by a factor of 3. Calculate the new dimensions. (2 marks)

Working:

Original length = 6 cm

New length = 6 × 3

= 18 cm

Original width = 4 cm

New width = 4 × 3

= 12 cm

Answer: 18 cm × 12 cm

c) Explain four ways in which topographical maps are useful in development planning. (4 marks)

Award 1 mark for each explanation.

1. Site selection: They help identify suitable locations for constructing schools, hospitals, roads and industries.
2. Infrastructure development: They assist planners in determining suitable routes for roads, railway lines and pipelines.
3. Environmental conservation: They help identify forests, wetlands, rivers and other environmentally sensitive areas that require protection.
4. Urban planning: They assist in planning settlements, residential areas and commercial centres.
5. Agricultural planning: They help identify suitable areas for crop farming, irrigation and livestock keeping.
6. Water resource management: They help locate rivers, dams and other water sources for development projects.

37.Study the map of Nyeri 1:50,000 (sheet 120/4) provided and answer the following questions.

a.

- Give the longitudinal extent of the area covered by the map. (2 marks)
  - 36°45`E to 37°00`E (1 X 2 = 2 marks)
  - Give the six figure grid reference of the trigonometric station at Nyeri Hill Forest. (2 marks)
  - 665548 (1 X 2 = 2 marks)
- Calculate the area of Nyeri Forest. Give your answer in square kilometers. (2 marks)
  - 2 + 19/2 = 11.5km2 (1 X 2 = 2 marks)

b.

- What is the bearing of The Ark Lodge from trigonometric station 120 UT 16. (2 marks)
  - 317°± 1° or N43°W (1 X 2 = 2 marks)
- Identify three man-made features in grid square 7263. (3 marks)
  - Road D449
  - Other track /footpath
  - Settlement /houses
  - Nderitu farm (3 X 1 = 3 marks)
- Give three drainage features found in the area covered by the map. (3 marks)
  - Rivers
  - Dams/reservoirs
  - Water holes
  - Water tank
  - Ditch (3 X 1 = 3 marks)

c. Describe the relief of the area covered by the map. (5 marks)

- There are several river valleys

- There is a hill in grid square 6963
- North Eastern and Western area has gentle slopes
- There are steep slopes in the north western and Southern parts.
- There are ridges in the south western part.
- The highest point is 2820m and lowest point is 1680m
- The area generally slopes downwards from west to east. (5 X 1 = 5 marks)

d. Citing evidence from the map, identify three social services offered in Nyeri Township. (6 marks)

- Administrative services - PC/DC/Admin offices
- Religion - church
- Recreation - golf course /club /showground/hotel
- Rehabilitation - prison
- Education - school
- Security - police station (3 X 2 = 6 marks)

MAP

The map of NYERI 1:50,000 (Sheet 12014) provided

38. Study the map of Kijabe (1:50000) sheet 134/3 provided and answer the questions that follow

a.

i. What type map of is Kijabe extract? (1mk)

- **Topographical map**

ii. Convert the map scale into statement scale (2mks)

- **1cm represents 0.5 km**

b.

i. Measure the length of the railway line to the west of Easting 30 in kilometres. (2mks)

- **8.1km**

ii. Give six digit grid reference of the forest guard post. (2mks)

- **375948**

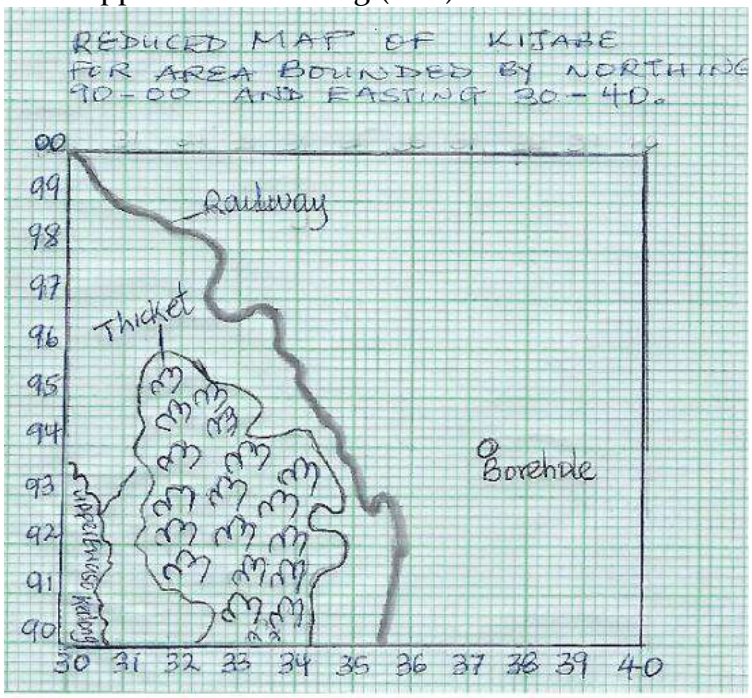
c. Draw a square measuring 10cm by 10cm to represent the area enclosed by easting 30 and 40 and northings 90 and 00. (2mks)
On it mark and label;

i. Thicket vegetation (1mk)

ii. Railway line (1mk)

iii. Bore hole (1mk)

iv. River upper Ewaso Kedong (1mk)



d. Describe the relief of the area shown by the map (5mks)

i. **There are many river valleys in the areas**

ii. **There are hills in the area covered by the map e.g. Kijabe hill**

iii. **There are many river valleys in the area covered by the map such as the ones occupied by River Upper Ewaso Kedong and its tributaries**

iv. **There are gentle slopes to the south western part of the map**

v. **There are steep slopes to the east of kijabe hill**

vi. **There is an escarpment to the east of Kijabe hill** (any 5x1mk each)

e.

i. Explain two factors influencing dairy farming in the area covered by the map (6marks)

- **Availability of pasture for the animals to graze as evidenced by the presence of thicket vegetation**
- **Availability of water for the animals to drink as evidenced the presence of many permanent rivers such as Upper Ewaso Kedong river**
- **Availability of a ready market for milk evidenced by the presence of many settlements at Kijabe**
- **Availability of transport for transporting milk to the collection centre/market/dairy as evidenced by the presence of dry weather road /all weather road loose surface E442/ all weather road bound surface A104** (any 2x2 marks)

ii. Citing evidence from the map, state three functions of Kijabe town (3mks)

- **Residential centre- presence of houses and built up areas**
- **Transport centre- precence of railwail line, all weather road C68/ Dry weather roads E442**

- **Communication centre- post office**
- **Quarrying – quarry/ quarry pits**
- **Trade/ commercial centre- shops**
- **Medical centre – hospital**
- **Religious centre – mission** (any 3x1mark)

SUMMARY OF KEY CONCEPTS

Key term	Meaning
Practical Geography	Application of geographical skills and techniques to study the environment.
Map	Representation of the whole or part of the Earth's surface on a flat surface.
Topographical map	Detailed representation of natural and human-made features of an area.
Map reading	Identifying and understanding features represented on a map.
Map interpretation	Analysing and explaining geographical information obtained from a map.
Settlement	A place where people establish homes and other structures.
Nucleated settlement	Settlement in which buildings are closely grouped.
Dispersed settlement	Settlement in which buildings are widely scattered.
Linear settlement	Settlement in which buildings follow a line along a geographical feature.
Agriculture	Cultivation of crops and rearing of animals.
Fishing	Catching or harvesting fish and other aquatic organisms.
Forestry	Establishment, management and conservation of forests.
Wildlife conservation	Protection of wild animals, plants and their habitats.
Tourism	Travelling outside one's usual environment for leisure or other purposes.
Mining	Extraction of valuable minerals from the Earth's crust.
Quarrying	Extraction of construction materials from the Earth's surface.
Social services	Facilities and activities that improve human welfare.
Map enlargement	Increasing the size of a map while maintaining proportions.
Map reduction	Decreasing the size of a map while maintaining proportions.
Sketch map	A simplified drawing showing selected geographical features.
GIS	A computer-based system for managing and analysing geographical information.
GPS	A satellite-based system for determining geographical location.
Remote sensing	Collecting information about the Earth's surface without direct contact.

SUGGESTED LEARNER PROJECT

Project title: Investigating human activities in a selected area in Kenya using topographical maps.

Project instructions

Learners should work in groups to:

1. Obtain a topographical map of a selected area in Kenya.

2. Identify at least five human activities represented on the map.
3. Identify the distribution of settlements.
4. Identify transport and communication networks.
5. Locate agricultural, industrial and commercial activities.
6. Identify social services and recreational facilities.
7. Select a small section of the map for enlargement.
8. Draw an enlarged sketch map using the grid method.
9. Explain how the information can support development planning.
10. Present their findings through a written report, sketch maps and an oral presentation.

Expected project output

- A labelled sketch map.
- An enlarged map section.
- A list of identified human activities.
- An explanation of the distribution of activities.
- Recommendations for improving development planning in the selected area.

Assessment criteria

Assessment area	**Marks**
Identification of geographical features	5
Interpretation of human activities	5
Accuracy of enlarged sketch map	5
Explanation of planning applications	5
Presentation and teamwork	5
Total	25

25.0 TEACHER'S GUIDE: ASSESSMENT OF LEARNING

The teacher should assess learners through a combination of practical and written activities.

Assessment method	**Evidence of learning**
Oral questioning	Correct explanation of map-reading concepts.

Written exercises	Ability to interpret human activities.
Practical map work	Accurate identification of geographical features.
Group discussions	Collaboration and communication.
Sketch-map drawing	Accuracy in enlargement and reduction.
Project work	Application of geographical knowledge to real-life situations.
Presentations	Ability to communicate geographical findings.

MAPWORK SUMMARY NOTES

HUMAN/ECONOMIC ACTIVITIES

Description of Human Activities

- Identify types
- Evidence –man made features

- Reasons e.g. tea-cool temps and heavy rainfall

Agriculture

a. **Plantation farming**
    - Evidenced by presence of:
        - ✓ "C"-coffee
        - ✓ Named estates e.g. Kaimosi tea estate

b. **Small scale crop farming**
    - Cotton ginnery or sheds
    - Coffee hullerlies
    - Posho mills for maize, millet, sorghum
    - Tea factory/store

c. **Livestock Farming**
    - Dairy farms
    - Veterinary stations
    - Cattle dips
    - Creameries
    - Water holes
    - Dams
    - Butcheries
    - Slaughter houses

Mining

- Symbol for a mine/mineral works
- Name of the mine
- Particular mineral e.g. soda ash
- Quarry symbol
- Processing plant of a mineral e.g. cement indicates cement is mined in that area

Forestry/Lumbering

- Saw mills
- Forest reserves
- Forest station
- Forest guard post
- Roads ending abruptly into a forest estate used to transport logs to saw mills

Fishing

- Fish traps

- Fishing co-operative society
- Fish ponds
- Fish hatcheries
- Fisheries department
- Fish landing grounds(*banda)*

Manufacturing/Processing Industry

- Saw mills for lumber products
- Ginnery for cotton processing
- Mill for maize, millet, wheat processing
- Creameries for milk processing
- Factory for manufacturing or processing a known commodity.

Services

a. **Trade**
    - Shops
    - Markets
    - Stores
    - Trading centres

b. **Transport**
    - **Land**
        - Roads
            - All weather roads- which are used all year round i.e. tarmac and murram roads.
            - Dry weather roads- which are used reliably during dry seasons.
            - Motorable trucks- rough roads which are used by people on foot and by vehicles on dry season.
            - Other trucks and foot paths
            - Railways, station, sliding, level crossing lines and railways light
    - **Air**
        - Air fields
        - Airports
        - Air strips
    - **Water**
        - Ferries
        - Bridges

c. **Communication**

- Post offices(P.O.)
- Telegraph(T.G.)
- Telephone lines(T)

d. **Tourism**

- Camping sites
- Tourist class hotels and restaurants
- National parks
- Game reserves
- Curio shops
- Museums
- Historical monuments

e. **Administration**

- DO, DC, PC, police post, chiefs camp.

Social Services

a. **Religious Services**

- Church
- Mosque
- Temples

b. **Education**

- Schools
- Colleges
- Universities

c. **Health Services**

- Hospitals
- Dispensaries

d. **Recreational Services**

- Golf clubs/courses
- Stadiums

Description of Settlement

- A settlement is a place with housing units where people live together
    - Densely distributed settlements- high concentration of settlements(black dots)
    - Moderately distributed settlements- settlements moderate in quantity
    - Sparsely distributed settlements-few settlements spread over a large area.
    - Very sparse if very few

- Identify type of settlement patterns present

Type of Settlements

a. **Rural settlements**
   - Consist of villages and homesteads and homesteads in which people are involved in subsistence agriculture and traditional activities such as pottery weaving, curving, etc.

b. **Urban settlement**
   - Consist of dense permanent and sometimes high buildings and population engaged in non agricultural activities such as industrial activities.

Factors Influencing Settlement

1. **Physical Factors**
   a. **Climate**
      - ✓ Areas with moderate temps and adequate rainfall are densely settled while those with extremely low or high temps have fewer settlements.

   b. **Relief**
      - ✓ ***Terrain:*** Steep slopes are less settled due to thin soils and difficulty to erect buildings.
      - ✓ ***Aspect:*** Slopes facing away from the sun in high latitudes are less settled than those facing the sun.
      - ✓ Wind ward slopes of mountains on the path of rain bearing winds are more settled due to heavy rainfall making them ideal for agriculture.

   c. **Drainage**
      - ✓ Rivers and springs attract settlements because they provide clean water.
      - ✓ Areas with drainage swamps are less settled because it's difficult to erect buildings and they also harbour mosquitoes and snails which cause diseases.

   d. **Vegetation**
      - ✓ Dense forests discourage settlements because of wild animals and also harbour disease vectors such as tsetse flies e.g. Miombo woodland of Tanzania and Lambwe valley in Kenya.

   e. **Pests and diseases**
      - ✓ Areas prone to pests and diseases are less settled because people like to live in healthy environment.

   f. **Natural resources**
      - ✓ Settlements start where there is mineral extraction. e.g. Magadi
      - ✓ Lakes with abundant fish may also attract settlement.

2. **Human Factors**
   a. **Political factors**
      - ✓ 1967 TZ settled peoples in villages and the rest of land was left for farming (Ujamaa villages)

- ✓ After independence Kenya settled its landless in settlement schemes e.g. Mwea, Laikipia, Nyandarua.
- ✓ Settlement of refugees in refugee camps due to political upheavals

b. **Historical factors**

- ✓ Weaker communities were forced to move elsewhere by wars.
- ✓ Settlement of communities in strategic sites such as hilltops or plateaus to see approaching enemies e.g. Fulani of Nigeria in Jos plateau.

c. **Cultural factors**

- ✓ Farming communities settled in agriculturally productive areas.
- ✓ Pastoralists settle in areas with enough land to provide pasture for their animals at ease.

d. **Economic factors**

- ✓ Rural to urban migration for employment and trading.
- ✓ Mining activities may lead to development of settlements e.g. Magadi due to trona mining.

Types of Settlements Patterns

a. **Nucleated/Clustered Settlement Pattern**



- Buildings are close to each other

Factors

- Availability of social amenities such as schools and health care
- Shortage of building land
- Favourable climate leading to high agricultural potential e.g. Kenya highlands.
- Fertile soils.
- Presence of natural resources e.g. minerals in Magadi, Mwadui, Kimberly.
- Security concern especially in banditry prone areas

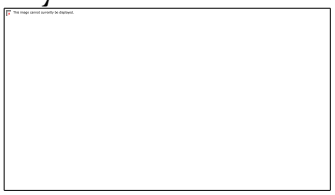
b. **Linear Settlement**



- Buildings are arranged in a line
- Presence of a transport line e.g. road or railway.
- Presence of a river or a spring to provide water for domestic or commercial use
- Presence of a coast line which has a favourable fishing ground e.g. shore of E. African coast.
- Suitable terrain for cultivation of crops such as at the foot of a scarp

c. **Dispersed/Scattered Settlement**

- Buildings are scattered
- Plenty of land to build whenever they want
- Avoidance of harsh climate e.g. arid and semi-arid areas.
- Poor infertile soils.
- Pests and diseases.
- Physical features such as ridges, valleys which separate houses.



d. **Radial Pattern**



- **Buildings are arranged like a star**
- Common at cross roads where housing units point in all directions.

Enlargement and Reduction of Maps

Steps

1. Identify the area requiring to be enlarged

2. Measure its length and width
3. Multiply (E) or divide (R) the by the number of times given. The scale also changes e.g.1:50000/2(enlarged)×2(reduced)
4. Draw the new frame with new dimensions
5. Insert the grid squares e.g. 2×2cm, 2/2, etc.
6. Draw diagonals on the frame
7. Transfer features exactly where they were

Drawing a Cross Section/Profile

- Line drawn on a piece of paper showing the nature of relief of a particular area.

Steps

1. Identify the given points and name them A and B
2. Joint point A and B using a pencil
3. Take a piece of paper and fold it into two parts
4. Place the papers edge along the line joining A and B
5. Mark all contours and their heights
6. Mark features along A-B e.g. R- river, H- hill, M- mountain
7. Determine the highest and lowest contour height to determine the appropriate vertical scale
8. Draw horizontal axis and mark it A-B
9. Draw vertical axis from A to B
10. Place the edge of folded paper along horizontal axis
11. Use values along vertical axis to plot contour heights. Remember to show features marked along A-B
12. Join plotted points using smooth curve (cross Section)
13. Include title on top vertical and horizontal map scale.

Calculation and Interpretation of Vertical Exaggeration and Gradient

Vertical Exaggeration

- Number of times that the vertical scale is larger than horizontal scale
- V.E. =Denominator of H.S. /D. of V.S. (cross section scale.
  e.g. V.S. =1:20M
  H.S=1:50000
  V.E.=50000/20×100 (To convert into cm) =25

Interpretation

- The vertical height has been exaggerated 25 times compared to the horizontal distance

Intervisibility

- Ability of one place to be seen from another

Steps

- Draw cross section
- Join points A-B using visibility line
- If the visibility line is above the cross section, the two points are ***intervisible***. If below they are ***not intervisible***.

Gradient

- Degree of steepness of a slope between two given points

Steps

- Identify the two points
- Calculate difference in height between the two points(**V**ertical **I**nterval) e.g. 500m
- Joint them with a light line
- Measure ground distance between the two points(**H**orizontal **E**quivalent)e.g.12 cm
  $G = {}^{V.I.}/_{H.E.}$
  $= {}^{500\times100}/_{12\times50000} = {}^{50000}/_{600000} = {}^{1}/_{12} = 1:12$

Interpretation

- For every 12 m travelled on the Ground, there is a vertical rise of 1m

STRAND 1.0: PRACTICAL GEOGRAPHY

SUB-STRAND 1.2: ELEMENTARY SURVEYING

1.0 INTRODUCTION TO SURVEYING

Surveying is an important practical aspect of Geography that involves measuring distances, angles, directions, heights and positions of points on the Earth's surface to determine their relative locations.

It provides information about the size, shape, position and physical characteristics of land and other geographical features.

Surveying is used in land ownership determination, construction, agriculture, road development, environmental conservation, town planning and geographical research.

In Kenya, surveying is important in:

- Determining boundaries of privately owned land.
- Planning residential and commercial developments.
- Construction of roads, bridges and railways.
- Mapping school compounds and public institutions.
- Establishing county and national infrastructure.
- Planning irrigation schemes.
- Mapping forests, rivers and other natural resources.
- Supporting environmental conservation.

1.1 Meaning and definition of surveying

Surveying is the science, art and technology of determining the relative positions of points on, above or below the Earth's surface through measurement of distances, directions, angles and elevations.

The measurements obtained are used to prepare maps, plans, charts and other geographical representations.

1.2 Meaning of elementary surveying

Elementary surveying refers to basic surveying techniques and procedures used to measure and record the positions, distances, directions and locations of geographical features using simple instruments and methods.

It introduces learners to practical measurement and mapping skills that can be applied in their immediate environment.

Examples include:

1. Measuring the length and width of a school compound.
2. Determining the distance between classrooms.
3. Mapping the position of trees within a school.
4. Measuring the distance between a school gate and the administration block.
5. Determining the boundaries of a playground.
6. Mapping the position of water points and sanitation facilities.

1.3 Objectives of surveying

The main objectives of surveying include:

1. **Determining positions:** Establishing the exact or relative location of geographical features.
2. **Measuring distances:** Finding the length between two or more points on the Earth's surface.

3. **Determining directions:** Establishing the direction of one point from another.
4. **Measuring heights:** Determining the elevation of geographical features above a reference level.
5. **Determining land boundaries:** Establishing the boundaries and dimensions of land parcels.
6. **Preparing maps:** Producing maps and plans showing geographical features.
7. **Supporting construction:** Providing measurements for the construction of roads, buildings, bridges and dams.
8. **Planning land use:** Helping determine suitable locations for various human activities.
9. **Monitoring changes:** Recording changes in landforms, buildings and other geographical features over time.
10. **Resource management:** Providing information for the sustainable management of land, water, forests and other resources.

1.4 Basic principles of surveying

Surveying is guided by important principles that help ensure accuracy and reliability.

A. Working from whole to part

This principle involves establishing the main control points of an area before measuring smaller details within it.

Explanation:

- The surveyor first establishes the general framework of the area.
- Smaller sections are then measured in relation to the established control points.
- This reduces the accumulation of errors.
- It ensures that the measurements of smaller sections fit into the overall survey framework.

Example: When mapping a school compound, the surveyor first determines the main boundary points before locating individual classrooms, trees, offices and other facilities.

B. Fixing positions using at least two independent measurements

The position of a point should be determined using at least two measurements from known reference points.

These measurements may involve:

- Distances.
- Angles.
- Bearings.
- Coordinates.

Example: A tree in a school compound may be located by measuring its distance from two known corners of the school boundary.

C. Ensuring accuracy through checks

Surveyors take additional measurements to check the accuracy of their work.

Examples:

- Measuring a line twice.

- Checking the closing distance of a survey.
- Comparing measurements obtained using different methods.
- Repeating observations where errors are suspected.

2.0 TYPES OF SURVEYING IN GEOGRAPHICAL STUDIES

There are different types of surveying depending on the purpose, area being surveyed, geographical features involved and techniques used.

The main types covered in this sub-strand are:

1. Cadastral surveying.
2. Topographical surveying.
3. Hydrographic surveying.
4. Engineering surveying.
5. Aerial surveying.
6. Astronomic surveying.

2.1 Cadastral surveying

Meaning of cadastral surveying

Cadastral surveying is the type of surveying concerned with measuring, identifying and establishing the boundaries, dimensions and positions of land parcels for purposes of ownership, registration, taxation and land administration.

It provides accurate information about individual land holdings and their legal boundaries.

Characteristics of cadastral surveying

1. It focuses on individual land parcels.
2. It establishes property boundaries.
3. It involves measuring land dimensions.
4. It uses boundary beacons and reference points.
5. It produces cadastral maps and survey plans.
6. It supports land registration and administration.
7. It requires accurate measurements.
8. It may involve subdivision or amalgamation of land parcels.

Instruments used in cadastral surveying

- Measuring tapes.
- Ranging rods.
- Theodolites.
- Total stations.
- Global Positioning System (GPS) receivers.
- Surveying chains.

- Surveying prisms.
- Boundary beacons.

Examples of cadastral surveying in Kenya

- Surveying land parcels before issuing title deeds.
- Subdividing agricultural land in Kiambu County.
- Establishing boundaries of residential plots in Nakuru.
- Surveying commercial plots in Nairobi.
- Determining boundaries of community land in Kajiado County.
- Surveying land for housing development in Uasin Gishu County.

Importance of cadastral surveying

1. **Establishes land ownership boundaries:** It helps determine the legal boundaries of individual land parcels.
2. **Prevents land disputes:** Accurate boundary information reduces disagreements between neighbours.
3. **Facilitates land registration:** Survey plans provide information required in land administration.
4. **Supports land subdivision:** It enables large parcels to be divided into smaller plots.
5. **Promotes land development:** Developers use cadastral information when planning buildings and other developments.
6. **Supports land taxation:** Accurate land records assist authorities in land valuation and taxation.
7. **Facilitates land transactions:** Buyers and sellers can establish the dimensions and location of property.
8. **Supports urban planning:** It helps authorities plan residential, commercial and industrial areas.

Challenges facing cadastral surveying in Kenya

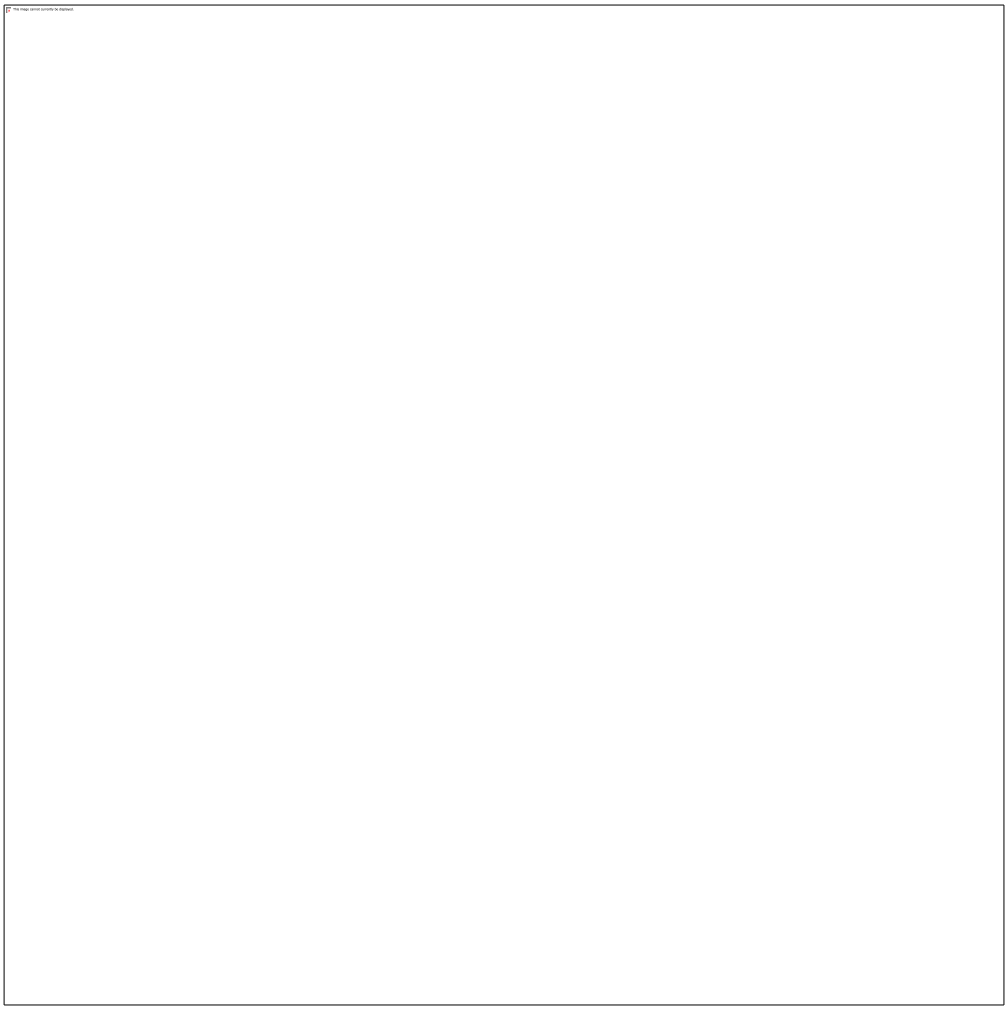
- Disputes over historical land boundaries.
- Encroachment on neighbouring properties.
- Inaccurate or outdated survey records.
- Destruction or displacement of boundary beacons.
- High cost of modern surveying equipment.
- Fraudulent land documents.
- Difficult terrain in some areas.
- Limited access to some remote areas.

2.2 Topographical surveying

Meaning of topographical surveying

Topographical surveying is the process of measuring and recording the natural and human-made features of an area, including their positions, elevations, shapes and relative distribution.

It provides information used to prepare topographical maps and plans.



Features measured during topographical surveying

A. Natural features

- Mountains.
- Hills.
- Valleys.
- Rivers.
- Lakes.
- Swamps.
- Forests.
- Plains.
- Cliffs.
- Slopes.

B. Human-made features

- Roads.
- Buildings.
- Bridges.
- Railway lines.

- Dams.
- Schools.
- Hospitals.
- Churches.
- Markets.
- Electricity transmission lines.

Instruments used in topographical surveying

1. Total station.
2. Theodolite.
3. Automatic level.
4. Levelling staff.
5. GPS receiver.
6. Measuring tape.
7. Ranging rods.
8. Compass.
9. Tripod.
10. Prisms.

Uses of topographical surveying

- Preparation of topographical maps.
- Determining the elevation of land.
- Planning road construction.
- Selecting suitable sites for buildings.
- Mapping rivers and drainage systems.
- Planning agricultural activities.
- Identifying suitable dam construction sites.
- Supporting environmental management.
- Planning settlement expansion.
- Mapping school compounds and public facilities.

Examples in Kenya

- Surveying the slopes of Mount Kenya.
- Mapping the terrain around the Rift Valley.
- Surveying land for construction of roads in Nakuru County.
- Mapping drainage patterns in Nairobi.
- Surveying land for irrigation projects in Mwea.

- Mapping school compounds before expansion.

Importance of topographical surveying

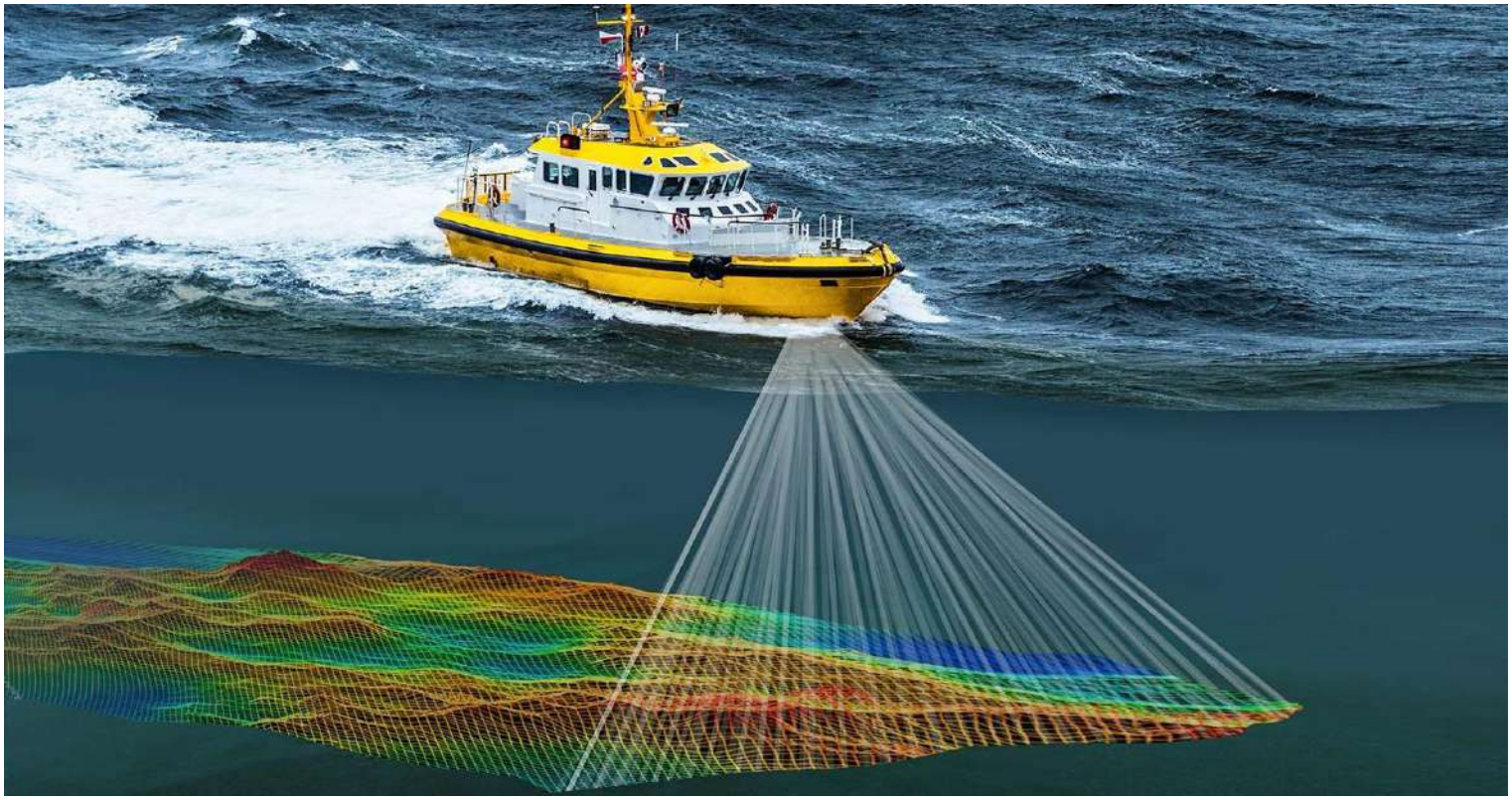
1. Helps identify suitable areas for construction.
2. Provides information about land slopes and elevations.
3. Supports road and railway planning.
4. Assists in identifying flood-prone areas.
5. Helps determine suitable agricultural land.
6. Supports preparation of detailed maps.
7. Assists in environmental conservation.
8. Helps plan water supply and drainage systems.

2.3 Hydrographic surveying

Meaning of hydrographic surveying

Hydrographic surveying is the process of measuring and mapping water bodies to determine their depth, shape, shoreline, underwater features, tides and other characteristics.

It is mainly concerned with collecting geographical information about oceans, seas, lakes, rivers, harbours and other water bodies.





Features measured during hydrographic surveying

1. Water depth.
2. Shoreline position.
3. Underwater landforms.
4. Lake and river bed features.
5. Tides and water levels.
6. Water currents.
7. Underwater obstacles.
8. Navigation channels.
9. Sediment deposits.
10. Locations of submerged structures.

Instruments used in hydrographic surveying

- Echo sounders.
- GPS receivers.
- Survey boats.
- Sonar equipment.
- Current meters.

- Tide gauges.
- Depth-measuring poles.
- Underwater sensors.
- Hydrographic data collection systems.

Methods used in hydrographic surveying

A. Sounding method

This involves measuring the depth of water at different points.

The depth may be measured using:

- Sounding poles in shallow water.
- Lead lines.
- Echo sounders in deeper water.

B. Echo sounding

This method uses sound waves to determine the depth of water.

The echo sounder sends sound pulses towards the bottom of a water body. The sound waves reflect from the bottom and return to the instrument.

The time taken by the sound waves to travel down and return is used to calculate the depth.

C. Sonar surveying

Sonar uses sound waves to detect underwater objects, measure depths and identify underwater features.

Examples of hydrographic surveying in Kenya

- Surveying Lake Victoria.
- Mapping the coastline along the Indian Ocean.
- Measuring water depths around the Port of Mombasa.
- Surveying Lake Naivasha.
- Mapping navigation channels in harbours.
- Surveying river channels for water resource development.

Importance of hydrographic surveying

1. **Navigation:** Helps ships and boats navigate safely by identifying water depths and underwater obstacles.
2. **Port development:** Provides information required when constructing and expanding harbours.
3. **Fishing:** Helps identify underwater features and suitable fishing grounds.
4. **Water resource management:** Provides information about lakes, rivers and reservoirs.
5. **Flood management:** Helps understand river channels and water movement.
6. **Dredging:** Identifies areas where sediment needs to be removed.
7. **Marine construction:** Supports the construction of underwater pipelines, bridges and other structures.

8. **Environmental conservation:** Helps monitor changes in aquatic environments.
9. **Tourism:** Supports the development of safe boating and water-based recreational activities.
10. **Scientific research:** Provides information for studying aquatic ecosystems.

Challenges facing hydrographic surveying

- High cost of specialised equipment.
- Difficult weather and water conditions.
- Strong currents and waves.
- Limited access to some water bodies.
- Technical difficulties in deep water.
- Sedimentation that changes water depths.
- Need for specialised personnel.

2.4 Engineering surveying

Meaning of engineering surveying

Engineering surveying is the type of surveying carried out to provide accurate measurements and geographical information required for the planning, design, construction and maintenance of engineering projects.

It ensures that structures are constructed in the correct positions, dimensions, heights and alignments.

Activities involved in engineering surveying

1. Measuring land before construction.
2. Establishing building positions.
3. Determining road alignments.
4. Measuring heights and levels.
5. Establishing bridge positions.
6. Setting out construction boundaries.
7. Monitoring structural movement.
8. Measuring drainage gradients.
9. Establishing tunnel alignments.
10. Checking the dimensions of engineering structures.

Instruments used in engineering surveying

- Total stations.
- Theodolites.
- Automatic levels.
- Levelling staffs.
- GPS receivers.
- Measuring tapes.

- Laser levels.
- Tripods.
- Prisms.
- Drones.

Examples of engineering surveying in Kenya

- Surveying before construction of the Nairobi Expressway.
- Surveying for the Standard Gauge Railway.
- Surveying before construction of bridges across rivers.
- Measuring land for housing developments.
- Surveying sites for dams and water reservoirs.
- Surveying road expansion projects.
- Setting out foundations for school buildings.

Importance of engineering surveying

1. Ensures accurate positioning of buildings.
2. Supports road and railway construction.
3. Helps establish suitable sites for bridges.
4. Prevents construction errors.
5. Helps determine the levels of construction sites.
6. Supports drainage and sewerage planning.
7. Promotes safety in engineering projects.
8. Helps monitor changes in constructed structures.
9. Reduces unnecessary construction costs.
10. Supports proper use of land.

Challenges facing engineering surveying

- Difficult terrain.
- Unstable ground conditions.
- Poor weather.
- High cost of equipment.
- Human errors during measurement.
- Construction activities interfering with survey work.
- Limited access to construction sites.

2.5 Aerial surveying

Meaning of aerial surveying

Aerial surveying is the process of collecting geographical information about the Earth's surface using cameras, sensors or other equipment mounted on aircraft, helicopters, drones or satellites.

It enables surveyors to obtain information about large geographical areas without measuring every feature directly on the ground.

Methods of aerial surveying

A. Aerial photography

This involves taking photographs of the Earth's surface from an aircraft or drone.

The photographs are used to identify and map geographical features.

Uses include:

- Mapping settlements.
- Identifying roads and railway lines.
- Mapping forests.
- Monitoring agricultural land.
- Studying urban expansion.
- Identifying changes in land use.

B. Drone surveying

This involves using unmanned aerial vehicles (UAVs), commonly called drones, fitted with cameras or sensors to collect geographical information.

Applications:

- Mapping school compounds.
- Measuring agricultural fields.
- Monitoring construction projects.
- Mapping inaccessible areas.
- Monitoring environmental changes.
- Inspecting infrastructure.

C. Satellite surveying

This involves using information collected by satellites orbiting the Earth to map and monitor geographical features.

Applications:

- Mapping large geographical areas.
- Monitoring forest cover.
- Studying drought and flooding.
- Mapping urban development.
- Monitoring agricultural activities.

Instruments and equipment used in aerial surveying

1. Aircraft.
2. Helicopters.
3. Unmanned aerial vehicles (drones).
4. Aerial cameras.
5. GPS receivers.
6. Laser scanners.
7. Photogrammetric equipment.
8. Satellite sensors.
9. Computers.
10. Image-processing software.

Examples of aerial surveying in Kenya

- Mapping urban development in Nairobi.
- Monitoring agricultural activities in Nakuru County.
- Mapping forests in the Mau Forest Complex.
- Monitoring land use around Lake Naivasha.
- Surveying road construction projects.
- Mapping flood-affected areas along the Tana River.
- Monitoring changes in settlement patterns in growing towns.

Importance of aerial surveying

1. **Covers large areas:** Large geographical areas can be mapped within a relatively short time.
2. **Access to inaccessible areas:** It allows mapping of mountainous, forested and swampy regions.
3. **Urban planning:** It helps identify settlement patterns and areas suitable for development.
4. **Agricultural planning:** It assists in monitoring crop distribution and farm conditions.
5. **Environmental monitoring:** It helps detect deforestation, soil degradation and changes in land cover.
6. **Disaster management:** It provides information about areas affected by floods, landslides and other disasters.
7. **Infrastructure development:** It supports the planning of roads, bridges, pipelines and buildings.
8. **Wildlife conservation:** It helps monitor wildlife habitats and changes in vegetation.
9. **Resource management:** It assists in identifying and monitoring natural resources.
10. **Map production:** It provides photographs and spatial information used in producing maps.

Challenges facing aerial surveying

- High cost of equipment.
- Need for specialised personnel.

- Poor weather conditions.
- Cloud cover that may affect image quality.
- Technical difficulties in processing images.
- Restricted airspace.
- Privacy and security concerns.
- Limited battery life of drones.
- Need for ground verification of some observations.

2.6 Astronomic surveying

Meaning of astronomic surveying

Astronomic surveying is the process of determining geographical positions, directions and orientation on the Earth's surface by observing celestial bodies such as the Sun, Moon and stars.

It uses astronomical observations to determine geographical coordinates and establish directions.



Basic concepts in astronomic surveying

A. Celestial bodies

These are natural objects found in space.

Examples:

- Sun.
- Moon.
- Stars.

- Planets.

B. Latitude

Latitude is the angular distance of a place north or south of the Equator, measured in degrees.

C. Longitude

Longitude is the angular distance of a place east or west of the Prime Meridian, measured in degrees.

D. Celestial sphere

The celestial sphere is an imaginary sphere surrounding the Earth onto which celestial bodies appear to be projected for astronomical observation.

E. Zenith

The zenith is the point in the sky directly above an observer.

Instruments used in astronomic surveying

- Theodolites.
- Sextants.
- Chronometers.
- Astronomical telescopes.
- Precision clocks.
- GPS receivers.
- Star charts.
- Observation instruments.

Methods used in astronomic surveying

1. **Observation of the Sun:** The apparent position of the Sun is observed to help determine direction and geographical position.
2. **Observation of stars:** Selected stars are observed to determine latitude, longitude and orientation.
3. **Time measurement:** Accurate time observations are used in determining longitude.
4. **Angular measurement:** Angles between celestial objects and the horizon are measured using specialised instruments.

Applications of astronomic surveying

- Determining latitude and longitude.
- Establishing geographical directions.
- Supporting navigation.
- Establishing reference positions.
- Supporting geodetic surveys.
- Determining the orientation of survey networks.
- Supporting scientific research.

Examples of applications in Kenya

- Establishing geographical coordinates for mapping.
- Supporting national geodetic reference systems.
- Assisting navigation and positioning research.
- Supporting geographical research in universities and scientific institutions.

Importance of astronomic surveying

1. Helps determine geographical coordinates.
2. Supports accurate navigation.
3. Helps establish directions.
4. Supports the preparation of geographical maps.
5. Provides reference information for surveying.
6. Supports scientific research.
7. Helps establish the orientation of survey networks.
8. Contributes to the study of the Earth's position and movement.

Challenges facing astronomic surveying

- Cloud cover may obstruct celestial bodies.
- Light pollution affects observations.
- Requires specialised instruments.
- Requires accurate time measurements.
- Weather conditions may interfere with observations.
- Requires trained personnel.
- Observations may be difficult during daytime or poor visibility.

3.0 COMPARISON OF THE SIX TYPES OF SURVEYING

The following table summarises the six types of surveying studied in this sub-strand.

Type of surveying	Main focus	Examples of application
Cadastral	Land boundaries and ownership	Subdivision of land in Nakuru
Topographical	Natural and human-made features and relief	Mapping the Rift Valley
Hydrographic	Water bodies and underwater features	Surveying Lake Victoria
Engineering	Construction and infrastructure	Road and bridge construction
Aerial	Mapping from aircraft, drones and satellites	Mapping urban growth
Astronomic	Position and direction using celestial observations	Determining latitude and longitude

3.1 Differences between the types of surveying

1. Cadastral surveying concentrates on land ownership and boundaries, while topographical surveying concentrates on the physical and human-made features of an area.
2. Hydrographic surveying focuses on water bodies, while aerial surveying collects geographical information from above the Earth's surface.

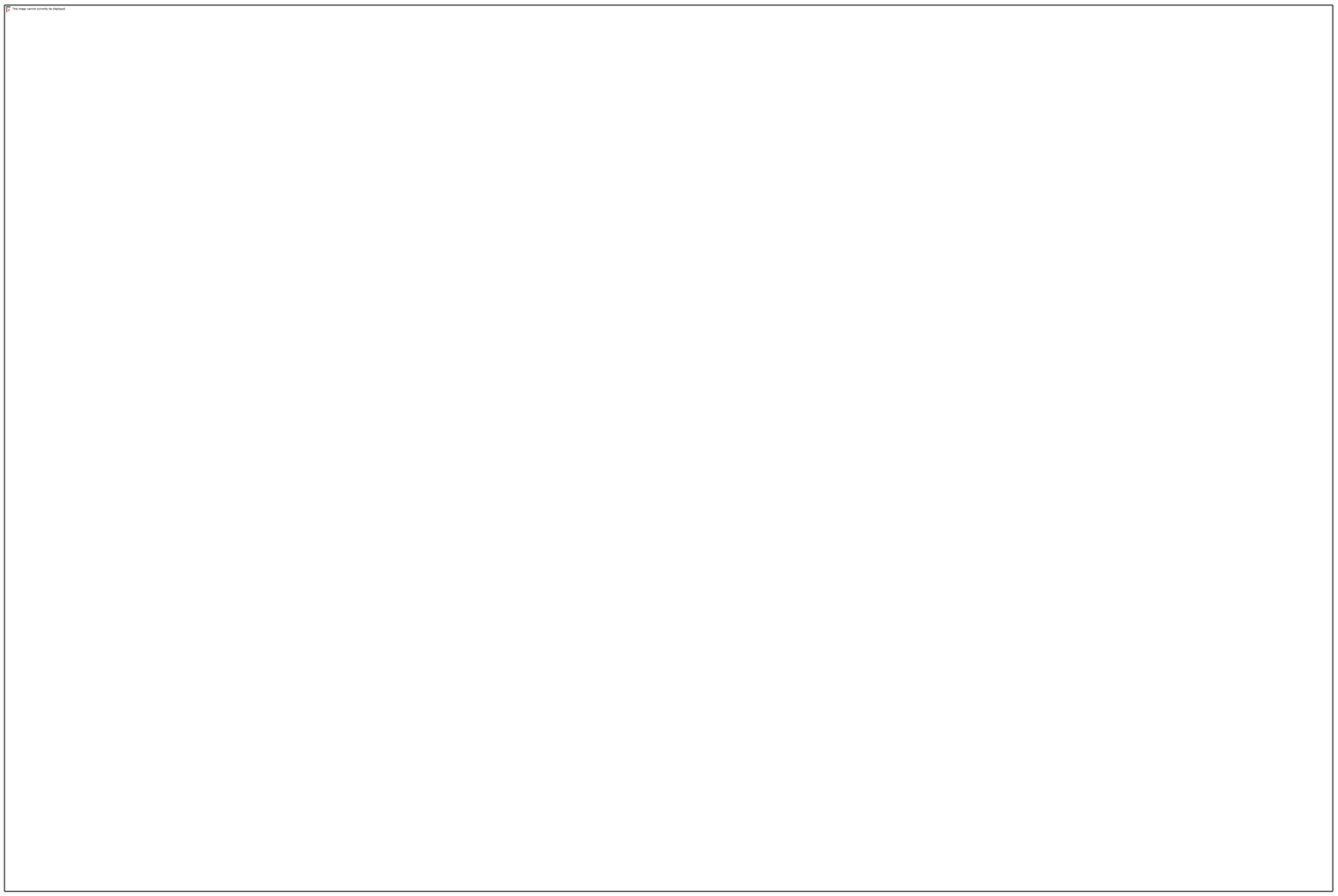
3. Engineering surveying supports construction projects, while astronomic surveying uses celestial observations to determine geographical positions and directions.
4. Topographical surveying records land relief, while cadastral surveying establishes land parcel dimensions and boundaries.
5. Aerial surveying can cover extensive areas rapidly, while elementary ground surveying may require direct measurements on the ground.

4.0 IMPORTANCE OF SURVEYING IN SOCIETY

4.1 Meaning of the importance of surveying

Surveying is important because it provides accurate geographical measurements and information required for land administration, infrastructure development, environmental management and other human activities.

It supports decision-making by providing reliable information about the Earth's surface.



4.2 Importance of surveying in different sectors of society

A. Land ownership and administration

Surveying contributes to proper land administration through:

- Establishing land boundaries.
- Determining land parcel sizes.
- Supporting land registration.
- Preparing survey plans.

- Reducing boundary disputes.
- Facilitating land transactions.
- Supporting land subdivision and consolidation.
- Identifying public and private land.

Kenyan example: Cadastral surveying supports the preparation of land survey records used in land administration and registration.

B. Agriculture

Surveying is important in agricultural development because it:

1. Determines the size of agricultural land.
2. Establishes farm boundaries.
3. Helps plan irrigation systems.
4. Identifies suitable locations for farm buildings.
5. Helps determine land gradients.
6. Supports soil and water conservation.
7. Assists in farm subdivision.
8. Helps plan drainage systems.
9. Supports mechanised farming.
10. Helps monitor agricultural land use.

Kenyan example: Surveying is used when planning irrigation canals and agricultural plots in the Mwea Irrigation Scheme.

C. Transport and communication

Surveying supports transport infrastructure through:

- Determining suitable road routes.
- Planning railway alignments.
- Establishing bridge positions.
- Measuring gradients of roads.
- Planning airports and airstrips.
- Mapping communication infrastructure.
- Establishing positions of electricity transmission lines.
- Planning pipelines.

Kenyan example: Surveying provides measurements needed when constructing and maintaining highways and railway infrastructure.

D. Building and construction

Surveying is important in the construction industry because it:

1. Determines the boundaries of construction sites.

2. Establishes building positions.
3. Measures land elevations.
4. Helps determine foundation levels.
5. Ensures buildings are aligned correctly.
6. Helps calculate land gradients.
7. Supports drainage planning.
8. Helps monitor construction progress.
9. Reduces construction errors.
10. Promotes safety.

Example: Before constructing classrooms in a Kenyan school, surveyors may measure the compound to determine the appropriate location and alignment of the buildings.

E. Urban and rural planning

Surveying supports proper settlement development by:

- Identifying suitable residential areas.
- Planning commercial centres.
- Establishing industrial zones.
- Mapping existing settlements.
- Planning recreational facilities.
- Determining areas for roads and drainage.
- Identifying areas unsuitable for construction.
- Supporting controlled urban expansion.

F. Environmental conservation

Surveying contributes to environmental protection through:

1. Mapping forests.
2. Identifying wetlands.
3. Monitoring soil erosion.
4. Mapping river systems.
5. Monitoring changes in land use.
6. Identifying environmentally sensitive areas.
7. Supporting forest restoration programmes.
8. Mapping wildlife habitats.
9. Monitoring coastal erosion.
10. Supporting environmental impact assessments.

Kenyan example: Aerial surveying can help monitor changes in forest cover in the Mau Forest Complex.

G. Water resource management

Surveying supports water development by:

- Identifying suitable dam sites.
- Mapping river channels.
- Determining reservoir capacity.
- Planning water supply systems.
- Establishing drainage routes.
- Mapping groundwater-related infrastructure.
- Monitoring changes in water bodies.
- Supporting irrigation projects.

H. Mining and mineral exploration

Surveying is important in mining because it:

1. Helps locate mining areas.
2. Determines mine boundaries.
3. Measures the extent of mineral deposits.
4. Supports mine planning.
5. Helps design access roads.
6. Supports quarry development.
7. Assists in monitoring mined land.
8. Helps plan mine rehabilitation.

I. Disaster management

Surveying contributes to disaster preparedness and response through:

- Mapping flood-prone areas.
- Identifying landslide-prone slopes.
- Mapping areas affected by drought.
- Planning evacuation routes.
- Identifying suitable emergency centres.
- Monitoring changes in river channels.
- Mapping settlements exposed to natural hazards.
- Supporting rescue and recovery operations.

Example: Topographical and aerial surveys can provide information for flood-risk planning along the Tana River.

J. Tourism and recreation

Surveying supports tourism by:

- Mapping tourist attractions.
- Establishing boundaries of protected areas.
- Planning tourist access roads.
- Mapping hiking trails.
- Identifying suitable campsites.
- Mapping coastal attractions.
- Supporting the development of recreational facilities.

K. Education and research

Surveying is important in educational institutions because it:

1. Develops practical geographical skills.
2. Promotes scientific observation.
3. Improves measurement skills.
4. Encourages teamwork.
5. Supports fieldwork activities.
6. Helps learners understand maps.
7. Provides information for geographical research.
8. Promotes problem-solving and critical thinking.

L. National development and security

Surveying supports national development through:

- Preparation of national maps.
- Establishment of administrative boundaries.
- Infrastructure planning.
- Mapping national resources.
- Supporting security operations.
- Planning public facilities.
- Monitoring land use.
- Supporting regional development.

5.0 ELEMENTARY SURVEYING METHODS

Elementary surveying uses simple methods to measure distances, directions and positions of geographical features.

The methods include:

1. Pacing method.
2. Chain surveying.
3. Tape surveying.

4. Compass surveying.
5. Plane table surveying.
6. Simple levelling.

The main practical method emphasised in this sub-strand is the **pacing method**, which learners can use to map their school compound.

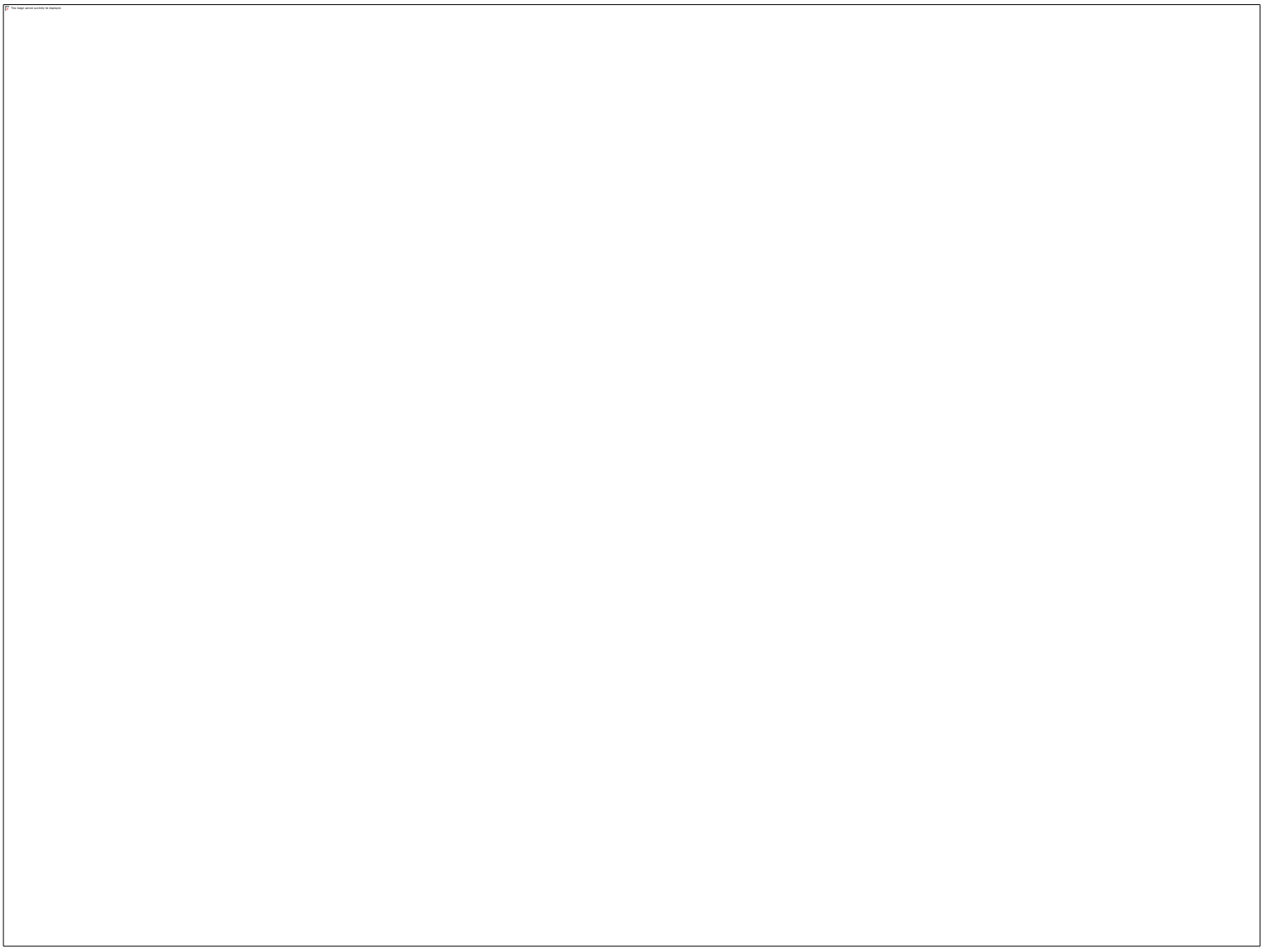
5.1 Pacing method

Meaning of pacing

Pacing is a simple method of measuring distances on the ground by counting the number of steps taken while walking between two points.

The distance covered is calculated by multiplying the number of paces by the average length of one pace.

Pacing is useful in elementary surveying because it does not require expensive equipment.



Equipment used in pacing

- Notebook.
- Pen or pencil.
- Calculator.
- Ranging rods or markers.

- Measuring tape for checking the average pace length.
- Compass, where direction is required.

Procedure for carrying out pacing

Step 1: Select two points

- Identify a starting point and an ending point.
- Mark the two points clearly.
- Ensure the route between them is safe and reasonably straight.

Step 2: Determine the average pace length

- Walk along a measured distance several times.
- Count the number of paces taken.
- Divide the measured distance by the average number of paces.

Step 3: Pace the required distance

- Start walking from the first point.
- Maintain a natural and consistent walking speed.
- Count the number of paces.
- Stop at the second point.

Step 4: Record the measurements

- Record the number of paces.
- Record the average pace length.
- Calculate the distance covered.

Step 5: Repeat the measurement

- Repeat the exercise to improve accuracy.
- Compare the measurements obtained.
- Calculate an average where necessary.

Formula used in pacing

Distance=Number of paces×Average pace length

Worked example 1: Calculating distance using pacing

A learner walks from the school gate to the administration block and takes 80 paces. If the learner's average pace length is 0.75 metres, calculate the distance.

Solution

Given:

- Number of paces = 80.
- Average pace length = 0.75 m.

D=80×0.75

D=60 m

Answer

The distance from the school gate to the administration block is 60 metres.

Worked example 2: Determining the average pace length

A learner walks a measured distance of 100 metres and takes 125 paces. Calculate the average pace length.

Solution

Average pace length=Distance/Number of paces

=100/125

=0.8 m=0.8 m

Answer

The average pace length is 0.8 metres.

Worked example 3: Determining the distance between two buildings

A learner takes 150 paces to walk from the library to the science laboratory. The average pace length is 0.65 metres. Determine the distance.

Solution

D=150×0.65

D=97.5 m

Therefore, the distance between the library and the science laboratory is 97.5 metres.

5.2 Types of pacing

A. Single pacing

This involves counting each step taken while walking between two points.

It is suitable for short distances.

B. Double pacing

This involves counting every second step or counting complete pairs of steps.

The average length of a double pace is determined during calibration.

Important: The surveyor must use the same definition of a pace throughout the exercise to avoid calculation errors.

5.3 Factors affecting the accuracy of pacing

1. **Height of the surveyor:** Taller people may have longer strides than shorter people.
2. **Nature of the ground:** Rough, rocky or uneven surfaces affect walking speed and stride length.
3. **Slope:** Walking uphill or downhill may change the length of a pace.
4. **Fatigue:** Tiredness may cause variations in stride length.
5. **Walking speed:** Different walking speeds may affect consistency.
6. **Obstacles:** Trees, buildings and other obstacles may force the surveyor to change direction.
7. **Experience:** Experienced surveyors may maintain a more consistent pace.

8. **Weather conditions:** Rain and slippery surfaces may affect walking.
9. **Footwear:** Different types of footwear may influence walking patterns.
10. **Counting errors:** Failure to count accurately may result in incorrect measurements.

5.4 Advantages of pacing

- It is simple to use.
- It does not require expensive equipment.
- It is suitable for short distances.
- It can be carried out by individual learners or groups.
- It is useful for preliminary measurements.
- It helps learners develop practical surveying skills.
- It can be used in areas where sophisticated instruments are unavailable.

5.5 Disadvantages of pacing

- It is less accurate than modern surveying methods.
- It is affected by the nature of the ground.
- It is difficult to use on steep slopes.
- It may be affected by fatigue.
- It requires calibration of the average pace length.
- It is unsuitable for very long distances where high accuracy is required.
- Obstacles may interfere with measurements.

5.6 Chain surveying

Meaning of chain surveying

Chain surveying is a method of surveying in which horizontal distances are measured directly on the ground using a chain or measuring tape.

It is particularly suitable for small areas with relatively simple details and fairly level ground.



Instruments used in chain surveying

1. Surveying chain.
2. Measuring tape.
3. Ranging rods.
4. Arrows or chain pins.
5. Pegs.
6. Cross-staff.
7. Offset rod.
8. Field notebook.

Types of surveying chains

- Metric chain.
- Engineer's chain.
- Gunter's chain.
- Revenue chain.

In modern metric surveying, measuring tapes are also commonly used for distance measurement.

Procedure for chain surveying

1. Reconnoitre the area.
2. Identify suitable survey stations.
3. Mark the stations using pegs.
4. Establish a main survey line.
5. Measure the main survey line.
6. Measure subsidiary lines.
7. Take offsets to locate important features.
8. Record all measurements in a field book.
9. Prepare a scale drawing of the surveyed area.

Uses of chain surveying

- Measuring small plots of land.
- Mapping school compounds.
- Surveying small agricultural fields.
- Measuring boundaries.
- Preparing simple site plans.
- Locating buildings and other features.

Advantages

- Simple to understand.
- Relatively inexpensive.
- Easy to carry out in open areas.
- Suitable for small and fairly level areas.
- Measurements can be checked easily.

Disadvantages

- Difficult in densely vegetated areas.
- Unsuitable for steep and rugged terrain.
- Time-consuming where there are many obstacles.
- Less suitable for large areas.
- Errors may occur due to incorrect alignment or measurement.

5.7 Tape surveying

Meaning of tape surveying

Tape surveying is a method of measuring distances on the ground using a measuring tape made from materials such as steel, fibreglass or other suitable materials.

It is commonly used for measuring short distances and establishing dimensions of small areas.



Types of measuring tapes

1. Cloth tape.
2. Fibreglass tape.
3. Steel tape.
4. Invar tape.

Uses of tape surveying

- Measuring classroom dimensions.
- Measuring school playgrounds.
- Measuring plot boundaries.
- Determining the length and width of buildings.
- Checking distances between survey stations.
- Measuring short road sections.

Precautions when using a measuring tape

- Keep the tape straight.
- Avoid unnecessary bending.
- Apply consistent tension.
- Ensure the tape is properly aligned.

- Read the measurements carefully.
- Avoid using damaged tapes.
- Record measurements immediately.

5.8 Compass surveying

Meaning of compass surveying

Compass surveying is a method of surveying in which the directions of survey lines are determined using a magnetic compass, while distances are measured using a chain or tape.

It is useful when mapping the relative positions and directions of geographical features.

Instruments used

- Prismatic compass.
- Surveyor's compass.
- Chain or measuring tape.
- Ranging rods.
- Tripod.
- Field notebook.
- Pegs.

Uses of compass surveying

1. Determining directions.
2. Mapping boundaries.
3. Preparing simple plans.
4. Establishing survey lines.
5. Mapping school compounds.
6. Determining the relative positions of features.

Advantages

- Relatively simple to use.
- Portable.
- Useful for measuring directions.
- Suitable for preliminary surveys.
- Can be combined with tape or chain measurements.

Disadvantages

- Magnetic interference may affect readings.
- Nearby iron objects may influence the compass.
- Magnetic declination may cause differences between magnetic and true north.

- Less accurate than some modern surveying instruments.

5.9 Plane table surveying

Meaning of plane table surveying

Plane table surveying is a method of surveying in which observations and measurements are plotted directly onto a drawing sheet fixed to a plane table while the surveyor is working in the field.

Instruments used

- Plane table.
- Tripod.
- Alidade.
- Spirit level.
- Plumbing fork.
- Plumb bob.
- Drawing sheet.
- Pencil and ruler.

Uses

- Preparing simple maps.
- Mapping small areas.
- Locating geographical features.
- Mapping school compounds.
- Carrying out preliminary field surveys.

Advantages

- Observation and plotting are done simultaneously.
- Errors can be noticed during fieldwork.
- It is useful for mapping small areas.
- It does not require extensive mathematical calculations.

Disadvantages

- It is affected by rain and wind.
- It is difficult to use in heavily forested areas.
- Drawing sheets may become damaged.
- It is less suitable for highly accurate surveys.
- It can be difficult to use over large areas.

5.10 Simple levelling

Meaning of levelling

Levelling is the surveying process of determining the relative heights or elevations of different points on the Earth's surface.

It helps establish whether land is higher, lower or at the same level as another point.

Instruments used in levelling

- Automatic level.
- Dumpy level.
- Levelling staff.
- Tripod.
- Measuring tape.
- Field notebook.

Uses of levelling

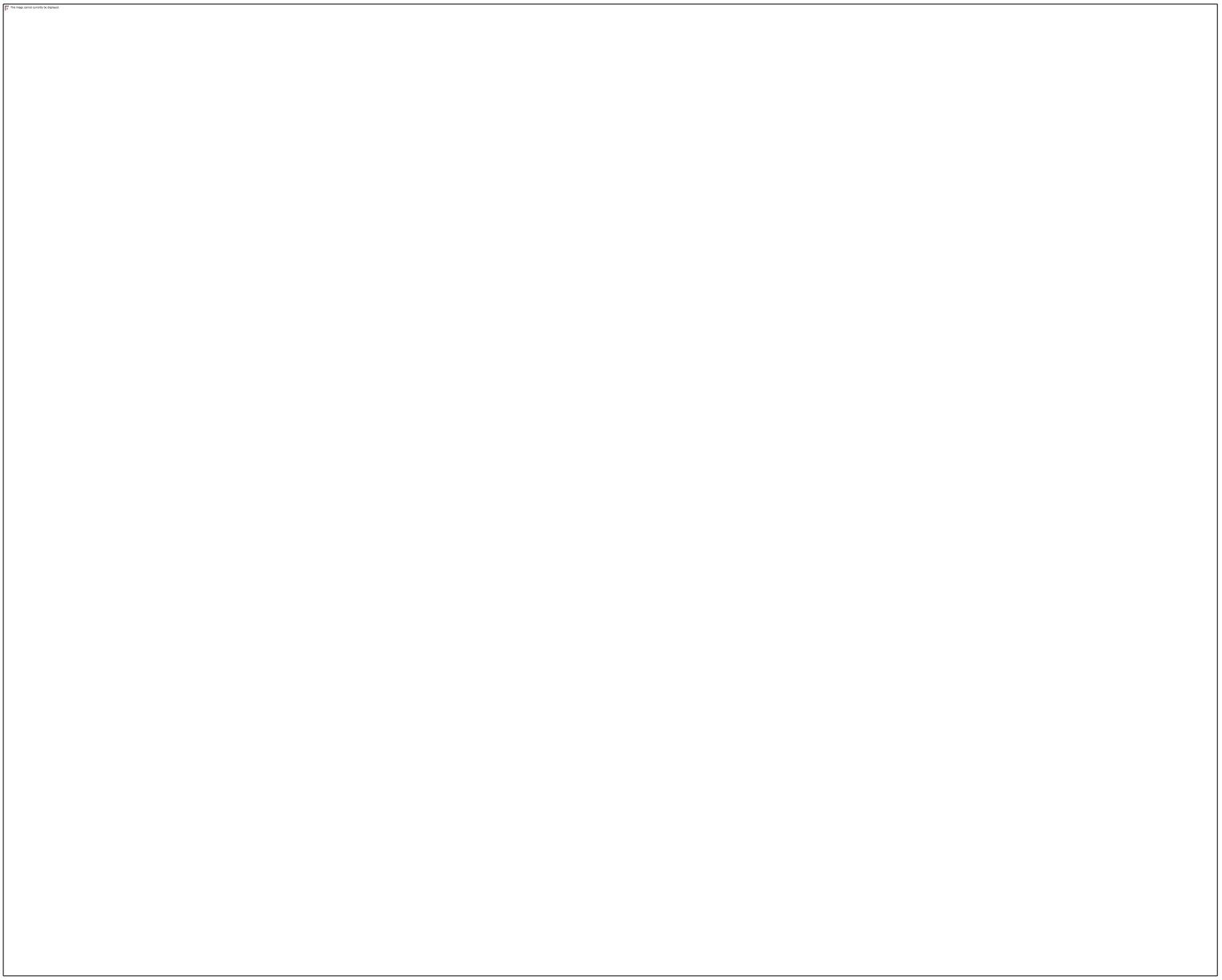
1. Determining the heights of different points.
2. Establishing building foundation levels.
3. Planning drainage systems.
4. Measuring road gradients.
5. Planning irrigation canals.
6. Determining suitable dam sites.
7. Supporting construction projects.
8. Monitoring changes in land elevation.

6.0 MAPPING THE SCHOOL COMPOUND USING THE PACING METHOD

6.1 Meaning of school compound mapping

School compound mapping is the process of identifying, measuring, locating and representing buildings, facilities, boundaries and other features within a school environment on a sketch map or plan.

It enables learners to apply geographical surveying techniques to their immediate surroundings.



6.2 Objectives of mapping a school compound

By mapping the school compound, learners should be able to:

1. Identify important features within the school.
2. Measure distances between school facilities.
3. Determine the relative positions of buildings.
4. Estimate the size of the school compound.
5. Draw a sketch map of the school.
6. Develop teamwork and communication skills.
7. Apply practical geographical skills.
8. Appreciate the importance of surveying in planning.

6.3 Features to be mapped within a school compound

A. Buildings

- Administration block.
- Classrooms.

- Library.
- Laboratory.
- Staffroom.
- Dining hall.
- Kitchen.
- Dormitories.
- Stores.

B. Recreational facilities

- Football field.
- Netball court.
- Basketball court.
- Assembly ground.
- Playground.

C. Sanitation facilities

- Toilets.
- Bathrooms.
- Handwashing points.
- Waste disposal areas.

D. Environmental features

- Trees.
- Gardens.
- Flower beds.
- Grass lawns.
- Drainage channels.
- Water points.

E. Other facilities

- School gate.
- Security office.
- Parking area.
- Borehole.
- Water tank.
- Electricity facilities.

6.4 Equipment required for mapping the school compound

Equipment	Use
Notebook	Recording measurements and observations.
Pencil	Drawing the sketch map.
Ruler	Drawing straight lines.
Measuring tape	Checking distances and calibrating pace length.
Compass	Determining directions.
Ranging rods	Marking survey stations.
Calculator	Calculating distances and averages.
Graph paper	Preparing the sketch map.
Eraser	Correcting drawing errors.

6.5 Steps involved in mapping the school compound using pacing

Step 1: Reconnaissance of the school compound

Reconnaissance is the preliminary examination of an area before carrying out a survey.

Learners should:

- Walk around the school compound.
- Identify the main boundary points.
- Observe the location of buildings.
- Identify roads and pathways.
- Locate playgrounds and gardens.
- Identify suitable survey stations.
- Note any obstacles that may affect measurements.

Step 2: Formation of groups

Learners should be divided into manageable groups.

Each group should have assigned responsibilities:

- Group leader.
- Surveyor.
- Recorder.
- Pace counter.

- Direction observer.
- Sketch-map drawer.

Step 3: Establishing the main survey line

- Identify two points that form the main survey line.
- Mark the points using ranging rods or other suitable markers.
- Select a clear route between the points.
- Ensure the route is accessible.

Step 4: Calibrating the average pace length

Learners should measure a known distance using a measuring tape.

For example, a distance of 20 metres may be used.

Each learner walks the measured distance several times while counting their paces.

The average pace length is calculated using:

Average pace length=Known distanceAverage number of pacesAverage pace length=Average number of pacesK nown distance

Step 5: Measuring distances between features

Learners use the pacing method to measure distances between important school facilities.

Examples:

- School gate to administration block.
- Administration block to classrooms.
- Classrooms to playground.
- Library to science laboratory.
- Dining hall to kitchen.
- Classrooms to sanitation facilities.

Step 6: Recording measurements

All measurements should be recorded in a field notebook.

Sample fieldwork measurement table

Assume the average pace length is 0.75 metres.

Survey line	Number of paces	Average pace length	Distance
Gate to administration	40	0.75 m	30 m
Administration to classrooms	30	0.75 m	22.5 m
Classrooms to playground	60	0.75 m	45 m

Library to laboratory	20	0.75 m	15 m
Dining hall to kitchen	16	0.75 m	12 m

These are illustrative measurements, not actual measurements of a particular school.

Step 7: Determining directions

Learners use a compass to establish the directions of the different facilities.

For example:

- The administration block is north of the school gate.
- The playground is east of the classrooms.
- The library is west of the administration block.

The actual directions should be established during fieldwork rather than assumed.

Step 8: Preparing a sketch map

Learners transfer the measurements and observations onto a drawing sheet.

They should:

1. Draw the outline of the school compound.
2. Show the position of the gate.
3. Locate the administration block.
4. Draw the classrooms.
5. Locate the library and laboratory.
6. Show the playground.
7. Indicate sanitation facilities.
8. Draw pathways and access roads.
9. Include a north arrow.
10. Provide a suitable title and key.

Step 9: Checking the accuracy of the map

- Compare the sketch map with the actual school compound.
- Check the relative positions of facilities.
- Confirm the recorded distances.
- Correct any errors.
- Ensure the map is neat and readable.

Step 10: Presentation of findings

Each group should present its sketch map to the class and explain:

- The method used.
- The equipment used.

- The distances measured.
- The arrangement of school facilities.
- Challenges experienced.
- Recommendations for improving school planning.

6.6 Sample school compound sketch map

A good school compound sketch map should represent the actual arrangement of facilities. The illustration above is a guide; learners should prepare their own map using measurements obtained from their school.

6.7 Sample fieldwork recording sheet

Name of school: .....

Date of survey: .....

Group: .....

Average pace length: .....

No.	Starting point	Ending point	Paces	Distance (m)
1	School gate	Administration		
2	Administration	Classrooms		
3	Classrooms	Playground		
4	Library	Laboratory		
5	Dining hall	Kitchen		
6	Classrooms	Toilets		
7	Administration	Water point		

6.8 Precautions when mapping a school compound

1. Obtain permission from the school administration before beginning the survey.
2. Avoid interfering with lessons.
3. Use safe walking routes.
4. Avoid restricted areas.
5. Maintain accurate pace counts.
6. Calibrate individual pace lengths.
7. Record measurements immediately.
8. Avoid disturbing school property.

9. Work cooperatively in groups.
10. Observe safety around roads and construction areas.

7.0 FACTORS AFFECTING THE ACCURACY OF SURVEYING

Accuracy is the degree to which a measurement agrees with the actual or accepted value.

Surveying requires careful measurements because inaccurate information may lead to poor planning, construction errors and land disputes.

7.1 Factors affecting surveying accuracy

A. Human factors

1. **Lack of experience:** Inexperienced surveyors may make mistakes when taking measurements.
2. **Poor observation:** Failure to observe instruments correctly may result in inaccurate readings.
3. **Fatigue:** Tired surveyors may make errors when counting paces or recording measurements.
4. **Carelessness:** Incorrect recording of measurements affects the final survey.
5. **Poor teamwork:** Lack of coordination among group members may result in inconsistent measurements.

B. Environmental factors

1. **Weather conditions:** Rain, strong winds and fog may interfere with surveying.
2. **Nature of terrain:** Steep, rocky and uneven land makes measurements difficult.
3. **Vegetation:** Thick vegetation may obstruct survey lines.
4. **Temperature:** Temperature changes may affect the length of some measuring instruments.
5. **Water bodies:** Rivers, swamps and lakes may make some areas difficult to access.

C. Instrumental factors

1. Poorly calibrated instruments.
2. Damaged measuring tapes.
3. Faulty compass readings.
4. Loose instrument components.
5. Incorrect instrument positioning.
6. Poor maintenance of equipment.

D. Technical factors

- Incorrect measurement procedures.
- Wrong calculations.
- Incorrect plotting of survey points.
- Poor selection of survey stations.
- Failure to carry out measurement checks.

7.2 Ways of improving surveying accuracy

1. Use properly calibrated instruments.

2. Repeat measurements where necessary.
3. Employ trained personnel.
4. Record measurements immediately.
5. Select suitable survey stations.
6. Avoid unnecessary obstacles.
7. Use appropriate surveying methods.
8. Maintain surveying instruments properly.
9. Check calculations carefully.
10. Work under suitable weather conditions.

8.0 CHALLENGES FACING SURVEYING IN KENYA

Despite its importance, surveying faces various challenges.

8.1 High cost of surveying equipment

- Modern equipment such as total stations, GPS receivers and drones can be expensive.
- Some institutions and small surveying firms may not afford advanced equipment.
- Maintenance and replacement costs may be high.

8.2 Difficult terrain

- Mountainous areas make movement and measurement difficult.
- Swamps and wetlands restrict access.
- Dense forests may obstruct survey lines.
- Steep slopes may increase the time required to complete surveys.

8.3 Poor weather conditions

- Heavy rainfall may interrupt fieldwork.
- Strong winds may affect aerial surveys.
- Cloud cover may interfere with some aerial observations.
- Fog may reduce visibility.

8.4 Land disputes

- Disagreements over boundaries may delay surveys.
- Disputed ownership may restrict access to land.
- Destruction of boundary beacons may affect survey work.

8.5 Shortage of skilled personnel

- Modern surveying requires technical knowledge.
- Some areas may have limited access to qualified professionals.
- Training and professional development may be expensive.

8.6 Inadequate and outdated records

- Old maps may not show recent developments.
- Missing survey records may complicate boundary determination.
- Changes in land use may make some existing information outdated.

8.7 Security challenges

- Some survey areas may be affected by insecurity.
- Survey equipment may be stolen.
- Difficult access may expose survey teams to safety risks.

8.8 Technological challenges

- Some areas have limited digital infrastructure.
- Specialised software may be expensive.
- Poor internet connectivity may affect data transfer.
- Technical failures may interrupt data collection.

8.9 Measures to improve surveying in Kenya

1. Investing in modern surveying equipment.
2. Training more surveying professionals.
3. Updating geographical records.
4. Strengthening land administration systems.
5. Promoting the use of digital mapping.
6. Improving access to surveying technology.
7. Resolving land disputes through proper legal procedures.
8. Improving security in surveying areas.
9. Promoting collaboration between government agencies and private surveying firms.
10. Creating public awareness about the importance of accurate land boundaries.

9.0 SAFETY MEASURES DURING SURVEYING

Surveying involves working outdoors, sometimes near roads, rivers, construction sites and uneven terrain. Safety must therefore be observed throughout the exercise.

9.1 General safety precautions

- Wear suitable clothing and footwear.
- Wear reflective jackets when working near roads.
- Avoid surveying during dangerous weather.
- Carry drinking water.
- Avoid working near unstable slopes.
- Do not enter deep water without proper safety arrangements.

- Handle instruments carefully.
- Avoid touching electrical installations.
- Work under the guidance of a teacher or qualified surveyor.
- Keep equipment safely after use.
- Avoid exposing sensitive school or private property information unnecessarily.

9.2 Importance of observing safety measures

1. Prevents accidents.
2. Protects learners and surveyors from injuries.
3. Prevents damage to equipment.
4. Promotes efficient fieldwork.
5. Encourages responsibility.
6. Ensures successful completion of surveying activities.

10.0 MODERN TECHNOLOGIES USED IN SURVEYING

Modern technology has improved the accuracy, speed and efficiency of surveying.

10.1 Global Positioning System (GPS)

GPS is a satellite-based navigation system used to determine the position of a receiver on or near the Earth's surface.

Uses of GPS

- Determining geographical coordinates.
- Locating land boundaries.
- Mapping roads.
- Measuring positions of geographical features.
- Navigation.
- Monitoring movement and changes in geographical features.

10.2 Total station

A total station is an electronic surveying instrument that measures horizontal angles, vertical angles and distances to determine the positions of points.

Uses

- Land surveying.
- Construction setting out.
- Measuring distances.
- Establishing land boundaries.

- Mapping buildings.
- Engineering projects.

10.3 Geographic Information Systems (GIS)

GIS is a computer-based system used to collect, store, manage, analyse and display geographical information.

Uses

- Mapping land use.
- Planning settlements.
- Monitoring environmental changes.
- Managing natural resources.
- Planning transport networks.
- Supporting disaster management.

10.4 Remote sensing

Remote sensing is the collection of information about the Earth's surface without direct physical contact, usually through satellites, aircraft or drones.

Uses

- Monitoring deforestation.
- Mapping agricultural land.
- Monitoring drought.
- Identifying flood-affected areas.
- Mapping urban expansion.
- Studying environmental changes.

10.5 Unmanned Aerial Vehicles (UAVs)

These are remotely controlled or programmed aircraft commonly called drones.

Uses

- Mapping school compounds.
- Surveying agricultural land.
- Monitoring construction sites.
- Mapping inaccessible areas.
- Producing aerial photographs.
- Monitoring environmental changes.

10.6 Differences between traditional and modern surveying

Traditional surveying	Modern surveying
Often uses simple instruments.	Uses electronic and digital instruments.
Measurements may take more time.	Measurements can be collected rapidly.
May involve more manual calculations.	Uses digital data processing.
Often covers small areas at a time.	Can cover large areas using aerial technologies.
Examples include pacing and chain surveying.	Examples include GPS, total stations and drone surveying.
May require many people for some tasks.	Some operations can be completed by smaller teams.

Important: Traditional methods remain useful, particularly in elementary geographical fieldwork and situations where modern equipment is unavailable.

11.0 PRACTICAL LEARNING ACTIVITIES

These activities are designed to help learners develop surveying competencies through participation, observation, measurement, collaboration and problem-solving.

Activity 1: Researching types of surveying

Learning resources

- Geography textbooks.
- Internet-enabled devices.
- Printed maps.
- Photographs of surveying instruments.
- Library resources.

Procedure

1. Divide learners into six groups.
2. Assign each group one type of surveying.
3. Ask learners to research its meaning.
4. Identify instruments used.
5. Identify areas where it is applied.
6. Find examples from Kenya.
7. Prepare a short presentation.
8. Share the findings with the class.

Expected outcomes

Learners should be able to:

- Identify different types of surveying.
- Explain their applications.
- Recognise surveying equipment.
- Appreciate the contribution of surveying to society.

Activity 2: Mapping the school compound using pacing

Learning resources

- Measuring tape.
- Notebook.
- Pencil.
- Ruler.
- Compass.
- Ranging rods.
- Graph paper.

Procedure

1. Obtain permission to survey the school compound.
2. Form groups.
3. Identify the major features within the compound.
4. Calibrate the average pace length.
5. Measure distances between selected facilities.
6. Record the measurements.
7. Determine directions.
8. Draw a sketch map.
9. Present the maps to classmates.
10. Discuss the importance of surveying in school planning.

Activity 3: Interviewing a resource person

Invite a qualified surveyor, land officer, civil engineer or geographical information specialist to discuss the importance of surveying in society.

Suggested interview questions

1. What is surveying?
2. What are the major types of surveying?
3. Which instruments are commonly used?
4. How does surveying assist in land ownership?
5. How does surveying support construction?
6. How does surveying promote environmental conservation?

7. What challenges do surveyors face in Kenya?
8. What career opportunities are available in surveying?
9. How has modern technology improved surveying?
10. What advice would you give learners interested in surveying?

Activity 4: Preparing a school compound map

Learners should prepare a sketch map showing:

- School gate.
- Administration block.
- Classrooms.
- Library.
- Laboratory.
- Playground.
- Dining hall.
- Kitchen.
- Toilets.
- Water points.
- Trees and gardens.
- Access roads.

The map should include a title, north arrow, key and suitable scale where appropriate.

Activity 5: Developing a community awareness message

Learners work in groups to prepare messages explaining the importance of surveying in the community.

Sample awareness message

"Accurate surveying promotes proper land ownership, prevents boundary disputes, supports infrastructure development and assists in the sustainable management of natural resources. Communities should appreciate the importance of professional surveying in promoting orderly and sustainable development."

15.0 SUMMARY OF KEY CONCEPTS

Term	Meaning
Surveying	Science and practice of measuring positions, distances, directions and elevations of points on the Earth's surface.
Elementary surveying	Basic techniques used to measure and map geographical features.
Cadastral surveying	Surveying concerned with land boundaries and ownership.
Topographical surveying	Surveying that records natural and human-made features and land relief.
Hydrographic surveying	Surveying of water bodies and underwater features.
Engineering surveying	Surveying undertaken to support construction and engineering projects.
Aerial surveying	Collecting geographical information using aircraft, drones and satellites.
Astronomic surveying	Determining geographical positions and directions through observations of celestial bodies.
Pacing	Measuring distances by counting steps taken between two points.
Chain surveying	Measuring distances using a chain or tape.
Tape surveying	Measuring ground distances using a measuring tape.
Compass surveying	Determining directions using a magnetic compass.
Plane table surveying	Measuring and plotting geographical features directly in the field.
Levelling	Determining the relative heights of points on the Earth's surface.
Reconnaissance	Preliminary examination of an area before surveying.
Survey station	A selected point from which surveying measurements are made.
Pace length	Distance covered in one defined pace.
GPS	Satellite-based system used to determine geographical positions.

GIS	Computer-based system for managing and analysing geographical information.
Remote sensing	Collecting information about the Earth's surface without direct physical contact.
Total station	Electronic instrument used to measure angles and distances.

REVISION QUESTIONS

SECTION A: MULTIPLE-CHOICE QUESTIONS

Instructions: Answer all questions by selecting the correct alternative A, B, C or D. Each question carries 1 mark.

TOTAL: 30 MARKS

1. Which of the following best defines surveying?

A. The study of weather conditions in an area.

B. The measurement of distances, directions, positions and elevations on the Earth's surface.

C. The study of population distribution.

D. The investigation of economic activities.

2. Which type of surveying is mainly concerned with determining land ownership boundaries?

A. Hydrographic surveying.

B. Astronomic surveying.

C. Cadastral surveying.

D. Aerial surveying.

3. The main purpose of topographical surveying is to:

A. Determine the ownership of land only.

B. Measure rainfall in an area.

C. Record natural and human-made features and land relief.

D. Study the movement of stars only.

4. Which type of surveying is used to measure the depth of lakes, seas and oceans?

A. Cadastral surveying.

B. Hydrographic surveying.

C. Engineering surveying.

D. Astronomic surveying.

5. Surveying undertaken before the construction of roads and bridges is known as:

A. Engineering surveying.

B. Aerial surveying.

C. Hydrographic surveying.

D. Cadastral surveying.

6. Which of the following is an example of aerial surveying equipment?

A. Measuring chain.

B. Levelling staff.

C. Drone.

D. Ranging rod.

7. Astronomic surveying uses observations of:

A. Underground minerals.

B. Celestial bodies.

C. Agricultural crops.

D. Forest vegetation.

8. Which instrument is most appropriate for measuring horizontal and vertical angles electronically?

A. Measuring tape.

B. Total station.

C. Ranging rod.

D. Chain.

9. Which of the following is a major use of cadastral surveying in Kenya?

A. Measuring rainfall.

B. Determining land parcel boundaries.

C. Measuring ocean currents.

D. Determining atmospheric pressure.

10. Which of the following features is mainly measured during topographical surveying?

A. Land elevation.

B. Population growth.

C. Market prices.

D. Political opinions.

11. Hydrographic surveying is particularly important in the development of:

A. Railway stations.

B. Harbours and ports.

C. Residential estates.

D. Agricultural plantations.

12. Which instrument is commonly used to determine the depth of water electronically?

A. Echo sounder.

B. Prismatic compass.

C. Measuring chain.

D. Ranging rod.

13. Which of the following is a major application of engineering surveying?

A. Determining the direction of stars.

B. Establishing building positions.

C. Measuring fish populations.

D. Recording rainfall distribution.

14. A surveyor uses a drone to take photographs of a large agricultural area. Which type of surveying is being carried out?

A. Cadastral surveying.

B. Astronomic surveying.

C. Aerial surveying.

D. Hydrographic surveying.

15. Which of the following is an instrument used in astronomic surveying?

A. Sextant.

B. Measuring chain.

C. Cross-staff.

D. Ranging rod.

16. Which of the following is the most suitable method for measuring short distances in a school compound without sophisticated equipment?

A. Astronomic surveying.

B. Pacing.

C. Hydrographic surveying.

D. Satellite surveying.

17. A learner walks 100 metres using 125 paces. What is the average pace length?

A. 0.5 metres.

B. 0.6 metres.

C. 0.8 metres.

D. 1.25 metres.

18. A surveyor takes 80 paces to cover a distance. If the average pace length is 0.75 metres, what is the distance covered?

A. 40 metres.

B. 50 metres.

C. 60 metres.

D. 75 metres.

19. Which of the following is a major advantage of pacing?

A. It requires expensive electronic equipment.

B. It is simple and inexpensive.

C. It is highly accurate over all terrains.

D. It can measure underwater distances.

20. Which of the following factors may reduce the accuracy of pacing?

A. Consistent walking speed.

B. Proper calibration.

C. Uneven ground.

D. Repeated measurements.

21. Which instrument is used in chain surveying to measure ground distances?

A. Echo sounder.

B. Surveying chain.

C. Sextant.

D. Telescope.

22. Which instrument is used in compass surveying to determine direction?

A. Prismatic compass.

B. Levelling staff.

C. Measuring tape.

D. Echo sounder.

23. In plane table surveying, geographical features are:

A. Measured only at night.

B. Plotted directly onto a drawing sheet in the field.

C. Measured using sound waves.

D. Recorded using rainfall instruments.

24. The process of determining the relative heights of different points is known as:

A. Pacing.

B. Levelling.

C. Chain surveying.

D. Cadastral surveying.

25. What is the first important activity before carrying out a field survey?

A. Drawing the final map.

B. Reconnaissance of the area.

C. Calculating the final scale.

D. Removing all vegetation.

26. Which of the following is a major benefit of surveying in agriculture?

A. Increasing land disputes.

B. Planning irrigation systems.

C. Encouraging soil erosion.

D. Reducing agricultural production.

27. Which of the following technologies is used to collect and analyse geographical information?

A. GIS.

B. Barometer.

C. Thermometer.

D. Rain gauge.

28. Which of the following is a major challenge facing surveying in Kenya?

A. Availability of accurate instruments everywhere.

B. Low cost of all surveying equipment.

C. Difficult terrain and high equipment costs.

D. Absence of geographical features.

29. Why should learners calibrate their pace length before mapping a school compound?

A. To determine the colour of the map.

B. To improve the accuracy of distance measurements.

C. To identify the age of buildings.

D. To determine the population of the school.

30. Which of the following is an important safety measure during field surveying?

A. Working near moving vehicles without supervision.

B. Handling instruments carelessly.

C. Wearing appropriate protective clothing.

D. Entering restricted areas without permission.

SECTION B: STRUCTURED QUESTIONS

TOTAL: 50 MARKS

Instructions: Answer all questions. Show all working in calculation questions. Give relevant examples from Kenya where necessary.

QUESTION 1: INTRODUCTION TO SURVEYING (10 MARKS)

a) Define the term surveying. (2 marks)

b) State four objectives of surveying. (4 marks)

c) Explain two basic principles of surveying. (4 marks)

QUESTION 2: TYPES OF SURVEYING (10 MARKS)

a) Name five types of surveying used in geographical studies. (5 marks)

b) Explain the importance of any five types of surveying in Kenya. (5 marks)

QUESTION 3: IMPORTANCE OF SURVEYING IN SOCIETY (8 MARKS)

a) State four ways in which surveying contributes to agricultural development in Kenya. (4 marks)

b) Explain four ways in which surveying contributes to infrastructure and settlement development. (4 marks)

QUESTION 4: PACING METHOD (8 MARKS)

a) Define the term pacing. (2 marks)

b) Explain three steps followed when using the pacing method to measure distance. (3 marks)

c) A learner takes 120 paces to walk from the school gate to the administration block. If the average pace length is 0.7 metres, calculate the distance covered. (2 marks)

d) State one factor that may affect the accuracy of pacing. (1 mark)

QUESTION 5: MAPPING THE SCHOOL COMPOUND (8 MARKS)

a) State four features that can be represented on a sketch map of a school compound. (4 marks)

b) Explain four steps followed when mapping a school compound using the pacing method. (4 marks)

QUESTION 6: SURVEYING TECHNOLOGY AND CHALLENGES (6 MARKS)

a) Name two modern technologies used in surveying. (2 marks)

b) Explain two challenges facing surveying in Kenya. (2 marks)

c) State two safety precautions that should be observed during surveying fieldwork. (2 marks)

ANSWER KEY: SECTION A

MULTIPLE-CHOICE ANSWERS – 30 MARKS

Question	Answer	Question	Answer	Question	Answer
1	B	11	B	21	B
2	C	12	A	22	A
3	C	13	B	23	B
4	B	14	C	24	B
5	A	15	A	25	B
6	C	16	B	26	B
7	B	17	C	27	A
8	B	18	C	28	C
9	B	19	B	29	B
10	A	20	C	30	C

17.0 SECTION B: MARKING SCHEME

TOTAL: 50 MARKS

QUESTION 1: INTRODUCTION TO SURVEYING (10 MARKS)

a) Define the term surveying. (2 marks)

- Surveying is the science and art of measuring distances, angles and elevations on the Earth's surface to determine the relative positions of different points and represent them on maps or plans. (2 marks)

b) State four objectives of surveying. (4 marks)

Award 1 mark for each correct response.

1. To determine the relative positions of different points on the Earth's surface.
2. To prepare maps, plans and charts showing geographical features.
3. To establish boundaries of land parcels and properties.
4. To determine distances, directions, angles and elevations between points.
5. To provide information for planning and construction of infrastructure.
6. To identify suitable sites for agricultural, industrial and settlement activities.
7. To monitor changes in physical and human features over time.

(Any 4 × 1 = 4 marks)

c) Explain two basic principles of surveying. (4 marks)

Award 2 marks for each well-explained principle.

1. Working from whole to part

- Surveying should begin by establishing accurate control points over a large area before subdividing it into smaller sections for detailed measurements. (1 mark)
- This helps to minimise the accumulation and spread of errors during surveying. (1 mark)

2. Fixing a point using at least two independent measurements

- The position of a new point should be determined using at least two independent measurements from known reference points. (1 mark)
- This improves accuracy and helps to check the correctness of the measurements. (1 mark)

(2 × 2 = 4 marks)

QUESTION 2: TYPES OF SURVEYING (10 MARKS)

a) Name five types of surveying used in geographical studies. (5 marks)

Award 1 mark for each correct type.

1. Chain surveying.
2. Compass surveying.
3. Plane table surveying.
4. Levelling surveying.
5. Theodolite surveying.
6. Topographical surveying.
7. Aerial surveying.
8. Photogrammetric surveying.
9. Cadastral surveying.
10. Hydrographic surveying.
11. GPS/GNSS surveying.

(Any 5 × 1 = 5 marks)

b) Explain the importance of any five types of surveying in Kenya. (5 marks)

Award 1 mark for each correct explanation.

1. Chain surveying: Used to measure short distances and prepare simple plans of school compounds, farms and small plots of land.

2. Compass surveying: Helps in determining directions and bearings when mapping land boundaries and geographical features.

3. Plane table surveying: Used to prepare maps and plans directly in the field, particularly for small areas.

4. Levelling surveying: Helps to determine differences in height and establish suitable gradients for roads, drainage systems and irrigation canals.

5. Theodolite surveying: Used to measure horizontal and vertical angles accurately during road, bridge and building construction.

6. Topographical surveying: Helps to identify and represent relief features such as hills, valleys, rivers and human-made features.

7. Aerial surveying: Uses photographs taken from aircraft to map large areas, including forests, settlements and agricultural land.

8. Hydrographic surveying: Used to measure and map water bodies such as lakes, rivers and reservoirs.

9. Cadastral surveying: Helps in establishing, measuring and recording land ownership boundaries.

10. GPS/GNSS surveying: Helps to determine accurate geographical positions of points on the Earth's surface.

(Any 5 × 1 = 5 marks)

QUESTION 3: IMPORTANCE OF SURVEYING IN SOCIETY (8 MARKS)

a) State four ways in which surveying contributes to agricultural development in Kenya. (4 marks)

Award 1 mark for each correct response.

1. Helps in measuring and determining the sizes of agricultural land.
2. Helps farmers to plan farm layouts and establish field boundaries.
3. Assists in designing irrigation schemes and drainage systems.
4. Helps in identifying suitable sites for farm buildings, dams and water reservoirs.
5. Assists in determining land slopes for soil and water conservation.
6. Helps in planning terraces to control soil erosion.
7. Supports proper land-use planning and crop zoning.

(Any 4 × 1 = 4 marks)

b) Explain four ways in which surveying contributes to infrastructure and settlement development. (4 marks)

Award 1 mark for each correct explanation.

1. Road construction: Surveying helps determine suitable routes, distances, gradients and alignment for roads and highways.

2. Building construction: It helps establish accurate building positions, dimensions and boundaries before construction begins.

3. Urban and rural planning: It provides information used in designing residential areas, commercial centres and public facilities.

4. Water supply development: It helps identify suitable locations and routes for water pipelines, dams and reservoirs.

5. Railway construction: It assists in determining appropriate railway routes and gradients.

6. Electricity distribution: It helps establish suitable routes for electricity transmission lines and distribution networks.

7. Sewerage and drainage: It helps determine gradients and routes for drainage channels and sewer systems.

(Any 4 × 1 = 4 marks)

QUESTION 4: PACING METHOD (8 MARKS)

a) Define the term pacing. (2 marks)

- Pacing is a simple method of measuring distance by counting the number of steps or paces taken while walking between two points. (2 marks)

b) Explain three steps followed when using the pacing method to measure distance. (3 marks)

Award 1 mark for each correct step.

1. Walk over a known distance and count the number of paces taken to determine the average pace length.
2. Walk from the starting point to the destination while counting the number of paces taken.
3. Multiply the total number of paces by the average pace length to obtain the distance covered.

(3 × 1 = 3 marks)

c) A learner takes 120 paces to walk from the school gate to the administration block. If the average pace length is 0.7 metres, calculate the distance covered. (2 marks)

Solution:

Formula:

Distance = Number of paces × Average pace length

Substitution:

= 120 × 0.7

= 84 metres

Answer: 84 metres

Mark allocation:

- Correct formula and substitution. (1 mark)
- Correct answer with appropriate unit. (1 mark)

d) State one factor that may affect the accuracy of pacing. (1 mark)

Award 1 mark for any one correct response.

1. Differences in walking speed.
2. Uneven or sloping ground.
3. Fatigue of the person taking measurements.
4. Variations in individual step length.
5. Presence of obstacles along the route.
6. Walking on slippery or rough surfaces.

QUESTION 5: MAPPING THE SCHOOL COMPOUND (8 MARKS)

a) State four features that can be represented on a sketch map of a school compound. (4 marks)

Award 1 mark for each correct response.

1. Classrooms.
2. Administration block.

3. School playground.
4. School gate.
5. Toilets and sanitation facilities.
6. Roads and footpaths.
7. Staffroom.
8. Library.
9. Water points.
10. Trees and gardens.
11. School kitchen.
12. Assembly ground.

(Any 4 × 1 = 4 marks)

b) Explain four steps followed when mapping a school compound using the pacing method. (4 marks)

Award 1 mark for each correct step explained.

1. Identify the area to be mapped: Walk around the school compound and identify its boundaries and important features.

2. Determine the average pace length: Measure a known distance by pacing several times and calculate the average length of one pace.

3. Measure distances: Walk between important features, counting the paces taken and converting them into actual distances using the average pace length.

4. Prepare the sketch map: Draw the school compound using a suitable scale and indicate the relative positions of the identified features.

Other acceptable steps:

- Select a suitable starting or reference point.
- Record measurements in a field notebook.
- Include a title, key, scale and north direction.
- Check measurements for accuracy.

(Any 4 × 1 = 4 marks)

QUESTION 6: SURVEYING TECHNOLOGY AND CHALLENGES (6 MARKS)

a) Name two modern technologies used in surveying. (2 marks)

Award 1 mark for each correct response.

1. Global Positioning System (GPS).
2. Geographic Information Systems (GIS).
3. Remote sensing technology.
4. Drones or Unmanned Aerial Vehicles (UAVs).
5. Total stations.

6. Laser scanning technology.
7. Digital photogrammetry.
8. Global Navigation Satellite Systems (GNSS).

(Any 2 × 1 = 2 marks)

b) Explain two challenges facing surveying in Kenya. (2 marks)

Award 1 mark for each correct explanation.

1. High cost of equipment: Modern surveying equipment and software are expensive, making them difficult to acquire, especially for small organisations.

2. Difficult terrain: Steep slopes, dense forests, swamps and inaccessible areas make field measurements difficult.

3. Unfavourable weather: Heavy rainfall, strong winds and fog may interfere with fieldwork and reduce measurement accuracy.

4. Shortage of skilled personnel: Some areas lack adequately trained surveyors to operate modern equipment.

5. Land ownership disputes: Conflicts over land boundaries may delay surveying activities.

6. Poor infrastructure: Inaccessible roads and remote locations may make it difficult to reach surveying sites.

(Any 2 × 1 = 2 marks)

c) State two safety precautions that should be observed during surveying fieldwork. (2 marks)

Award 1 mark for each correct response.

1. Wear appropriate protective clothing, safety boots and reflective jackets.
2. Avoid working in dangerous areas such as steep slopes and unstable ground.
3. Observe traffic rules when surveying near roads.
4. Avoid touching exposed electrical wires and other dangerous installations.
5. Carry a first-aid kit during fieldwork.
6. Use surveying equipment carefully to prevent injuries.
7. Work in groups, especially in remote or unfamiliar areas.
8. Avoid conducting fieldwork during dangerous weather conditions.

(Any 2 × 1 = 2 marks)

SUGGESTED LEARNER PROJECT

PRACTICAL COMPETENCY-BASED PROJECT

Project title: Surveying and Mapping Our School Compound Using the Pacing Method

Project task

Learners should work in groups to conduct a simple survey of their school compound and produce a sketch map showing the distribution of important facilities.

Project requirements

1. Identify the school boundary.
2. Identify the main buildings and facilities.
3. Calibrate the average pace length.
4. Measure distances between selected facilities.
5. Record measurements in a field notebook.
6. Determine the directions of selected features.
7. Draw a sketch map of the school compound.
8. Identify areas requiring improvement in school planning.
9. Present the completed map to the class.
10. Explain the importance of surveying in school development.

Expected project products

- A fieldwork recording sheet.
- A table of measurements.
- A sketch map of the school compound.
- A short fieldwork report.
- An oral presentation.

Project assessment rubric

Assessment area	**Marks**
Identification of school features	5
Accuracy of measurements	5
Proper recording of field data	5
Quality of sketch map	5
Explanation of surveying applications	5
Teamwork and presentation	5
Total	30

20.0 TEACHER'S GUIDE: ASSESSMENT OF LEARNING

The teacher should assess learners continuously through practical activities, observation, oral questions, written exercises and project work.

Assessment method	**Expected evidence**
Oral questioning	Correct explanation of surveying concepts.
Group discussions	Ability to identify types of surveying.
Research activities	Collection and presentation of relevant information.
Practical exercises	Ability to use pacing to measure distances.
Sketch-map drawing	Accurate representation of school facilities.
Fieldwork reports	Proper recording and interpretation of measurements.
Project presentations	Effective communication and collaboration.

STRAND 1.0: PRACTICAL GEOGRAPHY

SUB-STRAND 1.3: STATISTICAL METHODS

1.0 INTRODUCTION TO STATISTICAL METHODS

1.1 Meaning of statistical methods

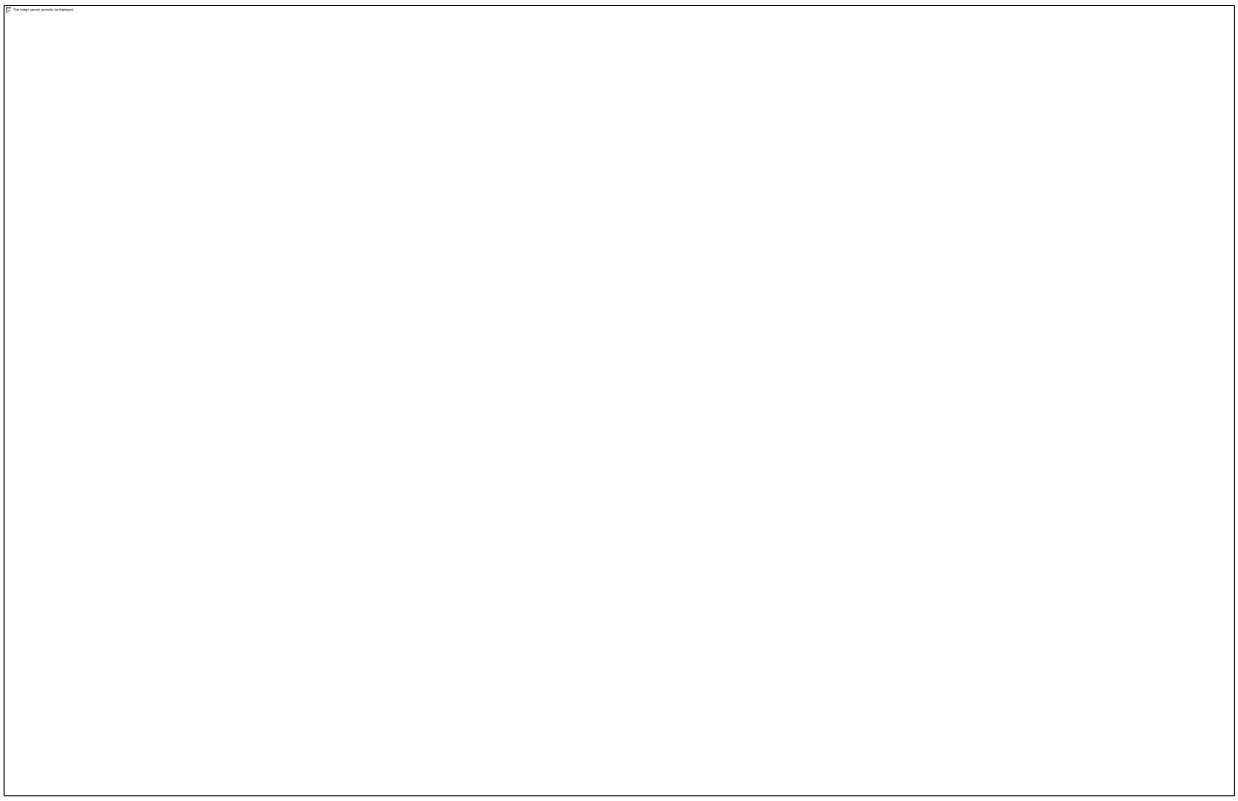
Statistical methods refer to the techniques and procedures used to collect, organise, classify, analyse, present, interpret and draw conclusions from numerical information.

In Geography, statistical methods enable geographers to study geographical phenomena by examining numerical data collected from different locations and activities.

Statistical methods help geographers understand geographical patterns, relationships, variations and trends in the environment and human activities.

For example:

- Analysing rainfall records to determine the wettest and driest months in a county.
- Studying population figures to understand population growth in Kenya.
- Analysing agricultural production to compare crop yields in different counties.
- Studying temperature records to identify climatic variations.
- Analysing transport statistics to determine the volume of traffic on major roads.
- Studying settlement statistics to understand rural-urban population distribution.





1.2 Meaning of statistics

Statistics is the branch of knowledge concerned with the collection, organisation, presentation, analysis and interpretation of numerical data to support decision-making.

In Geography, statistics provides a scientific approach to understanding geographical information.

Examples of geographical statistics:

1. Population of different counties in Kenya.
2. Annual rainfall received in different parts of the country.
3. Average temperatures recorded at different weather stations.
4. Number of livestock kept in different regions.
5. Agricultural production in different farming areas.
6. Number of tourists visiting national parks.
7. Length of roads constructed in different counties.
8. Distribution of health facilities across geographical regions.

1.3 Meaning of geographical data

Geographical data refers to information about the Earth's physical environment, human activities and spatial distribution of geographical phenomena.

It may include numerical information, descriptions, measurements, locations and observations.

Examples:

Geographical phenomenon	Data collected
Rainfall	Amount of rainfall in millimetres
Temperature	Temperature in degrees Celsius
Population	Number of people
Agriculture	Tonnes of maize harvested
Transport	Number of vehicles passing a road
Settlement	Number of houses in an area
Water resources	Volume of water in cubic metres
Tourism	Number of visitors to a national park
Relief	Height of land above sea level
Trade	Value of goods sold

1.4 Importance of statistical methods in Geography

Statistical methods are important because they:

1. **Simplify geographical information:** Large quantities of data can be organised into tables, graphs and charts that are easier to understand.

2. **Facilitate comparison:** Statistics enables geographers to compare geographical phenomena in different places and at different times.

3. **Identify geographical patterns:** Statistical analysis helps identify patterns in rainfall, population distribution, agricultural production and settlement.

4. **Show geographical variations:** It reveals differences in geographical phenomena, such as variations in rainfall between Mombasa, Nairobi and Lodwar.

5. **Support planning:** Statistical information assists government agencies in planning schools, hospitals, roads and other public facilities.

6. **Promote informed decision-making:** Decision-makers use statistical evidence when making geographical and development decisions.

7. **Predict future trends:** Statistical information can be used to estimate future population growth, agricultural production and resource demand.

8. **Support geographical research:** Researchers use statistical techniques to investigate geographical problems and develop conclusions.

9. **Promote resource management:** Statistics helps determine the distribution and utilisation of natural and human resources.

10. **Evaluate development programmes:** Statistical information helps assess whether development projects have achieved their intended objectives.

11. **Support disaster management:** Statistical analysis of rainfall, river levels and past floods assists in identifying disaster-prone areas.

12. **Improve environmental conservation:** Statistics helps monitor changes in forest cover, wildlife populations and environmental conditions.

2.0 TYPES AND SOURCES OF GEOGRAPHICAL DATA

2.1 Types of geographical data

Geographical data can be classified into different categories depending on its nature and how it is measured.

A. Quantitative data

Quantitative data refers to numerical information that can be counted or measured.

It is expressed in numbers and can be analysed using mathematical and statistical methods.

Examples:

- Population of a town.
- Amount of rainfall received.
- Temperature of a place.
- Number of livestock in a village.
- Area of agricultural land.
- Distance between two settlements.
- Number of tourists visiting a national park.

Quantitative data is divided into two main categories.

i. Discrete data

Discrete data consists of countable numerical values that normally occur as whole numbers.

Examples:

- Number of learners in a classroom.
- Number of hospitals in a county.
- Number of vehicles on a road.
- Number of rivers in a region.
- Number of livestock in a homestead.

ii. Continuous data

Continuous data consists of measurements that can take any value within a given range, including decimal values.

Examples:

- Rainfall of 125.5 mm.
- Temperature of 24.6°C.

- Distance of 12.75 km.
- Altitude of 1,850.5 metres.
- River depth of 4.25 metres.

B. Qualitative data

Qualitative data refers to descriptive information that explains the characteristics or qualities of geographical phenomena.

It is generally expressed in words or categories rather than numerical measurements.

Examples:

- Types of vegetation.
- Soil characteristics.
- Types of settlement.
- Land-use categories.
- Types of agricultural activities.
- Weather conditions such as cloudy, sunny or rainy.

2.2 Sources of geographical data

Geographical data can be obtained from primary and secondary sources.

A. Primary sources of geographical data

Primary data is original information collected directly by a researcher for a particular geographical investigation.

It is collected from the field through direct observation, measurement, interviews, questionnaires and experiments.

Methods of collecting primary data

1. **Field observation:** Involves directly observing geographical features and activities and recording the findings.

Example: Observing settlement patterns in a rural area of Narok County.

2. **Questionnaires:** These are written questions administered to respondents to obtain information.

Example: Giving households questionnaires to establish their main sources of water.

3. **Interviews:** Involve asking individuals questions and recording their responses.

Example: Interviewing farmers in Uasin Gishu County about their maize production.

4. **Field measurements:** Involve measuring geographical features using appropriate instruments.

Example: Measuring rainfall using a rain gauge.

5. **Counting:** Involves determining the number of geographical features or activities.

Example: Counting vehicles passing through a road junction.

6. **Photography:** Involves taking photographs to provide visual records of geographical phenomena.

Example: Photographing changes in land use around Nakuru town.

7. **Experiments:** Involve conducting controlled investigations to obtain geographical information.

Example: Investigating the rate of soil infiltration under different vegetation covers.

8. **Sampling:** Involves selecting a representative section of a population or geographical area for investigation.

Example: Selecting 50 households from a village to study access to clean water.

B. Secondary sources of geographical data

Secondary data refers to information that has already been collected, processed or published by other individuals or institutions and is used by a researcher for a different investigation.

Sources include:

1. Kenya National Bureau of Statistics (KNBS).
2. Kenya Meteorological Department.
3. Ministry of Agriculture.
4. County government reports.
5. National government publications.
6. Census reports.
7. Geography textbooks.
8. Research journals.
9. Newspapers and magazines.
10. Digital databases.
11. Published maps and atlases.
12. Reports from international organisations.

2.3 Differences between primary and secondary data

Primary data	**Secondary data**
Collected directly by the researcher.	Obtained from existing sources.
Original information.	Previously collected information.
Can be designed to meet specific research objectives.	May not fully meet the researcher's requirements.
May be expensive and time-consuming to collect.	Often cheaper and quicker to obtain.
Examples include questionnaires and field measurements.	Examples include census reports and published research.

2.4 Factors to consider when selecting geographical data

1. **Accuracy:** Data should be correct and free from major errors.
2. **Reliability:** The source should provide dependable information.

3. **Relevance:** Information should relate directly to the geographical investigation.
4. **Timeliness:** Data should be sufficiently recent for the purpose of the study.
5. **Availability:** Data should be accessible to the researcher.
6. **Cost:** The cost of collecting or obtaining data should be manageable.
7. **Coverage:** Data should adequately represent the area being investigated.
8. **Consistency:** Data should use comparable methods, units and definitions.

3.0 METHODS OF ANALYSING STATISTICAL DATA IN GEOGRAPHY

3.1 Meaning of statistical data analysis

Statistical data analysis is the systematic process of examining, organising, summarising and interpreting collected numerical information to identify patterns, relationships, variations and trends.

In Geography, data analysis helps transform raw geographical information into meaningful conclusions.

For example, a researcher collecting monthly rainfall records in Nakuru County may analyse the data to determine:

- The wettest month.
- The driest month.
- The average monthly rainfall.
- The variation in rainfall.
- The consistency of rainfall throughout the year.

3.2 Main methods of analysing statistical data

The major statistical methods covered in this sub-strand include:

1. Measures of dispersion.
2. Frequency distribution.

Other useful supporting techniques include:

- Measures of central tendency.
- Percentage analysis.
- Ratio analysis.
- Comparison of statistical values.
- Trend analysis.

4.0 MEASURES OF DISPERSION

4.1 Meaning of measures of dispersion

Measures of dispersion are statistical techniques used to determine the extent to which numerical values in a data set are spread out or scattered around a central value.

They show whether the values in a geographical data set are close together or widely distributed.

In Geography, measures of dispersion help geographers understand variations in geographical phenomena.

Examples:

- Variations in rainfall received in different parts of Kenya.
- Differences in temperatures recorded at different weather stations.
- Variations in agricultural yields among farms.
- Differences in population sizes among settlements.
- Variations in the income levels of households.

4.2 Importance of measures of dispersion in Geography

1. **Determining geographical variations:** They show the extent of differences in geographical data.

2. **Comparing geographical areas:** They help compare the variability of rainfall, temperatures and agricultural production in different regions.

3. **Understanding climatic conditions:** They help establish whether rainfall or temperature is relatively consistent or highly variable.

4. **Agricultural planning:** Farmers and agricultural planners use variations in rainfall and crop yields to make decisions.

5. **Identifying unusual values:** Measures of dispersion help reveal unusually high or low observations.

6. **Supporting regional planning:** They help planners understand inequalities in population, income and resource distribution.

7. **Supporting geographical research:** They provide numerical evidence for explaining geographical patterns.

4.3 Types of measures of dispersion

The main measures of dispersion studied in this sub-strand are:

1. Range.
2. Variance.
3. Standard deviation.

5.0 RANGE

5.1 Meaning of range

Range is the simplest measure of dispersion. It is the difference between the highest and lowest values in a given data set.

It shows the total spread of the observations from the minimum value to the maximum value.

5.2 Formula for calculating range

Range=Highest value–Lowest value

5.3 Procedure for calculating range

1. Arrange the geographical data in ascending or descending order.
2. Identify the highest value.
3. Identify the lowest value.
4. Subtract the lowest value from the highest value.
5. Record the answer using the appropriate units.

5.4 Worked example 1: Rainfall distribution in Kenya

The following figures represent illustrative annual rainfall totals recorded at five weather stations in Kenya.

Weather station	Annual rainfall (mm)
Lodwar	250
Nairobi	800
Nakuru	950
Kisumu	1,200
Kakamega	1,800

Calculate the range of rainfall.

Solution

Step 1: Identify the highest value.

Highest rainfall = 1,800 mm.

Step 2: Identify the lowest value.

Lowest rainfall = 250 mm.

Step 3: Apply the formula.

Range=1800–250Range=1800–250

Range=1550 mmRange=1550 mm

Interpretation

The difference between the highest and lowest annual rainfall recorded among the five stations is 1,550 mm. This indicates considerable variation in rainfall among the selected locations.

5.5 Worked example 2: Temperature variation

The following temperatures were recorded at a weather station over five days:

18°C, 22°C, 25°C, 20°C and 27°C.

Calculate the range.

Solution

Highest temperature = 27°C.

Lowest temperature = 18°C.

Range=27–18Range=27–18

Range=9∘CRange=9∘*C*

The temperature varied by 9°C during the five-day period.

5.6 Advantages of range

1. It is easy to understand.
2. It is simple to calculate.
3. It requires only the highest and lowest values.
4. It provides a quick indication of the spread of data.
5. It is useful when comparing the overall variation of small data sets.

5.7 Disadvantages of range

1. It uses only two values in the data set.
2. It ignores all intermediate observations.
3. It is affected by extremely high or low values.
4. It does not show how the observations are distributed.
5. It may provide an incomplete picture of geographical variations.

5.8 Application of range in Kenya

Range can be used to:

- Compare rainfall variations between counties.
- Determine differences in daily temperatures.
- Compare crop production among agricultural regions.
- Identify differences in population sizes among settlements.
- Compare variations in river discharge during different seasons.

6.0 VARIANCE

6.1 Meaning of variance

Variance is a measure of dispersion that determines the average of the squared differences between individual data values and their arithmetic mean.

It shows how far the observations are spread around the mean.

A small variance indicates that most values are relatively close to the mean, while a large variance indicates that the values are more widely spread.

The variance of a random variable X is calculated using the formula:

$$\boxed{\text{Var}(X) = E(X^2) - [E(X)]^2}$$

Where:

- $E(X^2)$ is the expected value of the square of X.
- $E(X)$ is the mean (expected value) of X.
- $\text{Var}(X)$ represents the variance of X.

Example: Calculating Variance

For a normal distribution with a standard deviation (σ) of 1.4, the variance is calculated as follows:

$$\text{Var}(X) = \sigma^2$$

$$= (1.4)^2$$

$$\boxed{\text{Var}(X) = 1.96}$$

6.2 Importance of variance in Geography

1. It measures the degree of variation in geographical data.
2. It helps compare the consistency of rainfall in different regions.
3. It assists in studying temperature fluctuations.
4. It helps agricultural researchers examine variations in crop yields.
5. It supports population studies.
6. It helps identify geographical areas with highly variable conditions.
7. It provides a basis for calculating standard deviation.

6.3 Formula for calculating population variance

For a complete data set:

$$\boxed{\sigma^2 = \frac{\sum(x - \bar{x})^2}{N}}$$

Where:

- σ2= Population variance.
- x = Individual observation.
- $\bar{x}$ = Arithmetic mean.
- N = Total number of observations.
- ∑∑ = Sum of all values.

For a sample drawn from a larger population, the sample variance is calculated using:

$$s^2 = \frac{\sum(x - \bar{x})^2}{n - 1}$$

At this level, always establish whether the question requires population variance or sample variance before selecting the formula.

6.4 Steps followed when calculating variance

1. Write down the geographical data.
2. Calculate the arithmetic mean.
3. Subtract the mean from each observation.
4. Square each deviation.
5. Add all the squared deviations.
6. Divide the sum by the number of observations for population variance.
7. Express the answer in squared units.

6.5 Worked example: Calculating variance of rainfall data

The following figures represent rainfall totals in millimetres recorded during five selected days at a weather station.

10, 12, 14, 16, 18 mm.

Calculate the population variance.

Step 1: Calculate the mean

$$\bar{x} = \frac{\sum x}{N}$$

Substituting the values:

$$\bar{x} = \frac{10 + 12 + 14 + 16 + 18}{5}$$

$$= \frac{70}{5}$$

$$\bar{x} = 14 \text{ mm}$$

Step 2: Calculate deviations from the mean

Step 3: Square the deviations

Rainfall (x)	Mean ($\bar{x}$)	Deviation (x – $\bar{x}$)	Squared deviation
10	14	-4	16
12	14	-2	4
14	14	0	0

16	14	2	4
18	14	4	16
Total		0	40

Step 4: Calculate variance

Therefore:

$$\sum(x-\bar{x})^2 = 40$$

Step 4: Calculate the Population Variance

$$\sigma^2 = \frac{\sum(x-\bar{x})^2}{N}$$

Substituting:

$$\sigma^2 = \frac{40}{5}$$

$$\boxed{\sigma^2 = 8\ \text{mm}^2}$$

Interpretation

The variance of the rainfall observations is 8 square millimetres. This indicates the degree of spread of the five observations around the mean rainfall of 14 mm.

6.6 Advantages of variance

1. It uses all observations in a data set.
2. It provides a mathematical measure of data variation.
3. It is useful in comparing geographical data sets.
4. It forms the basis for calculating standard deviation.
5. It is useful in advanced geographical and environmental research.

6.7 Disadvantages of variance

1. It is more difficult to calculate than range.
2. It is affected by extreme values.
3. It is expressed in squared units, which may be difficult to interpret directly.
4. It requires the calculation of the mean.
5. It may involve lengthy calculations for large data sets.

7.0 STANDARD DEVIATION

7.1 Meaning of standard deviation

Standard deviation is a statistical measure that shows how far the observations in a data set typically spread around the arithmetic mean.

It is the positive square root of variance.

A low standard deviation indicates that the observations are clustered close to the mean, while a high standard deviation indicates greater variation.

Formula for Population Standard Deviation

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

Where:

- σ = Population standard deviation.
- N = Total number of observations.
- x_i = Individual observation.
- μ = Population mean.
- $\sum$ = Summation symbol.

Adjust the population standard deviation to spread the points out or pull them toward the mean. You can also drag each point in the graph.

7.2 Importance of standard deviation in Geography

1. It measures the degree of variation in geographical observations.
2. It helps compare rainfall consistency between different locations.
3. It helps analyse temperature variations.
4. It supports the study of agricultural productivity.
5. It helps identify unusual geographical observations.
6. It assists in studying population variations.
7. It supports geographical research and planning.
8. It helps determine the reliability and consistency of some geographical measurements.

Another way of expressing the formula is:

Standard deviation

$$\sigma = \sqrt{\text{Variance}}$$

7.4 Steps followed when calculating standard deviation

1. Calculate the arithmetic mean.
2. Determine the deviation of each value from the mean.
3. Square each deviation.
4. Calculate the sum of squared deviations.

5. Divide by the number of observations for population variance.
6. Find the square root of the variance.
7. Express the final answer in the original units.

7.5 Worked example: Calculating standard deviation

Using the rainfall data below:

10, 12, 14, 16, 18 mm.

We have already established that:

- Mean = 14 mm.
- Sum of squared deviations = 40.
- Population variance = 8 mm².

Therefore:

Standard deviation is the square root of the population variance.

$$\sigma = \sqrt{\sigma^2}$$

Step 2: Substitute the Variance

$$\sigma = \sqrt{8}$$

$$\sigma = 2.8284$$

Step 3: Round Off to Two Decimal Places

$$\boxed{\sigma = 2.83 \text{ mm}}$$

Interpretation

The standard deviation is approximately 2.83 mm. This indicates the typical spread of the recorded rainfall values around the mean of 14 mm.

7.6 Advantages of standard deviation

1. It uses all observations in the data set.
2. It is expressed in the same units as the original data.
3. It provides a useful measure of variability.
4. It allows comparison of variations in geographical data.
5. It is widely applied in scientific research.
6. It is useful in analysing climatic and environmental information.

7.7 Disadvantages of standard deviation

1. It is relatively difficult to calculate.
2. It is affected by extreme observations.
3. It requires the calculation of the mean.
4. It may be difficult for learners who have limited mathematical skills.
5. It is not always easy to interpret without considering the nature of the data.

7.8 Comparison of the three measures of dispersion

Range	Variance	Standard deviation
Difference between highest and lowest values.	Average squared deviation from the mean.	Positive square root of variance.
Easy to calculate.	Requires several calculations.	Requires calculating variance first.
Uses only two extreme values.	Uses all observations.	Uses all observations.
Expressed in original units.	Expressed in squared units.	Expressed in original units.
Easily affected by extreme values.	Affected by extreme values.	Affected by extreme values.

8.0 FREQUENCY DISTRIBUTION

8.1 Meaning of frequency distribution

Frequency distribution is a method of organising geographical data into groups or categories and showing the number of times each value or category occurs.

The number of times a particular value occurs is called its frequency.

Frequency distribution makes large quantities of geographical data easier to organise, summarise, analyse and interpret.

Examples of geographical applications:

- Number of households in different population-size categories.
- Number of days receiving different amounts of rainfall.
- Number of learners travelling different distances to school.
- Number of farms producing different quantities of maize.
- Number of settlements falling within different altitude ranges.
- Number of vehicles passing a road within specified time intervals.

8.2 Importance of frequency distribution

1. It organises large amounts of data into manageable groups.
2. It simplifies the presentation of geographical information.
3. It shows how frequently particular values occur.

4. It helps identify the most common observations.
5. It enables comparison between geographical categories.
6. It facilitates the calculation of statistical measures.
7. It helps identify patterns and trends.
8. It provides a basis for drawing statistical graphs.
9. It supports geographical decision-making.
10. It makes interpretation of geographical information easier.

8.3 Types of frequency distribution

There are two main forms of frequency distribution:

1. Ungrouped frequency distribution.
2. Grouped frequency distribution.

A. Ungrouped frequency distribution

This is a method of presenting data by listing each individual value alongside the number of times it occurs.

It is suitable for small data sets containing relatively few different values.

Example:

The following figures represent the number of vehicles counted at a road junction in Nakuru at different observation periods:

12, 15, 12, 18, 15, 12, 20, 18, 15, 12.

Prepare an ungrouped frequency distribution table.

Solution

First, identify the different values and count how often each occurs.

Number of vehicles	**Tally**	**Frequency**
12	IIII	4
15	III	3
18	II	2
20	I	1
Total		10

Interpretation

- 12 vehicles occurred most frequently.
- 20 vehicles occurred least frequently.
- A total of 10 observations were recorded.

- The table summarises the traffic counts in a simple form.

B. Grouped frequency distribution

Grouped frequency distribution is a method of organising data into class intervals and indicating the number of observations falling within each interval.

It is suitable for large data sets containing many different numerical values.

Example:

The following are distances in kilometres travelled by 20 learners from their homes to school:

1, 2, 3, 4, 5, 6, 2, 3, 4, 5, 7, 8, 3, 4, 6, 7, 9, 5, 2, 4.

Prepare a grouped frequency distribution table using the class intervals 1–3, 4–6 and 7–9.

Solution

Count the observations falling within each class interval.

Distance travelled (km)	Tally	Frequency
1–3	IIIIIII	7
4–6	IIIIIIIII	9
7–9	IIII	4
Total		20

Interpretation

- The highest frequency is in the 4–6 km category.
- The lowest frequency is in the 7–9 km category.
- Most learners travel between 4 and 6 kilometres to school.
- The data can assist in planning school transport and accessibility.

8.4 Important terms used in frequency distribution

A. Frequency

Frequency is the number of times a particular value or observation occurs.

B. Class interval

A class interval is a group or range of values into which observations are organised.

Example: 10–19, 20–29 and 30–39.

C. Class limits

These are the smallest and largest stated values within a class interval.

For the interval 10–19:

- Lower class limit = 10.

- Upper class limit = 19.

D. Class width

Class width is the difference between the upper and lower class boundaries of an interval.

For continuous class intervals such as 9.5–19.5, the class width is:

19.5–9.5=10

E. Class midpoint

The class midpoint is the central value of a class interval.

Midpoint=Lower limit+Upper limit/2

For a class interval of 10–19:

$$= \frac{10 + 19}{2} = 14.5$$

F. Cumulative frequency

Cumulative frequency is the running total of frequencies obtained by adding the frequency of each class to the frequencies of all preceding classes.

G. Relative frequency

Relative frequency is the proportion of the total observations falling within a particular category.

Relative frequency=Class frequencyTotal frequencyRelative frequency=Total frequencyClass frequency

H. Percentage frequency

Percentage frequency is the proportion of observations in a category expressed as a percentage.

Percentage frequency=Class frequencyTotal frequency×100Percentage frequency=Total frequencyClass frequency×100

8.5 Cumulative frequency distribution

Cumulative frequency distribution shows the running total of frequencies as one moves from one class interval to another.

It is useful in identifying how many observations fall below or above a particular value.

Example:

The following table shows the number of households according to the distance from a water source.

Distance (km)	Frequency	Cumulative frequency
0–1	5	5
1–2	8	13
2–3	12	25
3–4	10	35
4–5	5	40
Total	40	

Interpretation:

- Five households are located within the first distance category.
- Thirteen households are located within 2 km of the water source.
- Twenty-five households are located within 3 km.

- All 40 households are represented in the table.

8.6 Steps followed when constructing a frequency distribution table

1. Collect the required geographical data.
2. Examine the number and range of observations.
3. Identify the smallest and largest values.
4. Determine the number of class intervals where grouping is necessary.
5. Establish suitable class widths.
6. Prepare the class intervals.
7. Tally observations into the appropriate intervals.
8. Count the tallies to obtain frequencies.
9. Calculate cumulative or percentage frequencies where necessary.
10. Check that the sum of frequencies equals the total number of observations.

9.0 PRESENTATION OF STATISTICAL DATA

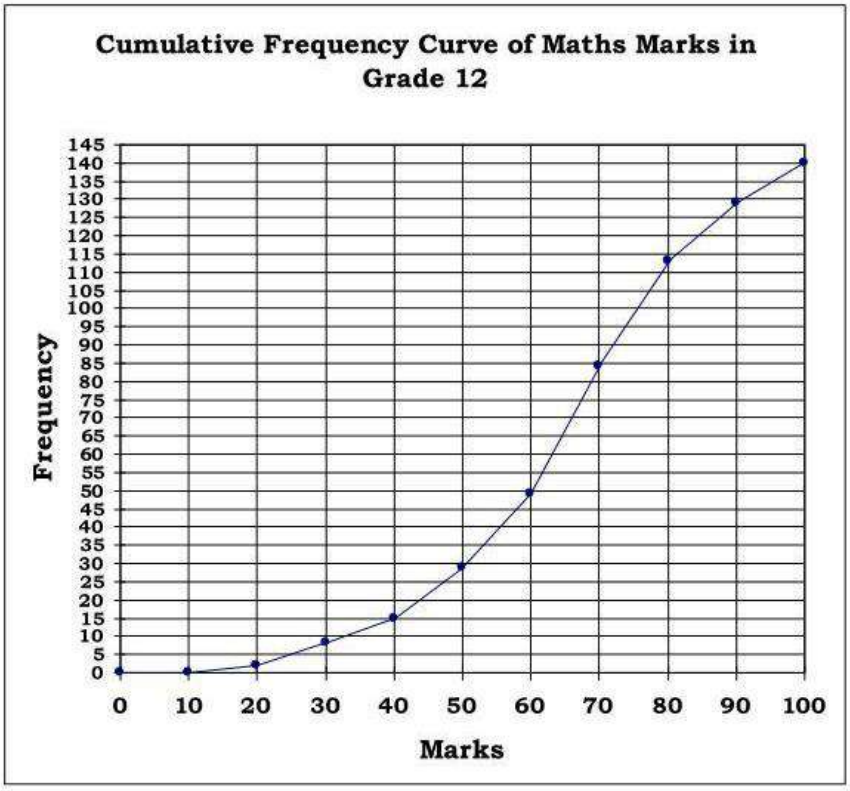
9.1 Meaning of statistical data presentation

Statistical data presentation refers to the process of displaying collected and analysed information in an organised and understandable form using tables, graphs, charts and diagrams.

In Geography, statistical data may be presented using:

1. Frequency distribution tables.
2. Simple bar graphs.
3. Compound bar graphs.
4. Cumulative bar graphs.
5. Divided bars or rectangles.
6. Proportional circles.
7. Line graphs.
8. Histograms.
9. Pie charts.
10. Pictograms.

The most suitable method depends on the nature, size and purpose of the data.



9.2 Importance of presenting statistical data

1. Simplifies complex information.
2. Makes comparison easier.
3. Shows geographical variations.
4. Makes patterns and trends visible.
5. Improves communication of research findings.
6. Helps identify relationships between variables.
7. Supports planning and decision-making.
8. Makes statistical information more attractive.
9. Facilitates interpretation of research results.
10. Helps communicate findings to people without advanced statistical knowledge.

10.0 COMPOUND BAR GRAPHS

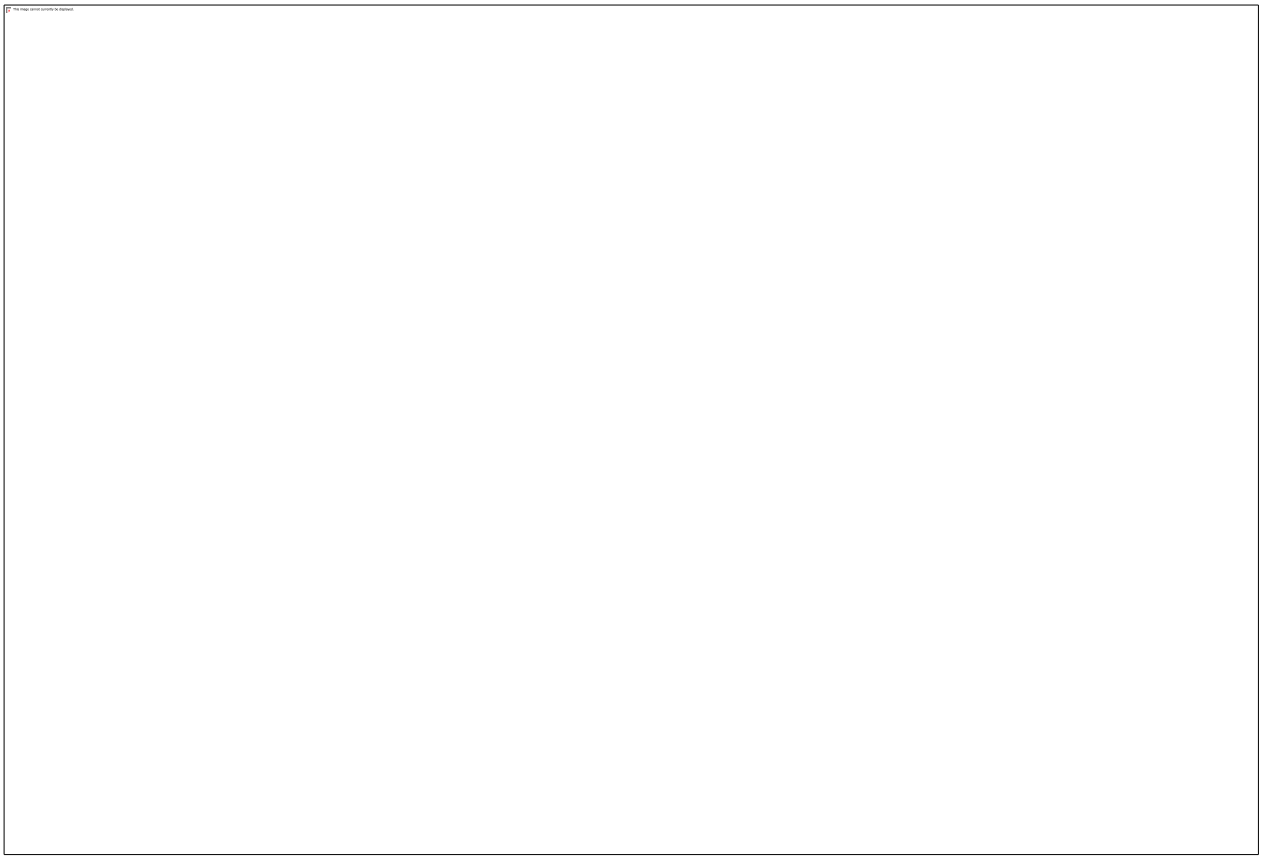
10.1 Meaning of a compound bar graph

A compound bar graph, also known as a component or subdivided bar graph, is a statistical diagram in which each bar represents a total value divided into different components.

Each component is represented by a separate segment of the bar.

The height or length of each bar represents the total quantity, while the different sections represent the individual components.

Compound bar graphs are useful for comparing both the total values and the composition of different geographical categories.



10.2 Uses of compound bar graphs in Geography

1. Comparing agricultural production of different crops in different counties.
2. Comparing population composition in different regions.
3. Showing the distribution of employment in different economic sectors.
4. Comparing household water sources in different settlements.
5. Showing energy consumption by different sources.
6. Comparing land use in different geographical areas.
7. Showing the composition of exports from different countries.

10.3 Worked example: Agricultural production in three Kenyan counties

The table below shows illustrative agricultural production in three counties.

Production figures are hypothetical and expressed in thousand tonnes.

County	Maize	Beans	Wheat	Total
Nakuru	40	20	30	90
Uasin Gishu	50	15	35	100
Trans Nzoia	45	25	20	90

Represent the data using a compound bar graph.

Agricultural production by county

Illustrative crop production in thousand tonnes. Each bar is divided into three crop components.

Maize

Beans

Wheat

015304560

Nakuru

Uasin Gishu

Trans Nzoia

- Nakuru: Maize 40, Beans 20, Wheat 30
- Uasin Gishu: Maize 50, Beans 15, Wheat 35
- Trans Nzoia: Maize 45, Beans 25, Wheat 20

Steps followed when drawing a compound bar graph

1. Draw two perpendicular axes.
2. Label the horizontal axis with the geographical categories.
3. Label the vertical axis with the quantity and units.
4. Select an appropriate scale.
5. Calculate the total for each category.
6. Draw bars of heights proportional to the total values.
7. Divide each bar into the appropriate components.
8. Use different shades, patterns or colours to distinguish components.
9. Provide a key explaining the different components.
10. Give the graph a suitable title.

Interpretation of the compound bar graph

From the example:

- Uasin Gishu has the highest total agricultural production.
- Nakuru and Trans Nzoia have equal total production.
- Maize is the largest component in all three counties.
- Trans Nzoia has the highest bean production.
- Uasin Gishu produces the largest quantity of wheat among the three counties.

10.4 Advantages of compound bar graphs

1. They show total values and their components simultaneously.
2. They allow comparison between different geographical categories.
3. They make the composition of data easy to understand.
4. They provide a clear visual presentation.

5. They are useful for showing changes in the composition of geographical phenomena.

10.5 Disadvantages of compound bar graphs

1. They may become complicated when many components are involved.
2. Smaller components may be difficult to compare accurately.
3. They require careful selection of scales.
4. They may become crowded when many categories are included.
5. They are not suitable for presenting very detailed information.

11.0 CUMULATIVE BAR GRAPHS

11.1 Meaning of a cumulative bar graph

A cumulative bar graph is a statistical graph in which values are represented as running totals, with each successive bar or component showing the accumulated quantity up to a particular category.

In geographical statistics, cumulative bar presentations can be used to show accumulated population figures, household totals, production totals or other running frequencies.

A cumulative bar presentation should be distinguished from an ordinary compound bar graph: in a compound graph the segments show separate components of a total, whereas cumulative values show running totals.



11.2 Uses of cumulative bar graphs

- Showing cumulative population totals.
- Showing the running total of households by distance from a facility.
- Showing accumulated agricultural production.
- Comparing cumulative numbers of people receiving services.
- Showing accumulated rainfall over successive periods.
- Presenting cumulative frequency data.

11.3 Worked example: Cumulative rainfall

The following table shows illustrative monthly rainfall in a selected Kenyan locality.

Month	Rainfall (mm)	Cumulative rainfall (mm)
January	40	40
February	50	90
March	100	190
April	150	340
May	120	460
June	60	520

Cumulative rainfall

Illustrative running total of monthly rainfall in millimetres.

0 mm150 mm300 mm450 mm600 mm

January

February

March

April

May

June

- January: Cumulative rainfall 40 mm
- February: Cumulative rainfall 90 mm
- March: Cumulative rainfall 190 mm
- April: Cumulative rainfall 340 mm
- May: Cumulative rainfall 460 mm
- June: Cumulative rainfall 520 mm

Steps followed when preparing cumulative bar data

1. Arrange the observations in the required order.
2. Record the frequency or value of each category.
3. Add the first value to obtain the first cumulative total.
4. Add the next value to the previous cumulative total.
5. Continue until all values have been accumulated.
6. Present the cumulative totals using an appropriate scale.
7. Label the axes and provide a suitable title.

8. Interpret the accumulated values.

Advantages

1. Shows the accumulated total clearly.
2. Helps establish how totals develop over time.
3. Simplifies interpretation of cumulative information.
4. Supports planning based on accumulated figures.
5. Makes comparison of running totals easier.

Limitations

1. It does not always show the individual contributions clearly.
2. Large cumulative values may overshadow smaller additions.
3. It requires correct ordering of observations.
4. Errors in earlier values affect all subsequent cumulative totals.

12.0 DIVIDED RECTANGLES AND DIVIDED BAR GRAPHS

12.1 Meaning of divided bar graphs

A divided bar graph is a statistical presentation in which a single rectangular bar is subdivided into sections representing different components of a total.

The entire bar represents 100% or the total quantity, while each section represents the proportion contributed by a particular component.

Divided bar graphs are also called percentage bar graphs when the components are expressed as percentages of the total.

12.2 Uses of divided bar graphs

1. Showing the percentage distribution of population by age.
2. Comparing land-use categories in different counties.
3. Showing household sources of energy.
4. Comparing employment sectors.
5. Showing the distribution of water sources.
6. Presenting the percentage contribution of different crops to total agricultural production.
7. Comparing the composition of national income.

12.3 Worked example: Household sources of energy

The following data represents the main sources of energy used by 200 households in a hypothetical rural community.

Source of energy	Number of households
Firewood	100

Charcoal	50
LPG	30
Electricity	20
Total	200

Calculate the percentage contribution of each source and prepare a divided bar graph.

Step 1: Calculate percentages

Percentage=Category valueTotal×100Percentage=TotalCategory value×100

Firewood:

100200×100=50%200100×100=50%

Charcoal:

50200×100=25%20050×100=25%

LPG:

30200×100=15%20030×100=15%

Electricity:

20200×100=10%20020×100=10%

Completed table

Energy source	Households	Percentage
Firewood	100	50%
Charcoal	50	25%
LPG	30	15%
Electricity	20	10%
Total	200	100%

Household sources of energy

Percentage composition of energy sources among 200 hypothetical households. Each bar is divided into its component percentages.

Firewood

Charcoal

LPG

Electricity

0306090120

Households

- Households: Firewood 50, Charcoal 25, LPG 15, Electricity 10

Interpretation

- Firewood is the most commonly used source of energy.
- Electricity is the least commonly used source.
- Half of the households depend on firewood.
- The data suggests that traditional biomass energy is important in the selected community.

Advantages of divided bar graphs

1. They show the percentage composition of a total.
2. They allow comparison between different components.
3. They are easy to construct.
4. They provide a compact presentation.
5. They simplify the interpretation of proportional data.

Disadvantages

1. Exact values may be difficult to identify visually.
2. Small components may be difficult to distinguish.
3. They become complicated when many components are involved.
4. They do not show absolute quantities unless these are provided separately.

13.0 PROPORTIONAL CIRCLES

13.1 Meaning of proportional circles

Proportional circles are statistical diagrams in which circles of different sizes are drawn to represent the relative magnitude of geographical quantities.

The area of each circle is proportional to the quantity it represents.

A larger quantity is represented by a larger circle, while a smaller quantity is represented by a smaller circle.

Proportional circles are useful when comparing numerical values associated with different geographical locations.

13.2 Uses of proportional circles in Geography

1. Comparing population sizes of towns.
2. Showing agricultural production in different counties.
3. Comparing livestock populations.
4. Representing mineral production in different regions.
5. Comparing industrial output.
6. Showing differences in tourist arrivals.
7. Comparing the volume of trade between countries.

8. Representing water consumption in different settlements.

13.3 Calculating proportional circle sizes

The area of a circle is determined by its radius.

A=πr2A=πr2

Where:

- AA = Area of the circle.
- ππ = 3.142 approximately.
- rr = Radius of the circle.

For proportional circles:

r1r2=V1V2r2r1=V2V1

Where:

- r1r1 = Radius of the first circle.
- r2r2 = Radius of the second circle.
- V1V1 = First geographical value.
- V2V2 = Second geographical value.

Important: The radius, not the diameter or area, is proportional to the square root of the quantity.

13.4 Worked example: Comparing population sizes of Kenyan towns

The following figures are hypothetical population values expressed in thousands.

Town	Population (thousands)
Town A	100
Town B	400
Town C	900

If Town A is represented by a circle with a radius of 1 cm, calculate the radii of the circles representing Town B and Town C.

Step 1: Town A

Population = 100,000

Radius = 1 cm.

Step 2: Calculate the Radius for Town B

Using the proportional circle formula:

$$\frac{r_B^2}{r_A^2} = \frac{P_B}{P_A}$$

Substituting the values:

$$\frac{r_B^2}{1^2} = \frac{400,000}{100,000}$$

$$r_B^2 = 4$$

Taking the square root:

$$r_B = \sqrt{4}$$

$$\boxed{r_B = 2 \text{ cm}}$$

Step 3: Calculate the Radius for Town C

$$\frac{r_C^2}{r_A^2} = \frac{P_C}{P_A}$$

Substituting the values:

$$\frac{r_C^2}{1^2} = \frac{900,000}{100,000}$$

$$r_C^2 = 9$$

Taking the square root:

$$r_C = \sqrt{9}$$

$$\boxed{r_C = 3 \text{ cm}}$$

Steps followed when drawing proportional circles

1. Collect the geographical data.

2. Identify the largest and smallest values.
3. Select a suitable radius for the smallest or reference value.
4. Calculate the radii of the remaining circles using the square-root relationship.
5. Draw circles using a compass.
6. Label each circle with its geographical category.
7. Provide a suitable title.
8. Include the units used.
9. Arrange the circles neatly without overlapping unnecessarily.
10. Interpret the differences in circle sizes.

Advantages of proportional circles

1. They provide a visual comparison of geographical quantities.
2. They are suitable for representing large numerical differences.
3. They are attractive and easy to interpret.
4. They can be used on geographical maps.
5. They help communicate spatial differences.

Disadvantages of proportional circles

1. Calculating the radii may be difficult.
2. Very small circles may be difficult to see.
3. Overlapping circles may create confusion.
4. They may be difficult to draw accurately without a compass.
5. Exact numerical values may not be easily identified from the circles alone.

14.0 OTHER METHODS OF PRESENTING GEOGRAPHICAL STATISTICAL DATA

Although the main emphasis in this sub-strand is on compound and cumulative bar graphs, proportional circles and divided rectangles, other methods are also useful.

14.1 Simple bar graphs

A simple bar graph uses rectangular bars of equal width to represent different numerical values.

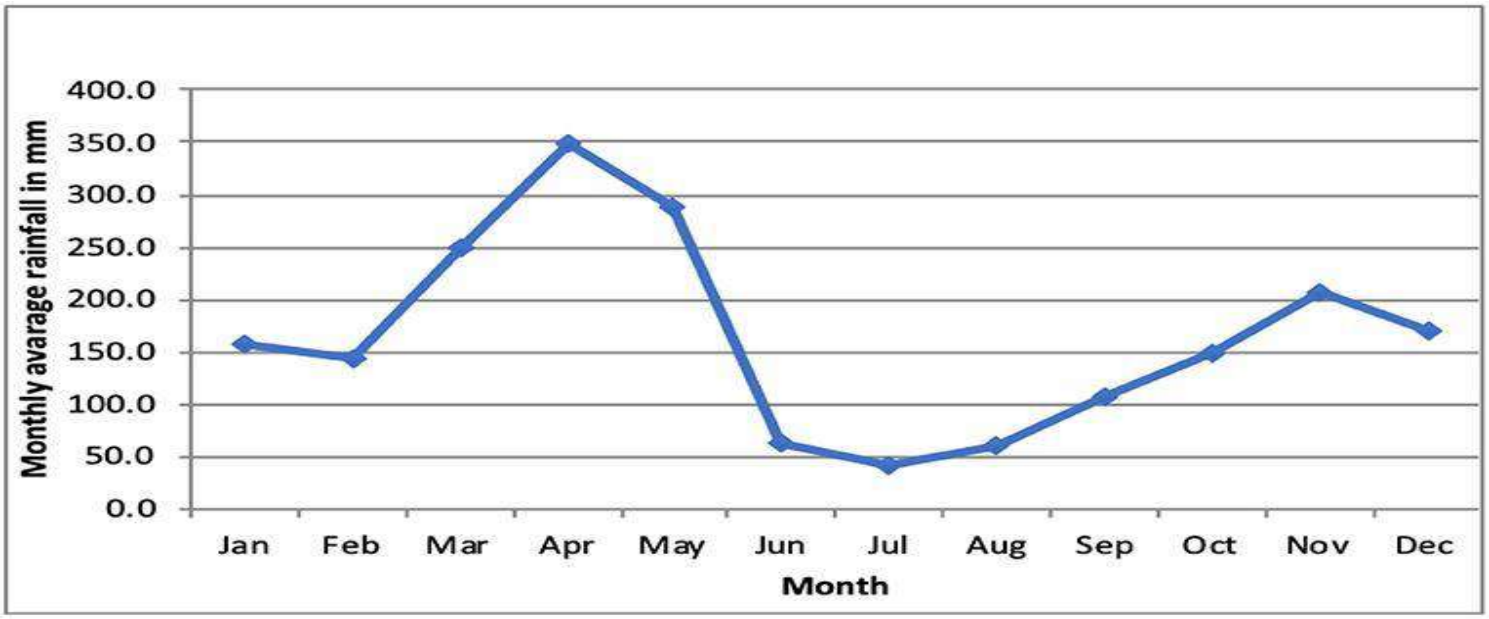
The length or height of each bar is proportional to the value represented.

Uses:

- Comparing population sizes.
- Comparing rainfall totals.
- Comparing agricultural production.
- Comparing the number of schools in different counties.

14.2 Line graphs

A line graph is a statistical diagram in which points representing numerical values are plotted and joined by straight lines.



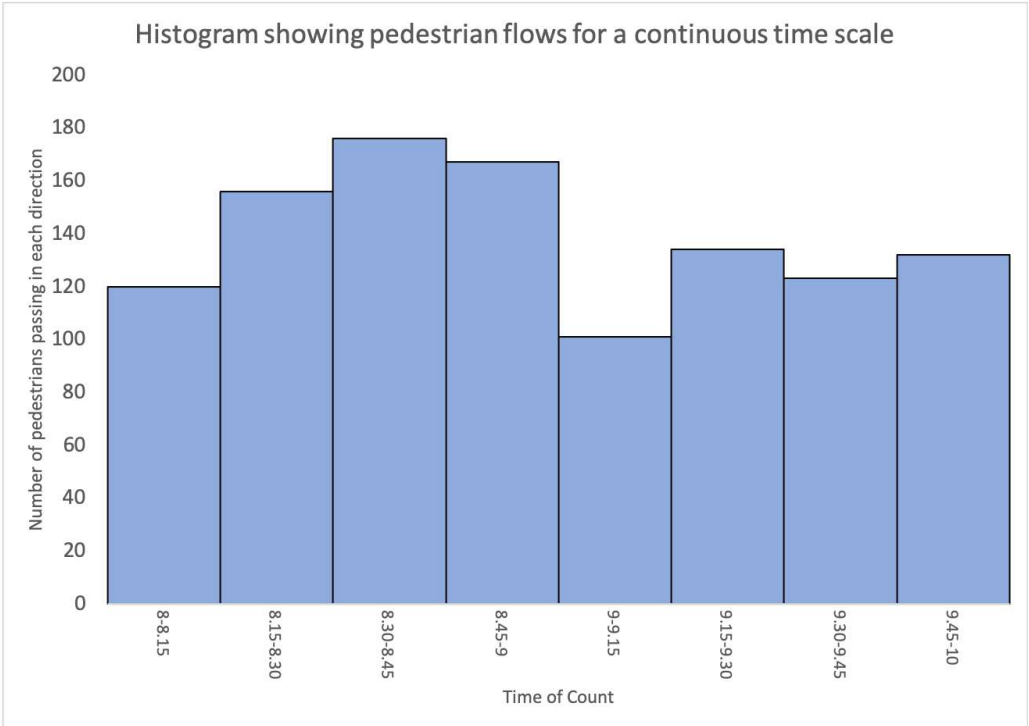
Uses:

- Showing changes in temperature over time.
- Showing annual population growth.
- Showing monthly rainfall variations.
- Showing changes in river discharge.

14.3 Histograms

A histogram is a graph used to represent a continuous frequency distribution using adjacent rectangular bars.

Unlike a simple bar graph, the bars in a histogram normally touch one another because the data represents continuous class intervals.



Uses:

- Presenting temperature distributions.
- Showing rainfall frequency.
- Representing population age distributions.
- Presenting altitude frequency distributions.

14.4 Pie charts

A pie chart is a circular statistical diagram divided into sectors, with each sector representing a proportion of the total.

The angle of each sector is proportional to the value represented.

Sector angle=Category valueTotal×360∘Sector angle=TotalCategory value×360∘

Worked example

A survey of 100 households found that 50 use firewood, 25 use charcoal, 15 use LPG and 10 use electricity.

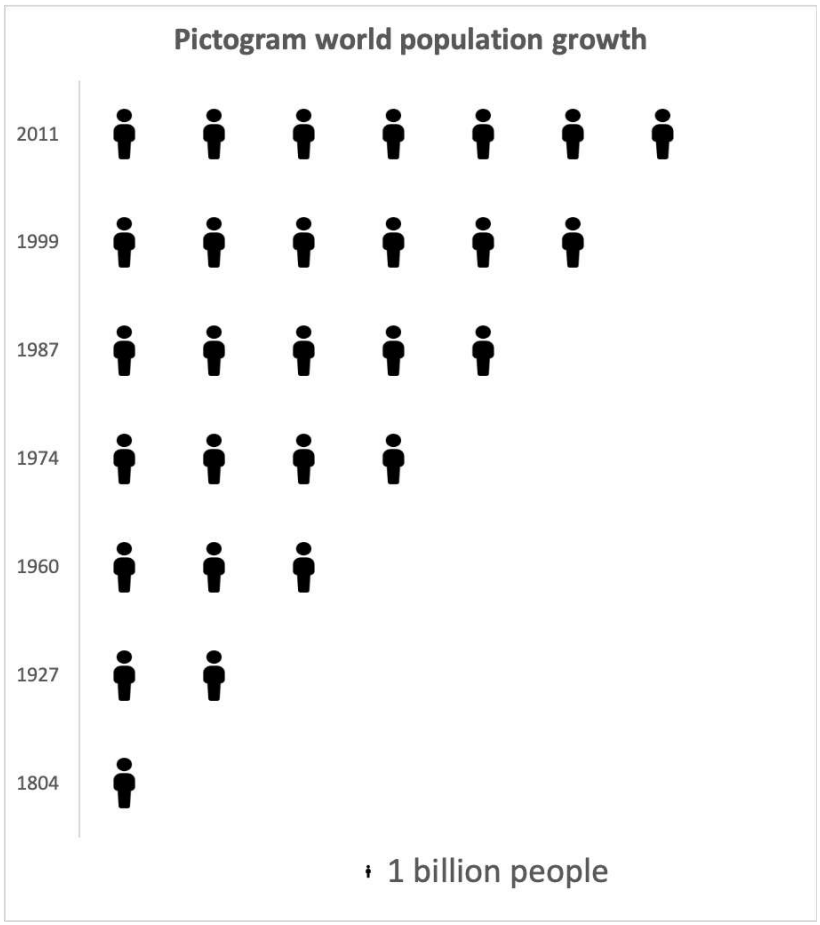
Calculate the sector angle for firewood.

=50/100×360∘ =180∘

The firewood sector should occupy 180° of the circle.

14.5 Pictograms

A pictogram is a statistical presentation that uses pictures or symbols to represent numerical quantities.



Uses:

- Showing numbers of livestock.
- Representing agricultural production.
- Showing population figures.
- Presenting tourist arrivals.

15.0 INTERPRETATION OF STATISTICAL DATA IN GEOGRAPHY

15.1 Meaning of statistical data interpretation

Statistical data interpretation is the process of examining presented statistical information to explain its meaning, identify patterns, establish relationships and draw conclusions.

It involves explaining what the figures, tables, graphs and diagrams reveal about geographical phenomena.

Interpretation goes beyond reading numerical values. It explains the geographical significance of the information.

15.2 Importance of interpreting statistical data

1. Helps explain geographical patterns and trends.
2. Identifies differences between geographical regions.
3. Helps establish relationships between geographical phenomena.
4. Supports geographical planning.
5. Helps identify environmental problems.
6. Provides information for resource management.
7. Helps evaluate development programmes.
8. Supports decision-making.
9. Helps identify areas requiring intervention.
10. Provides evidence for geographical conclusions.

15.3 Steps followed when interpreting statistical data

1. Read the title of the table, graph or diagram.
2. Identify the geographical area represented.
3. Identify the period covered by the data.
4. Examine the units of measurement.
5. Identify the highest and lowest values.
6. Identify similarities and differences.
7. Identify patterns and trends.
8. Establish relationships between the variables where appropriate.
9. Explain possible geographical reasons for the observed patterns.
10. Draw conclusions based on the evidence.

15.4 Interpretation of geographical data: Worked example

The following table shows illustrative annual rainfall figures recorded in five Kenyan towns.

Town	Annual rainfall (mm)
Lodwar	250
Garissa	400
Nairobi	800
Nakuru	950
Kakamega	1,800

Questions and interpretation

1. Which town receives the highest rainfall?

Kakamega receives the highest rainfall of 1,800 mm.

2. Which town receives the lowest rainfall?

Lodwar receives the lowest rainfall of 250 mm.

3. Calculate the difference between the highest and lowest rainfall.

1800–250=1550 mm1800–250=1550 mm

4. Identify two towns receiving less than 500 mm of rainfall.

- Lodwar.
- Garissa.

5. Explain why rainfall may vary among the towns.

- Differences in altitude.
- Variation in prevailing winds.
- Influence of relief features.
- Distance from moisture sources.
- Differences in regional climatic conditions.

6. State one geographical use of the information.

The information can assist agricultural planners in identifying areas requiring irrigation and selecting suitable crops.

Note: These figures are illustrative learning data and should not be treated as official climate normals.

APPLICATION OF STATISTICAL DATA IN GEOGRAPHICAL PLANNING

16.1 Meaning of geographical planning

Geographical planning is the process of organising and allocating geographical resources, facilities and activities in a systematic manner to achieve desired development objectives.

Statistical information provides evidence that helps planners determine where facilities should be located, what resources are required and which areas need priority attention.

16.2 Ways in which statistical data analysis is useful in planning

A. Population planning

Statistical analysis helps government agencies:

1. Determine population sizes in different areas.
2. Identify rapidly growing settlements.
3. Estimate future population needs.
4. Plan schools and health facilities.
5. Determine housing requirements.
6. Plan water and sanitation services.
7. Allocate public resources appropriately.

Kenyan example: Population statistics from KNBS can support county governments in planning health facilities, schools and other public services.

B. Agricultural planning

Statistical analysis assists in:

- Comparing agricultural production.
- Identifying high- and low-yielding areas.
- Determining crop distribution.
- Planning irrigation projects.
- Estimating food requirements.
- Identifying areas affected by drought.
- Planning agricultural extension services.

Example: Rainfall and crop-yield statistics can assist agricultural planners in selecting appropriate crops for different parts of Kenya.

C. Transport planning

Statistical data helps planners:

1. Determine traffic volumes.
2. Identify congested roads.
3. Estimate transport demand.
4. Identify suitable road expansion projects.
5. Plan public transport services.

6. Compare transport requirements between settlements.

D. Health facility planning

Statistical analysis helps in:

- Identifying areas with high population density.
- Determining the number of health facilities required.
- Identifying disease distribution patterns.
- Estimating healthcare demand.
- Planning the distribution of medical personnel.

E. Water resource planning

Statistical data helps planners:

- Determine water consumption.
- Identify water shortages.
- Estimate future water demand.
- Plan water supply systems.
- Monitor rainfall variations.
- Plan dams and reservoirs.
- Identify areas requiring water conservation.

F. Environmental planning

Statistical information is useful in:

1. Monitoring deforestation.
2. Assessing soil erosion.
3. Identifying areas affected by pollution.
4. Monitoring changes in wildlife populations.
5. Evaluating environmental conservation programmes.
6. Identifying areas vulnerable to natural hazards.

G. Urban and settlement planning

Statistical analysis helps in:

- Identifying rapidly growing urban centres.
- Planning residential areas.
- Estimating housing demand.
- Planning markets and shopping centres.
- Allocating land for public facilities.
- Improving waste management.
- Planning recreational facilities.

H. Tourism planning

Statistical information helps in:

- Determining tourist arrival numbers.
- Identifying popular tourist destinations.
- Estimating accommodation requirements.
- Planning tourist infrastructure.
- Comparing tourist arrivals over time.
- Assessing the contribution of tourism to the economy.

16.3 Importance of statistical analysis in national development

Statistical information supports national development by:

1. Promoting balanced regional development.
2. Improving allocation of government resources.
3. Supporting infrastructure development.
4. Identifying disadvantaged communities.
5. Monitoring economic and social progress.
6. Supporting environmental sustainability.
7. Promoting evidence-based policy development.
8. Improving disaster preparedness.
9. Supporting employment planning.
10. Facilitating monitoring and evaluation of development programmes.

17.0 FACTORS THAT INFLUENCE THE CHOICE OF STATISTICAL PRESENTATION

The method selected to present geographical data depends on several factors.

1. **Nature of data:** Continuous data may be presented using histograms, while categorical data may be presented using bar graphs.

2. **Purpose of presentation:** A pie chart may be suitable for showing proportions, while a line graph may be suitable for showing changes over time.

3. **Quantity of data:** Large data sets may require frequency distribution tables.

4. **Number of categories:** Too many categories may make some graphs difficult to interpret.

5. **Audience:** The method should be understandable to the people receiving the information.

6. **Accuracy required:** Some investigations require precise numerical values rather than visual comparisons.

7. **Availability of resources:** The choice may depend on the availability of drawing materials or digital tools.

8. **Nature of comparison:** A compound bar graph is useful when comparing totals and their components.

9. **Geographical purpose:** Maps and proportional circles may be useful when showing spatial differences.

10. **Time available:** Some methods are quicker to prepare than others.

17.1 Selecting suitable statistical methods

Geographical information	Suitable method
Rainfall changes over 12 months	Line graph
Population of different counties	Bar graph
Agricultural production by crop and county	Compound bar graph
Running total of rainfall	Cumulative bar presentation
Percentage distribution of household energy	Divided bar graph
Population sizes of different towns	Proportional circles
Frequency of rainfall amounts	Frequency distribution table
Distribution of continuous temperature observations	Histogram
Percentage composition of household expenditure	Pie chart
Number of livestock using symbols	Pictogram

18.0 COLLECTING, ANALYSING, PRESENTING AND INTERPRETING GEOGRAPHICAL DATA

This is an important practical geographical activity that enables learners to apply statistical methods in real-life situations.

18.1 Meaning of geographical statistical investigation

A geographical statistical investigation is a systematic study in which learners collect numerical information about a geographical phenomenon, analyse it, present the findings and draw conclusions.

Examples of suitable investigations include:

- Sources of water used by households.
- Distance travelled by learners to school.
- Types of crops grown in the community.
- Monthly rainfall distribution.
- Sources of energy used by households.
- Population distribution in a local settlement.
- Means of transport used by community members.

18.2 Steps involved in conducting a geographical statistical investigation

Step 1: Identification of the problem

Learners identify a geographical issue or phenomenon that requires investigation.

Examples:

- What are the main sources of water in the community?
- How far do learners travel to school?
- Which crops are commonly grown in the area?
- What are the main sources of household energy?

Step 2: Formulation of objectives

Learners identify what they intend to achieve through the investigation.

For example, an investigation on household water sources may aim to:

1. Identify the main sources of water.
2. Determine the number of households using each source.
3. Compare the availability of different water sources.
4. Establish challenges affecting access to clean water.

Step 3: Formulation of research questions

Examples:

- Which water sources are commonly used?
- How many households depend on rivers?
- How many households use boreholes?
- What challenges affect water availability?

Step 4: Selection of the study area

Learners identify the geographical area where the investigation will be conducted.

The area may be:

- The school compound.
- A nearby village.
- A market centre.
- A farming area.
- A residential neighbourhood.

Step 5: Selection of data collection methods

Learners choose appropriate methods, such as:

- Questionnaires.
- Interviews.
- Direct observation.
- Counting.

- Measurements.
- Secondary data research.

Step 6: Collection of data

Learners gather the required geographical information using the selected methods.

They should record all observations accurately.

Step 7: Organisation and classification of data

The collected data is arranged into categories or groups.

This may involve:

- Preparing tables.
- Grouping similar observations.
- Arranging numerical values.
- Calculating frequencies.
- Preparing class intervals.

Step 8: Analysis of data

Learners apply suitable statistical techniques.

Examples:

- Calculating range.
- Calculating variance.
- Calculating standard deviation.
- Preparing frequency distributions.
- Calculating percentages.
- Determining cumulative frequencies.

Step 9: Presentation of data

Learners select appropriate methods of presentation.

These may include:

- Compound bar graphs.
- Cumulative bar graphs.
- Divided bars.
- Proportional circles.
- Frequency tables.
- Pie charts.

Step 10: Interpretation of results

Learners explain the meaning of the analysed data.

They should identify:

- Highest and lowest values.
- Patterns and trends.
- Differences between categories.
- Possible geographical explanations.
- Implications for planning.

Step 11: Drawing conclusions

Learners summarise the major findings based on the evidence collected.

Step 12: Making recommendations

Learners suggest appropriate measures to address the geographical issue investigated.

Step 13: Writing a geographical report

The findings are organised into a report and presented to the teacher or class.

19.0 SAMPLE GEOGRAPHICAL FIELDWORK INVESTIGATION

Topic: Investigating household sources of water in a Kenyan community

19.1 Objectives

By the end of the investigation, learners should be able to:

1. Identify common sources of water in the community.
2. Collect numerical information about household water sources.
3. Organise the information into a frequency distribution table.
4. Calculate percentages.
5. Present the findings using a divided bar graph.
6. Interpret the results.
7. Suggest ways of improving access to clean water.

19.2 Data collected

The following is illustrative data collected from 40 households.

Water source	Number of households
Borehole	12
River	10
Piped water	8
Rainwater harvesting	6
Water vendors	4

Total	40

19.3 Calculation of percentages

Borehole:

1240×100=30%4012×100=30%

River:

1040×100=25%4010×100=25%

Piped water:

840×100=20%408×100=20%

Rainwater harvesting:

640×100=15%406×100=15%

Water vendors:

440×100=10%404×100=10%

19.4 Completed frequency and percentage table

Water source	Frequency	Percentage
Borehole	12	30%
River	10	25%
Piped water	8	20%
Rainwater harvesting	6	15%
Water vendors	4	10%
Total	40	100%

19.5 Presentation of findings

Household sources of water

Illustrative survey of 40 households. Values represent the percentage of households using each source.

River

Households25%

0%8%16%24%32%

Borehole

River

Piped water

Rainwater

Vendors

- Borehole: Households 30%
- River: Households 25%
- Piped water: Households 20%
- Rainwater: Households 15%
- Vendors: Households 10%

19.6 Interpretation of findings

1. Boreholes are the most common source of water.
2. Water vendors are the least common source.
3. Thirty per cent of households depend on boreholes.
4. Twenty-five per cent of households depend on river water.
5. A total of 45% of households depend on boreholes and rivers.
6. The community depends on several sources of water.

19.7 Recommendations

1. Improve access to piped water.
2. Construct additional boreholes where hydrogeologically suitable.
3. Protect rivers from pollution.
4. Encourage rainwater harvesting.
5. Improve water storage facilities.
6. Promote household water treatment.
7. Encourage sustainable water management.

20.0 WRITING A GEOGRAPHICAL STATISTICAL REPORT

20.1 Meaning of a geographical report

A geographical statistical report is a written document that presents the methods, findings, analysis, interpretation, conclusions and recommendations of a geographical investigation.

20.2 Main components of a geographical statistical report

1. Title

The title identifies the subject of the investigation.

Example: *An Investigation into Household Sources of Water in a Rural Community.*

2. Introduction

Provides background information about the geographical problem being investigated.

3. Objectives

States what the investigation intends to achieve.

4. Study area

Describes the location and characteristics of the area studied.

5. Methodology

Explains how data was collected and analysed.

6. Findings

Presents the collected information using tables, graphs and diagrams.

7. Analysis and interpretation

Explains the meaning of the results and identifies geographical patterns.

8. Conclusion

Summarises the major findings of the investigation.

9. Recommendations

Suggests measures for addressing the identified geographical problem.

10. References

Lists the books, reports, websites and other sources consulted.

11. Appendices

May include questionnaires, photographs, field notes and additional tables.

20.3 Qualities of a good geographical statistical report

1. It should have a clear title.
2. It should have well-stated objectives.
3. It should contain accurate information.
4. It should use appropriate statistical methods.
5. It should present findings logically.
6. It should include correctly labelled graphs and tables.
7. It should have clear interpretations.
8. It should provide evidence-based conclusions.
9. It should make practical recommendations.
10. It should use clear and appropriate geographical language.

21.0 CHALLENGES IN THE USE OF STATISTICAL METHODS IN GEOGRAPHY

21.1 Challenges in collecting geographical data

1. **High cost:** Collecting geographical data over large areas may require considerable financial resources.

2. **Inaccessibility:** Some geographical areas, such as mountainous regions and remote settlements, may be difficult to reach.

3. **Uncooperative respondents:** Some individuals may refuse to provide information during interviews or questionnaires.

4. **Inaccurate information:** Respondents may provide incorrect or incomplete answers.

5. **Limited equipment:** Lack of measuring instruments may affect data collection.

6. **Poor weather conditions:** Heavy rainfall and strong winds may interrupt fieldwork.

7. **Time limitations:** Collecting information from many locations may take a long time.

8. **Language barriers:** Differences in language may make communication difficult.

21.2 Challenges in analysing statistical data

1. Lack of statistical skills.
2. Mathematical calculation errors.
3. Large volumes of data.
4. Incomplete records.
5. Inaccurate measurements.
6. Limited access to computers.
7. Lack of appropriate statistical software.
8. Difficulty selecting suitable statistical methods.

21.3 Challenges in presenting statistical data

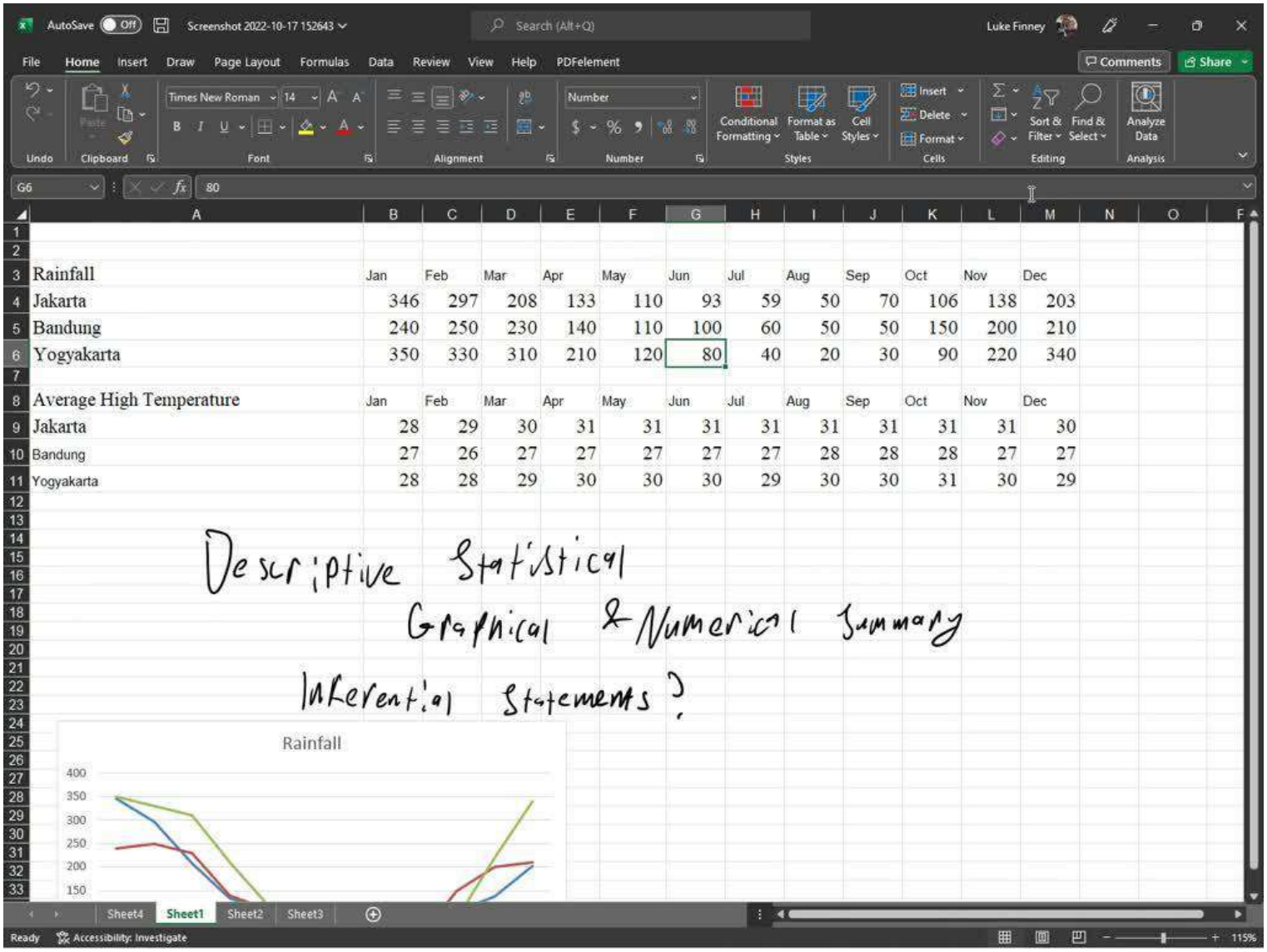
1. Poor selection of graph types.
2. Incorrect scales.
3. Poor labelling.
4. Overcrowding of diagrams.
5. Inappropriate units of measurement.
6. Difficulty interpreting complex graphs.
7. Inaccurate plotting of data.

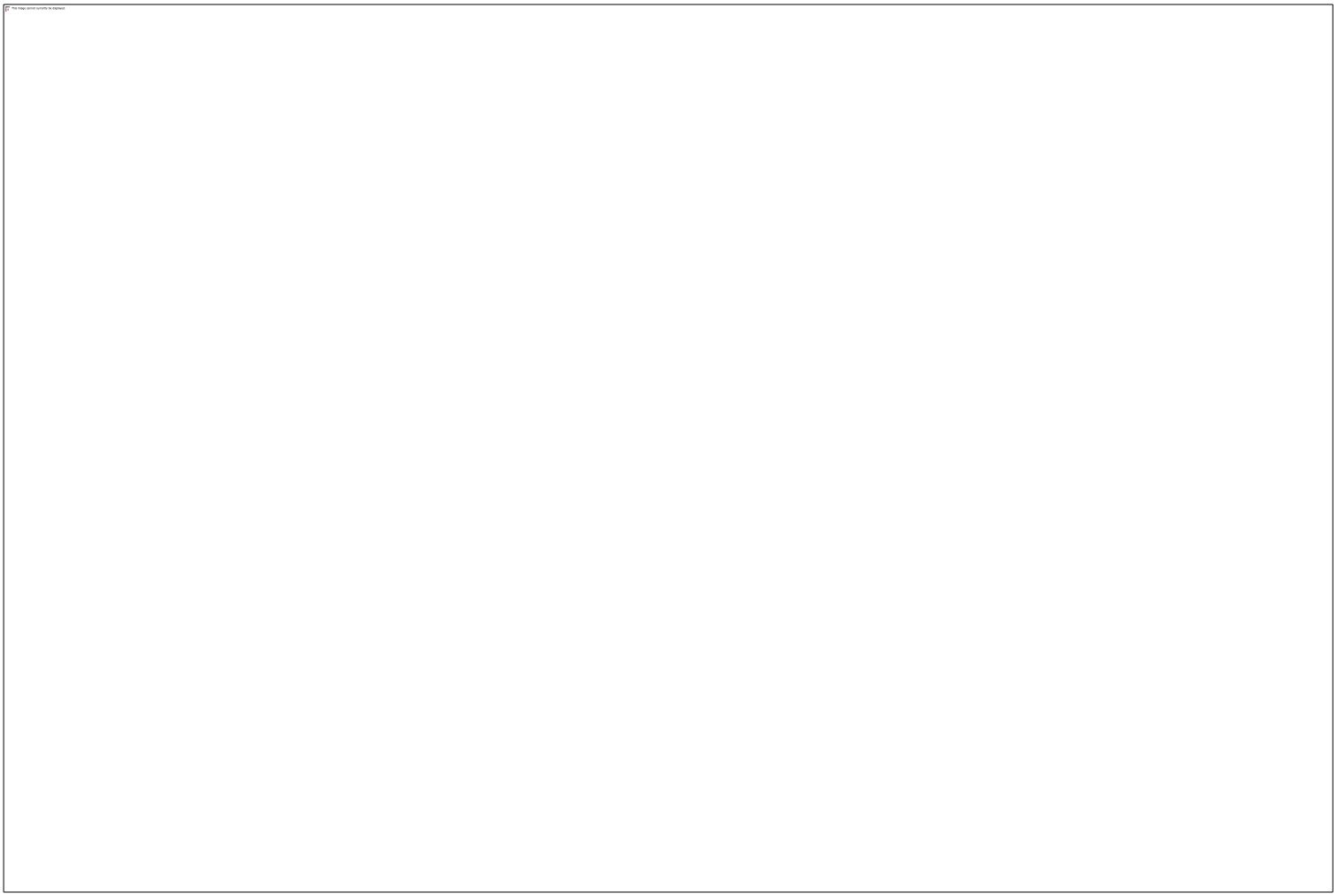
21.4 Ways of overcoming challenges

1. Train learners and researchers in statistical techniques.
2. Use appropriate data collection instruments.
3. Verify the accuracy of collected information.
4. Encourage cooperation among respondents.
5. Use suitable statistical software.
6. Provide adequate time for fieldwork.
7. Use clear and appropriate methods of presentation.
8. Ensure that graphs are properly labelled.
9. Use reliable data sources.
10. Carry out checks to minimise calculation errors.

22.0 APPLICATION OF DIGITAL TECHNOLOGY IN STATISTICAL ANALYSIS

Modern technology has made it easier to process and present geographical statistical data.


AutoSave Off
Screenshot 2022-10-17 152643
Search (Alt+Q)
Luke Finney
File Home Insert Draw Page Layout Formulas Data Review View Help PDFelement
Comments Share
Times New Roman 14
Number
Conditional Formatting
Format as Table
Cell Styles
Insert
Delete
Format
Sort & Filter
Find & Select
Analyze Data
Undo Clipboard Font Alignment Number Styles Cells Editing Analysis
G6
80
Rainfall
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Jakarta 346 297 208 133 110 93 59 50 70 106 138 203
Bandung 240 250 230 140 110 100 60 50 50 150 200 210
Yogyakarta 350 330 310 210 120 80 40 20 30 90 220 340
Average High Temperature
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Jakarta 28 29 30 31 31 31 31 31 31 31 31 30
Bandung 27 26 27 27 27 27 27 28 28 28 27 27
Yogyakarta 28 28 29 30 30 30 29 30 30 31 30 29
Descriptive Statistical
Graphical & Numerical Summary
Inferential Statements?
Rainfall
400
350
300
250
200
150
Sheet4 Sheet1 Sheet2 Sheet3
Ready Accessibility: Investigate
115%



22.1 Spreadsheet applications

Spreadsheet programmes such as Microsoft Excel and Google Sheets are used to:

- Organise geographical data.
- Prepare frequency tables.
- Calculate averages.
- Calculate range and variance.
- Calculate standard deviation.
- Draw graphs and charts.
- Compare statistical values.

22.2 Statistical software

Statistical software can be used to:

1. Analyse large data sets.
2. Calculate statistical measures.
3. Identify patterns.
4. Prepare statistical graphs.
5. Compare geographical variables.
6. Produce statistical reports.

22.3 Geographic Information Systems (GIS)

GIS integrates geographical locations with statistical information.

It is used to:

- Map population distribution.
- Show rainfall distribution.
- Analyse agricultural production.
- Map disease distribution.
- Identify areas requiring public services.
- Support regional planning.

22.4 Benefits of digital statistical analysis

- Saves time.
- Reduces repetitive calculations.
- Simplifies data organisation.
- Produces clear graphs.
- Handles large data sets.
- Improves presentation.
- Supports geographical planning.

22.5 Limitations of digital statistical analysis

- Requires access to computers or digital devices.
- Some software requires payment.
- Users need appropriate skills.
- Incorrectly entered data can produce misleading results.
- Technical failures may interrupt analysis.
- Digital data requires appropriate security and backup arrangements.

23.0 COMPETENCIES DEVELOPED THROUGH STATISTICAL METHODS

Core competency	**How it is developed**
Critical thinking and problem-solving	Analysing data, calculating dispersion and interpreting geographical patterns.
Communication and collaboration	Working in groups to collect and present geographical information.
Creativity and imagination	Designing graphs, charts and statistical diagrams.

Digital literacy	Using computers and spreadsheets to analyse data.
Learning to learn	Researching statistical methods and interpreting findings independently.
Self-efficacy	Carrying out statistical calculations and presenting research findings confidently.
Citizenship	Using statistical evidence to understand community challenges and development needs.

23.1 Pertinent and contemporary issues (PCIs)

A. Environmental conservation

Learners use statistical information to examine:

- Deforestation.
- Rainfall variations.
- Soil erosion.
- Water pollution.
- Wildlife population changes.

B. Sustainable development

Statistical methods help learners understand:

- Resource distribution.
- Agricultural production.
- Population growth.
- Access to public facilities.
- Environmental management.

C. Disaster risk reduction

Statistical analysis supports:

- Flood risk assessment.
- Drought monitoring.
- Rainfall analysis.
- Identification of disaster-prone areas.

D. Health and sanitation

Learners can analyse:

- Access to clean water.
- Distribution of health facilities.
- Sanitation coverage.

- Population distribution and healthcare demand.

E. Financial literacy

Learners can use statistical data to:

- Compare household expenditure.
- Analyse market prices.
- Examine agricultural income.
- Interpret economic information.

23.2 Values developed

1. **Integrity:** Recording and presenting accurate information.
2. **Responsibility:** Handling collected data carefully.
3. **Cooperation:** Working together during geographical investigations.
4. **Respect:** Respecting respondents and their information.
5. **Honesty:** Avoiding manipulation of statistical findings.
6. **Patriotism:** Using geographical information to understand national development.
7. **Tolerance:** Appreciating differences in research findings and interpretations.

REVISION EXERCISES

SECTION A: MULTIPLE-CHOICE QUESTIONS

30 MARKS – ANSWER ALL QUESTIONS

Instructions: Choose the correct answer from the alternatives A, B, C and D.

1. Statistical methods in Geography are mainly used to:

A. Construct buildings.

B. Collect, organise, analyse and interpret geographical data.

C. Predict earthquakes with certainty.

D. Determine political boundaries only.

2. Which of the following best defines geographical data?

A. Information about geographical phenomena and their distribution.

B. Information about mathematical equations only.

C. Information about human languages.

D. Information about historical events only.

3. Which of the following is an example of quantitative geographical data?

A. Type of vegetation.

B. Soil colour.

C. Annual rainfall.

D. Settlement pattern.

4. The number of livestock kept by a farmer is an example of:

A. Qualitative data.

B. Discrete data.

C. Continuous data.

D. Descriptive data.

5. Which of the following is a primary source of geographical data?

A. Published census report.

B. Geography textbook.

C. Field observation.

D. Newspaper article.

6. Which institution is responsible for producing official national statistical information in Kenya?

A. Kenya National Bureau of Statistics.

B. Kenya National Highways Authority.

C. Kenya Wildlife Service.

D. Kenya Forest Service.

7. The simplest measure of dispersion is:

A. Variance.

B. Standard deviation.

C. Range.

D. Mean.

8. Which of the following correctly defines range?

A. Sum of all observations.

B. Difference between the highest and lowest values.

C. Average of all observations.

D. Square root of the mean.

9. The following rainfall figures were recorded over five days: 10, 15, 20, 25 and 30 mm. What is the range?

A. 10 mm.

B. 15 mm.

C. 20 mm.

D. 25 mm.

10. Variance measures:

A. The highest value in a data set.

B. The difference between two observations.

C. The average squared deviations from the mean.

D. The total number of observations.

11. Standard deviation is obtained by:

A. Multiplying the variance by two.

B. Finding the square root of variance.

C. Subtracting the mean from the range.

D. Dividing the mean by the range.

12. Which measure of dispersion is expressed in squared units?

A. Range.

B. Mean.

C. Standard deviation.

D. Variance.

13. A small standard deviation indicates that:

A. The observations are widely spread.

B. The observations are relatively close to the mean.

C. The observations are all negative.

D. The data has no mean.

14. Which measure of dispersion uses only the highest and lowest observations?

A. Variance.

B. Standard deviation.

C. Range.

D. Arithmetic mean.

15. Frequency refers to:

A. The total range of observations.

B. The number of times a value occurs.

C. The highest value in a data set.

D. The difference between two values.

16. Grouped frequency distribution involves:

A. Arranging data into class intervals.

B. Drawing circles only.

C. Recording data without classification.

D. Removing all repeated observations.

17. The running total of frequencies is known as:

A. Relative frequency.

B. Class width.

C. Cumulative frequency.

D. Class midpoint.

18. Which graph is most suitable for comparing agricultural production by different crops in several counties?

A. Compound bar graph.

B. Line graph.

C. Pictogram.

D. Histogram.

19. A compound bar graph is used to show:

A. Only the highest value.

B. Totals and their individual components.

C. The direction of wind.

D. The location of settlements only.

20. Which of the following is a major characteristic of a divided bar graph?

A. It represents components as proportions of a total.

B. It represents rainfall using lines only.

C. It has no scale.

D. It represents only geographical directions.

21. In a percentage divided bar graph, the total length represents:

A. 25%.

B. 50%.

C. 75%.

D. 100%.

22. Proportional circles are used to represent:

A. Direction of rivers.

B. Relative magnitudes of geographical quantities.

C. Changes in temperature only.

D. Types of soil.

23. In proportional circle diagrams, the size of a circle is determined by its:

A. Radius only.

B. Diameter only.

C. Area.

D. Circumference.

24. Which graph is most suitable for showing changes in monthly rainfall over a year?

A. Line graph.

B. Proportional circle.

C. Divided bar graph.

D. Pictogram.

25. A histogram is mainly used to represent:

A. Continuous frequency distributions.

B. Geographical directions.

C. Land ownership boundaries.

D. Population locations on a map.

26. Which of the following is the correct formula for calculating a pie chart sector angle?

A. Category value ÷ Total × 100.

B. Category value ÷ Total × 360°.

C. Total ÷ Category value × 360°.

D. Category value × Total × 360°.

27. Which of the following is an important use of statistical analysis in agriculture?

A. Increasing soil erosion.

B. Identifying crop production patterns.

C. Preventing rainfall.

D. Eliminating agricultural activities.

28. Which of the following is a major challenge in statistical data collection?

A. Availability of reliable information.

B. Accurate measurement.

C. Uncooperative respondents.

D. Proper recording.

29. Which of the following is the most appropriate way of improving the accuracy of statistical analysis?

A. Ignoring unusual values.

B. Manipulating the collected data.

C. Using reliable sources and checking calculations.

D. Avoiding data classification.

30. Statistical information is useful in geographical planning because it:

A. Replaces all field investigations.

B. Provides evidence for informed decision-making.

C. Eliminates all geographical problems.

D. Prevents population growth.

SECTION B: STRUCTURED QUESTIONS

QUESTION 1: INTRODUCTION TO STATISTICAL METHODS (8 MARKS)

a) Define the term statistical methods. (2 marks)

b) State three sources of geographical statistical data. (3 marks)

c) Explain three reasons why statistical methods are important in geographical studies. (3 marks)

QUESTION 2: MEASURES OF DISPERSION (8 MARKS)

The following figures represent rainfall measurements in millimetres recorded over five days at a weather station in Nakuru County:

12, 14, 16, 18, 20.

a) Calculate the range of the rainfall data. (2 marks)

b) Calculate the arithmetic mean. (2 marks)

c) Calculate the population variance. (3 marks)

d) State one use of standard deviation in geographical studies. (1 mark)

QUESTION 3: FREQUENCY DISTRIBUTION (8 MARKS)

The following figures represent distances in kilometres travelled by 15 learners from their homes to school:

1, 2, 3, 4, 2, 5, 3, 4, 6, 2, 5, 3, 4, 7, 5.

a) Define frequency distribution. (2 marks)

b) Prepare an ungrouped frequency distribution table for the data. (4 marks)

c) Identify the distance travelled by the highest number of learners. (1 mark)

d) State one importance of frequency distribution in Geography. (1 mark)

QUESTION 4: COMPOUND AND DIVIDED BAR GRAPHS (8 MARKS)

The following table shows illustrative agricultural production in three counties.

County	**Maize (tonnes)**	**Beans (tonnes)**
Nakuru	400	200
Uasin Gishu	500	300
Trans Nzoia	600	200

a) Calculate the total agricultural production for each county. (3 marks)

b) State two steps followed when constructing a compound bar graph. (2 marks)

c) Explain three advantages of compound bar graphs in geographical studies. (3 marks)

QUESTION 5: PROPORTIONAL CIRCLES AND STATISTICAL INTERPRETATION (10 MARKS)

The following table shows hypothetical population figures for three towns.

Town	**Population**
A	100,000
B	400,000
C	900,000

a) Define proportional circles. (2 marks)

b) If Town A is represented by a circle of radius 2 cm, calculate the radius of the circles representing:

i. Town B. (2 marks)

ii. Town C. (2 marks)

c) State four advantages of proportional circles in geographical studies. (4 marks)

QUESTION 6: STATISTICAL ANALYSIS AND GEOGRAPHICAL PLANNING (8 MARKS)

a) Explain four ways in which statistical data analysis is useful in geographical planning in Kenya. (4 marks)

b) State two challenges encountered when collecting geographical statistical data. (2 marks)

c) State two methods of presenting statistical data in Geography. (2 marks)

27.0 ANSWER KEY: SECTION A

MULTIPLE-CHOICE ANSWERS – 30 MARKS

No.	Answer	No.	Answer	No.	Answer
1	B	11	B	21	D
2	A	12	D	22	B
3	C	13	B	23	C
4	B	14	C	24	A
5	C	15	B	25	A
6	A	16	A	26	B
7	C	17	C	27	B
8	B	18	A	28	C
9	C	19	B	29	C
10	C	20	A	30	B

28.0 SUGGESTED ANSWERS: SECTION B

QUESTION 1

a) Statistical methods are techniques used to collect, organise, analyse, present and interpret numerical data.

b)

- Kenya National Bureau of Statistics.
- Kenya Meteorological Department.
- County government reports.

c)

- Simplify large quantities of geographical information.
- Facilitate comparison of geographical phenomena.

- Support planning and decision-making.

QUESTION 2

a)

Range=20–12=8 mmRange=20–12=8 mm

b)

$x^- = 12+14+16+18+20 5x^- = 5 12+14+16+18+20$

$= 805 = 16 \text{ mm} = 580 = 16 \text{ mm}$

c)

x	**x – 16**	**$(x – 16)^2$**
12	-4	16
14	-2	4
16	0	0
18	2	4
20	4	16
		40

$\sigma 2 = 405 \sigma 2 = 540$

8 mm28 mm2

d) It helps determine the degree of variation in rainfall measurements.

QUESTION 3

a) Frequency distribution is the organisation of data into categories or class intervals showing the number of times each value occurs.

b)

Distance (km)	**Tally**	**Frequency**
1	I	1
2	III	3
3	III	3
4	III	3

5	III	3
6	I	1
7	I	1
Total		15

c) 2 km, 3 km, 4 km and 5 km have equal highest frequencies of three learners each.

d) It simplifies the organisation and interpretation of geographical data.

QUESTION 4

a)

- Nakuru: 400 + 200 = 600 tonnes.
- Uasin Gishu: 500 + 300 = 800 tonnes.
- Trans Nzoia: 600 + 200 = 800 tonnes.

b)

- Draw and label the axes.
- Select a suitable scale and divide each bar into the appropriate components.

c)

- Shows total values and individual components.
- Facilitates comparison between geographical categories.
- Simplifies the interpretation of statistical information.

QUESTION 5

a) Proportional circles are statistical diagrams in which the areas of circles are proportional to the geographical quantities represented.

b)

b) Calculation of the radii of the circles

Given that Town A has a radius of 2 cm and a population of 100,000:

The formula is:

$$\frac{r_1^2}{r_2^2} = \frac{P_1}{P_2}$$

Town A

Population = 100,000

Radius = 2 cm

Town B

Population = 400,000

$$\frac{r_B^2}{2^2} = \frac{400,000}{100,000}$$

$$r_B^2 = 4 \times 4$$

$$r_B^2 = 16$$

$$r_B = \sqrt{16}$$

$$\boxed{r_B = 4 \text{ cm}}$$

Town C

Population = 900,000

$$\frac{r_C^2}{2^2} = \frac{900,000}{100,000}$$

$$r_C^2 = 4 \times 9$$

$$r_C^2 = 36$$

$$r_C = \sqrt{36}$$

$$\boxed{r_C = 6 \text{ cm}}$$

c)

- They facilitate comparison of geographical quantities.
- They provide an attractive visual presentation.
- They are useful for showing population differences.
- They can represent statistical information on geographical maps.

QUESTION 6

a)

- Helps determine population requirements when planning schools and hospitals.
- Helps identify areas requiring agricultural development.
- Assists in planning roads and transport infrastructure.
- Supports environmental conservation and resource management.

b)

- High cost of data collection.
- Uncooperative respondents.

c)

- Compound bar graphs.
- Proportional circles.

COMPETENCY-BASED LEARNER PROJECT

PRACTICAL GEOGRAPHICAL INVESTIGATION

Project title: Statistical Investigation of Agricultural Production in the Local Community

Project situation

Agriculture is an important economic activity in many Kenyan communities. However, agricultural production varies from one farm to another because of differences in rainfall, soil fertility, farm size, farming methods and access to agricultural inputs.

Your community has requested learners to conduct a statistical investigation to establish the main crops grown and their production levels.

Project tasks

Working in groups, learners should:

1. Identify five common crops grown in the community.
2. Select a representative sample of farmers.
3. Collect information about crop production.
4. Record the findings in a frequency distribution table.
5. Calculate the total production for each crop.
6. Calculate the range of production values where appropriate.
7. Present the information using a compound bar graph.
8. Interpret the results.
9. Identify factors influencing agricultural production.
10. Prepare a report with recommendations for improving agricultural production.

Expected project products

- Completed questionnaires.
- Fieldwork records.
- Frequency distribution table.
- Statistical calculations.
- Compound bar graph.
- Written geographical report.
- Oral presentation.

Project assessment rubric

Assessment area	**Marks**
Identification of geographical problem	5
Collection of reliable data	5

Organisation of data	5
Accuracy of statistical calculations	5
Quality of graphical presentation	5
Interpretation and conclusions	5
Recommendations and presentation	5
Total	35

30.0 TEACHER'S GUIDE: ASSESSMENT OF LEARNING

The teacher should use a variety of assessment methods to establish whether learners have acquired the expected knowledge, skills, attitudes and values.

Assessment method	**Expected learner achievement**
Oral questions	Explains statistical methods and their importance.
Written exercises	Calculates range, variance and standard deviation.
Group discussions	Explains methods of analysing geographical data.
Practical activities	Prepares frequency distribution tables.
Graphical exercises	Draws compound and cumulative bar graphs.
Mathematical exercises	Calculates proportional circle radii.
Fieldwork	Collects and records geographical data.
Project work	Analyses, presents and interprets geographical information.
Report writing	Communicates geographical findings effectively.

STRAND 1.0: PRACTICAL GEOGRAPHY

SUB-STRAND 1.4: GEOGRAPHIC INFORMATION SYSTEMS (GIS)

1.0 Introduction to Geographic Information Systems (GIS)

1.1 Meaning of Geographic Information Systems (GIS)

A **Geographic Information System (GIS)** is a computer-based system used to collect, capture, store, manage, analyse, manipulate and present geographical or spatial information.

GIS combines maps, satellite images, aerial photographs, GPS coordinates and other geographical data to help people understand locations, patterns, relationships and changes occurring on the Earth's surface.

GIS allows users to connect information about a particular place with its geographical location.

Examples of GIS applications in Kenya:

1. Mapping roads and determining the shortest routes between towns.
2. Identifying areas affected by floods and drought.
3. Mapping schools, hospitals and other public facilities.
4. Monitoring forest cover and environmental changes.
5. Planning agricultural activities based on soil and rainfall conditions.
6. Mapping population distribution and settlement patterns.
7. Identifying suitable locations for boreholes and water projects.
8. Supporting emergency response teams in locating accidents and emergencies.

1.2 Components of GIS

A GIS operates through several interconnected components. These components work together to ensure that geographical information is collected, processed, stored, analysed and presented.

The main components are:

a) Hardware

Hardware refers to the physical equipment used in operating a GIS.

Examples include:

- Computers and laptops.
- Servers used to store large volumes of geographical data.
- GPS receivers used to capture geographical coordinates.
- Scanners used to convert paper maps into digital formats.
- Printers and plotters used to produce maps.
- Mobile phones and tablets used to collect geographical information.
- Digital cameras and drones used to capture geographical images.

b) Software

GIS software refers to computer programmes used to capture, manage, analyse and display geographical information.

Examples include:

- QGIS.
- ArcGIS.
- Google Earth.
- GRASS GIS.
- MapInfo Professional.
- Global Mapper.

c) Data

Data refers to the geographical information entered into a GIS for processing and analysis.

Examples include:

- Road locations.
- Rivers and lakes.
- School locations.
- Population figures.
- Soil types.
- Rainfall records.
- Land-use information.
- Elevation and terrain information.

d) People

People are the individuals who collect, manage, analyse and interpret geographical information.

Examples include:

- Geographers.
- Surveyors.
- Cartographers.
- GIS technicians.
- Urban planners.
- Environmental scientists.
- Government planners.
- Emergency response officers.

e) Methods and procedures

These refer to the rules, techniques and processes followed when collecting, processing, analysing and presenting geographical information.

Examples include:

- Data collection procedures.
- Mapping techniques.

- Coordinate systems.
- Data quality control.
- Spatial analysis procedures.
- Data storage and backup procedures.

1.3 Importance of GIS in Geography

GIS is important in geographical studies because it enables users to understand spatial patterns and relationships.

The importance of GIS includes:

1. **Improves map production:** GIS makes it easier to produce accurate digital maps showing geographical features.
2. **Supports decision-making:** It provides geographical evidence that helps governments and organisations make informed decisions.
3. **Facilitates urban planning:** GIS helps planners identify suitable locations for roads, buildings, schools and other facilities.
4. **Supports environmental management:** It helps monitor deforestation, soil erosion, pollution and changes in land use.
5. **Improves disaster management:** GIS identifies areas at risk of floods, landslides, droughts and other hazards.
6. **Supports transport planning:** It helps identify the shortest and most suitable routes between places.
7. **Improves agricultural production:** Farmers can use GIS information to understand soil conditions, rainfall distribution and crop suitability.
8. **Supports population studies:** GIS helps map population distribution, density and settlement patterns.
9. **Improves service delivery:** It helps identify areas that lack schools, hospitals, electricity and clean water.
10. **Facilitates research:** Researchers use GIS to collect, analyse and present geographical information.
11. **Saves time and resources:** Digital mapping and spatial analysis can make geographical investigations more efficient.
12. **Monitors geographical changes:** GIS can compare geographical information collected at different times to identify changes.

2.0 Development Cycle of GIS

2.1 Meaning of the GIS Development Cycle

The GIS development cycle refers to the systematic sequence of stages followed when developing and operating a Geographic Information System.

It involves collecting geographical data, entering it into a computer system, storing it, analysing it and presenting the results in a form that can be understood and used.

The main stages of the GIS development cycle include:

1. Data input.
2. Data storage.
3. Data output.
4. Modelling.
5. Data analysis.
6. Data presentation.

2.2 Stages of the GIS Development Cycle

a) Data input

Data input is the process of collecting geographical information and entering it into a GIS.

Information can be collected from different sources, including:

- GPS receivers.
- Satellite images.
- Aerial photographs.
- Existing maps.
- Field surveys.
- Remote sensing equipment.
- Census records.
- Government databases.
- Mobile phone applications.

Data input methods include:

- Digitising features from existing maps.
- Scanning paper maps.
- Entering GPS coordinates.
- Importing satellite images.
- Typing information into a database.
- Recording geographical observations during fieldwork.

Example: Learners use a GPS-enabled mobile phone to record the locations of classrooms, trees, boreholes and gates within the school compound.

b) Data storage

Data storage refers to keeping collected geographical information in an organised digital format for future use.

GIS stores two main categories of information:

- Spatial data.
- Attribute data.

Data can be stored in:

- Computer hard drives.
- External storage devices.
- Cloud storage systems.
- GIS databases.
- Digital files such as GeoJSON, shapefiles and KML.
- Spreadsheet files such as CSV.

Example: GPS coordinates of school buildings are stored in a CSV file containing the feature name, latitude and longitude.

c) Data output

Data output refers to the results produced by a GIS after geographical information has been processed.

GIS outputs may include:

- Digital maps.
- Printed maps.
- Tables.
- Graphs.
- Statistical summaries.
- Satellite image displays.
- Three-dimensional maps.
- Reports.

Example: A GIS produces a digital map showing the locations of all classrooms and water points in a school.

d) Modelling

Modelling refers to the use of GIS to represent real-world geographical situations and simulate possible changes or outcomes.

It involves creating a simplified representation of geographical processes to understand how different factors interact.

Examples of GIS modelling include:

- Flood-risk modelling.
- Soil erosion modelling.
- Population growth modelling.
- Urban expansion modelling.
- Road network modelling.
- Agricultural suitability modelling.

Example: GIS can be used to model the areas likely to be affected if a nearby river overflows its banks.

e) Data analysis

Data analysis refers to examining geographical information to identify patterns, relationships, trends and differences.

GIS analysis may involve:

- Measuring distances between geographical features.
- Calculating the area covered by a particular feature.
- Identifying the nearest hospital or school.
- Comparing land-use patterns.
- Identifying areas with high population density.
- Determining areas prone to flooding.
- Overlaying different geographical layers.

Example: A GIS can identify households located more than five kilometres from the nearest health centre.

f) Data presentation

Data presentation refers to displaying the results of GIS analysis in a clear and understandable format.

The results may be presented through:

- Thematic maps.
- Digital maps.
- Charts and graphs.
- Tables.
- Reports.
- Three-dimensional visualisations.
- Interactive online maps.

Example: Learners present a map showing the distribution of trees within their school compound.

2.3 Relationship between the Stages

The stages of the GIS development cycle are interconnected.

For example, when mapping the distribution of water points in a school:

1. **Data input:** GPS coordinates of water points are collected.
2. **Data storage:** Coordinates and information about each water point are stored in a database.
3. **Data output:** The stored information is retrieved from the GIS.
4. **Modelling:** Possible locations for additional water points are modelled.
5. **Data analysis:** Distances between water points and buildings are examined.
6. **Data presentation:** A map showing existing and proposed water points is produced.

Note: GIS development is often an iterative process. The stages may be repeated when new information is collected, errors are identified or new decisions need to be made.

3.0 Technologies Used in GIS

3.1 Meaning of GIS Technologies

GIS technologies refer to the tools, equipment, computer programmes and techniques used to collect, capture, process, store, analyse and present geographical information.

These technologies help users obtain accurate geographical information and convert it into useful maps and other outputs.

The main technologies used in GIS include:

1. Global Positioning System (GPS).
2. Remote sensing.
3. Geospatial Artificial Intelligence (GeoAI).
4. Desktop mapping.
5. Computer-Aided Design (CAD).
6. Database Management Systems (DBMS).

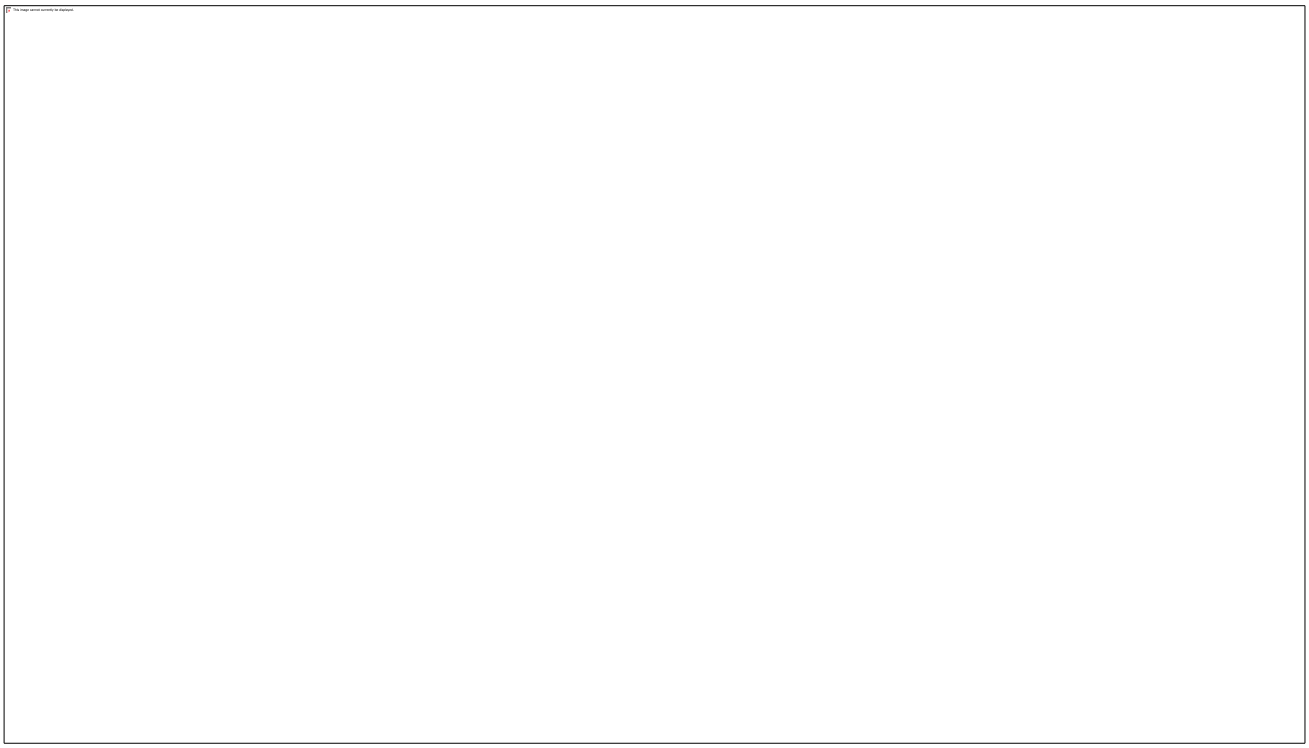
3.2 Global Positioning System (GPS)

Meaning of GPS

The Global Positioning System (GPS) is a satellite-based navigation system that provides information about the geographical location, direction, speed and time of a receiver on or near the Earth's surface.

GPS works through signals transmitted by satellites orbiting the Earth.

A GPS receiver calculates its position by receiving signals from several satellites.



How GPS Works

1. GPS satellites continuously transmit signals containing information about their positions and the time the signals were sent.
2. A GPS receiver detects signals from several satellites.
3. The receiver calculates the distance between itself and the satellites using signal travel time.

4. It uses signals from at least four satellites to determine its three-dimensional position and correct its clock.
5. The receiver displays the position as geographical coordinates, usually latitude and longitude, and altitude where available.

Uses of GPS in GIS

- Capturing the geographical coordinates of roads, rivers and buildings.
- Recording the location of schools and hospitals.
- Mapping boundaries of farms and other properties.
- Tracking vehicles and delivery services.
- Navigation and route planning.
- Monitoring wildlife movements.
- Mapping accident locations.
- Locating people during emergencies.
- Collecting fieldwork data.
- Mapping geographical features within a school compound.

Role of GPS in Road Emergency Responses

GPS is important in road emergency responses because it enables emergency teams to identify and reach accident locations.

Its roles include:

1. Identifying the exact or approximate location of road accidents.
2. Helping ambulance drivers locate injured people.
3. Guiding police officers to accident scenes.
4. Assisting fire and rescue teams to reach emergency locations.
5. Helping emergency call centres identify the location shared by a caller or transmitted by a device.
6. Identifying alternative routes when roads are blocked by accidents.
7. Supporting vehicle tracking and fleet management.
8. Helping emergency teams estimate travel distances and plan responses.

Example: When a road accident occurs along the Nairobi–Nakuru Highway, a caller may share GPS coordinates with emergency responders. The coordinates help the ambulance team identify the location and plan an appropriate route.

Advantages of GPS

- Provides geographical coordinates.
- Can be used in different weather conditions, although signal quality may be affected.
- Supports navigation and route planning.
- Enables accurate field data collection.
- Saves time when locating geographical features.

- Can be integrated with GIS software.

Limitations of GPS

- Signals may be weak inside buildings or underground.
- Tall buildings and dense vegetation may interfere with signal reception.
- Some devices may have limited accuracy.
- Equipment requires electrical power.
- GPS devices may be expensive.
- Incorrect use may result in inaccurate coordinates.

3.3 Remote Sensing

Meaning of Remote Sensing

Remote sensing is the process of collecting information about the Earth's surface without making direct physical contact with the objects or areas being studied.

It involves using sensors mounted on satellites, aircraft, drones and other platforms to detect and record reflected or emitted energy.





Types of Remote Sensing

a) Passive remote sensing

This involves sensors that detect naturally available energy reflected or emitted by objects on the Earth's surface.

Examples:

- Satellite cameras recording sunlight reflected from vegetation.
- Sensors detecting heat emitted from the Earth's surface.

b) Active remote sensing

This involves sensors that transmit their own energy towards an object and measure the energy reflected back.

Examples:

- Radar systems.
- LiDAR systems.

Platforms Used in Remote Sensing

1. **Satellites:** Used to capture images and information over large geographical areas.
2. **Aircraft:** Used to take aerial photographs and collect detailed geographical information.
3. **Drones:** Used to capture high-resolution images of farms, buildings and other features.
4. **Ground-based platforms:** Used to collect information from sensors positioned on the ground.

Uses of Remote Sensing in GIS

- Monitoring changes in forest cover.
- Identifying areas affected by drought.
- Mapping agricultural land.
- Monitoring crop health.
- Identifying settlements and urban expansion.
- Mapping water bodies.
- Monitoring floods and other natural disasters.
- Studying soil conditions.
- Mapping land-use and land-cover changes.
- Monitoring environmental pollution.

Advantages of Remote Sensing

- Covers large geographical areas.
- Provides information about inaccessible places.
- Enables repeated observation of the same area.
- Supports environmental monitoring.
- Provides different types of geographical information.
- Reduces the need for extensive ground surveys.

Limitations of Remote Sensing

- Some satellite images are expensive to acquire.
- Cloud cover can affect optical satellite imagery.
- High-resolution images may require specialised equipment and software.
- Interpretation requires technical knowledge.
- Ground verification may still be necessary.
- Some sensors have limited ability to identify very small features.

3.4 Geospatial Artificial Intelligence (GeoAI)

Meaning of GeoAI

Geospatial Artificial Intelligence (GeoAI) refers to the application of artificial intelligence techniques to geographical data to identify patterns, make predictions, automate geographical analysis and support decision-making.

It combines GIS, artificial intelligence, machine learning and geographical information.

GeoAI can analyse large volumes of satellite images, GPS records, maps and other geographical datasets.

Examples of GeoAI Applications

1. **Flood prediction:** Analysing rainfall, river levels, elevation and drainage information to identify areas at risk of flooding.
2. **Crop monitoring:** Identifying unhealthy crops from satellite and drone images.

3. **Traffic prediction:** Analysing road networks and traffic information to predict congestion.
4. **Urban growth monitoring:** Detecting changes in buildings and settlements over time.
5. **Forest monitoring:** Identifying areas experiencing deforestation.
6. **Wildlife conservation:** Analysing animal movement patterns and habitats.
7. **Disaster management:** Identifying areas likely to be affected by natural hazards.
8. **Land-use classification:** Automatically identifying forests, farms, roads and built-up areas from satellite images.

Advantages of GeoAI

- Analyses large geographical datasets quickly.
- Helps identify complex geographical patterns.
- Supports prediction and planning.
- Reduces repetitive manual analysis.
- Improves the speed of geographical investigations.

Limitations of GeoAI

- Requires reliable and sufficient data.
- May produce inaccurate results if the training data is poor.
- Requires specialised knowledge and computing resources.
- Some systems are expensive.
- Decisions based on AI results require human verification.

3.5 Desktop Mapping

Meaning of Desktop Mapping

Desktop mapping refers to the use of computer software on a desktop or laptop to create, edit, analyse and display maps.

It allows users to produce digital maps using geographical data obtained from field surveys, GPS devices, satellite images and existing maps.

Examples of desktop mapping software include:

- QGIS.
- ArcGIS Pro.
- MapInfo Professional.
- GRASS GIS.

Uses of Desktop Mapping

1. Creating digital maps.
2. Displaying geographical features.
3. Editing and updating maps.

4. Measuring distances and areas.
5. Analysing spatial patterns.
6. Producing thematic maps.
7. Comparing geographical information.
8. Preparing maps for printing and presentation.

Advantages of Desktop Mapping

- Makes map production easier.
- Allows maps to be edited and updated.
- Supports the use of different geographical data layers.
- Produces maps with clear symbols and labels.
- Supports spatial analysis.
- Allows digital maps to be saved and shared.

Limitations of Desktop Mapping

- Requires computers and suitable software.
- Some software packages are costly.
- Users require computer skills.
- Large datasets may require powerful computers.
- Incorrect data may produce misleading maps.

3.6 Computer-Aided Design (CAD)

Meaning of CAD

Computer-Aided Design (CAD) refers to the use of computer software to create, modify and present accurate technical drawings and designs.

CAD is mainly used in engineering, architecture, construction and surveying.

Examples of CAD software include:

- AutoCAD.
- MicroStation.
- Civil 3D.
- DraftSight.

Applications of CAD in GIS

- Designing road networks.
- Preparing building plans.
- Mapping property boundaries.
- Preparing engineering drawings.

- Designing drainage systems.
- Producing detailed site plans.
- Planning water supply networks.
- Supporting infrastructure development.

Advantages of CAD

- Produces accurate technical drawings.
- Allows easy editing of designs.
- Saves time in preparing plans.
- Supports measurements and calculations.
- Makes it possible to share digital designs.
- Can be integrated with GIS data.

Limitations of CAD

- Requires specialised training.
- Some software is expensive.
- Requires suitable computer hardware.
- Designs may not contain all the geographical information required for GIS analysis.
- Incorrect measurements may produce inaccurate designs.

Difference between CAD and GIS

CAD	GIS
Mainly used to create technical drawings and designs.	Mainly used to manage and analyse geographical information.
Focuses on the design and dimensions of objects.	Focuses on the location and spatial relationships of features.
Commonly used in engineering and architecture.	Commonly used in geography, planning and environmental management.
May contain limited geographical attributes.	Stores spatial data and associated attribute information.

3.7 Database Management Systems (DBMS)

Meaning of DBMS

A Database Management System (DBMS) is computer software used to create, store, organise, retrieve, update and manage data in a database.

In GIS, a DBMS helps users manage large amounts of spatial and attribute information.

Examples include:

- PostgreSQL.

- MySQL.
- Microsoft Access.
- Oracle Database.
- SQLite.

Uses of DBMS in GIS

1. Storing geographical information.
2. Organising spatial and attribute data.
3. Retrieving information when required.
4. Updating geographical records.
5. Reducing unnecessary duplication of information.
6. Supporting data sharing among users.
7. Maintaining data security.
8. Supporting spatial queries and analysis.

Advantages of DBMS

- Organises large volumes of data.
- Makes information easier to retrieve.
- Supports data updating.
- Improves data security.
- Reduces duplication of records.
- Allows multiple users to access information, depending on permissions.
- Supports integration with GIS software.

Limitations of DBMS

- Requires technical knowledge.
- Some systems are costly to install and maintain.
- Data may be lost if proper backup procedures are not followed.
- Security may be compromised if access controls are weak.
- Large databases may require powerful computer systems.

4.0 Types of Information Stored in GIS

4.1 Introduction

GIS stores geographical information in an organised manner to help users understand the location, characteristics and relationships of features on the Earth's surface.

The two main types of information stored in GIS are:

1. Spatial data.
2. Attribute data.

4.2 Spatial Data

Meaning of Spatial Data

Spatial data refers to information that describes the geographical location, shape, size, position and spatial relationships of features on the Earth's surface.

It answers questions such as:

- Where is a particular feature located?
- What shape does the feature have?
- How large is the feature?
- How far is one feature from another?

Spatial data is commonly represented using geographical coordinates, maps and geometrical features.

Types of Spatial Data

Spatial data is mainly represented in two formats:

a) Vector data

Vector data represents geographical features using points, lines and polygons.

The three main vector features are:

i) Point data

Point data represents geographical features that can be located using a single coordinate or a set of coordinates.

Examples:

- Schools.
- Hospitals.
- Boreholes.
- Trees.
- Bus stops.
- Electricity poles.
- Weather stations.
- Buildings represented by a point on a small-scale map.

ii) Line data

Line data represents geographical features that have length but are usually represented by a line on a map.

Examples:

- Roads.
- Rivers.
- Railway lines.

- Electricity transmission lines.
- Footpaths.
- Pipelines.
- Boundaries represented as lines.

iii) Polygon data

Polygon data represents geographical features that have enclosed areas.

Examples:

- Farms.
- Lakes.
- Forests.
- School compounds.
- Counties.
- National parks.
- Buildings represented by their footprints.
- Land parcels.

b) Raster data

Raster data represents geographical information using a grid of cells or pixels.

Each cell contains a value representing a particular geographical characteristic.

Examples:

- Satellite images.
- Aerial photographs.
- Digital elevation models.
- Rainfall distribution images.
- Temperature maps.
- Land-cover images.
- Soil moisture maps.

Characteristics of Raster Data

- It consists of rows and columns of cells.
- Each cell represents a portion of the Earth's surface.
- Each cell contains a value.
- Cell size determines the spatial resolution.
- It is suitable for representing continuous geographical phenomena.
- It is commonly obtained from satellite images and aerial photographs.

Characteristics of Vector Data

- It uses points, lines and polygons.
- It represents individual geographical features.
- It can provide accurate locations and boundaries.
- It is suitable for representing roads, buildings and property boundaries.
- It can be linked to attribute information.

Differences between Vector and Raster Data

Vector data	**Raster data**
Uses points, lines and polygons.	Uses grids of cells or pixels.
Suitable for individual geographical features.	Suitable for continuous geographical phenomena and imagery.
Represents roads, rivers and boundaries.	Represents satellite images, elevation and rainfall surfaces.
Features are represented using coordinates.	Features are represented using cell values.
Often produces clear boundaries for discrete features.	Detail depends on cell size and resolution.
Common formats include shapefiles and GeoJSON.	Common formats include GeoTIFF and JPEG imagery.

4.3 Attribute Data

Meaning of Attribute Data

Attribute data refers to descriptive information that explains the characteristics or properties of geographical features represented in a GIS.

It provides additional details about spatial features.

Attribute data answers questions such as:

- What is the name of the feature?
- What type of feature is it?
- How many people live in the area?
- What is the size of the farm?
- What is the condition of the road?
- What services are available at a hospital?

Examples of Attribute Data

Spatial feature	Attribute information
School	Name, enrolment, type and number of classrooms
Hospital	Name, number of beds, services and ownership
Road	Road name, surface type, length and condition
River	Name, length, flow characteristics and water quality
Farm	Owner's identification code, size, crop type and production
Borehole	Name, depth, water condition and operational status
Forest	Name, area, tree species and conservation status

Types of Attribute Information

a) Numerical attributes

These are attributes expressed in numbers.

Examples:

- Population.
- Farm size.
- Road length.
- Number of classrooms.
- Annual rainfall.
- Number of hospital beds.

b) Textual attributes

These are attributes expressed using words or letters.

Examples:

- Name of a school.
- Name of a river.
- Type of road surface.
- Name of a village.
- Type of crop grown.

c) Date and time attributes

These record when a geographical event occurred or when information was collected.

Examples:

- Date a road was inspected.

- Time a GPS point was recorded.
- Date a borehole was constructed.
- Date a satellite image was captured.

d) Categorical attributes

These classify geographical features into groups.

Examples:

- Road condition: good, fair or poor.
- Land use: residential, commercial or agricultural.
- School type: public or private.
- Vegetation type: forest, grassland or shrubland.

4.4 Relationship between Spatial and Attribute Data

Spatial and attribute data complement each other.

- Spatial data identifies the location and shape of a geographical feature.
- Attribute data describes the characteristics of that feature.
- Both are linked through a common feature identifier.
- Spatial data without attribute information may not provide sufficient details about a feature.
- Attribute data without spatial information may not show where the feature is located.

Example: School mapping

Feature ID	Name	Latitude	Longitude	Number of classrooms
SCH001	School A	-0.3000	36.1000	12
SCH002	School B	-0.3100	36.1100	8
SCH003	School C	-0.3200	36.1200	15

In the table:

- Latitude and longitude provide spatial information.
- School name and number of classrooms provide attribute information.
- Feature ID links the spatial and attribute records.

5.0 GIS Storage Methods for Spatial and Attribute Data

5.1 Meaning of GIS Data Storage

GIS data storage refers to the methods and digital formats used to organise and keep spatial and attribute information for future retrieval, analysis, editing and sharing.

GIS data must be stored in appropriate formats to maintain accuracy, support compatibility and allow users to retrieve information when required.

The storage methods specified in the curriculum include:

1. GeoTIFF.
2. Shapefiles.
3. Keyhole Markup Language (KML).
4. Comma-Separated Values (CSV).

Other useful GIS storage formats include GeoJSON, GeoPackage and geodatabases.

5.2 GeoTIFF

Meaning of GeoTIFF

GeoTIFF is a raster image file format that stores geographical images together with information about their geographical location and coordinate reference system.

It is commonly used to store satellite imagery, aerial photographs, elevation data and other raster information.

Information Stored in GeoTIFF

- Satellite images.
- Aerial photographs.
- Land-cover information.
- Digital elevation data.
- Rainfall distribution.
- Temperature information.
- Soil moisture information.

Features of GeoTIFF

1. Stores raster data in rows and columns of pixels.
2. Can contain geographical reference information.
3. Can preserve coordinate system information.
4. Supports different image resolutions.
5. Can be opened and analysed using GIS software.
6. Is suitable for displaying continuous geographical information.

Advantages of GeoTIFF

- Stores geographical images with location information.
- Supports satellite image analysis.
- Can represent elevation and environmental information.
- Compatible with many GIS applications.
- Useful for environmental monitoring.
- Can store large geographical raster datasets.

Limitations of GeoTIFF

- Large images may require considerable storage space.
- High-resolution images may require powerful computers.
- Raster data may lose detail when reduced to lower resolutions.
- It is not the most suitable format for storing individual road or building records.

5.3 Shapefiles

Meaning of Shapefiles

A shapefile is a vector data format used to store geographical features such as points, lines and polygons together with their associated attribute information.

It was developed for use with GIS software and is widely used in digital mapping.

Types of Information Stored in Shapefiles

- Point locations of schools and hospitals.
- Line features representing roads and rivers.
- Polygon features representing farms and forests.
- Attribute records describing geographical features.

Main Shapefile Components

A shapefile normally consists of several related files that share the same file name but have different extensions.

File extension	Function
.shp	Stores the geometry of geographical features.
.shx	Stores an index of the feature geometries.
.dbf	Stores attribute information in a tabular format.
.prj	Stores coordinate reference system information.
.cpg	Specifies character encoding where included.

Important: The .shp, .shx and .dbf files are essential parts of a traditional shapefile. The .prj file is highly useful because it identifies the coordinate reference system.

Advantages of Shapefiles

- Store point, line and polygon features.
- Support attribute information.
- Are supported by many GIS programmes.
- Are suitable for digital mapping.

- Can be shared between different GIS users.
- Are useful for mapping roads, buildings and boundaries.

Limitations of Shapefiles

- A shapefile is made up of several related files.
- Traditional shapefiles have limitations on field names and attribute types.
- They have a maximum file size limitation.
- They do not store advanced GIS relationships as effectively as some modern database formats.
- All related files must be kept together to avoid data problems.

5.4 Keyhole Markup Language (KML)

Meaning of KML

Keyhole Markup Language (KML) is an XML-based file format used to represent and display geographical information on digital maps and virtual globes.

It is commonly associated with Google Earth and other mapping applications.

Information Stored in KML

- Point locations.
- Lines representing roads and routes.
- Polygons representing areas and boundaries.
- Names of geographical features.
- Descriptions of places.
- Symbols and colours used on maps.
- Some display and time-related information.

Uses of KML

1. Displaying GPS locations on digital maps.
2. Sharing geographical information.
3. Showing routes between places.
4. Mapping tourist attractions.
5. Displaying school and hospital locations.
6. Presenting boundaries of geographical areas.
7. Visualising fieldwork results in Google Earth.

Advantages of KML

- Easy to share.
- Can display geographical features on Google Earth.
- Supports points, lines and polygons.

- Can contain descriptions and labels.
- Suitable for presenting geographical information.
- Can be converted into other GIS formats.

Limitations of KML

- Some applications may not support all KML features.
- It may become difficult to manage very large datasets.
- It is less suitable for advanced spatial database management.
- Complex datasets may require conversion before detailed analysis.

5.5 Comma-Separated Values (CSV)

Meaning of CSV

Comma-Separated Values (CSV) is a simple text-based file format used to store tabular data in which individual values are separated by commas.

In GIS, CSV files can store coordinates and attribute information about geographical features.

Information Stored in CSV

- Feature names.
- Latitude.
- Longitude.
- Altitude, where available.
- Feature identification numbers.
- Population figures.
- Road conditions.
- Names of geographical locations.
- Other descriptive information.

Example of a CSV File

The following table shows geographical information about features within a hypothetical school compound.

Feature ID	Feature name	Latitude	Longitude	Category
F001	Main gate	-1.0001	36.0001	Entrance
F002	Administration block	-1.0003	36.0004	Building
F003	Library	-1.0005	36.0006	Building
F004	Borehole	-1.0007	36.0008	Water point

F005	Football field	-1.0010	36.0010	Recreation

Note: The coordinates above are illustrative only and do not represent a real school location.

Example of CSV File Content

Feature_ID,Feature_Name,Latitude,Longitude,Category

F001,Main gate,-1.0001,36.0001,Entrance

F002,Administration block,-1.0003,36.0004,Building

F003,Library,-1.0005,36.0006,Building

F004,Borehole,-1.0007,36.0008,Water point

F005,Football field,-1.0010,36.0010,Recreation

Advantages of CSV

- Easy to create and edit.
- Can be opened using spreadsheet programmes.
- Requires relatively little storage space.
- Can be imported into many GIS applications.
- Supports coordinate and attribute information.
- Easy to share between users.

Limitations of CSV

- Does not directly store complex geometries such as polygon boundaries.
- Does not automatically store coordinate reference system information.
- Data may be incorrectly interpreted if columns are not properly formatted.
- Special characters and commas in text may cause formatting problems.
- Large datasets may be difficult to manage manually.

5.6 Other GIS Data Storage Formats

Although the curriculum identifies GeoTIFF, shapefiles, KML and CSV, learners should also be familiar with other useful formats.

a) GeoJSON

GeoJSON is a geographical data format based on JSON. It stores spatial features such as points, lines and polygons together with associated attributes.

b) GeoPackage

GeoPackage is an open standard format that stores different types of geographical information in a single database file.

It can store:

- Vector features.
- Raster and tile data.

- Attribute information.
- Coordinate reference system information.

c) Geodatabase

A geodatabase is a structured database designed to store, manage and organise geographical information.

It can support:

- Spatial features.
- Attribute tables.
- Relationships between datasets.
- Rules governing geographical information.
- Different geographical data types.

5.7 Comparison of GIS Storage Formats

Format	Main data type	Common application
GeoTIFF	Raster	Satellite imagery and elevation data
Shapefile	Vector	Roads, rivers and boundaries
KML	Vector and map display information	Google Earth mapping
CSV	Tabular data and coordinates	GPS point storage
GeoJSON	Vector	Web mapping and data sharing
GeoPackage	Vector and raster	Integrated GIS data storage
Geodatabase	Different GIS datasets	Organised geographical databases

6.0 Capturing Spatial and Attribute Data Using GIS Technology

6.1 Meaning of GIS Data Capture

GIS data capture refers to the process of collecting geographical information and converting it into a digital format that can be used in a GIS.

Data capture is an important stage because the quality of GIS analysis depends on the accuracy and completeness of the information collected.

GIS data capture may be carried out through:

- GPS receivers.
- GPS-enabled smartphones.
- Field surveys.
- Satellite images.

- Aerial photographs.
- Drones.
- Existing maps.
- Digital records.

6.2 Methods of Capturing Spatial Data

a) GPS data collection

This involves using a GPS receiver or smartphone to record the geographical coordinates of features.

For example, learners can record the locations of classrooms, trees and water points in the school compound.

b) Field surveying

This involves visiting geographical features and recording their locations, dimensions and characteristics.

Examples:

- Measuring the boundaries of a school compound.
- Recording the location of a water tank.
- Identifying the location of a playground.

c) Digitising

Digitising involves converting geographical features from paper maps or images into digital spatial data.

For example, a road shown on a printed map can be traced as a digital line using GIS software.

d) Remote sensing

Satellite images and aerial photographs can be used to identify and capture geographical features.

e) Mobile data collection

GPS-enabled mobile applications can be used to capture coordinates and descriptive information in the field.

6.3 Methods of Capturing Attribute Data

Attribute data can be captured through:

1. Interviews with people.
2. Questionnaires.
3. Direct observation.
4. Measurements.
5. Existing administrative records.
6. School registers.
7. Government databases.
8. Fieldwork recording sheets.

Example: When mapping a school, learners may record the name of each building, its purpose, number of rooms and condition.

6.4 Tools Required for GIS Data Capture in a School Compound

Tool	Function
GPS receiver	Records geographical coordinates
Smartphone	Captures GPS points and descriptive information
Measuring tape	Measures distances and dimensions
Field notebook	Records observations
Clipboard	Holds data collection sheets
Computer	Stores and processes data
GIS software	Displays and analyses geographical information
Spreadsheet software	Organises attribute information
Digital camera	Captures photographs of features
Power bank	Provides additional power for mobile devices

7.0 Practical Activity: Mapping Features within the School Compound Using GPS

7.1 Activity Introduction

Learners are guided to use GPS technology to capture spatial and attribute data of important geographical features within the school compound and store the information using the CSV method.

7.2 Learning Objectives

By the end of the practical activity, learners should be able to:

1. Identify geographical features within the school compound.
2. Use a GPS-enabled device to capture geographical coordinates.
3. Record spatial information accurately.
4. Collect attribute information about identified features.
5. Organise geographical data in a spreadsheet.
6. Save the collected information in CSV format.
7. Appreciate the importance of GIS in school planning and management.

7.3 Geographical Features to be Mapped

Learners may identify the following features:



1. Main school gate.
2. Administration block.
3. Classrooms.
4. Library.
5. Laboratory.
6. Borehole or water point.
7. Toilets and washrooms.
8. Playground.
9. Trees and gardens.
10. School kitchen.
11. Staffroom.
12. School boundary points.

7.4 Procedure for Capturing GPS Data

Step 1: Preparation

- Obtain permission from the school administration.
- Identify the area to be mapped.

- Select the features to be recorded.
- Prepare the data collection sheet.
- Ensure that the GPS device or smartphone is charged.
- Familiarise learners with basic GPS operation.

Step 2: Activate the GPS device

- Switch on the GPS receiver or enable location services on a smartphone.
- Open an appropriate GPS application.
- Allow the device to receive satellite signals.
- Wait for the position to stabilise.
- Check the coordinate format being displayed.

Step 3: Identify geographical features

- Move to the first geographical feature.
- Identify the exact point to be recorded.
- For a building, agree on a consistent reference point, such as the main entrance.
- For a tree, record the position of the tree trunk.
- For a gate, record the centre of the entrance.

Step 4: Record GPS coordinates

- Record the latitude.
- Record the longitude.
- Record altitude if required and available.
- Note the GPS accuracy displayed by the device.
- Assign a unique identification number to each feature.

Step 5: Collect attribute information

Record additional details such as:

- Name of the feature.
- Type of feature.
- Purpose or function.
- Condition.
- Date of data collection.
- Other relevant observations.

Step 6: Repeat the process

Move to the next feature and repeat the procedure until all selected features have been recorded.

Step 7: Organise the information

Enter the collected data into a spreadsheet using clearly labelled columns.

Step 8: Save the data

Save the spreadsheet in CSV format.

Step 9: Verify the data

Check that:

- All features have unique identification numbers.
- Latitude and longitude are in the correct columns.
- No important records are missing.
- The coordinates are within the expected school area.
- The attribute information is correctly recorded.

Step 10: Present the results

Import the CSV file into suitable GIS software and display the recorded locations on a digital map.

7.5 Sample Field Data Collection Sheet

Illustrative school compound data collection template. Actual coordinates must be captured during fieldwork.

ID	Feature	Latitude	Longitude	Attribute description
001	Main gate	To be captured	To be captured	Main entrance
002	Administration block	To be captured	To be captured	School offices
003	Classroom block A	To be captured	To be captured	Teaching rooms
004	Library	To be captured	To be captured	Reading and research
005	Borehole	To be captured	To be captured	Water source
006	Playground	To be captured	To be captured	Sports activities
007	School kitchen	To be captured	To be captured	Food preparation
008	Tree nursery	To be captured	To be captured	Seedling production

7.6 Sample CSV Template

The following template can be copied into a spreadsheet and completed using actual field measurements.

Feature_ID,Feature_Name,Latitude,Longitude,Feature_Type,Condition,Date

001,Main gate,,,Entrance,,

002,Administration block,,,Building,,

003,Classroom block A,,,Building,,

004,Library,,,Building,,

005,Borehole,,,Water point,,

006,Playground,,,Recreation,,

007,School kitchen,,,Building,,

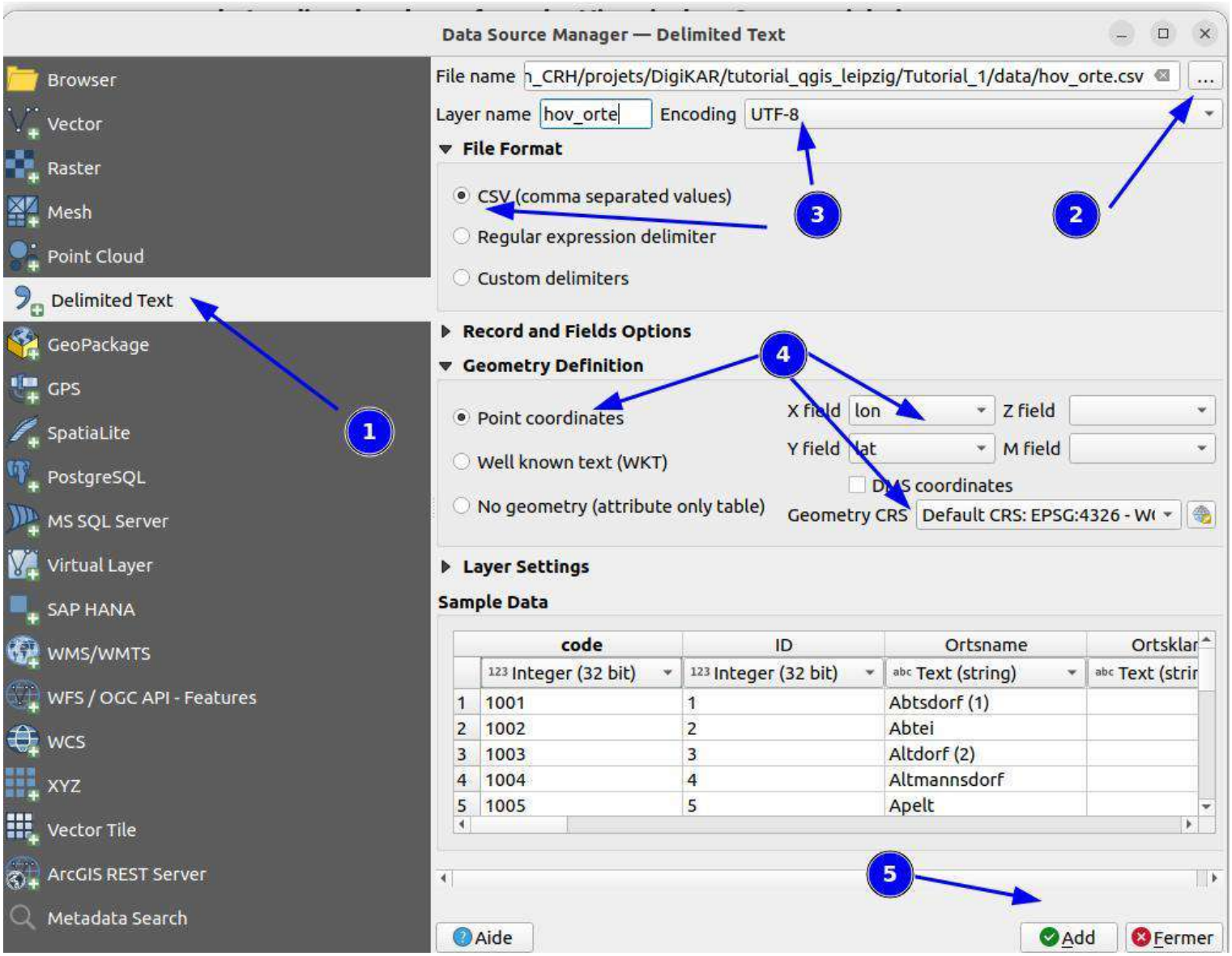
008,Tree nursery,,,Agriculture,,

7.7 How to Save Data in CSV Format Using a Spreadsheet

1. Open Microsoft Excel, LibreOffice Calc or another spreadsheet application.
2. Create a new spreadsheet.
3. Enter the field data in separate columns.
4. Label each column clearly.
5. Check that the coordinates are stored as numerical values.
6. Click the **File** menu.
7. Select **Save As** or **Download**.
8. Choose CSV format, such as CSV UTF-8 or CSV (Comma delimited).
9. Give the file a meaningful name, for example School_Compound_GIS_Data.csv.
10. Save the file in an appropriate folder.
11. Confirm that the file has been saved correctly.

7.8 Importing CSV Data into GIS Software

After collecting and saving the data, learners can display the recorded geographical features using GIS software such as QGIS.



General procedure:

1. Open QGIS on a computer.
2. Select the option for adding a delimited text layer.
3. Browse for the saved CSV file.
4. Select the correct latitude field for the Y coordinate.
5. Select the correct longitude field for the X coordinate.
6. Select the appropriate coordinate reference system.
7. Add the data to the map.
8. Confirm that the points appear in the correct geographical locations.
9. Add labels to identify the features.
10. Save the GIS project.

Important geographical knowledge: In most GIS coordinate systems using latitude and longitude, X represents longitude while Y represents latitude. The order should be checked when importing data to avoid placing features in the wrong locations.

8.0 Importance of GIS as a Tool for Decision-Making

8.1 Meaning of Decision-Making in GIS

Decision-making in GIS refers to the use of geographical information and spatial analysis to identify problems, evaluate alternatives and select suitable solutions.

GIS helps decision-makers understand where problems occur, which areas are affected and where resources should be directed.

8.2 Applications of GIS in Decision-Making

a) Urban and settlement planning

GIS helps urban planners:

- Identify suitable areas for residential development.
- Plan road networks.
- Locate public facilities.
- Monitor urban expansion.
- Identify informal settlements.
- Avoid development in high-risk areas.

b) Agricultural planning

GIS supports agricultural decisions by:

- Identifying suitable land for crop production.
- Mapping soil types.
- Monitoring rainfall distribution.
- Identifying drought-prone areas.
- Supporting irrigation planning.
- Monitoring crop health.

c) Transport planning

GIS helps transport authorities:

- Identify suitable road routes.
- Locate traffic congestion points.
- Plan road maintenance.
- Identify accident-prone areas.
- Determine alternative routes.
- Improve public transport services.

d) Disaster management

GIS helps disaster management agencies:

- Identify flood-prone areas.
- Map areas affected by drought.

- Locate vulnerable communities.
- Plan evacuation routes.
- Identify suitable emergency centres.
- Allocate relief resources.

e) Health service planning

GIS supports health planning by:

- Mapping hospitals and health centres.
- Identifying communities far from medical facilities.
- Monitoring disease distribution.
- Planning ambulance routes.
- Identifying areas requiring additional health facilities.

f) Environmental conservation

GIS helps environmental authorities:

- Monitor deforestation.
- Map wildlife habitats.
- Identify areas affected by pollution.
- Monitor soil erosion.
- Identify wetlands requiring protection.
- Plan environmental restoration.

g) Water resource management

GIS helps in:

- Mapping rivers, lakes and wetlands.
- Identifying suitable borehole locations.
- Monitoring water catchment areas.
- Planning water supply networks.
- Identifying areas facing water shortages.

h) Education planning

GIS helps education authorities:

- Map school distribution.
- Identify areas without adequate schools.
- Plan locations for new schools.
- Analyse distances learners travel to school.
- Support the distribution of educational resources.

8.3 Importance of GIS in Day-to-Day Life

GIS is important in everyday activities in the following ways:

1. **Navigation:** GPS-enabled maps help people locate destinations.
2. **Transport:** Digital maps help motorists identify routes and avoid traffic congestion.
3. **Delivery services:** Companies use GIS to locate customers and plan deliveries.
4. **Emergency responses:** Emergency teams use geographical coordinates to locate incidents.
5. **Agriculture:** Farmers use geographical information to plan crop production.
6. **Weather monitoring:** GIS supports the mapping of rainfall, temperature and weather-related hazards.
7. **Property management:** GIS helps identify land parcels and property boundaries.
8. **Tourism:** Tourists use digital maps to locate attractions and accommodation facilities.
9. **Public health:** GIS helps identify areas requiring health services.
10. **Environmental protection:** GIS supports the monitoring of forests, rivers and other natural resources.

8.4 Limitations of GIS in Decision-Making

Despite its importance, GIS has some limitations:

- It requires accurate and up-to-date geographical information.
- GIS equipment and software may be expensive.
- Users require specialised skills.
- Poor-quality data may lead to incorrect decisions.
- Some areas may have limited internet connectivity.
- GPS accuracy may be affected by physical obstructions.
- Sensitive geographical information may be exposed if data security is weak.
- GIS analysis may not fully account for social, cultural and economic factors.
- Some remote areas may lack sufficient geographical data.

8.5 Measures to Improve the Use of GIS

1. Providing training to GIS users.
2. Using accurate and reliable data sources.
3. Updating geographical information regularly.
4. Investing in appropriate hardware and software.
5. Maintaining secure GIS databases.
6. Using field verification to confirm collected information.
7. Promoting collaboration among GIS users and organisations.
8. Making geographical information accessible to relevant decision-makers.
9. Providing backup systems to prevent data loss.
10. Combining GIS findings with local knowledge and other forms of evidence.

9.0 Geographical Information Systems and Community Development in Kenya

GIS contributes to national and community development through the provision of geographical information for planning and resource management.

9.1 Applications in Kenya

a) Agricultural development

GIS can help agricultural planners map:

- Crop-growing areas.
- Soil types.
- Irrigation schemes.
- Drought-prone regions.
- Agricultural infrastructure.

Example: Agricultural planners can use GIS information to identify suitable areas for growing maize, tea, coffee and other crops.

b) Road development

GIS supports road construction and maintenance through:

- Mapping existing roads.
- Identifying inaccessible areas.
- Selecting suitable road routes.
- Mapping accident locations.
- Planning road maintenance.

c) Wildlife and tourism management

GIS supports:

- Mapping national parks and reserves.
- Monitoring wildlife habitats.
- Identifying wildlife migration routes.
- Monitoring human-wildlife conflicts.
- Planning tourism facilities.

d) Water resource management

GIS assists in:

- Mapping water sources.
- Identifying areas experiencing water shortages.
- Monitoring catchment areas.
- Planning water distribution networks.

e) Disaster management

GIS can be used to identify and monitor:

- Flood-prone areas.
- Drought-affected regions.
- Landslide-prone slopes.
- Areas exposed to environmental hazards.

f) County planning

County governments can use GIS to:

- Map public facilities.
- Plan markets and trading centres.
- Identify suitable sites for public projects.
- Monitor land use.
- Plan water and sanitation services.

10.0 Data Quality and Accuracy in GIS

10.1 Meaning of GIS Data Quality

GIS data quality refers to the degree to which geographical information is accurate, complete, consistent, reliable and suitable for its intended purpose.

Good-quality data is essential because inaccurate geographical information can lead to misleading maps and poor decisions.

10.2 Elements of GIS Data Quality

a) Accuracy

Accuracy refers to how closely recorded geographical information represents the actual position or characteristics of a feature.

Example: GPS coordinates should correctly represent the location of a school gate.

b) Completeness

Completeness refers to whether all necessary geographical features and attributes have been recorded.

Example: A school map should include all important buildings and water points selected for the investigation.

c) Consistency

Consistency refers to whether geographical information follows the same standards and formats.

Example: All GPS coordinates should use the same coordinate reference system.

d) Currency

Currency refers to how up-to-date the geographical information is.

Example: A map should be updated when a new classroom block is constructed.

e) Reliability

Reliability refers to the dependability of the data source and the methods used to collect information.

Example: Coordinates collected using a properly functioning GPS device and verified in the field are generally more dependable than guessed coordinates.

10.3 Ways of Improving GIS Data Quality

1. Using reliable data collection equipment.
2. Training people involved in data collection.
3. Repeating measurements where necessary.
4. Checking GPS accuracy.
5. Using standard coordinate reference systems.
6. Verifying information through field visits.
7. Updating records regularly.
8. Removing duplicate records.
9. Checking spelling and attribute entries.
10. Maintaining proper data backup procedures.

11.0 Emerging Trends in GIS

GIS continues to develop as new technologies become available.

Some emerging trends include:

a) Cloud GIS

Cloud GIS refers to GIS services and data stored or accessed through internet-based computing platforms.

Benefits include:

- Remote access to geographical information.
- Easier data sharing.
- Collaboration among users.
- Reduced need for local storage.

b) Mobile GIS

Mobile GIS involves the use of smartphones and tablets to collect, view and analyse geographical information while in the field.

c) Web GIS

Web GIS refers to GIS applications accessed through web browsers.

Examples include interactive online maps that allow users to view and explore geographical information.

d) 3D GIS

Three-dimensional GIS represents geographical features using length, width and height.

Applications include:

- Urban building visualisation.
- Terrain modelling.
- Infrastructure planning.
- Flood modelling.

e) Drone-based mapping

Drones are increasingly used to capture detailed aerial images for mapping and geographical investigations.

f) Artificial intelligence and machine learning

AI-based systems can analyse large geographical datasets, identify patterns and support prediction.

12.0 Suggested Key Inquiry Questions

Inquiry Question 1: How important is GIS in day-to-day lives?

GIS is important because it supports navigation, transport, delivery services, emergency response, agriculture, environmental monitoring, urban planning and the location of public services.

Learners should discuss examples of GIS applications in their homes, schools and communities.

Inquiry Question 2: What is the role of GPS in road emergency responses?

GPS helps emergency response teams identify the geographical location of accidents and other incidents. It guides ambulances, police and rescue teams to the affected locations and supports route planning.

Class discussion: What problems might arise if emergency responders are given inaccurate GPS coordinates?

13.0 Summary of Key Terms

Term	Meaning
GIS	A computer-based system for collecting, storing, analysing and presenting geographical information
GPS	A satellite-based system used to determine geographical position
Remote sensing	Collecting information about the Earth's surface without direct physical contact
GeoAI	Application of artificial intelligence to geographical information
Desktop mapping	Creating and analysing maps using computer software
CAD	Computer software used to create and modify technical drawings
DBMS	Software used to organise, store and manage data
Spatial data	Information showing the location, shape and size of geographical features
Attribute data	Descriptive information about geographical features
Vector data	Geographical information represented by points, lines and polygons
Raster data	Geographical information represented by cells or pixels
GeoTIFF	A raster image format containing geographical reference information

Shapefile	A vector format used to store geographical features and attributes
KML	An XML-based format for displaying geographical information on digital maps
CSV	A text-based format for storing tabular data separated by commas
Digitising	Converting geographical features into digital form
Geospatial analysis	Examining geographical data to identify patterns and relationships
Georeferencing	Assigning geographical coordinates to data so that it can be correctly located on the Earth's surface

REVISION EXERCISE

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Instructions: Answer all the questions. Choose the correct answer from the alternatives A, B, C and D.

1. What is the meaning of GIS?

A. Geographical Information System
B. General Information Service
C. Global Internet System
D. Geographical Investigation Service

2. Which of the following is a major component of GIS?

A. Fishing equipment
B. Hardware
C. Cooking utensils
D. Agricultural chemicals

3. Which stage of the GIS development cycle involves collecting geographical information and entering it into a computer?

A. Data output
B. Data presentation
C. Data input
D. Modelling

4. Which of the following is an example of GIS output?

A. Digital map
B. GPS satellite
C. Measuring tape
D. Field notebook

5. Which technology uses satellites to determine the geographical position of a place?

A. CAD
B. GPS
C. DBMS
D. Desktop mapping

6. Remote sensing involves collecting geographical information:

A. Through direct physical contact only
B. Without direct physical contact with the objects being studied
C. Through interviews only
D. Through handwritten maps only

7. Which of the following is an example of active remote sensing?

A. Ordinary photography using sunlight
B. Radar
C. Visual observation
D. Manual drawing

8. GeoAI combines GIS with:

A. Artificial intelligence
B. Traditional farming
C. Manual surveying only
D. Printing technology

9. Which of the following software applications is commonly used for desktop mapping?

A. QGIS
B. Microsoft Word
C. Calculator
D. Paint only

10. What is the main application of Computer-Aided Design (CAD)?

A. Preparing technical drawings and designs
B. Measuring rainfall manually
C. Recording population only
D. Forecasting weather only

11. What is the main purpose of a Database Management System (DBMS)?

A. To capture photographs
B. To organise and manage data
C. To transmit satellite signals
D. To measure temperature

12. Which type of GIS information describes the geographical location and position of a feature?

A. Attribute data
B. Spatial data
C. Text data
D. Numerical data

13. Which of the following is an example of point data?

A. River
B. Road
C. Borehole
D. County boundary

14. Which type of spatial data represents geographical features using lines?

A. Raster data
B. Point data
C. Line data
D. Attribute data

15. Which of the following is an example of polygon data?

A. A school compound boundary
B. A single tree location
C. A road centreline
D. A borehole location

16. How is raster data represented in a GIS?

A. Using points only
B. Using lines only
C. Using rows and columns of cells
D. Using written paragraphs

17. Which of the following is an example of attribute data?

A. Latitude
B. Longitude

C. Number of classrooms in a school
D. Position of a road

18. Which GIS file format is commonly used to store satellite images together with geographical reference information?

A. CSV
B. GeoTIFF
C. KML
D. TXT

19. Which component of a shapefile stores attribute information?

A. .shp
B. .shx
C. .dbf
D. .prj

20. Which application is commonly associated with the KML file format?

A. Google Earth
B. Microsoft Excel only
C. Word processing
D. Audio editing

21. What does CSV stand for?

A. Computer Spatial Values
B. Comma-Separated Values
C. Coordinate Storage Version
D. Computer Survey Variables

22. Which of the following is a major advantage of the CSV file format?

A. It stores complex polygon geometry directly
B. It is easy to create and edit
C. It automatically provides all coordinate systems
D. It cannot be shared

23. Which geographical coordinate indicates the north-south position of a place?

A. Longitude
B. Latitude
C. Altitude
D. Distance

24. Which geographical coordinate indicates the east-west position of a place?

A. Latitude
B. Altitude
C. Longitude
D. Height

25. Which of the following is an appropriate method of capturing spatial data within a school compound?

A. Guessing locations
B. Using GPS
C. Reading novels
D. Conducting interviews without recording locations

26. Why should each geographical feature be assigned a unique identification number in a GIS database?

A. To increase the file size
B. To distinguish one feature from another
C. To remove all attribute information
D. To prevent mapping

27. Which of the following demonstrates the application of GIS in agriculture?

A. Identifying suitable areas for crop production
B. Preparing examination timetables only
C. Printing newspapers
D. Recording songs

28. How does GIS support road emergency response services?

A. By delaying emergency vehicles
B. By identifying accident locations and suitable routes
C. By replacing all emergency personnel
D. By preventing all road accidents

29. Which of the following is a limitation of GIS technology?

A. It supports decision-making
B. It improves map production
C. It may require expensive equipment and specialised skills
D. It supports environmental monitoring

30. Why is GIS important in geographical decision-making?

A. It provides geographical information for planning
B. It eliminates the need for all human decisions
C. It prevents geographical changes
D. It replaces all fieldwork

Section B: Structured Questions (50 Marks)

1. (8 marks)

a) Define the term Geographic Information System (GIS). (2 marks)

b) State four components of GIS. (4 marks)

c) Give two examples of GIS applications in Kenya. (2 marks)

2. (8 marks)

a) Explain the meaning of the GIS development cycle. (2 marks)

b) Describe three stages of the GIS development cycle. (6 marks)

3. (8 marks)

a) Distinguish between spatial data and attribute data. (4 marks)

b) Describe the three types of vector data used in GIS. (3 marks)

c) State one example of raster data. (1 mark)

4. (8 marks)

a) Explain the meaning of GPS. (2 marks)

b) Describe four uses of GPS in geographical studies. (4 marks)

c) Explain two ways in which GPS supports road emergency responses. (2 marks)

5. (10 marks)

a) Explain the use of the following GIS storage formats:

i) GeoTIFF. (2 marks)

ii) Shapefile. (2 marks)

iii) KML. (2 marks)

iv) CSV. (2 marks)

b) State two advantages of storing GIS data in digital formats. (2 marks)

6. (8 marks)

Learners in a school are required to map geographical features within their school compound using GPS technology.

a) Identify four geographical features they may map. (2 marks)

b) Explain three steps they should follow when capturing GPS data. (3 marks)

c) State three pieces of attribute information they may record about the features. (3 marks)

15.0 Answer Key and Suggested Responses

Section A: Multiple-Choice Answers

Question	Answer	Question	Answer
1	A	16	C
2	B	17	C
3	C	18	B
4	A	19	C
5	B	20	A
6	B	21	B
7	B	22	B

8	A	23	B
9	A	24	C
10	A	25	B
11	B	26	B
12	B	27	A
13	C	28	B
14	C	29	C
15	A	30	A

Section B: Suggested Answers

1. (8 marks)

a) GIS is a computer-based system used to collect, store, manage, analyse and present geographical information. (2 marks)

b) Components:

- Hardware.
- Software.
- Data.
- People.
- Methods and procedures.

Award any four. (4 marks)

c) Applications:

- Mapping roads and public facilities.
- Monitoring environmental changes.
- Planning agricultural activities.
- Mapping flood-prone areas.
- Supporting emergency responses.

Award any two. (2 marks)

2. (8 marks)

a) GIS development cycle is the sequence of stages followed when collecting, storing, processing, analysing and presenting geographical information. (2 marks)

b) Any three stages explained:

- **Data input:** Collecting geographical information and entering it into a GIS.
- **Data storage:** Keeping spatial and attribute information in organised digital formats.
- **Data output:** Producing maps, tables and other results from GIS.
- **Modelling:** Creating representations of geographical situations to examine possible outcomes.
- **Data analysis:** Examining information to identify spatial patterns and relationships.
- **Data presentation:** Displaying GIS results through maps, reports and other visual forms.

(2 marks each)

3. (8 marks)

a)

- Spatial data describes the location, shape, size and position of geographical features. (2 marks)
- Attribute data describes the characteristics and properties of geographical features. (2 marks)

b)

- Point data: Represents features using points, such as boreholes and schools.
- Line data: Represents features using lines, such as roads and rivers.
- Polygon data: Represents features using enclosed areas, such as farms and lakes.

(1 mark each)

c) Satellite image, aerial photograph or digital elevation model. (1 mark)

4. (8 marks)

a) GPS is a satellite-based navigation system used to determine geographical position and other location-related information. (2 marks)

b) Uses:

- Recording coordinates of geographical features.
- Mapping roads and rivers.
- Locating schools and hospitals.
- Navigation and route planning.
- Monitoring wildlife.
- Collecting geographical fieldwork data.

Award any four. (4 marks)

c)

- It helps emergency teams identify accident locations.
- It guides ambulances and rescue teams to incident scenes.
- It assists in identifying alternative routes.
- It helps emergency call centres locate incidents.

Award any two explained points. (2 marks)

5. (10 marks)

a)

- **GeoTIFF:** Stores raster images together with geographical reference information, such as satellite imagery and elevation data. (2 marks)
- **Shapefile:** Stores vector geographical features such as points, lines and polygons, together with attribute information. (2 marks)
- **KML:** Stores geographical features and information for display on digital maps such as Google Earth. (2 marks)
- **CSV:** Stores tabular information such as feature names, latitude, longitude and other attributes in comma-separated columns. (2 marks)

b)

- Makes geographical information easier to store and retrieve.
- Allows data to be edited and updated.
- Makes information easier to share.
- Supports geographical analysis.
- Reduces the need for physical storage.

Award any two. (2 marks)

6. (8 marks)

a) Features:

- Classrooms.
- Administration block.
- Main gate.
- Library.
- Borehole.
- Playground.
- School kitchen.
- Toilets.
- Trees.

Award any four. (2 marks)

b) Steps:

- Switch on the GPS receiver or activate location services on a smartphone.
- Wait for the device to acquire a stable GPS signal.
- Identify the feature to be recorded.
- Record its latitude and longitude.
- Assign a unique identification number.

- Verify the recorded coordinates.
- Repeat the process for other features.

Award any three correctly explained steps. (3 marks)

c) Attribute information:

- Name of the feature.
- Type or category of the feature.
- Condition of the feature.
- Purpose or function.
- Date of data collection.
- Number of rooms or other relevant measurements.

Award any three. (3 marks)

Competency-Based Learning Project

Project: Developing a Digital GIS Map of the School Compound

Project task: Work in groups to develop a digital map showing important geographical features within your school compound.

Project Activities

1. Identify the geographical features to be mapped.
2. Obtain permission from the school administration.
3. Prepare a data collection sheet.
4. Use a GPS-enabled device to record the geographical coordinates of selected features.
5. Collect attribute information about each feature.
6. Organise the collected data in a spreadsheet.
7. Save the data using the CSV format.
8. Import the CSV file into GIS software.
9. Display the recorded geographical features on a digital map.
10. Add suitable labels and symbols.
11. Interpret the resulting map.
12. Present the completed map to the class.

Expected Project Output

Learners should produce:

- A completed field data collection sheet.
- A CSV file containing spatial and attribute information.
- A digital map of the school compound.
- A brief report explaining the methods used.
- Recommendations on how GIS information can improve school planning.

Competencies Developed

Competency	**How it is developed**
Digital literacy	Using GPS devices, spreadsheets and GIS software
Critical thinking and problem-solving	Identifying suitable methods of collecting and analysing data
Communication	Presenting the completed GIS map
Collaboration	Working together during field data collection
Creativity and imagination	Designing an informative digital map
Learning to learn	Researching new GIS technologies and applications

Values Developed

- Responsibility when handling equipment and geographical information.
- Cooperation during group activities.

- Respect for school property.
- Honesty when recording field data.
- Accountability when presenting findings.
- Respect for privacy and confidentiality.

Assessment Rubric

Assessment area	**Marks**
Identification of geographical features	5
Accuracy of GPS data collection	10
Collection of attribute data	5
Organisation of CSV data	5
Production of digital GIS map	10
Interpretation and presentation	5
Total	40

STRAND 2.0: NATURAL SYSTEMS AND PROCESSES

SUB-STRAND 2.1: WEATHER

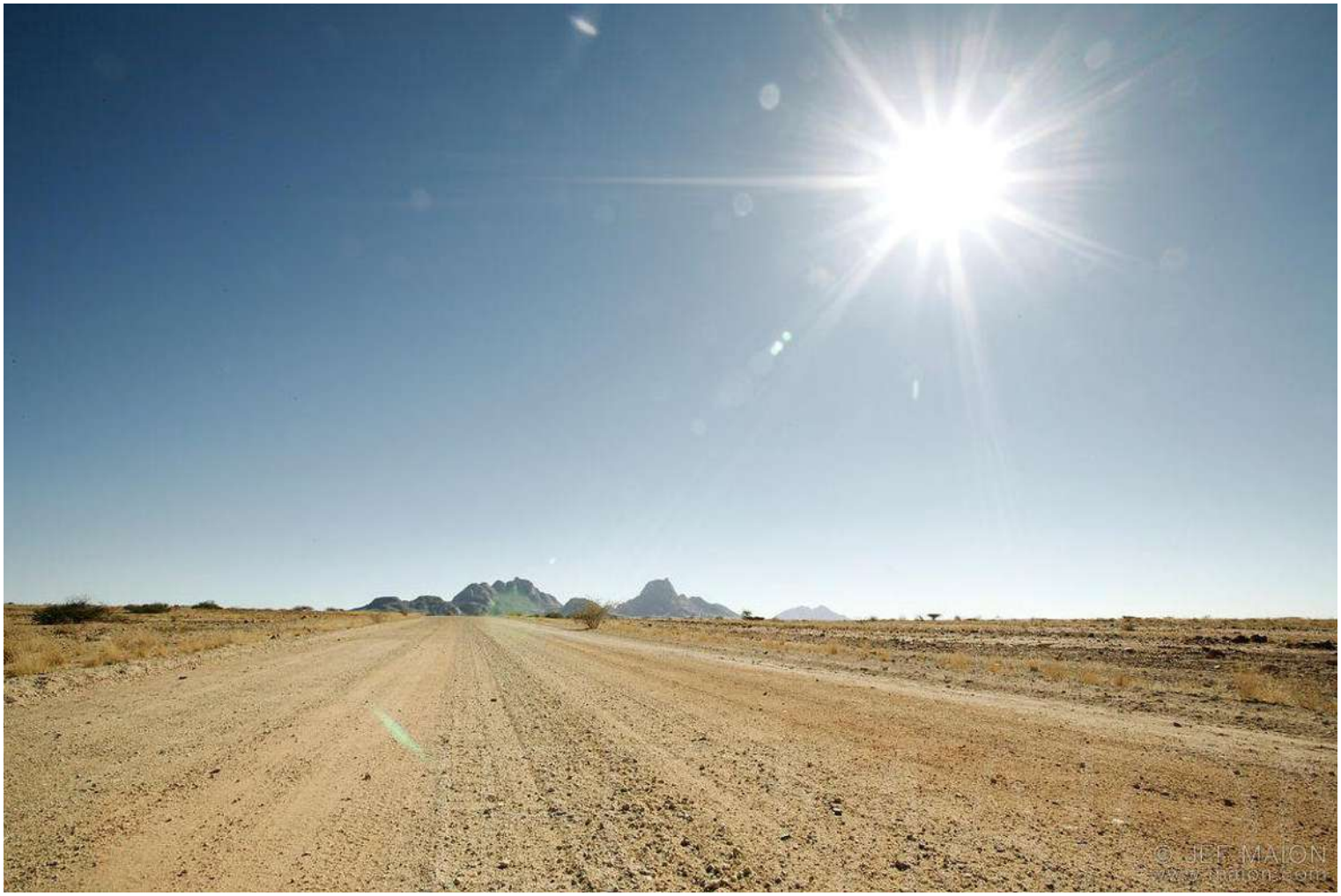
1.0 Introduction to Weather

Weather is one of the natural processes that influence human activities and the physical environment. It affects agriculture, transport, fishing, tourism, construction, settlement and many other economic activities.

In Kenya, weather conditions vary from one region to another because of differences in altitude, relief, distance from the sea, vegetation cover and prevailing winds.

For example:

- The Kenyan coast experiences generally warm and humid conditions.
- The central highlands experience relatively cool conditions because of their high altitude.
- Northern Kenya experiences hot and dry conditions for much of the year.
- The Lake Victoria basin experiences humid conditions and frequent rainfall in many areas.
- The slopes of Mount Kenya and the Aberdare Range receive considerable orographic rainfall.



1.1 Meaning of Weather

Weather refers to the condition of the atmosphere at a particular place and time, with respect to elements such as temperature, rainfall, humidity, cloud cover, wind, atmospheric pressure and sunshine.

Weather describes the short-term state of the atmosphere. It may change within minutes, hours or days.

Examples of weather conditions:

1. A hot and sunny afternoon in Lodwar.
2. A cool and cloudy morning in Nyahururu.
3. A rainy evening in Kisumu.
4. A windy day in Mombasa.
5. A cold and foggy morning in the Aberdare highlands.

1.2 Meaning of Climate

Climate refers to the average pattern of weather conditions experienced in a place over a long period, conventionally about 30 years or more.

Climate describes the general atmospheric conditions of a place over many years.

Examples:

- The climate of northern Kenya is generally arid and semi-arid.
- The Kenyan coast has a tropical maritime climate.
- The central highlands have relatively cool conditions compared with the lowlands.
- Mountain areas experience cooler conditions with increasing altitude.

1.3 Differences between Weather and Climate

Weather	Climate
Refers to the atmospheric condition of a place at a particular time.	Refers to the long-term average pattern of weather.
Changes over short periods.	Changes over long periods.
Can change within hours or days.	Usually assessed over decades.
Describes short-term atmospheric conditions.	Describes long-term atmospheric patterns.
Example: It is raining in Nakuru today.	Example: The area generally experiences two rainy seasons.

1.4 Importance of Studying Weather

The study of weather is important because it helps people understand atmospheric conditions and prepare for changes in the environment.

1. **Agriculture:** Farmers use weather information to determine suitable planting and harvesting periods.
2. **Transport:** Weather forecasts help pilots, motorists, sailors and other transport operators plan safe journeys.
3. **Disaster management:** Weather information helps communities prepare for floods, droughts, storms and strong winds.
4. **Water resource management:** Rainfall information helps in planning water storage, irrigation and water supply.
5. **Fishing:** Fishermen use wind and weather information to determine safe periods for fishing.
6. **Tourism:** Weather forecasts help tourists and tourism operators plan outdoor activities.
7. **Construction:** Builders use weather information to plan activities such as roofing, road construction and concrete work.
8. **Public health:** Weather information helps health authorities prepare for weather-related health risks, such as heat stress.

9. **Aviation:** Pilots use weather information to assess visibility, wind conditions, cloud cover and storms.
10. **Energy production:** Weather information supports the planning of solar, wind and hydroelectric power generation.
11. **Environmental conservation:** Weather observations help monitor environmental changes and ecosystem conditions.
12. **Daily activities:** People use weather forecasts to plan clothing, travel, outdoor work and social activities.

2.0 Elements of Weather

2.1 Meaning of Elements of Weather

Elements of weather are the measurable atmospheric conditions that describe the state of the atmosphere at a particular place and time.

The main elements of weather are:

1. Temperature.
2. Precipitation.
3. Humidity.
4. Cloud cover.
5. Wind.
6. Atmospheric pressure.
7. Sunshine.

2.2 Temperature

Meaning of Temperature

Temperature refers to the degree of hotness or coldness of the atmosphere at a particular place and time.

It indicates how warm or cold the air is.

Temperature is mainly influenced by the amount of solar energy received by the Earth's surface and the way this energy is transferred to the atmosphere.

Sources of Atmospheric Heat

The main source of heat for the Earth's atmosphere is the Sun.

The process through which the atmosphere receives heat includes:

a) Solar radiation

Solar radiation is energy transmitted from the Sun through space in the form of electromagnetic waves.

- The Earth's surface absorbs some of the incoming solar radiation.
- The absorbed energy warms the land and water surfaces.
- The warmed surfaces transfer heat to the air above them.

b) Terrestrial radiation

Terrestrial radiation is the energy emitted by the Earth's surface after absorbing solar radiation.

- The Earth's surface absorbs solar energy during the day.

- It becomes warmer.
- It releases energy as long-wave radiation.
- Greenhouse gases and clouds absorb and re-emit some of this energy, warming the lower atmosphere.

c) Conduction

Conduction is the transfer of heat from one substance to another through direct contact.

- The Earth's surface becomes heated by solar radiation.
- Air in contact with the warm surface gains heat.
- Heat is transferred from the ground to the lower layers of the atmosphere.

d) Convection

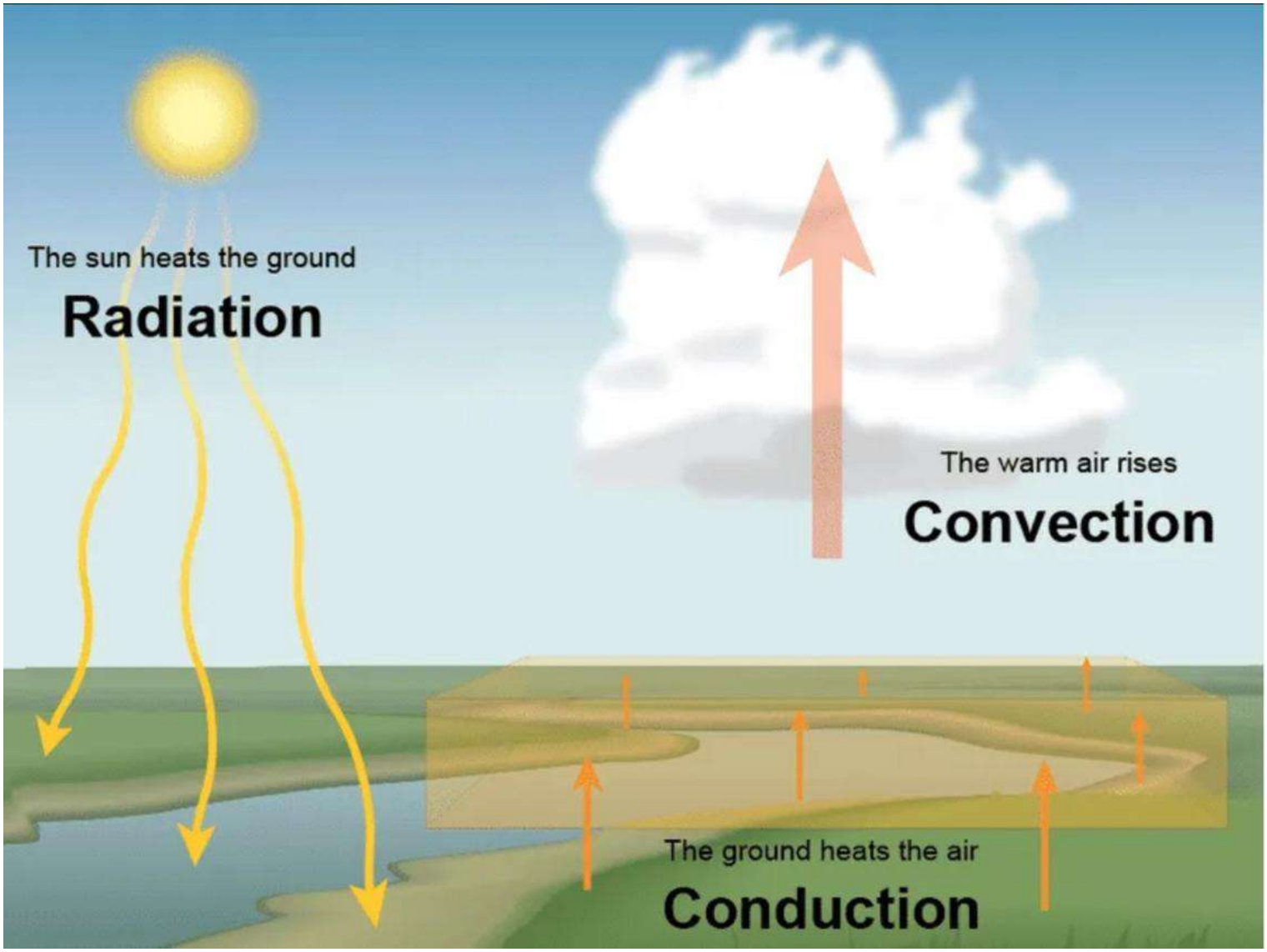
Convection is the transfer of heat through the vertical movement of fluids such as air.

- Air near the Earth's surface becomes heated.
- The warm air expands and becomes less dense.
- It rises into the atmosphere.
- Cooler, denser air descends to replace it.

e) Advection

Advection is the horizontal transfer of heat by moving air.

For example, warm air moving from a warmer region into a cooler region may increase temperatures in the receiving area.



Factors Influencing Temperature

1. Latitude

- Places near the Equator receive relatively direct solar rays.
- Places farther from the Equator receive more oblique solar rays.
- Therefore, temperatures generally decrease towards higher latitudes.

Kenyan example: Kenya lies close to the Equator and generally experiences warm temperatures, although altitude and other factors cause regional variations.

2. Altitude

- Temperature generally decreases with increasing altitude in the troposphere.
- Higher places are usually cooler than low-lying areas.
- The average environmental lapse rate is approximately 6.5°C per 1,000 metres, although actual lapse rates vary.

Kenyan example: Nyahururu and areas around Mount Kenya are generally cooler than low-lying areas such as Garissa and Lodwar.

3. Distance from the sea

- The sea heats up and cools down more slowly than land.

- Coastal areas generally experience smaller daily and annual temperature ranges than many inland areas.
- Inland areas may experience greater temperature variations.

Kenyan example: Mombasa experiences a maritime influence from the Indian Ocean, while inland areas may experience greater temperature variations.

4. Ocean currents

- Warm ocean currents can raise the temperatures of nearby coastal areas.
- Cold ocean currents can lower the temperatures of nearby coastal areas.
- They may also influence humidity and rainfall patterns.

5. Cloud cover

- Clouds may reduce the amount of solar radiation reaching the Earth's surface during the day.
- At night, clouds absorb and re-emit some outgoing terrestrial radiation.
- Therefore, cloudy days may be cooler, while cloudy nights may be warmer than clear nights under comparable conditions.

6. Nature of the Earth's surface

Different surfaces absorb and reflect solar radiation differently.

- Dark surfaces generally absorb more solar energy.
- Light-coloured surfaces reflect more solar energy.
- Vegetation may provide shade and cool the surrounding environment.
- Bare ground may heat up considerably during sunny conditions.

7. Prevailing winds

- Winds transport air from one region to another.
- Warm winds may raise temperatures.
- Cold winds may lower temperatures.
- Winds passing over the sea may bring moist air.

8. Aspect and slope orientation

- Slopes facing the direction of stronger sunshine may receive more solar energy.
- Slopes receiving less direct sunshine may remain relatively cool.
- In the Southern Hemisphere, north-facing slopes generally receive more direct sunshine; in the Northern Hemisphere, south-facing slopes generally receive more direct sunshine.

Measurement of Temperature

Temperature is measured using an instrument called a **thermometer**.

The common units of measurement are:

- Degrees Celsius (°C).
- Degrees Fahrenheit (°F).

- Kelvin (K).

In weather stations, temperatures are commonly recorded in degrees Celsius.

Types of Thermometers Used in Weather Stations

a) Ordinary thermometer

- Used to measure the temperature of the air at a particular time.
- Usually graduated in degrees Celsius.
- Must be properly exposed to ventilated air while protected from direct solar radiation.

b) Maximum thermometer

- Records the highest air temperature reached during a specified period, commonly 24 hours.
- It contains a constriction that prevents the liquid from returning freely after reaching its maximum level.
- It is reset after the reading is taken.

c) Minimum thermometer

- Records the lowest air temperature reached during a specified period.
- It commonly uses alcohol and an index that moves with the liquid.
- It is reset after the reading is taken.

d) Six's maximum and minimum thermometer

- Records both the highest and lowest temperatures over a specified period.
- It has two indices that indicate the maximum and minimum temperatures.
- It is useful in weather stations.

Stevenson Screen

A Stevenson screen is a specially designed wooden or metal enclosure used to house weather instruments such as thermometers.

Characteristics of a Stevenson screen

1. It is painted white to reflect solar radiation.
2. It has louvred sides to allow free circulation of air.
3. It is raised above the ground, commonly about 1.2 metres, following standard observing practice.
4. It has a double roof to reduce heating from direct sunshine.
5. It is positioned over a level surface, preferably short grass.
6. Its door is usually positioned to minimise direct sunlight entering during observations.
7. It protects instruments from direct sunshine and rainfall while allowing ventilation.

Importance of a Stevenson screen

- Protects thermometers from direct solar radiation.

- Prevents rainfall from directly affecting the instruments.
- Allows free circulation of air.
- Reduces errors caused by heating of the instrument enclosure.
- Provides more standardised conditions for temperature measurement.

Recording Temperature

Temperature readings are recorded at standard observation times.

A weather station may record:

- Current temperature.
- Maximum temperature.
- Minimum temperature.
- Date and time of observation.

Example of a temperature record

Date	**Maximum temperature (°C)**	**Minimum temperature (°C)**
Monday	28	17
Tuesday	29	18
Wednesday	27	16
Thursday	30	19
Friday	28	17

Calculating Daily Temperature Range

The daily temperature range is the difference between the maximum and minimum temperatures recorded during a day.

Daily range=Maximum temperature–Minimum temperatureDaily range=Maximum temperature–Minimum t emperature

Example

A weather station records:

- Maximum temperature = 30°C.
- Minimum temperature = 18°C.

30–18=12∘

Therefore, the daily temperature range is **12°C**.

Calculating Mean Daily Temperature

Mean daily temperature is the average of the maximum and minimum temperatures recorded during the day.

Mean daily temperature=Maximum+Minimum2Mean daily temperature=2Maximum+Minimum

Example

Maximum temperature = 28°C.

Minimum temperature = 16°C.

28+162=442=22∘C228+16=244=22∘*C*

Mean daily temperature = **22°C**.

Importance of Measuring Temperature

- Helps farmers plan agricultural activities.
- Supports weather forecasting.
- Helps identify heatwaves and cold conditions.
- Supports studies of climate change.
- Helps determine suitable conditions for crop growth.
- Assists in planning outdoor activities.
- Supports health and environmental monitoring.

2.3 Precipitation

Meaning of Precipitation

Precipitation refers to all forms of water, in liquid or solid form, that fall from the atmosphere and reach the Earth's surface.

The main forms of precipitation include:

- Rain.
- Drizzle.
- Snow.
- Sleet.
- Hail.



Forms of Precipitation

a) Rain

Rain is liquid water that falls from clouds in the form of water droplets.

- It is the most common form of precipitation in many parts of Kenya.
- It supports crop growth, livestock production and water supply.
- Heavy rainfall may cause flooding and soil erosion.

b) Drizzle

Drizzle consists of very small water droplets falling slowly from low clouds.

- It is usually light and continuous.
- It may occur in cloudy and cool conditions.
- It is common in some highland and coastal environments.

c) Snow

Snow consists of ice crystals that form in clouds and fall to the Earth's surface.

- It forms under sufficiently cold atmospheric conditions.
- It may occur on high mountain peaks.
- In Kenya, snow and ice are associated with the highest parts of Mount Kenya.

d) Sleet

Sleet generally refers to small ice pellets or a mixture of rain and partially frozen precipitation, depending on regional usage.

- It forms when precipitation passes through layers of cold air.
- It is more common in colder climates than in most parts of Kenya.

e) Hail

Hail consists of balls or irregular lumps of ice formed within strong thunderstorm clouds.

- Strong upward air currents carry water droplets into very cold parts of clouds.
- The droplets freeze and may grow as layers of ice accumulate.
- Hailstones eventually become heavy enough to fall.

How Precipitation Forms

1. The Sun heats water bodies and moist surfaces.
2. Water evaporates into the atmosphere.
3. Plants release water vapour through transpiration.
4. Moist air rises and expands.
5. Rising air cools.
6. Water vapour condenses around tiny particles called condensation nuclei.
7. Tiny cloud droplets or ice crystals form.
8. These particles grow through collision, coalescence or ice-crystal processes.
9. When they become sufficiently large and heavy, they fall as precipitation.

Types of Rainfall

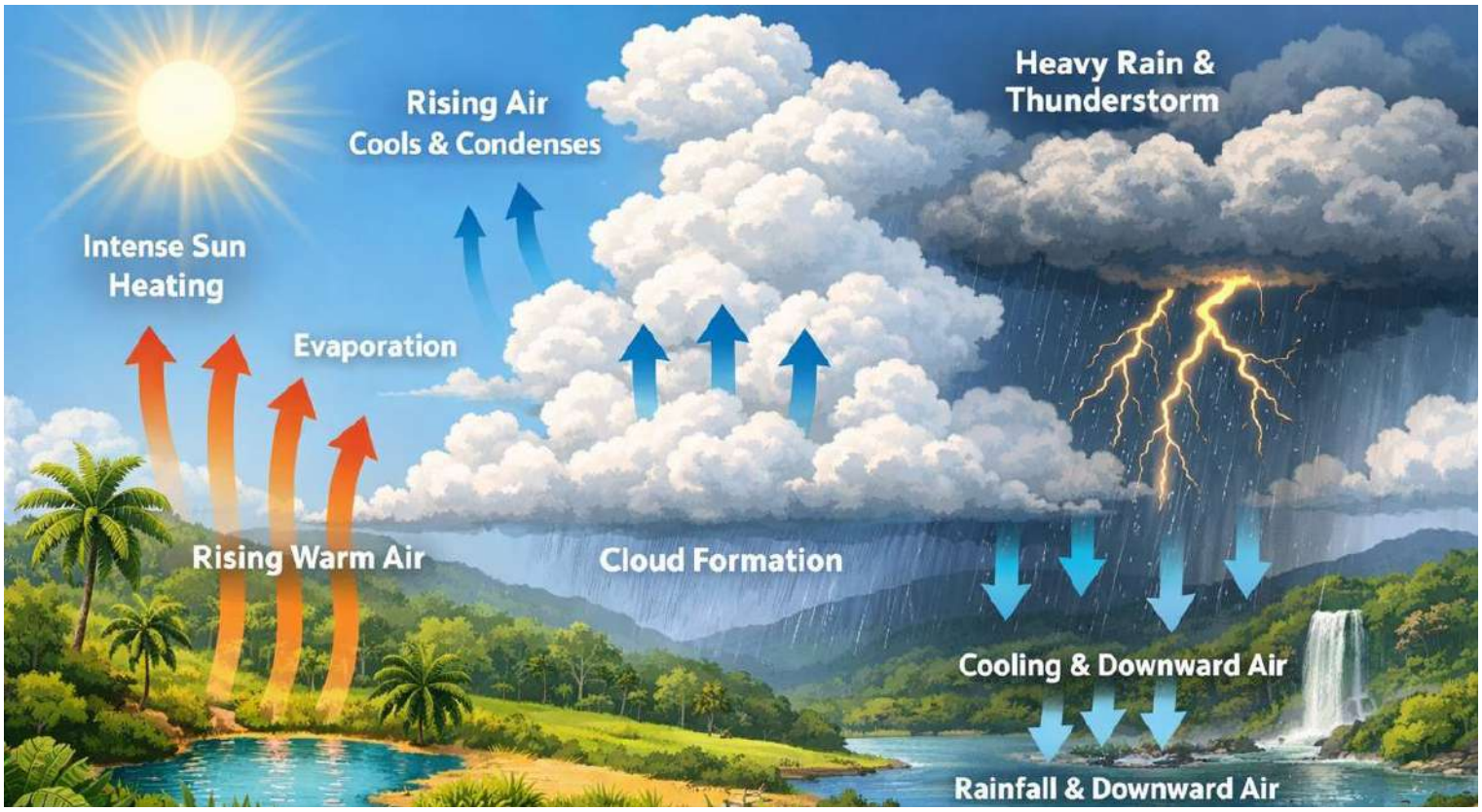
Rainfall is commonly classified according to the process that causes moist air to rise.

a) Convectional rainfall

Convectional rainfall occurs when the Earth's surface is strongly heated, causing warm moist air to rise, cool and condense to form clouds and rainfall.

Formation process

1. The Sun heats the Earth's surface.
2. The surface heats the air above it.
3. Warm moist air rises through convection.
4. The rising air expands and cools.
5. Water vapour condenses to form clouds.
6. Heavy rainfall may occur, sometimes accompanied by thunder and lightning.



Characteristics

- Often occurs in the afternoon in tropical regions.
- May be heavy and short-lived.
- May be accompanied by thunderstorms.
- Can occur throughout the year where moisture and heating are sufficient.

Areas in Kenya where it may occur

- Lake Victoria basin.

- Western Kenya.
- Some parts of the central highlands.
- Areas experiencing strong surface heating and adequate moisture.

b) Relief or orographic rainfall

Relief rainfall occurs when moist air is forced to rise over a highland or mountain barrier.

Formation process

1. Moist winds blow towards a mountain.
2. The air is forced to rise along the windward slope.
3. Rising air expands and cools.
4. Water vapour condenses to form clouds.
5. Rain falls on the windward side.
6. The air descends on the leeward side, warms and becomes relatively drier.

Characteristics

- Occurs mainly on windward slopes.
- Rainfall may increase with altitude up to a certain level.
- The leeward side may experience a rain-shadow effect.
- It is influenced by the direction of prevailing moist winds.

Kenyan examples

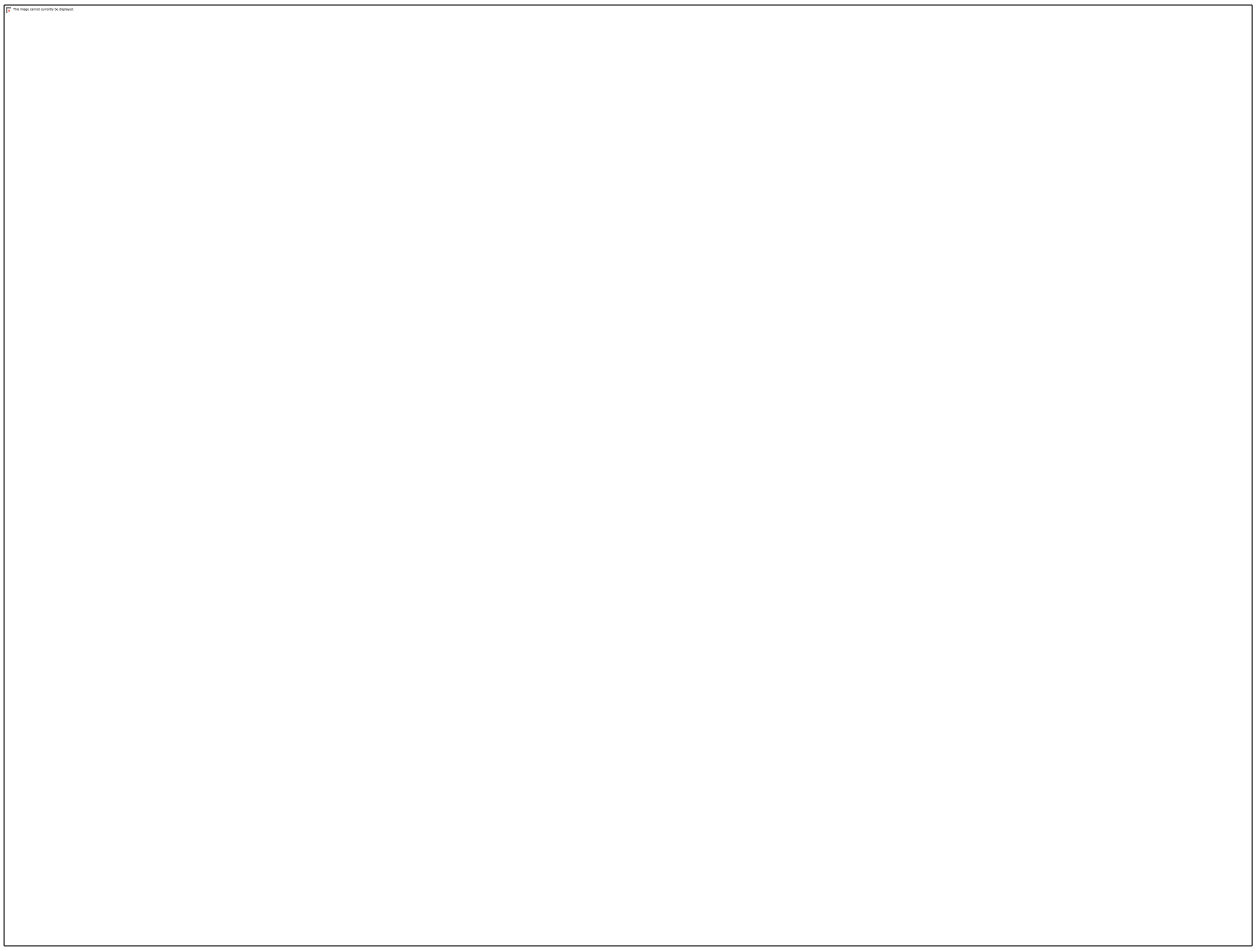
- Windward slopes of Mount Kenya.
- Parts of the Aberdare Range.
- Slopes of the Mau Escarpment.
- Other highland areas exposed to moist winds.

c) Frontal or cyclonic rainfall

Frontal rainfall occurs when two air masses with different temperatures meet and the warmer, less dense air is forced to rise over the colder, denser air.

Formation process

1. A warm air mass meets a cold air mass.
2. The warm air rises over the cold air.
3. The warm air expands and cools.
4. Water vapour condenses to form clouds.
5. Rainfall occurs along the frontal zone.



Characteristics

- Occurs along boundaries between contrasting air masses.
- May cover extensive areas.
- Can last for several hours or days.
- Often produces widespread cloud cover and rainfall.

Comparison of the Three Types of Rainfall

Convectional rainfall	**Relief rainfall**	**Frontal rainfall**
Caused by surface heating.	Caused by mountain barriers.	Caused by meeting air masses.
Warm moist air rises vertically.	Air rises along windward slopes.	Warm air rises over cold air.
Often produces heavy showers.	Mainly affects windward slopes.	May affect large geographical areas.
Common in tropical regions.	Common in mountainous regions.	Common in regions with active fronts.

Measurement of Precipitation

Precipitation is commonly measured using a **rain gauge**.

A rain gauge is an instrument used to collect and measure the amount of rainfall received at a particular place over a specified period.

Parts of a Standard Rain Gauge

1. **Funnel:** Directs rainwater into the collecting container.
2. **Collector:** Receives and stores the collected rainwater.
3. **Outer casing:** Protects the collecting parts and supports the instrument.
4. **Measuring cylinder:** Used to measure the collected rainfall.
5. **Rim:** Provides the opening through which rainfall enters.

How to Measure Rainfall Using a Rain Gauge

1. Place the rain gauge in an open area away from buildings and trees.
2. Ensure that it is vertical and firmly fixed.
3. Make sure its collecting rim is horizontal.
4. Allow rainfall to collect in the container.
5. At the observation time, remove the collected water carefully.
6. Pour the water into a graduated measuring cylinder where required.
7. Read the rainfall amount at eye level.
8. Record the reading in millimetres.
9. Empty and replace the container for the next observation.

Units of Rainfall Measurement

Rainfall is measured in millimetres (mm).

One millimetre of rainfall represents one litre of water spread evenly over an area of one square metre.

Recording Rainfall

Rainfall records are usually kept daily, monthly and annually.

Example of a rainfall record

Day	**Rainfall (mm)**
Monday	12
Tuesday	0
Wednesday	18
Thursday	5
Friday	10

Total	45

Total rainfall:

45 mm

The total rainfall for the five days is **45 mm**.

Precautions When Measuring Rainfall

- Place the rain gauge in an open area.
- Avoid placing it under trees or near buildings.
- Keep the instrument vertical.
- Ensure that the rim is horizontal.
- Avoid spilling water during measurement.
- Take readings at consistent times.
- Record rainfall immediately after measurement.
- Keep the instrument clean and in good condition.

Importance of Measuring Precipitation

1. Helps farmers plan planting and harvesting.
2. Supports drought monitoring.
3. Helps in flood forecasting.
4. Supports water resource management.
5. Assists in planning irrigation.
6. Helps monitor climate variability.
7. Supports hydrological studies.
8. Helps in designing drainage systems.
9. Supports the management of dams and reservoirs.
10. Provides information for weather forecasting.

2.4 Humidity

Meaning of Humidity

Humidity refers to the amount of water vapour present in the atmosphere.

Water vapour is the gaseous form of water found in the air. It enters the atmosphere mainly through evaporation from water bodies and transpiration from plants.

Humidity is an important element of weather because it influences cloud formation, rainfall, evaporation and human comfort.

Types of Humidity

a) Absolute humidity

Absolute humidity is the actual mass of water vapour contained in a given volume of air.

It is commonly expressed in grams per cubic metre (g/m^3).

Absolute humidity=Mass of water vapourVolume of airAbsolute humidity=Volume of airMass of water vapour

Example:

If 12 grams of water vapour are present in 3 cubic metres of air:

$12/3=4\ g/m^3$

The absolute humidity is 4 g/m^3.

b) Relative humidity

Relative humidity is the ratio of the actual amount of water vapour in the air to the maximum amount the air can hold at the same temperature, expressed as a percentage.

RH=Actual water vapour contentSaturation water vapour content×100RH=Saturation water vapour contentAct ual water vapour content×100

Example:

If the actual water vapour content is 12 g/m^3 and the saturation water vapour content at the same temperature is 20 g/m^3:

RH=12/20×100=60%

Therefore, the relative humidity is **60%**.

c) Specific humidity

Specific humidity is the mass of water vapour contained in a unit mass of moist air.

It is commonly expressed in grams of water vapour per kilogram of moist air (g/kg).

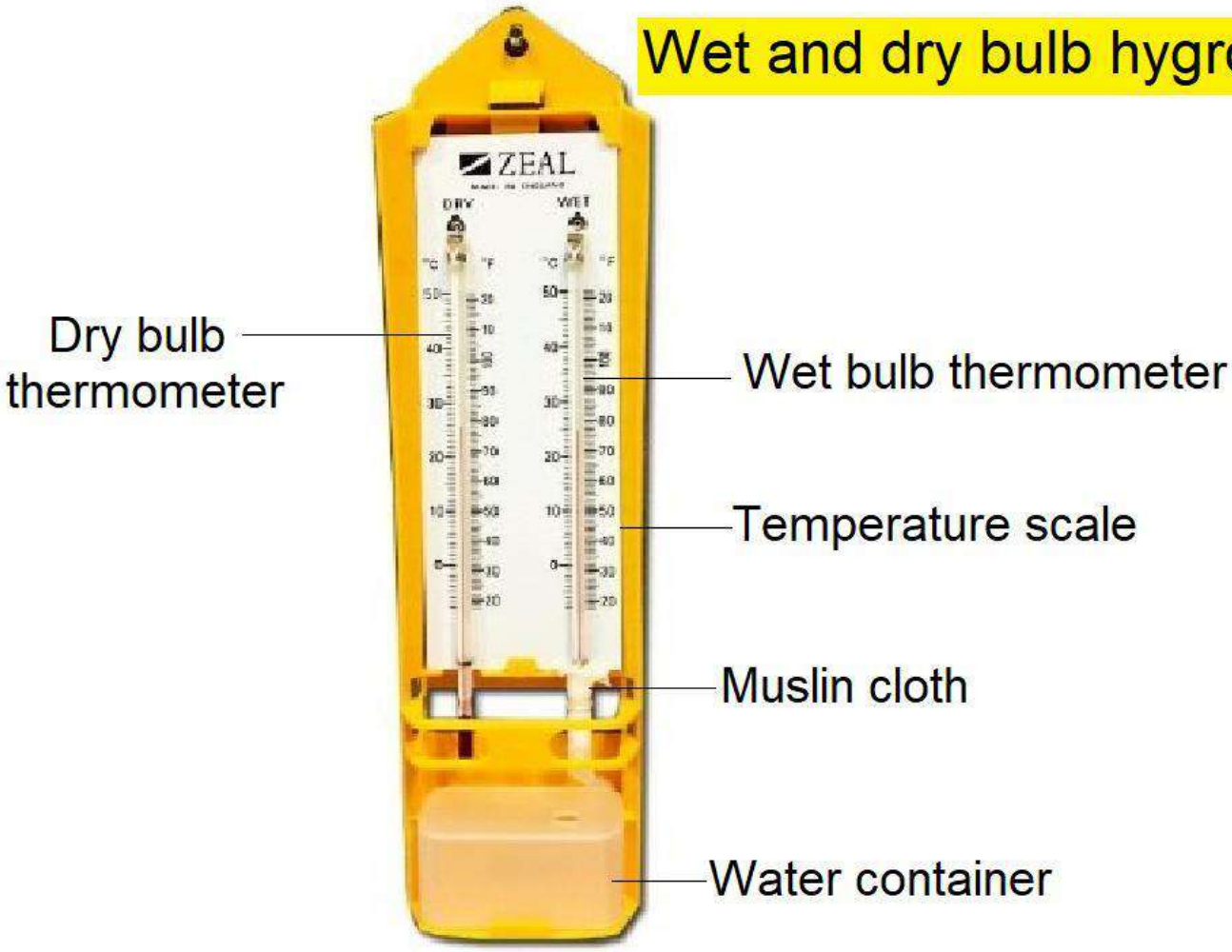
Factors Influencing Humidity

1. **Temperature:** Warm air can generally contain more water vapour before becoming saturated than cold air.
2. **Distance from water bodies:** Places near oceans, lakes and rivers often experience higher humidity because of evaporation.
3. **Vegetation:** Areas with dense vegetation may have higher humidity because plants release water vapour through transpiration.
4. **Evaporation:** High rates of evaporation increase the amount of water vapour entering the atmosphere.
5. **Wind:** Winds may transport moist or dry air from one area to another.
6. **Rainfall:** Rainfall and wet surfaces may contribute to increased atmospheric moisture.
7. **Altitude:** Humidity conditions vary with altitude because of differences in temperature, air pressure and moisture supply.

Measurement of Humidity

Humidity is measured using an instrument called a **hygrometer**.

A common type of humidity-measuring instrument used in weather stations is the wet-and-dry bulb hygrometer, also known as a psychrometer.



Wet-and-Dry Bulb Hygrometer

This instrument consists of two thermometers:

1. **Dry-bulb thermometer:** Measures the ordinary air temperature.
2. **Wet-bulb thermometer:** Has its bulb covered with a clean, moist wick.

How a Wet-and-Dry Bulb Hygrometer Works

- The dry-bulb thermometer records the air temperature.
- Water evaporates from the wet wick surrounding the wet-bulb thermometer.
- Evaporation removes heat from the wet bulb.
- The wet bulb therefore usually records a lower temperature than the dry bulb.
- The difference between the two readings is used with a psychrometric table to determine relative humidity.

Important observations:

- When the air is dry, evaporation from the wet bulb is faster and the temperature difference is usually greater.
- When the air is humid, evaporation is slower and the temperature difference is usually smaller.
- When the air is saturated, the wet-bulb and dry-bulb temperatures are approximately equal.

Other Humidity Instruments

a) Hair hygrometer

- Uses the property of human or animal hair to change length with changes in humidity.
- The change in length is connected to a pointer.
- The pointer indicates relative humidity on a scale.

b) Electronic hygrometer

- Uses electronic sensors to measure humidity.
- Displays readings digitally.
- Can be used in automated weather stations.

Recording Humidity

Relative humidity is recorded as a percentage (%).

Example:

Time	Relative humidity
6:00 a.m.	85%
9:00 a.m.	72%
12:00 noon	55%
3:00 p.m.	48%
6:00 p.m.	70%

The figures show how relative humidity may vary during the day.

Importance of Measuring Humidity

1. Helps predict cloud formation and rainfall.
2. Supports weather forecasting.
3. Helps farmers monitor conditions affecting crops.
4. Helps assess human comfort.
5. Supports the storage of agricultural products.
6. Helps monitor conditions in greenhouses.
7. Supports the study of evaporation and transpiration.
8. Helps in managing moisture-sensitive materials.

2.5 Cloud Cover

Meaning of Clouds

Clouds are visible masses of tiny water droplets, ice crystals or a mixture of both suspended in the atmosphere.

They form when moist air rises, cools and reaches saturation, causing water vapour to condense or deposit onto tiny particles in the atmosphere.



Meaning of Cloud Cover

Cloud cover refers to the proportion of the sky covered by clouds when observed from a particular location.

It is commonly estimated in oktas, where the sky is divided into eight equal parts.

Classification of Clouds

Clouds are classified according to their appearance, height and form.

The main cloud groups include:

1. High clouds.
2. Middle clouds.
3. Low clouds.
4. Clouds with extensive vertical development.

A. High Clouds

High clouds generally occur at altitudes above approximately 6,000 metres in the middle latitudes. Their actual heights vary with latitude and atmospheric conditions.

They are mainly composed of ice crystals.

1. Cirrus clouds

Characteristics:

- They are thin, white and wispy.
- They have a feather-like appearance.
- They occur at high altitudes.
- They are mainly made of ice crystals.
- They usually do not produce rainfall reaching the ground.
- They may indicate changes in weather conditions, especially when they increase and thicken ahead of an approaching weather system.

2. Cirrostratus clouds

Characteristics:

- They form thin, whitish sheets covering large areas of the sky.
- They may give the sky a milky appearance.
- They sometimes produce a halo around the Sun or Moon.
- They are mainly composed of ice crystals.
- They may precede widespread rainfall when associated with an approaching frontal system.

3. Cirrocumulus clouds

Characteristics:

- They consist of small white cloudlets.
- They often appear in rows or rippled patterns.
- They resemble fish scales.
- They occur at high altitudes.
- They are mainly composed of ice crystals.

B. Middle Clouds

Middle clouds generally occur at altitudes of about 2,000–7,000 metres in the middle latitudes. Their height ranges vary according to geographical location.

1. Altostratus clouds

Characteristics:

- They form grey or bluish-grey sheets.
- They cover large portions of the sky.
- The Sun may appear as a dim disc through them.

- They may produce light precipitation.
- They may thicken before more widespread rainfall.

2. Altocumulus clouds

Characteristics:

- They appear as white or grey patches.
- They may form rounded masses or rolls.
- They often occur in groups.
- They have a lumpy appearance.
- They may indicate atmospheric instability when conditions are favourable.

C. Low Clouds

Low clouds generally occur below approximately 2,000 metres in the middle latitudes.

1. Stratus clouds

Characteristics:

- They form a uniform grey layer.
- They often cover most of the sky.
- They resemble fog raised above the ground.
- They may produce drizzle or light rain.
- They commonly occur in cool, moist conditions.

2. Stratocumulus clouds

Characteristics:

- They appear as large, rounded cloud masses.
- They may form a broken or continuous layer.
- They are usually grey or whitish.
- They often cover much of the sky.
- They may produce light rain or drizzle.

3. Nimbostratus clouds

Characteristics:

- They are thick, dark grey clouds.
- They often cover large areas of the sky.
- They produce widespread, continuous rainfall or snowfall where temperatures are sufficiently low.

- They may reduce visibility.
- They are commonly associated with prolonged periods of precipitation.

D. Clouds with Extensive Vertical Development

These clouds grow vertically through a considerable depth of the atmosphere.

1. Cumulus clouds



Characteristics:

- They have a white, fluffy appearance.
- Their bases are usually relatively flat.
- Their tops resemble cauliflower.
- They commonly form due to convection.
- Small cumulus clouds may occur during fair weather.
- They may grow into larger storm clouds when atmospheric conditions are unstable.

2. Cumulonimbus clouds

Characteristics:

- They are very tall clouds with extensive vertical development.
- Their tops may spread out into an anvil shape.
- They are associated with thunderstorms.
- They may produce heavy rainfall.
- They may produce lightning and thunder.
- They can produce hail and strong gusty winds.
- Severe storms may pose dangers to people, buildings and transport.

Summary of Cloud Classification

Cloud	General appearance	Common weather association
Cirrus	Thin, wispy and feather-like	May indicate an approaching weather change
Cirrostratus	Thin, widespread veil	May precede widespread precipitation
Cirrocumulus	Small white ripples or cloudlets	Often associated with high-level atmospheric moisture
Altostratus	Grey or bluish sheet	May accompany prolonged rainfall
Altocumulus	Rounded patches or rolls	May indicate changing atmospheric conditions
Stratus	Uniform low grey layer	Drizzle or light rain
Stratocumulus	Low, rounded masses	Usually cloudy conditions; occasional light precipitation
Nimbostratus	Thick, dark and widespread	Continuous or prolonged precipitation
Cumulus	Fluffy, cauliflower-shaped	Often fair weather when small
Cumulonimbus	Tall, towering cloud with an anvil top	Thunderstorms, heavy rain, hail and lightning

Measurement of Cloud Cover

Cloud cover is commonly estimated by observing the proportion of the sky covered by clouds.

It is recorded in **oktas**.

One okta represents one-eighth of the sky.

Oktas	Description
0	Clear sky
1	One-eighth covered
2	Two-eighths covered
3	Three-eighths covered
4	Half the sky covered

5	Five-eighths covered
6	Six-eighths covered
7	Seven-eighths covered
8	Completely overcast

Instruments Used to Observe Cloud Conditions

a) Human observation

- An observer estimates the proportion of the sky covered by clouds.
- Cloud types and their movements are recorded.
- Observations may be made at standard weather observation times.

b) Ceilometer

A ceilometer is an electronic instrument used to measure the height of the cloud base above the ground.

- It commonly uses a laser or other light-based technology.
- It helps determine cloud-base height.
- It is particularly useful in aviation and automated weather stations.

c) Satellite imagery

- Weather satellites capture images of clouds over large geographical areas.
- They help identify cloud patterns and movement.
- They support monitoring of developing storms and weather systems.

Importance of Studying Clouds

1. Helps predict rainfall.
2. Supports weather forecasting.
3. Helps identify approaching thunderstorms.
4. Supports aviation safety.
5. Helps monitor atmospheric moisture.
6. Assists in understanding atmospheric circulation.
7. Helps farmers plan agricultural activities.
8. Supports the study of rainfall distribution.

2.6 Wind

Meaning of Wind

Wind refers to the horizontal movement of air from an area of relatively high atmospheric pressure towards an area of relatively low atmospheric pressure.

Wind is caused mainly by differences in atmospheric pressure resulting from unequal heating of the Earth's surface.

Wind is described according to:

- Direction.
- Speed.
- Origin.
- Duration.
- Seasonal behaviour.

Causes of Wind

1. Differences in atmospheric pressure

- Air moves from areas of high pressure towards areas of low pressure.
- Greater pressure differences generally produce stronger winds, although friction and other forces also influence wind speed.

2. Unequal heating of the Earth's surface

- The Earth's surface is heated unevenly.
- Warm air tends to rise, while cooler air tends to sink.
- This produces pressure differences that help generate winds.

3. Rotation of the Earth

- The Earth's rotation causes moving air to be deflected by the Coriolis effect.
- Winds are deflected to the right in the Northern Hemisphere.
- Winds are deflected to the left in the Southern Hemisphere.

4. Friction

- The movement of air is slowed by friction with the Earth's surface.
- Friction is greater over rough surfaces such as forests and built-up areas.
- It is generally lower over smooth surfaces such as open water.

5. Relief features

- Mountains and valleys influence wind direction and speed.
- Mountains may obstruct or channel air movement.
- Valleys may guide winds along their length.

Classification of Winds According to Speed

Wind speed refers to how fast air moves over a particular distance during a given time.

It is measured in:

- Metres per second (m/s).
- Kilometres per hour (km/h).

- Knots.

Winds can be described using the Beaufort scale.

The Beaufort Wind Scale

The Beaufort scale classifies wind according to its observed effects and approximate speed.

Beaufort force	Description	Approximate speed (km/h)
0	Calm	Less than 1
1	Light air	1–5
2	Light breeze	6–11
3	Gentle breeze	12–19
4	Moderate breeze	20–28
5	Fresh breeze	29–38
6	Strong breeze	39–49
7	Near gale	50–61
8	Gale	62–74
9	Strong gale	75–88
10	Storm	89–102
11	Violent storm	103–117
12	Hurricane-force	118 and above

The speed ranges are approximate and may differ slightly between reference tables.

Effects of Different Wind Speeds

a) Calm winds

- Smoke rises almost vertically.
- Leaves and small branches remain still.
- The air appears relatively motionless.

b) Light winds

- Leaves and small twigs move gently.

- Wind can be felt on the face.
- Small flags may move.

c) Moderate winds

- Small branches move.
- Dust and loose paper may be lifted.
- Flags extend more noticeably.

d) Strong winds

- Large branches move.
- Walking may become difficult.
- Some light objects may be blown away.
- Damage to weak structures may occur.

e) Gale-force and stronger winds

- Trees may be damaged or uprooted.
- Roofs and weak structures may be damaged.
- Transport and outdoor activities may be disrupted.
- Strong storms may pose serious risks to human life.

Measurement of Wind Speed

Wind speed is measured using an instrument called an **anemometer**.

How a cup anemometer works

1. It has three or four cups attached to horizontal arms.
2. The cups are arranged around a central vertical shaft.
3. Wind pushes the cups, causing them to rotate.
4. The rotation speed is related to wind speed.
5. A mechanical or electronic system converts the rotation into a wind-speed reading.

Other types of anemometers

- Propeller anemometer.
- Sonic anemometer.
- Hot-wire anemometer.

Measurement of Wind Direction

Wind direction is measured using a **wind vane**.

A wind vane indicates the direction from which the wind is blowing.

How a wind vane works

1. It has a freely rotating pointer or arrow.
2. The arrow turns in response to the wind.
3. The arrow aligns with the direction from which the wind is coming.
4. A fixed compass scale indicates the wind direction.

Important: A north wind blows from the north towards the south. Wind direction is named according to where the wind comes from, not where it is going.

Recording Wind Speed and Direction

Wind speed is recorded in m/s, km/h or knots.

Wind direction is recorded using compass points or degrees.

Compass direction	Description
N	North wind
NE	North-east wind
E	East wind
SE	South-east wind
S	South wind
SW	South-west wind
W	West wind
NW	North-west wind

Classification of Winds According to Origin and Behaviour

Winds may be classified into several groups:

1. Planetary or permanent winds.
2. Seasonal or periodic winds.
3. Local winds.
4. Variable winds.

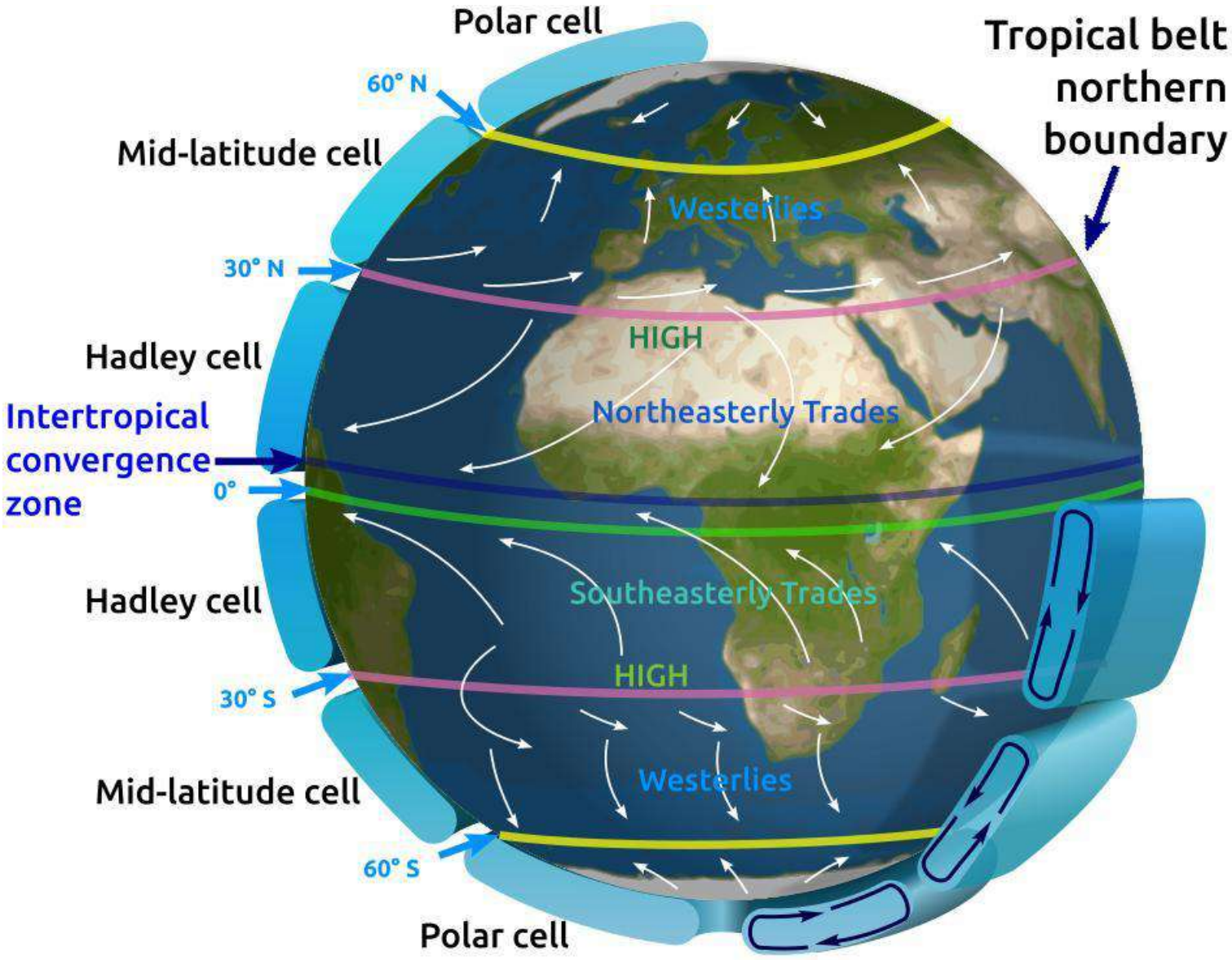
A. Planetary or Permanent Winds

These are large-scale winds that blow over extensive areas of the Earth in relatively consistent directions for much of the year.

They are influenced by global pressure belts, the Earth's rotation and atmospheric circulation.

The main planetary winds are:

a) Trade winds



Characteristics:

- Blow from subtropical high-pressure belts towards the equatorial low-pressure belt.
- They are generally easterly winds.
- North-east trade winds occur in the Northern Hemisphere.
- South-east trade winds occur in the Southern Hemisphere.
- They are influenced by the Coriolis effect.
- They contribute to the movement of moisture and heat around the tropics.

b) Westerlies

Characteristics:

- Blow from subtropical high-pressure belts towards subpolar low-pressure belts.
- They generally blow from west to east.
- They are found mainly in the middle latitudes.
- They influence the movement of weather systems in temperate regions.

c) Polar easterlies

Characteristics:

- Blow from polar high-pressure regions towards subpolar low-pressure regions.
- They are generally cold and dry.

- They generally blow from east to west.
- They are found in high-latitude polar regions.

B. Seasonal or Periodic Winds

These are winds that change direction or strength at particular times due to seasonal or regular changes in atmospheric pressure.

a) Monsoon winds

Monsoon winds are seasonal winds that change direction between seasons because of differences in heating and atmospheric pressure between land and sea.

Summer monsoon

- During summer, land heats up more rapidly than the sea.
- Low pressure develops over the warmer land.
- Relatively higher pressure occurs over the cooler sea.
- Moist winds blow from the sea towards the land.
- They may bring rainfall to affected regions.

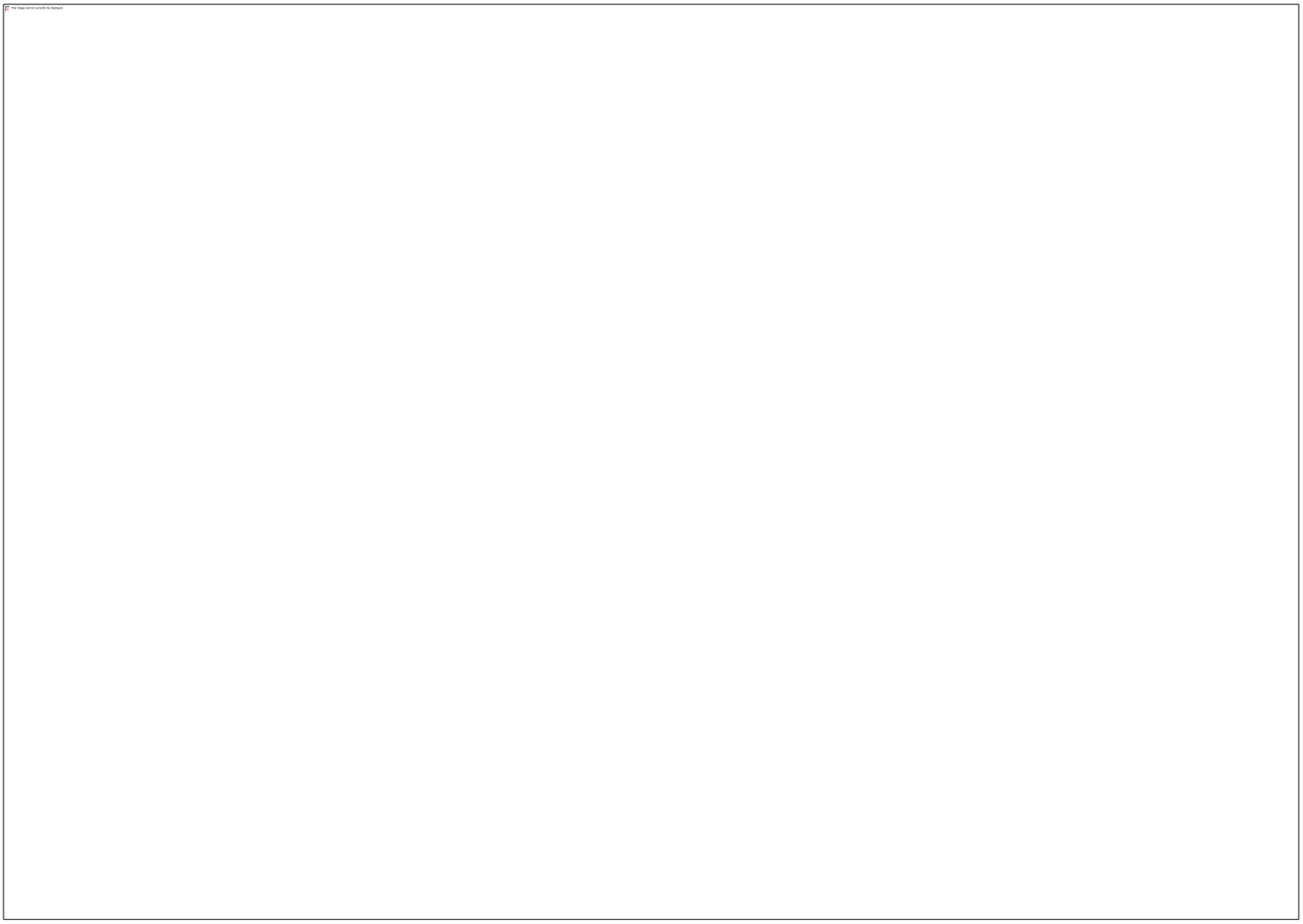
Winter monsoon

- During winter, land cools more rapidly than the sea.
- Higher pressure develops over the colder land.
- Relatively lower pressure occurs over the warmer sea.
- Winds blow from the land towards the sea.
- They are often relatively dry.

b) Land and sea breezes

Land and sea breezes are local winds caused by differences in the rates at which land and water heat and cool.

Sea breeze



- Occurs mainly during the day.
- Land heats up faster than the sea.
- Warm air over the land rises.
- Relatively cooler air moves from the sea towards the land.
- It may bring cooling and moisture to coastal areas.

Land breeze

- Occurs mainly at night.
- Land cools faster than the sea.
- Air over the relatively warmer sea rises.
- Cooler air moves from the land towards the sea.
- It is generally weaker than a sea breeze.

c) Valley and mountain breezes

These are local winds associated with the heating and cooling of mountain slopes.

Valley breeze

- Occurs mainly during the day.

- Mountain slopes are heated by the Sun.
- Air along the slopes becomes warm and rises.
- Air moves upslope from the valley.
- It is also called an anabatic wind.

Mountain breeze

- Occurs mainly at night.
- Mountain slopes cool rapidly.
- Air becomes colder and denser.
- It flows downslope towards the valley.
- It is also called a katabatic wind.

C. Local Winds

Local winds are winds that affect relatively small geographical areas and are influenced by local differences in temperature, pressure and relief.

Examples include:

- Land breeze.
- Sea breeze.
- Valley breeze.
- Mountain breeze.
- Katabatic winds.
- Anabatic winds.

D. Variable Winds

Variable winds are winds whose direction and speed change frequently over a particular area.

They may be influenced by:

- Changing pressure conditions.
- Passing weather systems.
- Local relief.
- Thunderstorms.
- Surface heating.

Importance of Wind

1. Influences the distribution of rainfall.
2. Supports the movement of clouds.
3. Helps in seed and pollen dispersal.
4. Supports wind power generation.

5. Influences evaporation.
6. Helps in ventilation of buildings.
7. Supports sailing and some transport activities.
8. Influences ocean surface currents.
9. Helps in the movement of weather systems.
10. Can cause soil erosion and damage during strong winds.

Harmful Effects of Strong Winds

- Destruction of buildings and roofs.
- Uprooting of trees.
- Damage to crops.
- Soil erosion.
- Disruption of road and air transport.
- Damage to electricity transmission lines.
- Spread of wildfires.
- Loss of life and property during severe storms.

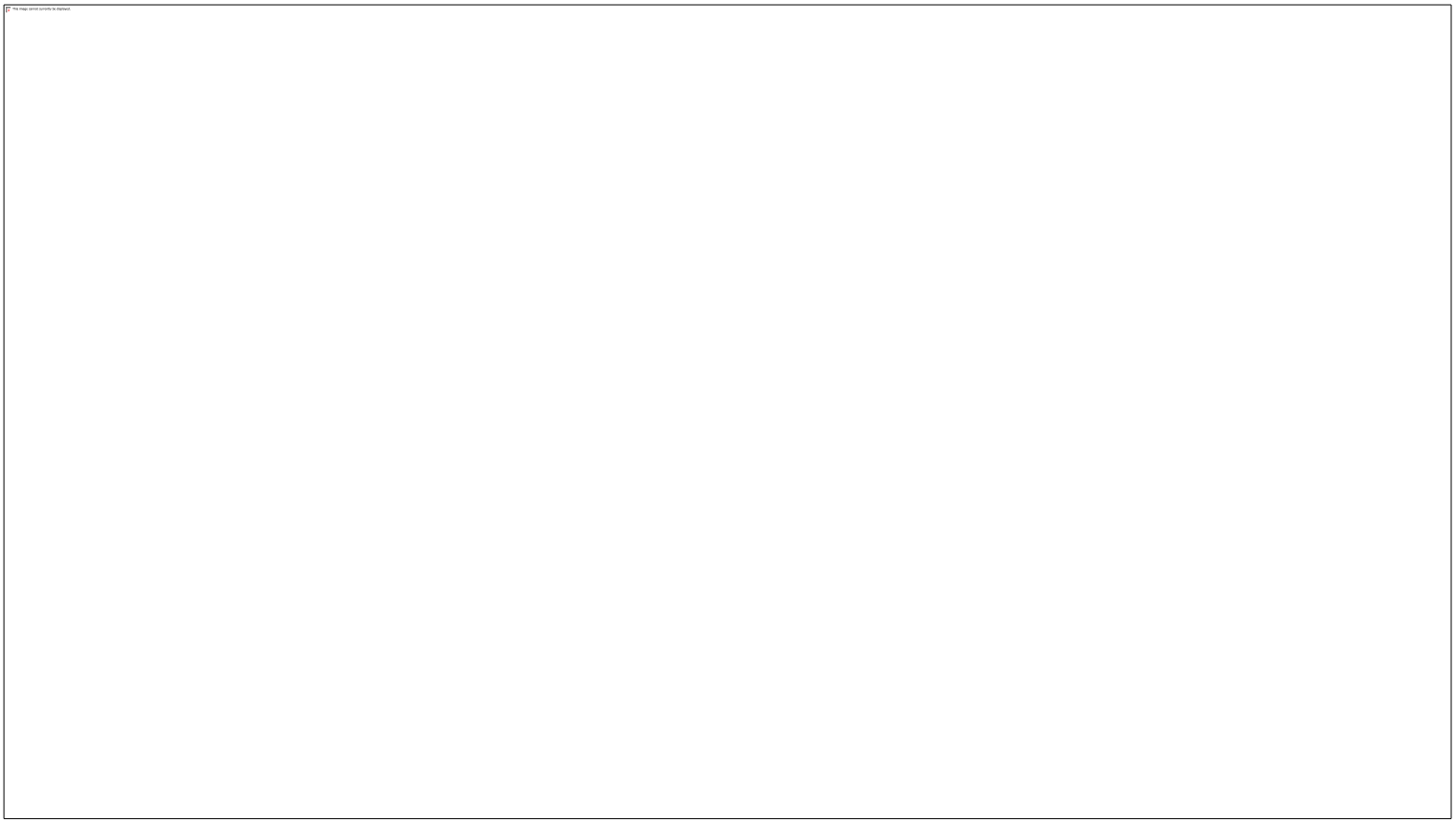
2.7 Atmospheric Pressure

Meaning of Atmospheric Pressure

Atmospheric pressure is the force exerted by the weight of the air above a unit area of the Earth's surface.

Air has mass and therefore exerts pressure on the Earth's surface and objects within the atmosphere.

Atmospheric pressure is measured using a **barometer**.



Units of Atmospheric Pressure

Atmospheric pressure is commonly measured in:

- Hectopascals (hPa).
- Millibars (mb).
- Pascals (Pa).
- Millimetres of mercury (mmHg).

The standard average sea-level atmospheric pressure is approximately:

1013.25 hPa1013.25 hPa

One hectopascal is equal to one millibar.

Types of Barometers

a) Mercury barometer

A mercury barometer uses a column of mercury to measure atmospheric pressure.

How it works

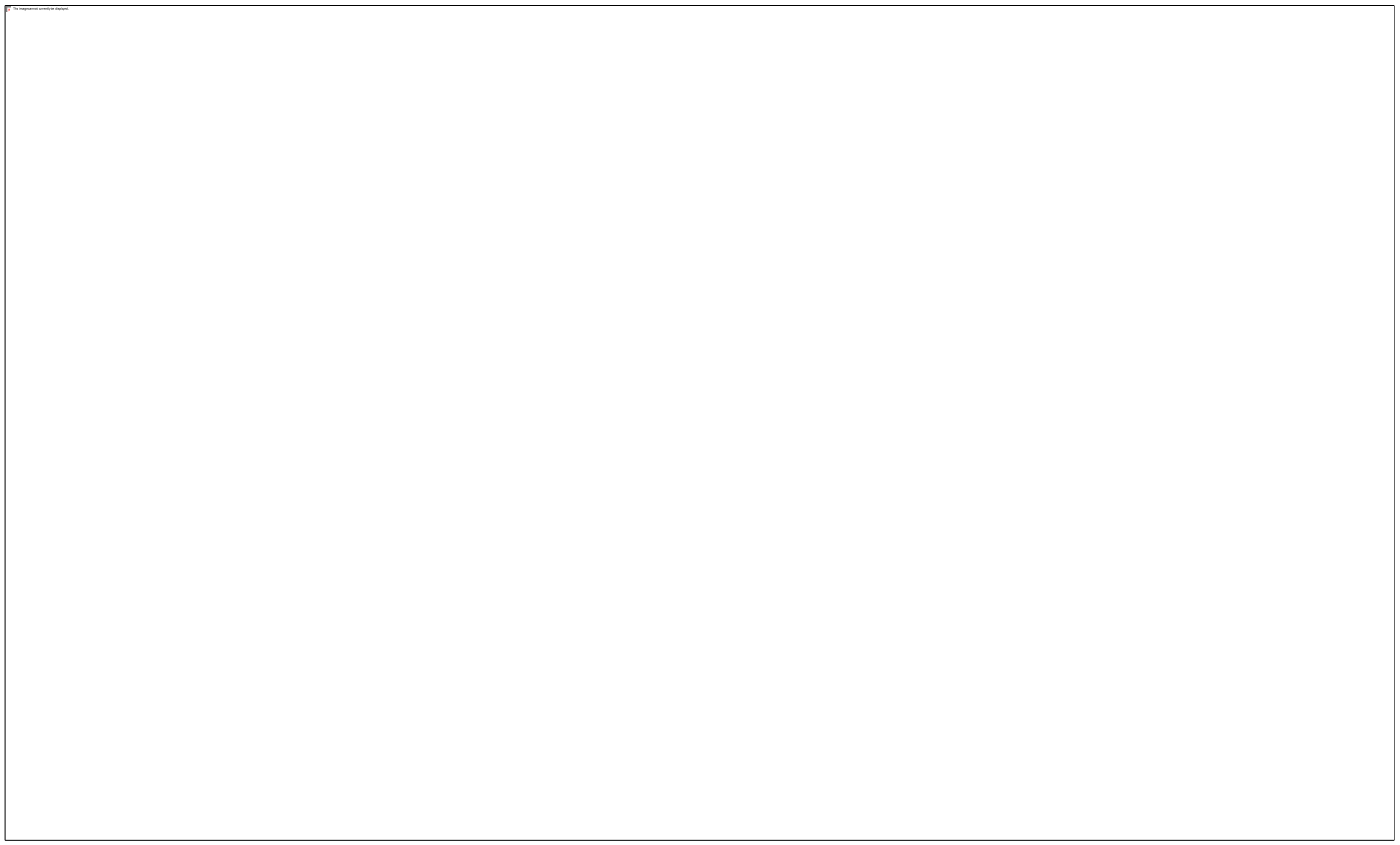
1. A glass tube is filled with mercury.
2. The tube is inverted into a container of mercury.
3. Atmospheric pressure acts on the mercury surface in the container.
4. The pressure supports a column of mercury in the tube.
5. The height of the mercury column indicates atmospheric pressure.

Limitations

- Mercury is toxic.
- The instrument is relatively delicate.
- It is difficult to transport.
- It requires careful handling and a vertical position.

b) Aneroid barometer

An aneroid barometer measures atmospheric pressure without using liquid.



How it works

1. It contains a sealed metal capsule with most of the air removed.
2. The capsule expands when external atmospheric pressure decreases.
3. It contracts when atmospheric pressure increases.
4. Mechanical linkages transfer the movement to a pointer.
5. The pointer indicates atmospheric pressure on a graduated scale.

Advantages

- Easy to transport.
- Does not contain mercury.
- Can be used in weather stations.
- Relatively convenient for field observations.

c) Digital barometer

- Uses electronic pressure sensors.

- Displays pressure readings digitally.
- Can be incorporated into automatic weather stations and some mobile devices.
- May record pressure changes continuously.

Factors Influencing Atmospheric Pressure

1. Altitude

- Atmospheric pressure decreases with increasing altitude.
- There is less air above a high-altitude location.
- The air is generally less dense at higher altitudes.

Kenyan example: Atmospheric pressure at the summit of Mount Kenya is lower than at sea level in Mombasa.

2. Temperature

- Warm air expands and becomes less dense.
- Rising warm air is commonly associated with lower surface pressure.
- Cold air is denser and tends to sink, often contributing to higher surface pressure.

3. Water vapour content

- Moist air is generally less dense than dry air at the same temperature and pressure.
- This is because water vapour molecules have a lower average molecular mass than the main components of dry air.
- Therefore, increased water vapour content can contribute to lower air density.

4. Earth's rotation

- The Earth's rotation influences atmospheric circulation.
- It helps determine the distribution of pressure belts and wind systems.

5. Unequal heating of the Earth's surface

- Different parts of the Earth receive different amounts of solar energy.
- This produces temperature differences.
- Temperature differences contribute to pressure variations and atmospheric movement.

Pressure Systems

a) High-pressure system

A high-pressure system is an area where atmospheric pressure is higher than that of the surrounding areas.

Characteristics:

- Air generally descends.
- Descending air becomes compressed and warms.
- Relative humidity may decrease.
- Cloud formation is often suppressed.
- Weather is frequently stable and relatively dry, although local conditions vary.

b) Low-pressure system

A low-pressure system is an area where atmospheric pressure is lower than that of the surrounding areas.

Characteristics:

- Air tends to converge towards the low-pressure centre at the surface.
- Air rises.
- Rising air expands and cools.
- Condensation and cloud formation may occur.
- Rainfall and unsettled weather are more likely where sufficient moisture is present.

Recording Atmospheric Pressure

Atmospheric pressure is recorded in hPa or millibars.

Example:

Time	Atmospheric pressure (hPa)
6:00 a.m.	1015
9:00 a.m.	1014
12:00 noon	1012
3:00 p.m.	1010
6:00 p.m.	1011

The readings show changes in atmospheric pressure during the day.

Importance of Measuring Atmospheric Pressure

1. Helps in weather forecasting.
2. Helps identify approaching low-pressure systems.
3. Supports the prediction of storms and unsettled weather.
4. Helps aviation operations.
5. Supports the study of wind movement.
6. Helps understand atmospheric circulation.
7. Provides information about changing weather conditions.

2.8 Sunshine

Meaning of Sunshine

Sunshine refers to the direct solar radiation received at the Earth's surface from the Sun.

In weather observations, sunshine duration refers to the total period during which direct sunlight is sufficiently strong to be recorded at a particular location.

Sunshine is important because it provides energy that drives many atmospheric and environmental processes.

Factors Influencing Sunshine Duration

1. **Cloud cover:** Thick clouds reduce the amount of direct sunshine reaching the ground.
2. **Latitude:** Latitude influences the angle of incoming solar radiation and length of daylight.
3. **Season:** Day length and the Sun's apparent position change during the year.
4. **Altitude:** Higher places may experience less atmospheric obstruction, although cloud and fog can reduce sunshine.
5. **Dust and atmospheric particles:** Dust, smoke and pollution can scatter or absorb solar radiation.
6. **Relief:** Mountains may cast shadows over nearby areas.
7. **Fog and mist:** These reduce direct sunlight reaching the Earth's surface.

Measurement of Sunshine

Sunshine duration is measured using a **Campbell–Stokes sunshine recorder** or modern electronic sunshine sensors.

Campbell–Stokes Sunshine Recorder

This instrument consists of:

- A solid glass sphere.
- A metal supporting frame.
- A specially designed recording card.
- A holder that positions the card behind the glass sphere.

How the Campbell–Stokes Sunshine Recorder Works

1. The glass sphere focuses direct sunlight onto the recording card.
2. The focused sunlight burns a trace on the card when sunshine is sufficiently strong.
3. The length of the burn trace indicates the duration of bright sunshine.
4. The card is removed at the end of the observation period.
5. The duration of sunshine is read from the time markings on the card.

Recording Sunshine

Sunshine duration is measured in hours.

Example:

Day	Sunshine duration
Monday	8 hours

Tuesday	6 hours
Wednesday	4 hours
Thursday	7 hours
Friday	9 hours

Total sunshine for the five days:

8+6+4+7+9=34 hours8+6+4+7+9=34 hours

Mean daily sunshine:

345=6.8 hours534=6.8 hours

Importance of Measuring Sunshine

1. Helps farmers plan crop production.
2. Supports solar energy production.
3. Helps predict evaporation rates.
4. Supports studies of plant growth.
5. Helps monitor changes in atmospheric conditions.
6. Supports tourism and outdoor activities.
7. Helps in the study of climate variability.
8. Assists in planning greenhouse operations.

3.0 Measurement and Recording of Weather Elements in a Weather Station

3.1 Meaning of a Weather Station

A weather station is a place equipped with instruments and facilities used to observe, measure, record and sometimes transmit weather information.

Weather stations provide information used in weather forecasting, climate studies, agriculture, transport and disaster management.

3.2 Types of Weather Stations

a) Surface weather station

- Measures weather conditions near the Earth's surface.
- Records temperature, rainfall, humidity, wind and atmospheric pressure.
- May be operated manually or automatically.

b) Automatic weather station

- Uses electronic sensors to measure weather elements.
- Automatically records and transmits weather information.

- May operate continuously with limited human intervention.

c) Upper-air weather station

- Collects information about atmospheric conditions at different heights.
- Uses weather balloons and radiosondes.
- Measures variables such as temperature, humidity, pressure and wind in the upper atmosphere.

d) Marine weather station

- Collects weather information over oceans, lakes and other water bodies.
- May be installed on ships, buoys or offshore platforms.
- Provides information about wind, pressure, temperature and waves.

e) Agricultural weather station

- Provides weather information relevant to farming.
- May monitor rainfall, temperature, humidity, soil moisture and wind.
- Supports irrigation and crop management.

3.3 Main Instruments in a Weather Station

Weather element	Instrument	Unit
Temperature	Thermometer	°C
Rainfall	Rain gauge	mm
Humidity	Hygrometer or psychrometer	%
Wind speed	Anemometer	m/s or km/h
Wind direction	Wind vane	Compass points or degrees
Atmospheric pressure	Barometer	hPa
Sunshine duration	Sunshine recorder	Hours
Cloud-base height	Ceilometer	Metres



3.4 How Weather Information Is Recorded

Weather information must be recorded systematically to ensure that observations are accurate and useful.

The procedure involves:

1. Identifying the weather elements to be measured.
2. Selecting appropriate instruments.
3. Installing the instruments correctly.
4. Taking observations at standard times.
5. Reading the instruments carefully.
6. Recording the observations in a weather register.
7. Checking the readings for errors.
8. Calculating daily or monthly averages and totals where required.
9. Storing the records safely.
10. Analysing the data to identify weather patterns.

3.5 Sample Weather Recording Table

The following is an illustrative record from a school weather station.

Date	Temperature (°C)	Rainfall (mm)	Relative humidity (%)	Wind speed (km/h)	Wind direction	Cloud cover (oktas)

Monday	24	8	75	12	SE	6
Tuesday	26	0	60	10	E	3
Wednesday	23	15	82	15	SE	7
Thursday	25	4	70	9	E	5
Friday	27	0	55	8	NE	2

The readings are hypothetical and are intended for classroom practice.

3.6 Importance of Standard Observation Times

Weather observations should be taken at consistent times because:

- It allows comparison between different days.
- It improves the reliability of weather records.
- It helps identify daily weather patterns.
- It supports the calculation of averages and totals.
- It allows weather stations to share comparable data.

Professional weather stations follow established observation standards. School weather stations may use a consistent timetable suitable for learning activities.

3.7 Precautions When Taking Weather Observations

1. Use the correct instrument for each weather element.
2. Ensure instruments are properly installed.
3. Read instruments at eye level where applicable.
4. Record observations immediately.
5. Avoid changing the position of instruments unnecessarily.
6. Keep instruments clean and in good working condition.
7. Use standard units.
8. Record the date and time of observation.
9. Protect instruments against damage.
10. Check unusual readings before accepting them.

4.0 Weather Forecasting

4.1 Meaning of Weather Forecasting

Weather forecasting is the process of predicting the future state of the atmosphere at a particular place or over a specified area using observations, scientific principles, mathematical models and technological tools.

Weather forecasts provide information about expected:

- Rainfall.

- Temperature.
- Wind speed and direction.
- Cloud cover.
- Humidity.
- Atmospheric pressure.
- Thunderstorms and other severe weather conditions.

4.2 Sources of Weather Information Used in Forecasting

a) Weather stations

- Measure atmospheric conditions at specific locations.
- Provide temperature, rainfall, wind, humidity and pressure records.
- Supply information for forecasting models.

b) Weather satellites

- Observe clouds and weather systems over large geographical areas.
- Monitor cloud movement.
- Detect the development of storms.
- Provide information on atmospheric moisture and temperature.

c) Weather radar

- Uses radio waves to detect precipitation.
- Helps monitor the location and movement of rainstorms.
- Can estimate rainfall intensity.
- Supports severe weather warnings.

d) Weather balloons

- Carry radiosondes into the atmosphere.
- Collect information about temperature, humidity and pressure at different heights.
- Help determine upper-air wind conditions.

e) Ships and buoys

- Collect weather information over oceans and lakes.
- Provide data about wind, pressure, temperature and other conditions.

f) Computer weather models

- Process large amounts of atmospheric data.
- Use mathematical equations to simulate atmospheric processes.
- Produce predictions of future weather conditions.

g) Ground observations

- Include observations of cloud types, rainfall, wind and other weather conditions.
- Help verify and supplement instrument readings.



4.3 Types of Weather Forecasts

Weather forecasts may be classified according to the period they cover.

a) Nowcasting

- Covers the immediate future, usually up to a few hours.
- Uses recent observations, radar and satellite information.
- Helps identify approaching thunderstorms and heavy rainfall.

b) Short-range forecast

- Covers the next few days.
- Provides information for daily activities.
- Helps farmers and transport operators make immediate plans.

c) Medium-range forecast

- Covers approximately three to ten days, depending on the forecasting service.
- Helps in planning activities over a longer period.

d) Long-range forecast

- Covers several weeks or months.
- Often provides general trends rather than exact daily weather conditions.
- Helps in seasonal agricultural and water-resource planning.

4.4 Steps Involved in Weather Forecasting

1. **Collection of weather data:** Information is obtained from weather stations, satellites, radar, balloons, ships and other sources.
2. **Transmission of data:** Observations are transmitted to forecasting centres.
3. **Data processing:** The information is checked, organised and prepared for analysis.
4. **Analysis of atmospheric conditions:** Meteorologists examine pressure systems, wind patterns, temperature, humidity and cloud movements.
5. **Use of computer models:** Numerical weather prediction models are used to estimate future atmospheric conditions.
6. **Interpretation of results:** Meteorologists examine model predictions alongside current observations and their professional knowledge.
7. **Preparation of forecasts:** Forecasts are prepared for specific areas and periods.
8. **Dissemination of forecasts:** Information is shared through television, radio, websites, mobile applications and other communication channels.
9. **Monitoring and updating:** Forecasts are reviewed as new information becomes available.

4.5 Importance of Weather Forecasting

Weather forecasting is important because it helps individuals, communities, businesses and governments prepare for future atmospheric conditions.

1. Agricultural planning

- Helps farmers determine suitable planting periods.
- Provides information about expected rainfall.
- Helps farmers plan harvesting.
- Supports irrigation planning.
- Helps farmers prepare for dry spells.
- Reduces losses caused by unfavourable weather.

Kenyan example: Farmers in Trans Nzoia and Uasin Gishu can use seasonal forecasts to plan maize planting and harvesting.

2. Disaster preparedness

- Provides early warnings of heavy rainfall.
- Helps communities prepare for floods.
- Supports drought preparedness.

- Helps authorities plan responses to storms.
- Reduces possible loss of life and property.

3. Transport safety

- Helps pilots assess wind, visibility and thunderstorms.
- Helps motorists prepare for wet or slippery roads.
- Helps marine transport operators assess wind and storm conditions.
- Helps transport authorities plan operations during severe weather.

4. Water resource management

- Helps predict periods of high rainfall.
- Supports dam and reservoir management.
- Helps plan water storage.
- Supports drought monitoring.
- Helps water authorities prepare for possible shortages.

5. Fishing activities

- Helps fishermen identify periods of strong winds and rough water.
- Supports safe planning of fishing activities.
- Helps determine suitable times for travelling on lakes and oceans.

6. Tourism

- Helps tourists plan travel and outdoor activities.
- Helps tour operators prepare for unfavourable weather.
- Supports the planning of safaris, mountain climbing and beach activities.

7. Construction

- Helps contractors plan roofing activities.
- Helps road construction teams plan work.
- Reduces disruption caused by heavy rainfall.
- Supports the safe operation of cranes and other equipment during strong winds.

8. Public health

- Helps authorities prepare for extreme heat.
- Supports planning for weather-related health risks.
- Helps communicate warnings about dangerous weather conditions.

9. Energy production

- Helps plan solar energy production.
- Supports wind power generation.
- Provides information useful in hydropower management.

- Helps electricity providers prepare for weather-related disruptions.

10. Environmental management

- Helps monitor drought conditions.
- Supports the management of forests and wetlands.
- Provides information for monitoring extreme weather.
- Helps assess possible environmental impacts of changing weather patterns.

11. School and community planning

- Helps schools plan outdoor activities.
- Helps communities organise events.
- Supports safe planning of sports and agricultural activities.
- Helps local authorities prepare for heavy rainfall and strong winds.

4.6 Why Is It Important to Invest in Weather Forecasting?

Investment in weather forecasting is important because it improves the quality, accuracy and availability of weather information.

Reasons include:

1. **Reduction of disaster losses:** Improved forecasting helps provide early warnings about floods, droughts and severe storms.
2. **Protection of human life:** Timely warnings allow people to move away from dangerous areas.
3. **Improved agricultural productivity:** Farmers can make better decisions about planting, irrigation and harvesting.
4. **Economic protection:** Businesses can prepare for weather-related disruptions.
5. **Improved transport safety:** Better forecasts help pilots, motorists and sailors avoid dangerous conditions.
6. **Efficient water management:** Forecasts help authorities plan water storage and distribution.
7. **Improved national planning:** Government institutions can use weather information when planning development projects.
8. **Climate research:** Long-term weather observations support the study of climate variability and climate change.
9. **Improved technological development:** Investment supports modern weather stations, satellites, radar and computer forecasting systems.
10. **Food security:** Reliable seasonal forecasts help communities prepare for rainfall shortages and other agricultural risks.
11. **Better public awareness:** Weather services help people understand and respond to changing atmospheric conditions.
12. **Regional cooperation:** Shared weather information improves preparedness for weather systems that cross national boundaries.

4.7 Limitations and Challenges of Weather Forecasting

- Weather systems are complex.
- Some areas have inadequate weather observation stations.
- Forecast accuracy may decrease over longer periods.
- Equipment and technology can be expensive.
- Some remote areas have limited communication networks.
- Poor-quality observations can affect forecasts.
- Severe local storms may develop rapidly.
- Some communities may not receive warnings in time.
- Lack of trained personnel may affect weather services.
- Forecasts can be misunderstood or ignored by the public.

4.8 Ways of Improving Weather Forecasting in Kenya

1. Increasing the number of modern weather stations.
2. Improving satellite and radar observation systems.
3. Training more meteorologists and weather technicians.
4. Maintaining weather instruments regularly.
5. Improving internet and communication networks.
6. Strengthening cooperation with regional and international weather organisations.
7. Making weather information accessible to rural communities.
8. Providing forecasts in languages understood by local communities.
9. Using mobile phone messaging to communicate warnings.
10. Supporting research and investment in modern forecasting technologies.

5.0 Construction of Simple Weather Instruments Using Locally Available Materials

5.1 Meaning of Weather Instrument Construction

Weather instrument construction refers to the process of designing and making simple devices used to observe or measure weather elements using locally available materials.

Learners can construct simple instruments to understand how professional meteorological instruments work.

Constructing weather instruments promotes:

- Creativity and innovation.
- Practical skills.
- Problem-solving.
- Environmental conservation through reuse of materials.
- Scientific observation.
- Collaboration and teamwork.

5.2 Construction of a Simple Rain Gauge

Materials Required

- Transparent plastic bottle with straight sides.
- Scissors or a suitable cutting tool.
- Ruler.
- Permanent marker.
- Small stones or gravel.
- Water.
- Adhesive tape.

Procedure

1. Obtain a clean transparent plastic bottle.
2. Cut off the upper part of the bottle carefully.
3. Place some small stones at the bottom to provide stability.
4. Add a little water to cover the stones.
5. Mark the initial water level.
6. Turn the cut-off upper part upside down to form a funnel.
7. Insert the funnel into the lower part of the bottle.
8. Use a ruler to mark a graduated scale on the bottle.
9. Place the rain gauge in an open area away from trees and buildings.
10. Secure it vertically so that it does not fall over.
11. After rainfall, read the increase in the water level.
12. Record the reading and empty the instrument before the next observation.

How It Works

- Rainwater enters through the funnel.
- The water collects in the lower part of the bottle.
- The water level rises as rainfall accumulates.
- The graduated scale is used to estimate the amount of rainfall.

Important limitation: A simple bottle rain gauge is suitable for classroom demonstrations but is not as accurate as a standard meteorological rain gauge. The shape of the collecting area, funnel and measuring scale must be properly calibrated for reliable measurements.

Precautions

- Place the instrument in an open area.
- Ensure that it is vertical.
- Avoid placing it under trees.

- Empty it after every reading.
- Record observations at consistent times.
- Ensure that the funnel does not become blocked.

5.3 Construction of a Simple Wind Vane

Materials Required

- Cardboard.
- Drinking straw.
- Pencil with an eraser.
- Drawing pin.
- Scissors.
- Plasticine or modelling clay.
- A straight stick or wooden support.
- Compass.
- Recycled plastic bottle or container for the base.

Procedure

1. Cut a large arrowhead and a tail from cardboard.
2. Make a small opening at each end of the straw.
3. Attach the arrowhead to one end of the straw.
4. Attach the tail to the other end.
5. Find the centre of the straw and mark it.
6. Push a drawing pin through the centre of the straw into the eraser of a pencil.
7. Check that the straw can rotate freely.
8. Fix the pencil vertically in a stable base.
9. Use a compass to identify the north, south, east and west directions.
10. Mark the four cardinal directions around the base.
11. Place the instrument in an open area.
12. Observe the direction in which the arrow points when the wind blows.

How It Works

- The wind pushes the larger tail of the vane.
- The arrow rotates around its central pivot.
- The arrow aligns with the direction from which the wind is blowing.
- The direction can be read using the compass markings.

Precautions

- Ensure that the arrow rotates freely.
- Make the tail larger than the arrowhead.
- Install the instrument away from buildings and trees.
- Ensure that the base is stable.
- Use a compass to mark directions accurately.

5.4 Construction of a Simple Anemometer

Materials Required

- Four small paper or plastic cups.
- Two lightweight sticks or straws.
- A pencil with an eraser.
- A drawing pin.
- A supporting stick.
- Adhesive tape.
- A stopwatch.

Procedure

1. Arrange two sticks or straws in the shape of a cross.
2. Join them firmly at the centre.
3. Attach a cup to each end of the cross.
4. Ensure that all cups face the same rotational direction.
5. Attach the centre of the cross to a freely rotating pivot.
6. Mount the pivot on a vertical supporting stick.
7. Place the instrument in an open area.
8. Observe how the cups rotate when the wind blows.
9. Use a stopwatch to count the rotations within a fixed period.
10. Record the number of rotations.
11. Compare the readings taken at different times.

How It Works

- Wind pushes the cups.
- The cups rotate around the central pivot.
- Faster wind generally produces faster rotation.
- The number of rotations can be compared to estimate changes in wind speed.

Limitation: A homemade anemometer does not give an accurate wind speed in m/s or km/h unless it has been calibrated against a standard instrument.

5.5 Construction of a Simple Wind Sock

Materials Required

- Lightweight fabric or strong plastic.
- Thread.
- Needle or adhesive.
- Wire or circular hoop.
- String.
- Wooden pole.
- Scissors.

Procedure

1. Cut the fabric into a long cone-shaped piece.
2. Join the edges to form a tube that narrows towards one end.
3. Attach a circular hoop to the wider opening.
4. Secure the narrow end so that air can flow through it.
5. Attach the wide opening to a freely moving support.
6. Raise the windsock on a pole in an open area.
7. Observe its direction and the extent to which it extends.

How It Works

- Wind enters through the wider opening.
- The windsock points in the direction the wind is blowing towards.
- Its degree of extension provides a rough indication of wind strength.

Important: Unlike a wind vane, a windsock points downwind. Its direction therefore shows where the wind is going, while a wind vane indicates where the wind is coming from.

5.6 Construction of a Simple Barometer Demonstration

Materials Required

- Empty glass jar.
- Balloon or thin rubber sheet.
- Drinking straw.
- Rubber band.
- Cardboard.
- Adhesive tape.
- Marker pen.

Procedure

1. Cut the neck of the balloon.
2. Stretch the remaining rubber sheet tightly over the mouth of the jar.
3. Secure it using a rubber band.
4. Attach one end of the straw to the centre of the stretched rubber sheet.
5. Allow the other end of the straw to extend horizontally.
6. Place a cardboard scale behind the straw.
7. Mark the initial position of the straw.
8. Observe the straw over several days.

How It Works

- Changes in atmospheric pressure cause the rubber sheet to move.
- The movement is transferred to the straw.
- The straw moves up or down against the scale.
- Changes in the straw's position indicate changes in atmospheric pressure.

Limitation: This is a qualitative demonstration, not a calibrated barometer. It cannot provide reliable pressure readings in hPa without calibration.

5.7 Construction of a Simple Hygrometer Demonstration

Materials Required

- Clean human or animal hair.
- Cardboard.
- Small pointer.
- Drawing pin.
- Supporting frame.
- Adhesive tape.
- Small weight.

Procedure

1. Fix one end of the hair firmly to a supporting frame.
2. Attach the other end to a lightweight pointer mechanism.
3. Add a small weight where necessary to keep the hair under slight tension.
4. Place a scale behind the pointer.
5. Expose the instrument to different humidity conditions.
6. Observe and record changes in the pointer's position.

How It Works

- Hair absorbs moisture from humid air and expands slightly.
- It contracts when the air becomes drier.
- The change in length moves the pointer.
- The pointer indicates changes in humidity.

Limitation: A homemade hair hygrometer requires calibration and is mainly useful for demonstrating the relationship between humidity and hair length.

6.0 Establishing a School Weather Station

6.1 Meaning of a School Weather Station

A school weather station is a designated area within the school compound where learners install and use simple weather instruments to observe, measure and record weather elements.

It provides learners with practical opportunities to understand weather through direct observation and measurement.

6.2 Requirements for Establishing a School Weather Station

The following are required:

1. A suitable open space.
2. Thermometers.
3. A rain gauge.
4. A wind vane.
5. An anemometer.
6. A hygrometer or simple humidity demonstration.
7. A barometer or pressure demonstration.
8. A sunshine recorder or sunshine observation chart.
9. A Stevenson screen or suitable protective enclosure.
10. Measuring cylinders.
11. A measuring ruler.
12. A weather recording book.
13. A noticeboard for displaying observations.
14. Supporting poles and protective fencing where necessary.

6.3 Selecting a Suitable Site

The weather station should be located in a suitable place to ensure that observations are representative and reliable.

Factors to consider include:

1. Open space

- Select an area with adequate space.

- Avoid locations surrounded by buildings.
- Avoid areas where trees obstruct wind movement.

2. Level ground

- The ground should be reasonably level.
- The rain gauge should be installed vertically.
- Instruments should be firmly supported.

3. Short grass surface

- A short grass surface is suitable for locating many standard weather instruments.
- Avoid placing instruments on hot concrete or bare surfaces where possible.

4. Accessibility

- The station should be easy for learners and teachers to access.
- It should be located where observations can be made regularly.

5. Security

- Protect instruments from theft and vandalism.
- Provide suitable fencing where necessary.
- Restrict unauthorised handling.

6. Safety

- Keep the station away from dangerous electrical installations.
- Ensure that poles and instruments are firmly secured.
- Use safe procedures when cutting materials and installing equipment.

6.4 Setting Up the School Weather Station

The following steps may be followed:

1. Obtain permission from the school administration.
2. Identify a suitable open location.
3. Clear the site without disturbing the natural surface unnecessarily.
4. Prepare the ground.
5. Install the rain gauge in an open area.
6. Install the Stevenson screen or protective thermometer enclosure.
7. Mount the wind vane and anemometer at a suitable height in an exposed position.
8. Install the barometer in a suitable sheltered location.
9. Install a sunshine recorder in an unobstructed position.
10. Set up the humidity-measuring instrument.
11. Mark the location of each instrument.
12. Prepare a weather recording timetable.

13. Train learners on instrument use.
14. Begin daily observations.
15. Display the collected weather records.

6.5 Sample School Weather Station Layout

A school weather station may include the following arrangements:

- The Stevenson screen should be positioned over short grass in a suitable open area.
- The rain gauge should be located away from obstructions.
- The wind vane and anemometer should be mounted in an exposed position.
- The sunshine recorder should have an unobstructed view of the Sun.
- The barometer should be kept in a sheltered indoor location.
- The weather register should be stored in a safe place.

6.6 Sample Daily Weather Observation Register

Weather element	Morning observation	Afternoon observation
Temperature		
Rainfall		
Relative humidity		
Wind speed		
Wind direction		
Cloud cover		
Atmospheric pressure		
Sunshine duration		
General weather condition		

6.7 Sample Weekly Weather Summary

The following figures are hypothetical and can be used for classroom calculations.

Day	Maximum temperature (°C)	Minimum temperature (°C)	Rainfall (mm)	Cloud cover (oktas)

Monday	27	16	10	6
Tuesday	28	17	0	3
Wednesday	25	15	18	8
Thursday	26	16	5	5
Friday	29	18	0	2
Saturday	28	17	4	4
Sunday	27	16	8	6

Classroom tasks

1. Calculate the daily temperature range for each day.
2. Calculate the mean daily temperature for Monday.
3. Calculate the total rainfall for the week.
4. Identify the wettest day.
5. Identify the day with the highest maximum temperature.
6. Identify the day with the lowest minimum temperature.
7. Describe the relationship between cloud cover and rainfall in the table.
8. Explain how the information could assist farmers in the community.

6.8 Benefits of a School Weather Station

1. Provides practical geographical learning experiences.
2. Develops observation and recording skills.
3. Promotes scientific investigation.
4. Helps learners understand weather instruments.
5. Provides local weather information.
6. Supports agricultural activities within the school.
7. Encourages teamwork and collaboration.
8. Promotes environmental awareness.
9. Helps learners develop data analysis skills.
10. Creates opportunities for weather-related projects.

6.9 Challenges of Establishing a School Weather Station

- Limited financial resources.

- Lack of standard weather instruments.
- Theft or vandalism.
- Inadequate space.
- Lack of trained personnel.
- Damage caused by strong winds or storms.
- Irregular recording of observations.
- Poor maintenance of instruments.

6.10 Solutions to the Challenges

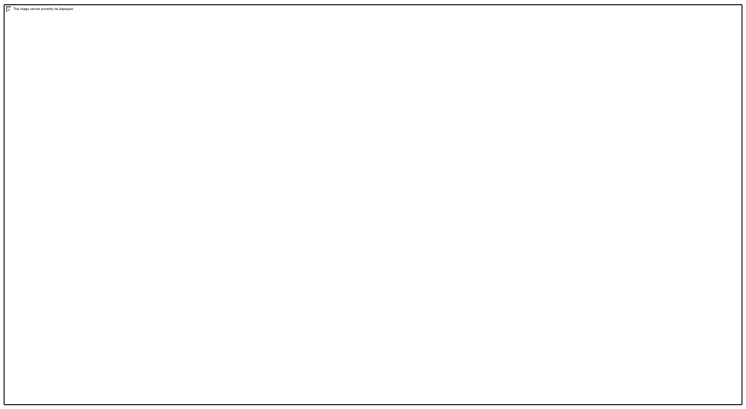
1. Construct simple instruments using locally available materials.
2. Seek support from the school administration and community.
3. Establish a weather observation club.
4. Train learners and teachers.
5. Provide suitable security.
6. Prepare an instrument maintenance timetable.
7. Keep accurate records.
8. Invite meteorological personnel to train learners.

7.0 Field Visit to a Weather Station

7.1 Meaning of a Field Visit

A field visit is an organised educational trip to a geographical location where learners observe real-life features, processes, activities and equipment.

A visit to a weather station allows learners to examine professional meteorological instruments and understand how weather information is collected and used.



7.2 Objectives of a Weather Station Visit

By the end of the visit, learners should be able to:

1. Identify instruments used in a weather station.
2. Explain the functions of different weather instruments.
3. Observe how weather elements are measured.
4. Understand how weather observations are recorded.

5. Explain how weather forecasts are prepared.
6. Appreciate the importance of meteorological services.
7. Relate weather information to community activities.

7.3 Preparation Before the Visit

Learners should:

- Obtain permission from the school administration.
- Identify the weather station to be visited.
- Contact the station management.
- Prepare questions for the resource person.
- Prepare notebooks and writing materials.
- Organise transport where necessary.
- Receive safety instructions.
- Divide themselves into working groups.

7.4 Activities During the Visit

Learners should:

1. Observe the general layout of the weather station.
2. Identify the different weather instruments.
3. Record the names of the instruments.
4. Ask the resource person to explain how each instrument works.
5. Observe how readings are taken.
6. Examine the weather recording registers.
7. Learn how information is transmitted to forecasting centres.
8. Observe any available weather forecasting equipment.
9. Record the uses of weather information in the community.
10. Ask questions about challenges facing meteorological services.

7.5 Sample Questions to Ask a Resource Person

1. What is the main purpose of this weather station?
2. Which weather elements are measured here?
3. What instruments are used to measure temperature?
4. How is rainfall measured and recorded?
5. How is wind speed determined?
6. How is wind direction recorded?
7. How is relative humidity measured?
8. How often are observations taken?

9. How is weather information transmitted?
10. How are weather forecasts prepared?
11. What technologies are used in modern weather forecasting?
12. How do farmers benefit from the information provided?
13. What challenges are experienced in collecting weather data?
14. How does the station communicate severe weather warnings to the public?

7.6 Activities After the Visit

Learners should:

- Discuss their observations in groups.
- Compare the instruments observed with those studied in class.
- Organise the collected information.
- Prepare a written report.
- Present their findings to the class.
- Suggest ways in which weather information can benefit their community.

7.7 Sample Weather Station Fieldwork Report

Title: A Visit to a Weather Station

1. Introduction

This report describes a geographical field visit to a weather station. The visit was organised to help learners understand how weather elements are measured, recorded and used in weather forecasting.

2. Objectives

The objectives of the visit were:

- To identify weather instruments.
- To understand how weather elements are measured.
- To observe how weather information is recorded.
- To understand the importance of weather forecasting.

3. Location

The visit was conducted at _____ on _____.

4. Methods Used

The following methods were used:

- Direct observation.
- Interviewing the resource person.
- Taking notes.
- Examining weather instruments.
- Asking questions.

5. Findings

The following instruments were observed:

Instrument	Weather element measured
Thermometer	Temperature
Rain gauge	Rainfall
Hygrometer	Humidity
Anemometer	Wind speed
Wind vane	Wind direction
Barometer	Atmospheric pressure
Sunshine recorder	Sunshine duration
Ceilometer	Cloud-base height

6. Challenges Experienced

Possible challenges included:

- Limited time.
- Difficulty understanding some technical terms.
- Inability to operate certain instruments.
- Limited access to some restricted areas.

7. Recommendations

- Schools should establish weather stations.
- Learners should be given more practical lessons.
- Communities should receive regular weather information.
- Schools should collaborate with meteorological institutions.

8. Conclusion

The visit provided learners with practical knowledge about weather measurement, recording and forecasting. It also demonstrated the importance of weather information in everyday life and community development.

8.0 Interpretation and Application of Weather Information

8.1 Meaning of Weather Data Interpretation

Weather data interpretation refers to the process of examining recorded weather information to identify patterns, trends, relationships and changes in atmospheric conditions.

8.2 Ways of Presenting Weather Data

Weather information may be presented using:

a) Tables

Tables organise weather readings into rows and columns.

b) Bar graphs

Bar graphs are useful for comparing rainfall amounts, temperatures and other weather measurements.

c) Line graphs

Line graphs show changes in weather elements over time.

d) Climographs

Climographs present monthly temperature and rainfall information for a particular place.

e) Weather maps

Weather maps display information such as pressure systems, wind direction, temperature distribution and rainfall patterns.

8.3 Example of Interpreting Weather Data

The table below shows hypothetical monthly rainfall data for a school weather station.

Month	**Rainfall (mm)**
January	35
February	28
March	85
April	160
May	120
June	55

Questions and interpretation

1. **Which month received the highest rainfall?**

April received the highest rainfall of 160 mm.

2. **Which month received the lowest rainfall?**

February received the lowest rainfall of 28 mm.

3. **What was the total rainfall for the six months?**

35+28+85+160+120+55=483 mm35+28+85+160+120+55=483 mm

4. **Calculate the mean monthly rainfall.**

4836=80.5 mm6483=80.5 mm

The mean monthly rainfall was 80.5 mm.

5. **Describe the rainfall trend.**

Rainfall increased from February to April and decreased from April to June.

6. **How can the information help farmers?**

Farmers can use the rainfall records to plan planting, irrigation and water storage activities.

8.4 Importance of Weather Records to the Community

Weather records help communities to:

- Plan agricultural activities.
- Monitor rainfall shortages.
- Prepare for floods.
- Plan water harvesting.
- Determine suitable periods for construction.
- Organise outdoor events.
- Monitor changes in local atmospheric conditions.
- Support environmental conservation.
- Improve community disaster preparedness.

9.0 Weather Hazards and Community Preparedness

Weather may sometimes produce hazardous conditions that threaten people, property and the environment.

9.1 Meaning of Weather Hazards

Weather hazards are potentially dangerous atmospheric conditions that may cause injury, loss of life, property damage, environmental destruction or disruption of economic activities.

9.2 Examples of Weather Hazards in Kenya

a) Drought

Drought is a prolonged period of significantly below-normal rainfall that results in water shortages.

Effects:

- Crop failure.
- Livestock deaths.
- Food shortages.
- Reduced water supply.
- Increased competition for resources.
- Loss of income.

b) Flooding

Flooding occurs when water covers land that is normally dry.

Causes:

- Heavy rainfall.
- River overflow.
- Poor drainage.
- Blocked drainage channels.
- Rapid surface runoff.

Effects:

- Destruction of homes and roads.
- Loss of life.
- Displacement of communities.
- Soil erosion.
- Contamination of water supplies.
- Destruction of crops.

c) Thunderstorms

Thunderstorms are storms associated with cumulonimbus clouds and characterised by thunder and lightning. They may also produce heavy rainfall, strong winds and hail.

Effects:

- Lightning injuries and deaths.
- Damage to buildings.
- Destruction of crops.
- Disruption of electricity supply.
- Flash floods.

d) Strong winds

Effects:

- Destruction of roofs.
- Uprooting of trees.
- Soil erosion.
- Damage to crops.
- Disruption of transport.
- Damage to power lines.

e) Heatwaves

A heatwave is a prolonged period of unusually hot weather relative to the normal conditions of a particular area.

Effects:

- Heat stress.
- Increased water demand.

- Crop stress.
- Increased risk of wildfires.
- Reduced productivity.

f) Hailstorms

Effects:

- Damage to crops.
- Destruction of roofs.
- Injury to people and animals.
- Damage to vehicles.
- Disruption of outdoor activities.

9.3 Measures for Reducing the Effects of Weather Hazards

1. Providing timely weather forecasts and early warnings.
2. Constructing proper drainage systems.
3. Avoiding settlement in flood-prone areas.
4. Planting drought-resistant crops.
5. Practising rainwater harvesting.
6. Establishing emergency response plans.
7. Protecting water catchment areas.
8. Promoting afforestation.
9. Educating communities about weather hazards.
10. Providing safe shelters during severe storms.
11. Improving livestock management during drought.
12. Maintaining accurate weather records.

10.0 Summary of Weather Elements and Instruments

Weather element	**Meaning**	**Instrument**	**Unit**
Temperature	Degree of hotness or coldness of the air	Thermometer	°C
Precipitation	Water falling from the atmosphere	Rain gauge	mm
Humidity	Amount of water vapour in the air	Hygrometer	%
Cloud cover	Proportion of sky covered by clouds	Visual observation	Oktas
Wind speed	Rate at which air moves	Anemometer	m/s or km/h

Wind direction	Direction from which wind blows	Wind vane	Compass points/degrees
Atmospheric pressure	Force exerted by the weight of air per unit area	Barometer	hPa
Sunshine duration	Period of bright sunshine	Sunshine recorder	Hours
Cloud-base height	Height of the base of a cloud above the ground	Ceilometer	Metres

11.0 Key Geographical Terms

Term	**Definition**
Weather	Atmospheric conditions at a particular place and time
Climate	Long-term average pattern of weather conditions
Temperature	Degree of hotness or coldness of the atmosphere
Precipitation	Water falling from the atmosphere in liquid or solid form
Humidity	Amount of water vapour in the atmosphere
Relative humidity	Ratio of actual water vapour content to saturation content, expressed as a percentage
Cloud cover	Proportion of the sky covered by clouds
Wind	Horizontal movement of air from high pressure towards low pressure
Atmospheric pressure	Force exerted by air per unit area
Sunshine duration	Total period of bright sunshine received at a place
Rain gauge	Instrument used to measure rainfall
Anemometer	Instrument used to measure wind speed
Wind vane	Instrument used to determine wind direction

Barometer	Instrument used to measure atmospheric pressure
Hygrometer	Instrument used to measure humidity
Psychrometer	Wet-and-dry bulb instrument used to determine relative humidity
Stevenson screen	Ventilated enclosure used to house weather instruments
Isobars	Lines joining places with equal atmospheric pressure
Convectional rainfall	Rainfall caused by the rising of warm moist air
Relief rainfall	Rainfall caused by moist air rising over highland barriers
Frontal rainfall	Rainfall caused by the meeting of contrasting air masses
Weather forecasting	Prediction of future atmospheric conditions
Meteorology	Scientific study of the atmosphere and weather
Meteorologist	A person who studies the atmosphere and weather
Cumulonimbus	A tall cloud associated with thunderstorms
Cirrus	High, thin, wispy cloud
Monsoon	Seasonal wind that changes direction between seasons

REVISION EXERCISE

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Instructions: Answer all the questions. Choose the correct answer from the alternatives A, B, C and D.

1. What is the meaning of weather?

A. Average atmospheric conditions over many years
B. Condition of the atmosphere at a particular place and time
C. The study of rocks and minerals
D. Movement of ocean currents

2. Which of the following is an element of weather?

A. Soil texture
B. Temperature
C. Rock structure
D. Vegetation type

3. What is the main source of heat for the Earth's atmosphere?

A. The Moon
B. The ocean floor
C. The Sun
D. Volcanic activity

4. Which instrument is used to measure atmospheric temperature?

A. Barometer
B. Thermometer
C. Anemometer
D. Rain gauge

5. Which instrument records the highest temperature reached during a specified period?

A. Maximum thermometer
B. Minimum thermometer
C. Wet-bulb thermometer
D. Ordinary rain gauge

6. Why is a Stevenson screen painted white?

A. To absorb more solar radiation
B. To reflect solar radiation
C. To increase rainfall
D. To prevent wind movement

7. Which of the following is a form of precipitation?

A. Evaporation
B. Transpiration
C. Hail
D. Condensation

8. What type of rainfall results from intense heating of the Earth's surface?

A. Relief rainfall
B. Frontal rainfall
C. Convectional rainfall
D. Cyclonic rainfall

9. Relief rainfall occurs when:

A. Warm air meets cold air
B. Moist air rises over a mountain barrier
C. Air moves from high pressure to low pressure
D. The sea becomes warmer than the land

10. Which instrument is used to measure rainfall?

A. Hygrometer
B. Rain gauge
C. Barometer
D. Wind vane

11. In which unit is rainfall commonly measured?

A. Degrees Celsius
B. Millimetres
C. Hectopascals
D. Kilometres per hour

12. What does humidity refer to?

A. Amount of water vapour in the atmosphere
B. Speed of moving air
C. Weight of the atmosphere
D. Amount of cloud cover

13. Relative humidity is expressed as a:

A. Fraction only
B. Percentage
C. Length
D. Volume

14. Which instrument is used to measure atmospheric humidity?

A. Anemometer
B. Hygrometer
C. Barometer
D. Rain gauge

15. When the wet-bulb and dry-bulb temperatures are approximately equal, the air is likely to be:

A. Very dry
B. Saturated
C. Extremely windy
D. Freezing

16. Which type of cloud is characterised by a thin, wispy appearance?

A. Cumulonimbus
B. Cirrus
C. Nimbostratus
D. Stratocumulus

17. Which type of cloud is commonly associated with thunderstorms?

A. Cirrus
B. Stratus
C. Cumulonimbus
D. Cirrostratus

18. Which unit is commonly used to estimate cloud cover?

A. Oktas
B. Millibars
C. Degrees Celsius
D. Knots only

19. What does one okta represent when measuring cloud cover?

A. One-quarter of the sky
B. One-half of the sky
C. One-eighth of the sky
D. The entire sky

20. Wind is the movement of air from:

A. Low pressure to high pressure
B. High pressure to low pressure
C. The Equator to the poles only
D. The sea towards the land only

21. Which instrument is used to measure wind speed?

A. Wind vane
B. Thermometer
C. Anemometer
D. Barometer

22. Which instrument indicates the direction of the wind?

A. Rain gauge
B. Wind vane
C. Hygrometer
D. Sunshine recorder

23. A wind named after the direction from which it blows is known as:

A. Downwind
B. Crosswind
C. A directional wind
D. A wind from the named direction

24. When does a sea breeze usually occur?

A. At night when the land cools faster
B. During the day when the land heats faster than the sea
C. Only during winter
D. When mountains block the wind

25. Under which conditions does a mountain breeze generally occur?

A. During the day when slopes are heated
B. At night when cold air flows downslope
C. During heavy rainfall only
D. When the sea is warmer than the land

26. Which instrument is used to measure atmospheric pressure?

A. Barometer
B. Anemometer
C. Rain gauge
D. Thermometer

27. What is the approximate standard average atmospheric pressure at sea level?

A. 500 hPa
B. 750 hPa
C. 1013.25 hPa
D. 1500 hPa

28. Which instrument is used to measure the duration of sunshine?

A. Hygrometer
B. Campbell–Stokes sunshine recorder
C. Wind vane
D. Rain gauge

29. Why is weather forecasting important in agriculture?

A. It helps eliminate all crop diseases
B. It helps farmers plan planting and harvesting activities
C. It stops rainfall
D. It increases soil acidity

30. What is the main reason for investing in weather forecasting?

A. To prevent all changes in weather
B. To improve preparedness and reduce weather-related losses
C. To eliminate the need for farming
D. To stop the movement of air

Section B: Structured Questions (50 Marks)

Answer all questions. The total marks for this section are 50.

Question 1: Elements of Weather (8 Marks)

a) Define the term weather. (2 marks)

b) State four elements of weather. (4 marks)

c) Give two reasons why the study of weather is important to farmers in Kenya. (2 marks)

Question 2: Temperature and Precipitation (8 Marks)

a) Explain three factors influencing atmospheric temperature. (3 marks)

b) Name three instruments used to measure or record temperature in a weather station. (3 marks)

c) A weather station recorded a maximum temperature of 30°C and a minimum temperature of 18°C.

Calculate the daily temperature range. (2 marks)

Question 3: Humidity and Clouds (8 Marks)

a) Define relative humidity. (2 marks)

b) Explain how a wet-and-dry bulb hygrometer is used to determine relative humidity. (3 marks)

c) Describe three characteristics of cumulonimbus clouds. (3 marks)

Question 4: Winds and Atmospheric Pressure (8 Marks)

a) Define wind. (2 marks)

b) Explain three differences between a sea breeze and a land breeze. (3 marks)

c) State three factors that influence atmospheric pressure. (3 marks)

Question 5: Weather Station Instruments and Recording (10 Marks)

a) Name the instruments used to measure the following weather elements:

i) Rainfall. (1 mark)

ii) Wind speed. (1 mark)

iii) Wind direction. (1 mark)

iv) Atmospheric pressure. (1 mark)

b) Explain three characteristics of a Stevenson screen. (3 marks)

c) State three precautions to observe when measuring rainfall using a rain gauge. (3 marks)

Question 6: Weather Forecasting and Practical Work (8 Marks)

a) Define weather forecasting. (2 marks)

b) Explain three reasons why it is important to invest in weather forecasting in Kenya. (3 marks)

c) State three steps learners should follow when establishing a simple weather station in their school. (3 marks)

Answer Key and Suggested Responses

Section A: Multiple-Choice Answers

Question	Answer	Question	Answer
1	B	16	B

2	B	17	C
3	C	18	A
4	B	19	C
5	A	20	B
6	B	21	C
7	C	22	B
8	C	23	D
9	B	24	B
10	B	25	B
11	B	26	A
12	A	27	C
13	B	28	B
14	B	29	B
15	B	30	B

Section B: Suggested Answers and Marking Guide

Question 1: Elements of Weather (8 Marks)

a) Weather is the condition of the atmosphere at a particular place and time with respect to elements such as temperature, rainfall, humidity, wind and cloud cover. (2 marks)

b) Any four:

- Temperature.
- Precipitation.
- Humidity.
- Cloud cover.
- Wind.
- Atmospheric pressure.
- Sunshine. (4 marks)

c) Any two explained reasons:

- Helps farmers determine suitable planting periods.
- Helps farmers plan harvesting activities.
- Helps farmers prepare for drought.
- Helps farmers plan irrigation.
- Helps farmers protect crops against severe weather. (2 marks)

Question 2: Temperature and Precipitation (8 Marks)

a) Any three explained factors:

- **Latitude:** Places near the Equator generally receive more direct solar radiation than places at higher latitudes.
- **Altitude:** Temperature generally decreases with increasing altitude.
- **Distance from the sea:** Coastal areas generally experience smaller temperature ranges because water heats and cools more slowly than land.
- **Cloud cover:** Clouds may reduce daytime heating and reduce night-time heat loss.
- **Ocean currents:** Warm and cold currents influence temperatures in nearby coastal regions.
- **Prevailing winds:** Winds transport warm or cold air from other regions.

(3 marks)

b) Any three:

- Maximum thermometer.
- Minimum thermometer.
- Ordinary thermometer.
- Six's maximum and minimum thermometer. (3 marks)

c)

Daily range=Maximum temperature–Minimum temperatureDaily range=Maximum temperature–Minimum t emperature

=30–18=30–18

=12∘C=12∘*C*

(2 marks)

Question 3: Humidity and Clouds (8 Marks)

a) Relative humidity is the ratio of the actual amount of water vapour in the air to the maximum amount it can hold at the same temperature, expressed as a percentage. (2 marks)

b)

- A dry-bulb thermometer records ordinary air temperature.
- A wet-bulb thermometer has its bulb covered with a moist wick.

- Evaporation cools the wet bulb.
- The difference between the two readings is used with a psychrometric table to determine relative humidity.

Award any three relevant points. (3 marks)

c) Any three:

- Cumulonimbus clouds have extensive vertical development.
- They may have an anvil-shaped top.
- They are associated with thunderstorms.
- They may produce heavy rainfall.
- They may produce lightning and thunder.
- They may produce hail and strong winds.

(3 marks)

Question 4: Winds and Atmospheric Pressure (8 Marks)

a) Wind is the horizontal movement of air from an area of relatively high pressure towards an area of relatively low pressure. (2 marks)

b) Differences:

Sea breeze	**Land breeze**
Occurs mainly during the day.	Occurs mainly at night.
Blows from sea towards land.	Blows from land towards sea.
Land heats faster than the sea.	Land cools faster than the sea.
Warm air rises over land.	Relatively warm air rises over the sea.

Award any three clear differences. (3 marks)

c) Any three:

- Altitude.
- Temperature.
- Water vapour content.
- Unequal heating of the Earth's surface.
- Atmospheric circulation and the Earth's rotation.

(3 marks)

Question 5: Weather Station Instruments and Recording (10 Marks)

a)

i) Rain gauge. (1 mark)

ii) Anemometer. (1 mark)

iii) Wind vane. (1 mark)

iv) Barometer. (1 mark)

b) Any three:

- It is painted white to reflect solar radiation.
- It has louvred sides to allow air circulation.
- It is raised above the ground.
- It has a double roof to reduce heating.
- It is positioned over a suitable surface, preferably short grass.
- It protects thermometers from direct sunshine and rainfall.

(3 marks)

c) Any three:

- Place the rain gauge in an open area away from trees and buildings.
- Ensure the instrument is vertical.
- Ensure the collecting rim is horizontal.
- Avoid spilling water during measurement.
- Take readings at consistent times.
- Keep the instrument clean.
- Record rainfall in millimetres.

(3 marks)

Question 6: Weather Forecasting and Practical Work (8 Marks)

a) Weather forecasting is the process of predicting future atmospheric conditions using weather observations, scientific principles and forecasting technologies. (2 marks)

b) Any three explained reasons:

- It helps farmers plan planting and harvesting.
- It helps communities prepare for floods and droughts.
- It improves aviation and road transport safety.
- It supports water resource management.
- It reduces loss of life and property.
- It supports economic planning.
- It improves disaster preparedness.

(3 marks)

c) Any three:

- Obtain permission and identify a suitable open site.

- Prepare the ground and install weather instruments.
- Position the rain gauge away from obstructions.
- Install the wind vane and anemometer in an exposed position.
- Install the Stevenson screen in a suitable location.
- Prepare a weather recording timetable.
- Train learners to use the instruments.
- Begin recording weather observations.

(3 marks)

Competency-Based Learning Project

Project: Developing a Community Weather Observation and Early-Warning System

Project Situation

A farming community in Kenya has experienced unpredictable rainfall, occasional floods and prolonged dry spells. Farmers have reported losses because they do not receive sufficient local weather information.

Learners are required to investigate local weather conditions and develop a simple weather observation project that can support the school and surrounding community.

Project Activities

1. Identify the main weather elements affecting the community.
2. Research the weather conditions experienced in the area.
3. Identify the weather instruments required.
4. Construct at least two simple weather instruments using locally available materials.
5. Establish a suitable weather observation site in the school.
6. Measure and record selected weather elements daily.
7. Prepare weekly weather summaries.
8. Present weather information using tables and graphs.
9. Explain how the information can assist farmers and other community members.
10. Develop recommendations on how the community can benefit from weather forecasting.

Expected Project Outputs

Learners should produce:

- A constructed rain gauge.
- A constructed wind vane or anemometer.
- A weather observation register.
- A weekly weather summary.
- A rainfall or temperature graph.
- A written project report.
- A short presentation to the class.

Competencies Developed

Competency	**Application in the project**
Critical thinking and problem-solving	Identifying suitable methods of measuring weather elements
Creativity and imagination	Constructing weather instruments from locally available materials
Communication	Presenting weather observations and findings
Collaboration	Working in groups to establish a weather station
Digital literacy	Using digital tools to record and present weather information
Learning to learn	Researching weather elements and forecasting
Citizenship	Sharing useful weather information with the community

Values Developed

- Responsibility in handling weather instruments.
- Cooperation during group work.
- Honesty in recording weather observations.
- Respect for other learners' contributions.
- Accountability in completing fieldwork.
- Care for the environment.

Assessment Rubric

Assessment area	**Marks**
Identification of weather elements	5
Construction of weather instruments	10
Accuracy of weather observations	10
Recording and presentation of data	5
Interpretation of weather information	5
Recommendations and community application	5
Total	40

STRAND 2.0: NATURAL SYSTEMS AND PROCESSES

SUB-STRAND 2.2: CLIMATE

1.0 MEANING AND CONCEPT OF CLIMATE

1.1 Definition of climate

Climate refers to the average weather conditions of a place, usually calculated over a long period of at least 30 years.

It describes the general pattern of atmospheric conditions experienced in a region over many years.

Climate is determined by the long-term patterns of:

- Temperature.
- Rainfall and other forms of precipitation.
- Humidity.
- Atmospheric pressure.
- Wind direction and speed.
- Cloud cover.
- Sunshine duration.

Example: The climate of Mombasa is generally hot and humid, while the climate of Lodwar is generally hot and dry.

1.2 Difference between weather and climate

Weather and climate are related geographical concepts, but they differ in the period over which atmospheric conditions are observed.

Weather	**Climate**
Refers to the condition of the atmosphere at a particular place and time.	Refers to the average atmospheric conditions of a place over a long period.
Changes frequently, sometimes within hours.	Changes gradually over many years.
Describes short-term atmospheric conditions.	Describes long-term atmospheric patterns.
Studied using daily or short-term observations.	Studied using long-term records, usually covering at least 30 years.
Example: It is raining in Kisumu this afternoon.	Example: Kisumu experiences a generally warm climate with rainfall throughout the year.

1.3 Elements of climate

The elements of climate are the atmospheric conditions used to describe the climate of a place.

1. **Temperature:** The degree of hotness or coldness of the atmosphere. It is measured using a thermometer in degrees Celsius (°C).
2. **Rainfall:** Water droplets falling from clouds to the Earth's surface. Rainfall is measured using a rain gauge in millimetres (mm).
3. **Humidity:** The amount of water vapour present in the atmosphere.
4. **Atmospheric pressure:** The force exerted by the weight of air on the Earth's surface. It is measured using a barometer.
5. **Wind:** Moving air from an area of high pressure to an area of low pressure.
6. **Cloud cover:** The extent to which the sky is covered by clouds.
7. **Sunshine:** The duration and intensity of sunlight received at a place.

1.4 Factors influencing climate

Climate varies from one place to another because of differences in physical and geographical conditions.

A. Latitude

Latitude refers to the angular distance of a place north or south of the Equator.

- Areas near the Equator receive more direct solar radiation throughout the year.
- These areas generally experience high temperatures.
- Areas towards the poles receive slanting solar radiation and are generally colder.
- Seasonal differences in temperature become more pronounced towards higher latitudes.

Examples:

- Equatorial regions of Kenya experience generally high temperatures.
- Northern Canada and Greenland experience very cold climatic conditions.

B. Altitude

Altitude is the height of a place above sea level.

- Temperature generally decreases with increasing altitude.
- High-altitude areas are usually cooler than lowland areas at similar latitudes.
- Mountainous areas may experience snow and frost.
- Altitude can influence the type of vegetation and crops grown.

Kenyan examples:

- Nairobi is generally cooler than Mombasa partly because Nairobi is at a higher altitude.
- The slopes of Mount Kenya experience cooler conditions than the surrounding lowlands.
- The highlands around Kericho are suitable for tea growing because of their cool, wet conditions.

C. Distance from the sea

The sea influences the temperature and humidity of nearby land areas.

- Coastal areas generally experience smaller temperature ranges than inland areas.
- Water heats and cools more slowly than land.
- Coastal areas often experience high humidity because of moisture from the sea.
- Inland areas may experience greater differences between daytime and night-time temperatures.

Examples:

- Mombasa experiences a maritime influence from the Indian Ocean.
- Places deep inside continents, such as parts of central Asia, experience more extreme seasonal temperature differences.

D. Ocean currents

Ocean currents are large movements of seawater in particular directions.

- Warm ocean currents raise temperatures along nearby coastlines.

- Cold ocean currents lower temperatures along nearby coastlines.
- Cold currents can reduce evaporation and rainfall.
- Some cold currents contribute to the development of coastal deserts.

Examples:

- The warm Gulf Stream influences the climate of western Europe.
- The cold Benguela Current contributes to the dry conditions along parts of the Namibian coast.
- The cold Humboldt Current influences the arid conditions along the coast of Peru and northern Chile.

E. Prevailing winds

Prevailing winds are winds that blow from a particular direction over a region for a long period.

- Winds blowing from oceans may carry moisture and cause rainfall.
- Winds blowing from dry land areas may carry little moisture.
- Winds can transport warm or cold air from one region to another.
- Seasonal changes in wind direction may cause seasonal rainfall patterns.

Example: Moist winds from the Indian Ocean contribute to rainfall in parts of coastal Kenya.

F. Relief and aspect

Relief refers to the shape and height of the land, while aspect refers to the direction a slope faces.

- Mountains force moist air to rise, cool and condense, causing orographic rainfall.
- Windward slopes often receive more rainfall than leeward slopes.
- Leeward slopes may experience a rain-shadow effect.
- Slopes facing the sun may receive more solar radiation than slopes facing away from it.

Example: The windward slopes of Mount Kenya receive more rainfall than some areas lying in its rain shadow.

G. Vegetation cover

Vegetation influences local temperature and moisture conditions.

- Forests provide shade and reduce surface heating.
- Plants release water vapour through transpiration.
- Vegetation helps maintain humidity and the water cycle.
- Removal of vegetation can increase surface temperatures and soil dryness.
- Forest destruction can alter local rainfall patterns.

Example: The Mau Forest Complex plays an important role in regulating water catchments and supporting the climate of surrounding areas.

H. Human activities

Human activities can modify local and global climatic conditions.

- Burning fossil fuels releases greenhouse gases.
- Deforestation reduces the ability of forests to absorb carbon dioxide.

- Industrial activities release gases and particles into the atmosphere.
- Urbanisation creates heat islands because buildings and roads absorb and retain heat.
- Agriculture and livestock production can release greenhouse gases.

Example: The expansion of built-up areas in Nairobi can contribute to higher local temperatures compared with surrounding rural areas.

2.0 CLASSIFICATION OF CLIMATE IN THE WORLD

2.1 Meaning of climate classification

Climate classification is the systematic grouping of places with similar long-term climatic characteristics into different categories.

It helps geographers to:

- Identify regions with similar climatic conditions.
- Compare climatic patterns in different parts of the world.
- Understand the distribution of natural vegetation.
- Explain the distribution of crops and livestock.
- Support agricultural and economic planning.
- Study environmental changes.
- Identify regions vulnerable to droughts, floods and other climatic hazards.

2.2 Major approaches to climate classification

There are several methods of classifying climate. Two important systems are:

1. Köppen climate classification.
2. Thornthwaite climate classification.

2.3 Köppen climate classification

The Köppen climate classification system was developed by the German-Russian climatologist Wladimir Köppen.

It classifies the world's climates mainly according to:

- Average monthly and annual temperatures.
- Average monthly and annual precipitation.
- Seasonal distribution of rainfall.
- The relationship between climate and natural vegetation.

The system uses letters to represent major climatic groups and their subdivisions.

Major climatic groups in the Köppen system

A. Tropical rainy climates

These climates occur mainly in regions near the Equator.

Characteristics:

- Generally high temperatures throughout the year.

- Small annual temperature range.
- Generally high solar radiation.
- Some areas receive rainfall throughout the year.
- Other areas experience distinct wet and dry seasons.

Main subdivisions:

1. **Tropical rainforest climate (Af)**

- Experiences high temperatures throughout the year.
- Receives heavy rainfall in most months.
- Has high humidity.
- Supports dense evergreen forests.
- Has no distinct dry season.

Examples: Amazon Basin, Congo Basin and parts of Indonesia.

2. **Tropical monsoon climate (Am)**

- Experiences high temperatures throughout the year.
- Receives heavy seasonal rainfall.
- Has a short dry season.
- Rainfall is strongly influenced by seasonal wind changes.

Examples: Parts of India, Bangladesh and Myanmar.

3. **Tropical savanna climate (Aw or As)**

- Experiences high temperatures throughout the year.
- Has distinct wet and dry seasons.
- Supports grasslands with scattered trees.
- Rainfall is seasonal.

Examples: Much of East Africa, including large parts of Kenya and Tanzania.

B. Dry climates

Dry climates occur where potential evaporation is greater than precipitation over the relevant climatic period.

Characteristics:

- Low and unreliable rainfall in many areas.
- High evaporation in hot deserts.
- Sparse vegetation.
- Large daily temperature ranges in many desert areas.
- Water shortage is a common challenge.

Main subdivisions:

1. **Desert climate (BW)**

- Receives very little rainfall.
- Has sparse vegetation.
- Experiences high evaporation in hot desert areas.
- May have very hot days and cold nights.

Examples: Sahara Desert, Arabian Desert and parts of the Australian interior.

2. **Steppe or semi-arid climate (BS)**

- Receives more rainfall than desert regions.
- Rainfall may be unreliable or seasonal.
- Supports short grasses and drought-resistant shrubs.
- Often supports pastoralism and drought-tolerant farming.

Examples: Sahel region of Africa and parts of northern Kenya.

C. Temperate climates

These climates generally experience moderate temperatures compared with tropical and polar climates.

Characteristics:

- Moderate temperatures.
- Seasonal changes in temperature.
- Rainfall varies according to location.
- Different types of forests and grasslands occur.

Common subdivisions include:

1. **Humid subtropical climate (Cfa/Cwa)**

- Hot summers.
- Mild winters.
- Rainfall may occur throughout the year or mainly during summer.
- Supports mixed forests and crop farming.

2. **Mediterranean climate (Csa/Csb)**

- Hot, dry summers.
- Mild, wet winters.
- Rainfall mainly occurs during the cooler months.
- Supports crops such as olives, grapes and citrus fruits.

Examples: Mediterranean Basin, central Chile, parts of California and southwestern Australia.

3. **Marine west coast climate (Cfb/Cfc)**

- Mild summers.
- Cool winters.
- Rainfall is generally distributed throughout the year.

- Cloudy and moist conditions are common.

Examples: Western Europe, New Zealand and parts of southern Chile.

D. Continental climates

These climates occur mainly in the interiors and eastern parts of large landmasses in the middle and higher latitudes.

Characteristics:

- Large annual temperature ranges.
- Warm or hot summers in some areas.
- Cold winters.
- Seasonal precipitation.
- Snowfall may occur during winter.

Common subdivisions include:

- Humid continental climate.
- Subarctic climate.

Examples: Interior Canada, parts of Russia and northeastern China.

E. Polar climates

These climates occur in areas close to the North and South Poles.

Characteristics:

- Extremely low temperatures.
- Long, cold winters.
- Short, cool summers or no true warm summer.
- Low precipitation, much of it falling as snow.
- Limited vegetation.

Main subdivisions:

1. **Tundra climate (ET)**

- Has very cold winters.
- Has short, cool summers.
- The subsoil may remain permanently frozen.
- Supports mosses, lichens, grasses and dwarf shrubs.

2. **Ice-cap climate (EF)**

- Experiences extremely low temperatures throughout the year.
- Permanent ice and snow cover much of the surface.
- Vegetation is virtually absent.

Examples: Interior Antarctica and Greenland's ice-sheet areas.

F. Highland climates

Highland climates are associated with high mountain areas. In the Köppen system, some highland areas are represented within other categories depending on their temperature and precipitation characteristics; highland climate is also commonly studied as a distinct geographical climatic environment.

Characteristics:

- Temperature generally decreases with altitude.
- Rainfall may increase on windward slopes.
- Leeward slopes may be dry.
- Climatic conditions change over short horizontal distances because of differences in altitude and aspect.
- Vegetation changes with height.

Examples: Mount Kenya, the Ethiopian Highlands, the Andes and the Himalayas.

2.4 Advantages of the Köppen classification system

1. It is based on measurable climatic data.
2. It uses a systematic system of letters and symbols.
3. It helps compare climates across different continents.
4. It relates climate to natural vegetation.
5. It is useful in geographical and environmental studies.
6. It helps identify climatic regions for agricultural planning.

2.5 Limitations of the Köppen classification system

1. It does not fully explain the causes of climatic conditions.
2. Boundaries between climatic regions may be gradual rather than sharp.
3. It may not show small local climatic differences.
4. Some climatic regions have been altered by human activities.
5. Its use of average data may conceal extreme weather events.
6. It does not fully describe the effects of altitude and local relief in every region.

2.6 Thornthwaite climate classification

The Thornthwaite system was developed by the American climatologist Charles Warren Thornthwaite.

It classifies climate mainly according to the relationship between precipitation and the amount of water lost through evapotranspiration.

Evapotranspiration is the combined loss of water to the atmosphere through evaporation from surfaces and transpiration from plants.

The system considers:

- Precipitation.
- Potential evapotranspiration.

- Water surplus.
- Water deficiency.
- Soil moisture conditions.
- Thermal conditions.

Main climatic categories in the Thornthwaite system

The system identifies broad moisture conditions, including:

1. **Perhumid climates:** These receive much more moisture than is required to meet potential evapotranspiration. Water surplus is high.
2. **Humid climates:** These generally have adequate moisture to support vegetation growth.
3. **Moist sub-humid climates:** These have relatively adequate moisture, although seasonal shortages may occur.
4. **Dry sub-humid climates:** These experience more frequent moisture deficits.
5. **Semi-arid climates:** These have limited moisture and are more vulnerable to drought.
6. **Arid climates:** These experience severe moisture shortages.

Thornthwaite also considers thermal efficiency, which helps distinguish climates according to their heat conditions.

Importance of the Thornthwaite system

- Helps assess agricultural suitability.
- Helps identify areas experiencing water shortages.
- Supports irrigation planning.
- Assists in studying drought vulnerability.
- Helps assess the moisture requirements of vegetation.
- Supports water-resource management.

Limitations of the Thornthwaite system

- Requires detailed climatic data.
- Calculations may be complex.
- Results depend on the accuracy of precipitation and evapotranspiration estimates.
- It may not fully represent local climatic variations.
- Its categories may be difficult to interpret without technical knowledge.

2.7 Comparison of Köppen and Thornthwaite systems

Köppen classification	**Thornthwaite classification**
Uses temperature and precipitation patterns.	Emphasises precipitation and evapotranspiration.

Relates climate to natural vegetation.	Relates climate to moisture and thermal efficiency.
Uses letter codes such as Af, BWh and Csa.	Uses moisture and thermal categories.
Useful for global climatic mapping.	Particularly useful in water-resource and agricultural studies.
Relatively straightforward to interpret.	Often requires more detailed calculations.

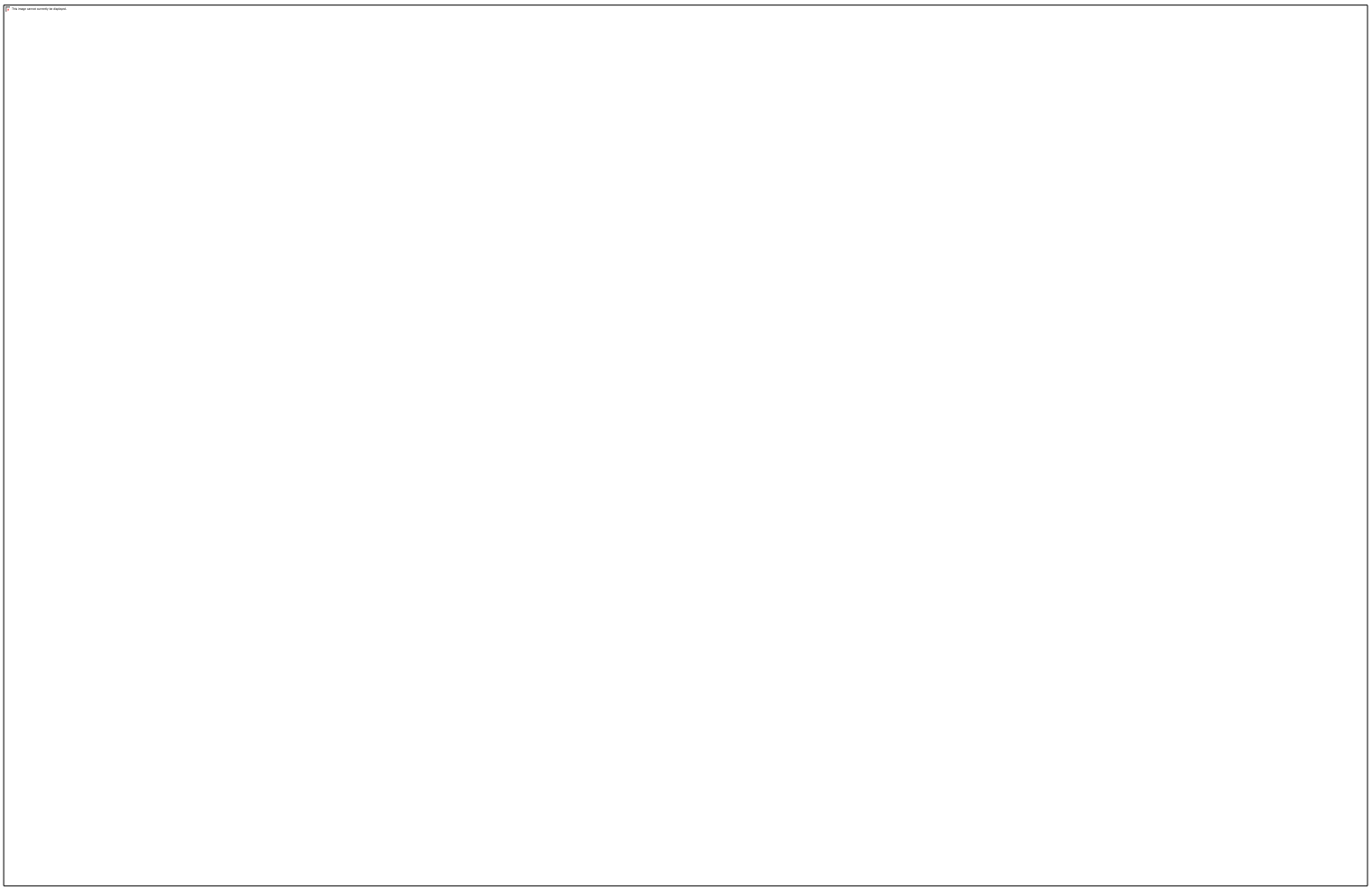
3.0 MAJOR CLIMATIC REGIONS OF THE WORLD

3.1 Meaning of climatic regions

Climatic regions are large geographical areas that share similar long-term patterns of temperature, rainfall and other climatic elements.

The major climatic regions commonly studied are:

1. Tropical.
2. Dry.
3. Temperate.
4. Continental.
5. Polar.
6. Highland.



3.2 Tropical climatic region

The tropical climatic region lies mainly between the Tropic of Cancer (23½°N) and the Tropic of Capricorn (23½°S).

Characteristics

1. **High temperatures:** Temperatures are generally high throughout the year because of the high angle of the sun.
2. **Small annual temperature range:** Differences between the warmest and coolest months are often small, especially near the Equator.
3. **High solar radiation:** Tropical regions receive considerable solar energy throughout the year.
4. **Variable rainfall:** Some areas receive rainfall throughout the year, while others experience distinct wet and dry seasons.
5. **High evaporation:** Warm temperatures encourage rapid evaporation.
6. **High humidity:** Humidity is often high in areas with abundant moisture.
7. **Diverse vegetation:** Vegetation ranges from dense tropical rainforests to savanna grasslands and thorn scrub.

Types of tropical climate

A. Equatorial climate

- Occurs near the Equator.
- High temperatures throughout the year.
- Heavy rainfall distributed across most months.
- Small annual temperature range.
- High humidity and cloud cover.
- Dense evergreen forests.

Examples: Congo Basin, Amazon Basin and parts of Indonesia.

B. Tropical monsoon climate

- Experiences high temperatures throughout the year.
- Has a marked wet season and a shorter dry season.
- Receives heavy rainfall during the monsoon season.
- Seasonal reversal of winds influences rainfall.

Examples: India, Bangladesh and parts of Southeast Asia.

C. Tropical savanna climate

- Experiences high temperatures throughout the year.
- Has a distinct wet season and dry season.
- Supports tall grasses and scattered trees.
- Rainfall is seasonal and may be unreliable in some areas.

Examples: Kenya, Tanzania, Uganda and parts of West Africa.

Human activities in tropical regions

- Crop farming: cocoa, coffee, bananas, sugarcane and rice in suitable areas.
- Livestock keeping: cattle, goats and sheep in savanna regions.
- Forestry: timber production in tropical forest areas.
- Tourism: wildlife tourism and forest tourism.
- Fishing: river, lake and coastal fishing.
- Settlement: population distribution varies according to rainfall, disease conditions, soils and accessibility.

Challenges experienced in tropical regions

- Flooding caused by heavy rainfall.
- Drought in areas with seasonal or unreliable rainfall.
- Soil erosion due to intense rainfall.
- Tropical diseases in some warm and humid environments.
- Deforestation and loss of biodiversity.
- Destruction of crops by pests and diseases.

Kenyan application: The tropical savanna climate supports wildlife conservation and livestock keeping in parts of Maasai Mara, Amboseli and Tsavo. However, prolonged dry seasons can cause water shortages and livestock losses.

3.3 Dry climatic region

Dry climates occur mainly in areas where precipitation is low compared with potential evapotranspiration.



Characteristics

1. Low and unreliable rainfall.
2. High evaporation in hot desert regions.
3. Sparse vegetation.
4. Large daily temperature ranges in many deserts.
5. Low humidity in many inland desert areas.
6. Frequent droughts.
7. Limited surface water.
8. Some areas experience sudden flash floods after heavy rainfall.

Types of dry climate

A. Hot desert climate

- Very low rainfall.
- High daytime temperatures in many locations.
- Clear skies and intense sunshine are common.
- Nights may be cold because of rapid heat loss.
- Vegetation is sparse and drought-resistant.

Examples: Sahara Desert, Arabian Desert and Australian deserts.

B. Cold desert climate

- Low precipitation.
- Cold winters.
- Short and sometimes warm summers.
- Vegetation is limited.
- Snow may occur during winter.

Examples: Gobi Desert and parts of Central Asia.

C. Semi-arid or steppe climate

- Receives more rainfall than desert regions.
- Rainfall is often seasonal and unreliable.
- Supports grasses and drought-resistant shrubs.
- Supports pastoralism and some crop farming.

Examples: Sahel region and parts of northern Kenya.

Human activities in dry regions

- Nomadic and semi-nomadic pastoralism.
- Irrigation farming where water is available.
- Mining of minerals.
- Tourism and recreation.
- Solar energy production.
- Trade and transport along established routes.

Challenges in dry climatic regions

- Water scarcity.
- Frequent droughts.
- Desertification.
- Poor crop yields.
- Loss of livestock.
- Food insecurity.
- Competition over pasture and water.
- Sandstorms and dust storms.

Kenyan application: Turkana, Marsabit, Wajir and Garissa contain extensive arid and semi-arid areas. Communities practise pastoralism, while irrigation is possible in selected areas where reliable water sources are available.

3.4 Temperate climatic region

Temperate climates occur mainly in the middle latitudes between tropical and polar climatic regions.



Characteristics

1. Moderate temperatures compared with tropical and polar regions.
2. Noticeable seasonal changes.
3. Rainfall varies according to location and season.
4. Natural vegetation includes deciduous forests, mixed forests and grasslands.
5. Some areas experience warm summers and cool winters.
6. Many areas support intensive agriculture and industrial development.

Main types of temperate climate

A. Mediterranean climate

Characteristics:

- Hot, dry summers.
- Mild, wet winters.
- Rainfall mainly occurs during winter.
- Summer drought is common.
- Evergreen shrubs and drought-resistant vegetation are common.

Examples: Countries bordering the Mediterranean Sea, central Chile, California and southwestern Australia.

Human activities:

- Growing grapes and olives.
- Citrus fruit farming.
- Wheat farming.
- Tourism.
- Livestock keeping.

B. Marine west coast climate

Characteristics:

- Mild summers.
- Cool winters.
- Rainfall throughout much of the year.
- Frequent cloud cover.
- Moderate annual temperature range.

Examples: Western Britain, western France, New Zealand and parts of coastal Chile.

Human activities:

- Dairy farming.
- Sheep rearing.
- Forestry.
- Mixed crop farming.
- Fishing and tourism.

C. Humid subtropical climate

Characteristics:

- Hot, humid summers.
- Mild winters.
- Rainfall throughout the year or concentrated in particular seasons.
- Thunderstorms may occur during summer.

Examples: Southeastern China, southeastern United States and parts of eastern Australia.

Human activities:

- Rice cultivation.
- Tea growing.
- Cotton farming.
- Fruit production.
- Manufacturing and trade.

Challenges in temperate regions

- Winter storms and snow.

- Heatwaves.
- Flooding.
- Drought during dry summers.
- Forest fires in some Mediterranean areas.
- Soil erosion and environmental pollution.

3.5 Continental climatic region

Continental climates are mainly found in the interiors and eastern parts of large continents, especially in the middle and higher latitudes.

Characteristics

1. Large annual temperature range.
2. Warm or hot summers in some regions.
3. Very cold winters.
4. Seasonal rainfall patterns.
5. Snowfall during winter in many areas.
6. Natural vegetation includes coniferous forests, mixed forests and grasslands.
7. Frost may occur during colder months.

Types of continental climate

A. Humid continental climate

- Warm summers.
- Cold winters.
- Precipitation occurs during much of the year.
- Snowfall may occur in winter.

Examples: Parts of eastern Europe, northeastern China and the northeastern United States.

B. Subarctic climate

- Long, very cold winters.
- Short, cool summers.
- Low to moderate precipitation.
- Much of the vegetation consists of coniferous forests known as taiga.

Examples: Interior Alaska, northern Canada and Siberia.

Human activities

- Wheat and barley farming in suitable areas.
- Forestry and timber processing.
- Dairy farming in suitable locations.
- Mining.

- Fishing.
- Manufacturing and trade.

Challenges

- Severe winter cold.
- Snowstorms and blizzards.
- Short growing seasons.
- Frozen soils.
- High heating costs.
- Difficult transport during winter.

3.6 Polar climatic region

Polar climates occur in the high-latitude areas surrounding the North and South Poles.

Characteristics

1. Extremely low temperatures.
2. Long, very cold winters.
3. Very short and cool summers in tundra areas.
4. Low precipitation, much of which falls as snow.
5. Permanent ice and snow in ice-cap areas.
6. Permafrost occurs in many tundra areas.
7. Sparse vegetation.
8. Very short growing seasons.

Types of polar climate

A. Tundra climate

- Extremely cold winters.
- Short, cool summers.
- The ground may remain frozen for long periods.
- Supports mosses, lichens, grasses and small shrubs.
- Trees are generally absent because of the harsh conditions and short growing season.

B. Ice-cap climate

- Extremely cold throughout the year.
- Permanent snow and ice cover.
- Vegetation is almost absent.
- Human settlement is extremely limited.

Examples: Antarctica, Greenland and Arctic islands.

Human activities

- Scientific research.
- Fishing in surrounding seas.
- Limited hunting and traditional activities by some indigenous communities.
- Tourism in selected areas.
- Mineral exploration in some polar and subpolar locations, subject to environmental and legal restrictions.

Challenges

- Extreme cold.
- Ice and snow hazards.
- Limited vegetation and food production.
- Difficult transport.
- High cost of settlement and infrastructure.
- Climate change and melting ice.

3.7 Highland climatic region

Highland climates occur in mountainous areas where altitude strongly influences temperature and rainfall.

Characteristics

1. Temperature generally decreases with increasing altitude.
2. Windward slopes may receive heavy rainfall.
3. Leeward slopes may be relatively dry.
4. Vegetation changes with altitude.
5. Snow and glaciers may occur on very high mountains.
6. Local climate may vary considerably over short distances.
7. Mountain valleys may experience temperature inversions.

Human activities

- Tea and coffee farming on suitable slopes.
- Horticulture and vegetable growing.
- Dairy farming.
- Tourism and mountaineering.
- Forestry.
- Hydroelectric power generation.
- Water catchment conservation.

Kenyan examples:

- Mount Kenya.
- Aberdare Ranges.

- Mau Highlands.
- Cherangany Hills.
- Parts of the Kenya Highlands.

Challenges

- Soil erosion on steep slopes.
- Landslides.
- Frost in high-altitude areas.
- Difficult transport.
- Loss of mountain glaciers.
- Deforestation and degradation of water catchments.

4.0 LOCATION OF THE MAJOR CLIMATIC REGIONS OF THE WORLD

4.1 Distribution of world climatic regions

The major climatic regions are not randomly distributed. Their location is influenced by latitude, altitude, relief, distance from the sea, ocean currents and prevailing winds.

A. Tropical climatic region

It is mainly found between the Tropic of Cancer and the Tropic of Capricorn.

Examples of countries and areas:

- Democratic Republic of Congo.
- Kenya.
- Uganda.
- Tanzania.
- Brazil.
- Indonesia.
- Malaysia.
- Parts of India.
- Northern Australia.

B. Dry climatic region

It is mainly found around the subtropical high-pressure belts and in continental interiors.

Examples:

- Sahara Desert in North Africa.
- Kalahari Desert in southern Africa.
- Namib Desert in Namibia.
- Arabian Desert in Southwest Asia.
- Gobi Desert in Mongolia and China.

- Australian deserts.
- Atacama Desert in Chile.
- Parts of northern Kenya and the Horn of Africa.

C. Temperate climatic region

It occurs mainly in the middle latitudes.

Examples:

- Western Europe.
- Parts of southern Europe.
- Central Chile.
- Parts of California in the United States.
- Southeastern Australia.
- New Zealand.
- Parts of eastern Asia.

D. Continental climatic region

It occurs mainly in the interiors and eastern parts of large continents in the middle and higher latitudes.

Examples:

- Central and eastern Canada.
- Northeastern United States.
- Russia.
- Siberia.
- Mongolia.
- Northeastern China.
- Parts of eastern Europe.

E. Polar climatic region

It occurs around the Arctic and Antarctic regions.

Examples:

- Antarctica.
- Greenland.
- Northern Canada.
- Northern Alaska.
- Arctic islands.
- Northern parts of Russia.

F. Highland climatic region

It occurs in high mountain areas around the world.

Examples:

- Mount Kenya in Kenya.
- Ethiopian Highlands.
- Atlas Mountains in North Africa.
- Himalayas in Asia.
- Andes in South America.
- Alps in Europe.
- Rocky Mountains in North America.

4.2 Factors influencing the distribution of climatic regions

1. **Latitude:** Determines the angle at which solar radiation reaches the Earth's surface.
2. **Altitude:** High areas are generally cooler than low-lying areas.
3. **Relief:** Mountains influence rainfall distribution through orographic uplift and rain-shadow effects.
4. **Distance from the sea:** Coastal areas are generally more influenced by maritime conditions than inland areas.
5. **Ocean currents:** Warm and cold currents influence temperatures and moisture conditions along coastlines.
6. **Prevailing winds:** Winds transport moisture and heat from one region to another.
7. **Pressure belts:** Global high- and low-pressure systems influence rainfall and dry conditions.
8. **Vegetation:** Forests and grasslands influence local moisture and temperature conditions.
9. **Human activities:** Deforestation, urbanisation and greenhouse gas emissions can modify climatic conditions.

4.3 Activity: Locating climatic regions on a world map

Learning activity

Using an outline map of the world:

1. Draw the Equator, Tropic of Cancer and Tropic of Capricorn.
2. Mark the Sahara Desert, Amazon Basin, Congo Basin, Mediterranean Basin, central Asia and Antarctica.
3. Use different colours to represent the major climatic regions.
4. Prepare a key showing each climatic region.
5. Display the completed map in class.
6. Explain why the different climatic regions occur in their respective locations.

Expected learning outcome: The learner should be able to identify and locate the major climatic regions and explain their distribution.

5.0 CHARACTERISTICS AND COMPARISON OF THE MAJOR CLIMATIC REGIONS

5.1 Comparison of climatic regions

Climatic region	Temperature	Rainfall	Natural vegetation	Main economic activities
Tropical	Generally high	Moderate to very high, often seasonal	Rainforests, savanna grasslands	Farming, livestock keeping, forestry, tourism
Dry	Very hot or cold depending on location	Low and unreliable	Thorn scrub, sparse grasses, desert plants	Pastoralism, irrigation, mining, tourism
Temperate	Moderate with seasonal changes	Moderate; varies by type	Deciduous and mixed forests, grasslands	Mixed farming, dairy, industry, trade
Continental	Warm summers and cold winters in many areas	Seasonal or moderate	Coniferous and mixed forests, grasslands	Grain farming, forestry, mining
Polar	Extremely cold	Low, often as snow	Mosses, lichens or no vegetation	Research, fishing, limited tourism
Highland	Decreases with altitude	Varies with relief and exposure	Vegetation changes with altitude	Tourism, farming, forestry, livestock keeping

5.2 Relationship between climate and human activities

Climate influences human activities in several ways.

A. Agriculture

- Rainfall determines the availability of water for crop growth.
- Temperature influences the types of crops that can grow.
- Length of growing season determines the time available for crop maturity.
- Frost may destroy crops in cold areas.
- Drought reduces crop yields and may cause crop failure.
- Heavy rainfall may cause flooding and soil erosion.

Examples:

- Tea thrives in the cool, wet Kenyan highlands.
- Rice is grown in areas with adequate water, including irrigated schemes.
- Drought-resistant crops such as sorghum and millet are suitable for some semi-arid areas.
- Wheat is grown in selected highland areas with suitable temperatures and rainfall.

B. Livestock keeping

- Grass availability depends partly on rainfall.
- Water availability influences livestock distribution.
- High temperatures may cause heat stress in animals.
- Drought can cause pasture shortages and livestock deaths.
- Different animal breeds are adapted to different climatic conditions.

Example: Pastoral communities in northern Kenya keep livestock such as goats, sheep, camels and cattle, depending on local conditions.

C. Settlement

- Areas with favourable temperatures and adequate water often attract more settlement.
- Extremely cold deserts and very hot deserts may have sparse populations.
- Flood-prone areas may discourage permanent settlement.
- Climate influences the design and materials used in houses.

D. Transport

- Heavy rainfall may damage roads and bridges.
- Floods can interrupt road and railway transport.
- Snow and ice may close roads in cold regions.
- Fog can reduce visibility and disrupt air and road transport.
- Strong winds can affect aviation and marine transport.

E. Tourism

- Warm, sunny weather attracts tourists to beaches.
- Wildlife tourism is influenced by rainfall and vegetation.
- Mountain climates attract climbers and hikers.
- Snow supports winter sports in cold regions.
- Extreme weather can discourage tourism and damage tourist facilities.

F. Fishing

- Temperature affects the distribution of fish species.
- Rainfall influences the flow of rivers and the levels of lakes.
- Storms and strong winds can make fishing dangerous.
- Changes in ocean temperatures can affect fish migration and breeding.

G. Energy production

- Solar energy production depends on the availability of sunlight.
- Hydroelectric power depends on water availability.
- Wind power depends on wind speed and consistency.
- Extreme temperatures influence energy demand for heating and cooling.

5.3 Activity: Climate and livelihoods in Kenya

In groups:

1. Identify three climatic regions or climatic environments found in Kenya.
2. Name the main economic activities in each region.
3. Explain how rainfall and temperature influence those activities.
4. Identify two climate-related challenges experienced by each community.
5. Suggest practical ways of reducing the challenges.
6. Present your findings to the class.

6.0 MEANING AND CONCEPT OF CLIMATE CHANGE

6.1 Definition of climate change

Climate change refers to long-term changes in the average temperature, rainfall patterns, wind systems and other climatic conditions of the Earth or a particular region.

Climate change may occur naturally, but the rapid warming experienced since the industrial era is mainly caused by human activities that increase the concentration of greenhouse gases in the atmosphere.

Examples of climate change include:

- A long-term rise in average global temperatures.
- Changes in the timing and distribution of rainfall.
- More frequent or intense heat extremes in many regions.
- Melting glaciers and ice sheets.
- Rising sea levels.
- Changes in the distribution of plant and animal species.
- Changes in the frequency or intensity of some extreme weather events.

6.2 Difference between climate change and global warming

Climate change	**Global warming**
Refers to long-term changes in climate patterns.	Refers specifically to the long-term increase in Earth's average surface temperature.
Includes changes in temperature, rainfall, winds and extreme events.	Focuses mainly on increasing average temperatures.
May involve changes in both warming and cooling patterns in different locations.	Describes the overall warming trend of the planet.
Has broad environmental and socio-economic effects.	Is a major driver of current climate change.

Important point: Global warming is one of the major aspects of modern climate change.

6.3 The greenhouse effect

The greenhouse effect is the natural process through which certain gases in the atmosphere absorb and re-emit some of the heat radiated from the Earth's surface, keeping the planet warm enough to support life.

Greenhouse gases include:

- Carbon dioxide (CO_2).
- Methane (CH_4).
- Nitrous oxide (N_2O).
- Water vapour.
- Ozone.
- Certain industrial gases such as hydrofluorocarbons.

The natural greenhouse effect is essential for life. However, human activities have increased the concentration of many greenhouse gases, strengthening the greenhouse effect and causing additional warming.

How the enhanced greenhouse effect occurs

1. Solar radiation enters the Earth's atmosphere.
2. Some incoming solar radiation is reflected back into space by clouds, the atmosphere and bright surfaces.
3. The Earth's surface absorbs some of the incoming energy and becomes warm.
4. The warm surface releases energy as infrared radiation.
5. Greenhouse gases absorb and re-emit some of this outgoing infrared radiation.
6. Increased greenhouse gas concentrations cause more heat to be retained within the Earth-atmosphere system.
7. This contributes to a rise in global average temperatures.

6.4 Evidence of climate change

Scientists use different forms of evidence to establish that the climate is changing.

A. Rising global temperatures

- Instrumental records show a long-term increase in global average temperatures.
- Many of the warmest years in the instrumental record have occurred in recent decades.
- Heatwaves have become more frequent or intense in many regions.

B. Melting glaciers

- Mountain glaciers are losing ice in many parts of the world.
- Glaciers are important sources of water for some rivers.
- Their retreat affects water availability and mountain ecosystems.

C. Declining ice cover

- Arctic sea ice has declined in extent and thickness over the long term.
- Ice sheets in Greenland and Antarctica are losing mass.

- Changes in ice cover affect global energy balance.

D. Rising sea levels

- Ocean water expands as it warms.
- Melting land-based glaciers and ice sheets add water to the oceans.
- Rising sea levels threaten low-lying coastal areas.

E. Changes in rainfall patterns

- Some regions experience more intense rainfall events.
- Other regions experience prolonged dry conditions.
- The timing of rainy seasons may change.
- These changes affect agriculture and water supply.

F. Changes in ecosystems

- Some plant and animal species are shifting their geographical ranges.
- Seasonal biological events, such as flowering and migration, may change.
- Coral reefs are affected by warming ocean waters and marine heatwaves.

G. Changes in extreme events

- Heat extremes have become more common in many regions.
- Heavy precipitation events have intensified in many areas.
- Climate change can influence drought risk, wildfire conditions and the intensity of some storms, although impacts differ by region and event type.

7.0 CAUSES OF CLIMATE CHANGE

The causes of climate change can be grouped into human and natural causes.

7.1 Human causes of climate change

Human activities are the main cause of the recent long-term global warming.

A. Burning fossil fuels

Fossil fuels include coal, petroleum and natural gas.

- They are burnt to produce electricity.
- They are used in motor vehicles, ships and aircraft.
- Industries use them to generate heat and power machinery.
- Burning fossil fuels releases large quantities of carbon dioxide.
- Increased carbon dioxide concentrations strengthen the greenhouse effect.

Examples in Kenya:

- Petrol and diesel used by vehicles.
- Diesel generators.
- Fossil-fuel-powered industrial processes.

- Thermal power generation using fossil fuels.

B. Deforestation

Deforestation is the large-scale removal of forest cover.

- Trees absorb carbon dioxide during photosynthesis.
- Cutting down trees reduces the amount of carbon dioxide removed from the atmosphere.
- Burning cleared vegetation releases stored carbon.
- Forest destruction may affect local rainfall and water cycles.
- Soil becomes more exposed to erosion and degradation.

Kenyan examples:

- Destruction of forest areas in water catchments.
- Clearing trees for settlement and agricultural expansion.
- Illegal logging and uncontrolled charcoal production.

C. Industrial activities

- Industries burn fossil fuels to produce energy.
- Some industrial processes release carbon dioxide.
- Cement production releases carbon dioxide during chemical processing.
- Certain industrial gases have very high warming potential.
- Industrial expansion can increase energy demand and emissions.

D. Agriculture and livestock production

- Livestock such as cattle produce methane during digestion.
- Rice cultivation under flooded conditions can release methane.
- Use of nitrogen-based fertilisers can lead to nitrous oxide emissions.
- Burning crop residues releases greenhouse gases and air pollutants.
- Land clearing for farming reduces natural vegetation cover.

Example: Large livestock populations and poor manure management can contribute to greenhouse gas emissions.

E. Transport

- Motor vehicles burn petroleum fuels.
- Aircraft and ships use fossil fuels.
- Increased transport demand increases fuel consumption.
- Traffic congestion causes vehicles to spend more time burning fuel.
- Poorly maintained engines may increase fuel consumption and emissions.

F. Waste disposal

- Decomposing organic waste in poorly managed landfills produces methane.

- Open burning of rubbish releases carbon dioxide and other pollutants.
- Wastewater treatment may release methane and nitrous oxide.
- Poor waste management increases environmental pollution.

G. Urbanisation

- Construction requires energy-intensive materials such as cement and steel.
- Increased settlement creates greater demand for electricity and transport.
- Removal of vegetation reduces carbon storage.
- Roads and buildings absorb and retain heat, contributing to urban heat islands.

7.2 Natural causes of climate change

Natural factors can influence the Earth's climate over different timescales.

A. Volcanic eruptions

- Large volcanic eruptions release ash and gases into the atmosphere.
- Sulphur dioxide can form aerosols that reflect some incoming sunlight.
- These aerosols may cause temporary global cooling.
- Volcanic eruptions also release carbon dioxide, although modern human emissions are much larger.

B. Changes in solar activity

- The Sun's energy output varies slightly over time.
- Changes in solar activity can influence the amount of energy received by the Earth.
- Solar variations are not the main explanation for the rapid warming observed in recent decades.

C. Changes in the Earth's orbit

The Earth's orbit and the tilt and direction of its axis change gradually over long periods.

These changes are known as Milankovitch cycles.

They influence:

- The distribution of solar energy across the Earth.
- The strength of seasons.
- Long-term patterns of ice ages and warmer periods.

D. Ocean circulation changes

- Oceans store and transport large amounts of heat.
- Changes in ocean circulation redistribute heat around the planet.
- These changes can influence regional temperatures and rainfall patterns.

E. Natural changes in vegetation and land cover

- Natural changes in vegetation influence the amount of carbon stored on land.
- Changes in land cover can affect how much solar energy is reflected or absorbed.
- Natural processes may influence the balance of greenhouse gases.

7.3 Comparison of human and natural causes

Human causes	Natural causes
Burning fossil fuels	Volcanic eruptions
Deforestation	Changes in solar activity
Industrial processes	Changes in Earth's orbit
Agriculture and livestock production	Natural ocean circulation changes
Transport emissions	Natural changes in vegetation
Poor waste management	Natural variations in climate systems

Key geographical point: Natural factors have influenced Earth's climate throughout geological history. However, the rapid global warming observed since the mid-20th century is primarily attributable to human-caused greenhouse gas emissions.

8.0 EFFECTS OF CLIMATE CHANGE ON HUMAN ACTIVITIES

Climate change affects people differently depending on their location, income, occupation, access to resources and ability to prepare for hazards.

8.1 Effects on agriculture

1. **Reduced crop yields:** High temperatures and water shortages can reduce crop growth and productivity.
2. **Crop failure:** Prolonged drought can cause crops to wither and die.
3. **Changes in growing seasons:** Shifts in the timing of rainfall may affect planting and harvesting calendars.
4. **Increased pests and diseases:** Warmer conditions may favour some crop pests and diseases.
5. **Soil degradation:** Intense rainfall can cause soil erosion and nutrient loss.
6. **Flood damage:** Floods may destroy crops, irrigation systems and farm infrastructure.
7. **Reduced pasture:** Drought reduces the growth of grasses and other fodder.
8. **Increased irrigation demand:** Farmers may need more water to maintain crop production.
9. **Livestock losses:** Heat stress and water shortages can cause illness and death among livestock.
10. **Changes in crop suitability:** Some crops may become less suitable in areas that become hotter or drier.

Kenyan examples:

- Drought can reduce maize harvests in some rain-fed farming areas.
- Prolonged dry conditions in northern Kenya reduce pasture and water availability.
- Tea and coffee farmers may face changing rainfall and temperature conditions.

- Flooding can damage farms and irrigation infrastructure along river valleys.

8.2 Effects on water resources

- Reduced river flow during prolonged drought.
- Declining water levels in some lakes and reservoirs.
- Increased competition for water between households, agriculture and industries.
- Reduced groundwater recharge in some areas.
- Increased sedimentation following intense rainfall and soil erosion.
- Water contamination during floods.
- Increased demand for domestic water during hot periods.
- Greater pressure on dams and water-supply systems.

8.3 Effects on human health

1. **Heat-related illness:** High temperatures can cause heat exhaustion and heatstroke.
2. **Spread of some diseases:** Changes in temperature and rainfall can influence the distribution of disease-carrying organisms.
3. **Malnutrition:** Crop failure can reduce food availability and dietary quality.
4. **Waterborne diseases:** Flooding can contaminate drinking water and increase the risk of diarrhoeal diseases.
5. **Respiratory problems:** Dust storms and wildfire smoke can worsen respiratory conditions.
6. **Mental health challenges:** Disasters, displacement and loss of livelihoods can cause stress and anxiety.
7. **Injuries and deaths:** Floods, landslides, storms and heat extremes can cause injuries and loss of life.

8.4 Effects on settlement and housing

- Floods destroy homes and other buildings.
- Landslides may bury settlements in steep areas.
- Sea-level rise threatens low-lying coastal settlements.
- Extreme heat makes some houses uncomfortable and increases cooling needs.
- Drought may force communities to move in search of water and pasture.
- Infrastructure may require stronger designs to withstand extreme conditions.

8.5 Effects on transport and communication

- Heavy rainfall damages roads and bridges.
- Floods interrupt road and railway transport.
- Landslides block mountain roads.
- Strong winds may damage communication infrastructure.
- Extreme heat can damage road surfaces and railway tracks.

- Poor visibility caused by fog, dust and heavy rainfall can increase road accidents.
- Coastal storms can disrupt ports and marine transport.

8.6 Effects on tourism

- Changes in wildlife habitats affect wildlife tourism.
- Drought may reduce vegetation and water availability in game reserves.
- Floods may damage hotels, roads and tourist facilities.
- Changes in snow and ice affect mountain tourism.
- Coral bleaching damages marine tourism attractions.
- Extreme heat may discourage outdoor tourism activities.

Kenyan examples:

- Drought can affect wildlife populations in Amboseli and Tsavo ecosystems.
- Changes in rainfall influence wildlife migration and availability of water.
- Coastal erosion and sea-level rise threaten some beach facilities and coastal infrastructure.

8.7 Effects on energy production

- Drought may reduce water levels in hydroelectric dams.
- High temperatures increase demand for cooling and electricity.
- Storms may damage electricity transmission lines.
- Changes in wind patterns may influence wind power generation.
- Reduced water availability may affect industrial cooling processes.

8.8 Effects on biodiversity and ecosystems

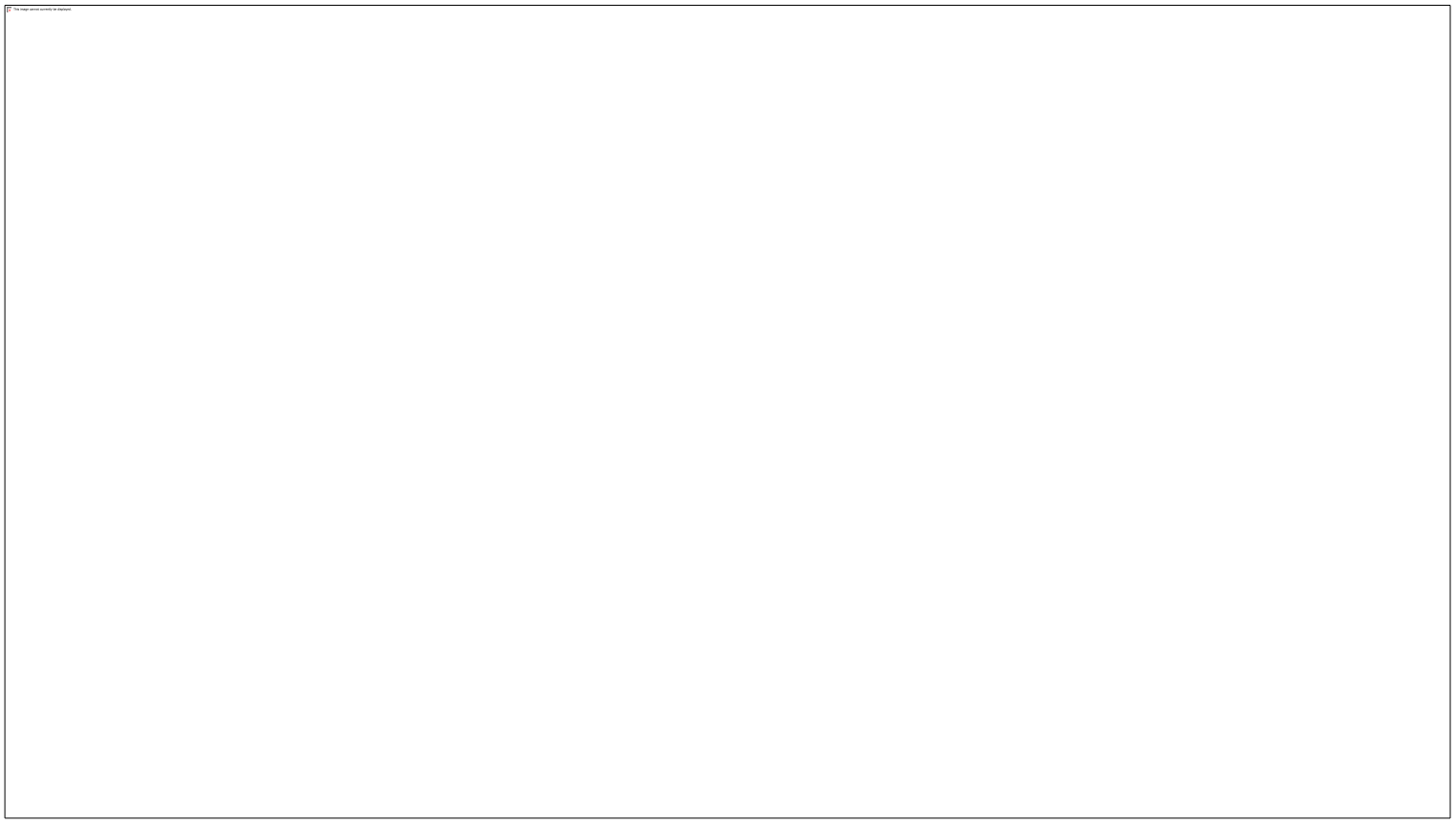
- Some species lose suitable habitats.
- Changes in temperature and rainfall affect breeding and migration patterns.
- Coral reefs may experience bleaching due to unusually warm seawater.
- Forest fires may destroy habitats.
- Some species may move to higher altitudes or cooler regions.
- Ecosystems may lose biodiversity when species cannot adapt quickly enough.

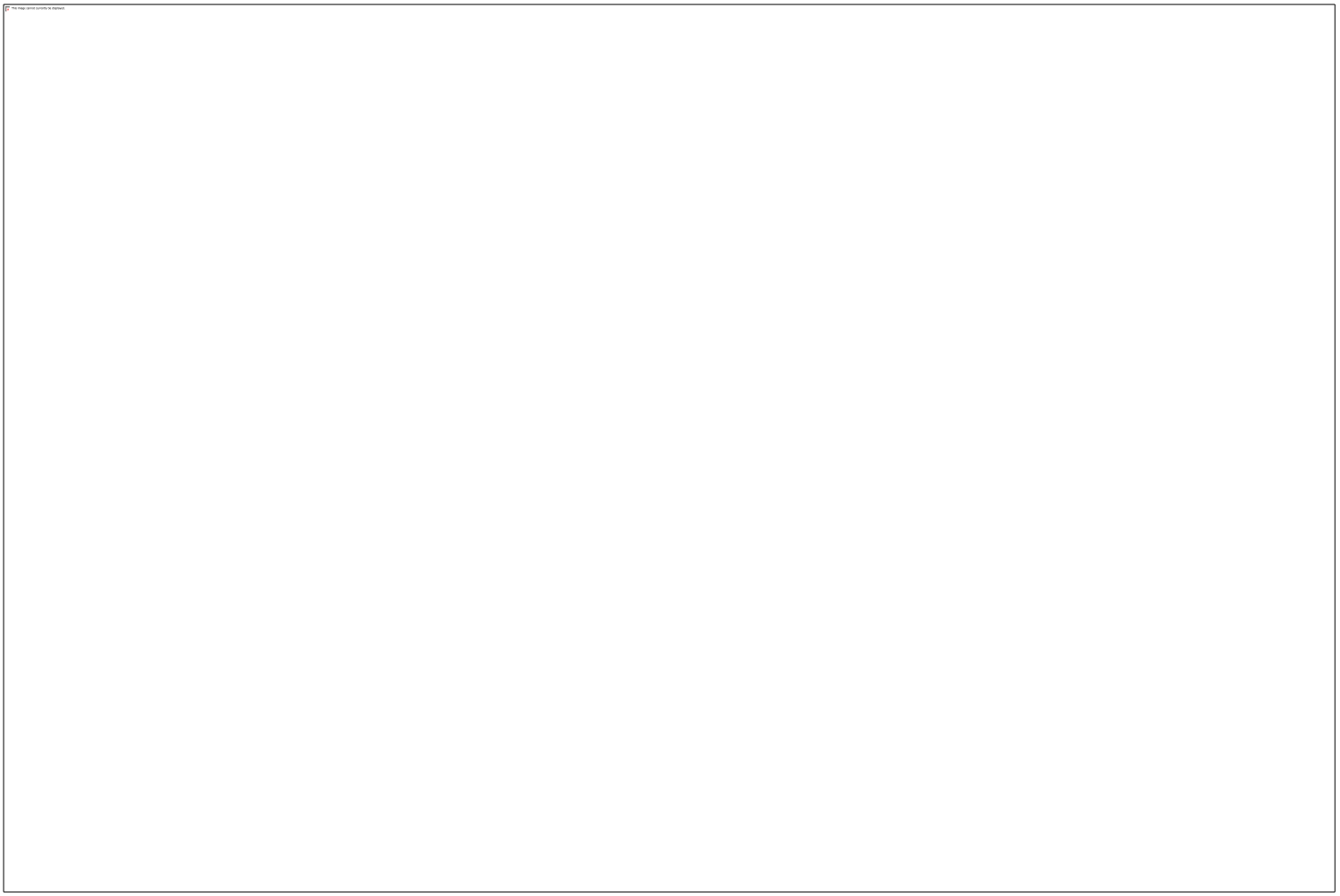
8.9 Effects on industries and businesses

- Water shortages interrupt industrial production.
- Flooding damages factories, shops and warehouses.
- Heat reduces the comfort and productivity of workers.
- Transport interruptions delay the delivery of raw materials.
- Agricultural industries may face shortages of raw materials.
- Insurance and disaster-recovery costs may increase.

8.10 Effects on education

- Floods may damage classrooms and learning materials.
- Drought may cause water shortages in schools.
- Extreme heat can make classrooms uncomfortable.
- Displacement may interrupt learners' attendance.
- Disasters may cause temporary school closures.
- Families facing economic hardship may struggle to meet education-related costs.





9.0 CLIMATE CHANGE AND DISASTER RISK IN KENYA

9.1 Meaning of climate-related disaster

A climate-related disaster is a serious disruption to a community or society caused by a hazardous climatic event interacting with exposure and vulnerability.

Examples include:

- Drought.
- Floods.
- Heatwaves.
- Landslides triggered by heavy rainfall.
- Storms and strong winds.
- Coastal flooding.
- Wildfires under hot and dry conditions.

A hazard does not automatically become a disaster. Its impact depends on factors such as population exposure, preparedness, infrastructure, poverty and the ability of people to respond.

9.2 Major climate-related hazards in Kenya

A. Drought

Drought is a prolonged period of unusually low rainfall that leads to water shortages.

Causes and contributing factors:

- Failure or delay of seasonal rains.
- Prolonged below-average rainfall.
- High temperatures and evaporation.
- Land degradation.
- Poor water-resource management.

Effects:

- Crop failure.
- Livestock deaths.
- Food insecurity.
- Water shortages.
- Loss of household income.
- Migration in search of pasture and water.
- Conflict over natural resources.

Areas commonly affected: Arid and semi-arid counties such as Turkana, Marsabit, Wajir, Garissa and Mandera.

B. Floods

Flooding occurs when water covers land that is normally dry.

Causes:

- Heavy or prolonged rainfall.
- River overflow.
- Poor drainage systems.
- Building on floodplains.
- Deforestation and catchment degradation.
- Blocked drainage channels.
- Coastal storm surges and high tides in some areas.

Effects:

- Loss of life and injuries.
- Destruction of homes and roads.
- Crop and livestock losses.
- Water contamination.
- Displacement of communities.
- Disruption of schooling and businesses.
- Increased risk of waterborne diseases.

C. Landslides and mudslides

A landslide is the downward movement of soil, rock or debris along a slope.

Factors contributing to landslides:

- Heavy rainfall that saturates soil.
- Steep slopes.
- Deforestation.
- Poor land-use practices.
- Road construction that destabilises slopes.
- Weak or weathered underlying rocks.

Effects:

- Destruction of homes.
- Burial of roads and farmland.
- Loss of life.
- Damage to water pipes and electricity lines.
- Displacement of households.

D. Heatwaves

A heatwave is a period of unusually high temperatures lasting several days or longer relative to the normal conditions of a region.

Effects:

- Heat exhaustion and heatstroke.
- Increased water demand.
- Reduced livestock productivity.
- Crop stress.
- Increased energy demand.
- Higher risk of wildfires in dry areas.

E. Strong winds and storms

Effects:

- Destruction of roofs and buildings.
- Damage to trees and electricity lines.
- Loss of crops.
- Disruption of air and marine transport.
- Injuries caused by flying debris.
- Damage to communication infrastructure.

F. Coastal erosion and sea-level rise

Effects:

- Loss of beaches.
- Damage to coastal roads and buildings.
- Saltwater intrusion into freshwater sources.
- Loss of coastal habitats.
- Threats to settlements and tourism facilities.

9.3 Disaster preparedness and management

Disaster preparedness refers to actions taken before a disaster to ensure that people and institutions can respond effectively.

Disaster management involves planning and actions taken before, during and after disasters to reduce losses and restore normal conditions.

A. Before a disaster

- Identify areas exposed to floods, droughts and landslides.
- Prepare community disaster-management plans.
- Establish early-warning systems.
- Educate residents on climate-related hazards.
- Keep emergency supplies.
- Construct safe evacuation routes.
- Protect water sources.
- Maintain drainage systems.
- Avoid building in high-risk areas.
- Conduct emergency drills in schools and communities.

B. During a disaster

- Follow official warnings and instructions.
- Move to designated safe areas.
- Avoid crossing flooded rivers and roads.
- Switch off electricity where flooding threatens electrical installations, if it is safe to do so.
- Provide first aid to injured people.
- Contact emergency responders.
- Protect children, older persons and persons with disabilities.
- Avoid spreading unverified information.

C. After a disaster

- Provide emergency food, water and shelter.
- Assess damage and identify urgent needs.
- Restore water, electricity and communication services.

- Repair roads and essential infrastructure.
- Provide medical and psychosocial support.
- Rehabilitate damaged farms and ecosystems.
- Review the response plan and improve future preparedness.

9.4 Road safety risks associated with climate-related conditions

Climate conditions can increase risks on roads and highways. Drivers, passengers, cyclists and pedestrians should understand these risks.

Common road risks

1. **Heavy rainfall:** Reduces visibility and makes roads slippery.
2. **Flooded roads:** Conceal potholes, open drains and damaged road surfaces.
3. **Strong winds:** May destabilise motorcycles, bicycles and high-sided vehicles.
4. **Fog:** Reduces visibility and makes it difficult to judge distances.
5. **Dust storms:** Reduce visibility and may cause respiratory irritation.
6. **Landslides:** Can bury or block roads, especially in hilly areas.
7. **Heat:** May cause tyre pressure problems and vehicle overheating.
8. **Damaged bridges:** Floods may weaken bridges and culverts.

Safe road behaviour during adverse weather

- Reduce speed during heavy rainfall.
- Increase the distance between vehicles.
- Switch on appropriate vehicle lights when visibility is poor.
- Avoid sudden braking on slippery roads.
- Never drive through fast-flowing floodwater.
- Do not attempt to cross a flooded bridge.
- Follow official road-closure and evacuation instructions.
- Check tyres, brakes, wipers and lights before travelling.
- Avoid parking under unstable trees during strong winds.
- Pedestrians should use safe crossing points and reflective clothing when visibility is poor.

10.0 ADAPTATION TO CLIMATE CHANGE

10.1 Meaning of climate change adaptation

Climate change adaptation refers to adjustments made by individuals, communities, organisations and governments to actual or expected climatic changes in order to reduce harm or take advantage of possible benefits.

Adaptation focuses on living with the effects of climate change while reducing vulnerability and increasing resilience.

Example: A farmer in a semi-arid area may plant drought-tolerant sorghum instead of relying entirely on maize.

10.2 Strategies for adapting to climate change

A. Adaptation in agriculture

1. **Growing drought-resistant crops**

- Farmers should grow crops that can survive periods of limited rainfall.
- Examples include sorghum, millet, cowpeas and selected drought-tolerant maize varieties.

2. **Crop diversification**

- Farmers should grow different types of crops.
- This reduces dependence on a single crop.
- If one crop fails, others may still produce a harvest.

3. **Changing planting dates**

- Farmers can adjust planting dates according to reliable seasonal forecasts.
- This helps crops benefit from available rainfall.

4. **Agroforestry**

- Trees are planted alongside crops or pasture.
- Trees provide shade, reduce wind speed and help protect soil.
- Some trees provide fruits, fodder and timber.

5. **Conservation agriculture**

- Farmers minimise unnecessary soil disturbance.
- Crop residues may be retained as mulch.
- Soil cover helps conserve moisture and reduce erosion.

6. **Irrigation**

- Water is supplied artificially when rainfall is insufficient.
- Drip irrigation reduces water wastage.
- Irrigation should be planned to avoid over-extraction of water.

7. **Improved livestock management**

- Farmers keep breeds adapted to local climatic conditions.
- They conserve hay and other animal feeds.
- They establish reliable livestock watering points.
- They manage herd sizes according to pasture availability.

8. **Climate information services**

- Farmers use seasonal forecasts to guide farming decisions.
- Weather information helps them plan planting, harvesting and livestock movement.

B. Adaptation in water-resource management

- Harvest rainwater from roofs.
- Construct water pans and small reservoirs where environmentally suitable.
- Protect springs, rivers and wetlands.
- Reduce water wastage.
- Repair leaking water pipes.
- Reuse treated wastewater where safe and appropriate.
- Promote efficient irrigation.
- Protect forests and catchment areas.
- Develop sustainable groundwater management plans.

C. Adaptation in human settlement

- Avoid building homes on floodplains.
- Construct buildings using climate-resilient designs.
- Improve urban drainage systems.
- Plant trees in towns and cities.
- Establish green spaces to reduce urban heat.
- Relocate households from extremely high-risk areas where necessary and through fair, planned processes.
- Improve access to safe water and sanitation.

D. Adaptation in transport

- Construct roads with adequate drainage.
- Strengthen bridges and culverts.
- Avoid building roads in unstable areas where possible.
- Maintain drainage channels.
- Establish alternative transport routes.
- Use weather information to plan journeys.
- Improve early-warning systems for road closures.

E. Adaptation in health

- Establish heat-health warning systems.
- Provide safe drinking water.
- Improve sanitation.
- Strengthen disease surveillance.
- Educate communities on heat-related illness.
- Establish emergency health services.
- Protect vulnerable groups during extreme weather.

F. Adaptation in tourism

- Diversify tourism products.
- Protect wildlife habitats.
- Restore degraded ecosystems.
- Improve water conservation in tourist facilities.
- Develop disaster-response plans for tourist destinations.
- Provide climate information to tourism operators.

G. Adaptation in education

- Improve school drainage.
- Harvest rainwater.
- Plant shade trees in school compounds.
- Establish emergency plans for floods and storms.
- Teach learners about climate change.
- Protect learning materials from water damage.
- Develop flexible arrangements for learning disruptions caused by disasters.

10.3 Examples of climate adaptation in Kenya

Strategy	**Application in Kenya**	**Expected benefit**
Drought-tolerant crops	Growing sorghum and millet in suitable ASAL areas	Reduces crop failure
Irrigation	Water-efficient irrigation in suitable farming schemes	Supports crop production during dry periods
Rainwater harvesting	Water tanks in homes and schools	Improves water availability
Agroforestry	Planting trees on farms	Protects soil and conserves moisture
Early-warning systems	Sharing seasonal forecasts and drought alerts	Improves preparedness
Pasture conservation	Hay storage and controlled grazing	Reduces livestock losses
Flood management	Drainage improvement and riverbank protection	Reduces flood damage
Catchment conservation	Protecting forests and wetlands	Supports water security

10.4 Importance of climate change adaptation

1. Reduces loss of human life.
2. Protects property and infrastructure.
3. Improves food security.
4. Protects water resources.
5. Reduces livestock losses.
6. Protects public health.
7. Supports sustainable economic development.
8. Reduces vulnerability to climatic hazards.
9. Protects ecosystems and biodiversity.
10. Improves community resilience.

11.0 MITIGATION OF CLIMATE CHANGE

11.1 Meaning of climate change mitigation

Climate change mitigation refers to actions taken to reduce greenhouse gas emissions or increase the removal of greenhouse gases from the atmosphere.

Mitigation addresses the causes of climate change rather than only responding to its effects.

Example: Replacing electricity generated from fossil fuels with solar or wind energy can reduce carbon dioxide emissions.

11.2 Strategies for mitigating climate change

A. Afforestation and reforestation

Afforestation is the establishment of forests on land that has not recently been under forest cover.

Reforestation is the re-establishment of trees in areas where forests have been removed or degraded.

Importance:

- Trees absorb carbon dioxide during photosynthesis.
- Forests store carbon in vegetation and soils.
- Trees protect water catchment areas.
- Forests support biodiversity.
- Trees reduce soil erosion.
- Forests help regulate local environmental conditions.

Kenyan examples:

- Tree planting in school compounds.
- Restoration of degraded sections of the Mau Forest Complex.
- Protection and restoration of forests around Mount Kenya and the Aberdares.

B. Use of renewable energy

Renewable energy comes from natural sources that are replenished over time.

Examples:

- Solar energy.
- Wind energy.
- Geothermal energy.
- Hydropower.
- Sustainable forms of biomass energy.

Importance:

- Reduces dependence on fossil fuels.
- Reduces greenhouse gas emissions when replacing fossil-fuel energy.
- Improves energy security.
- Supports sustainable development.

Kenyan examples:

- Geothermal power generation in the Rift Valley.
- Wind power generation at Lake Turkana.
- Solar energy use in homes, schools and businesses.
- Hydropower generation from suitable river systems.

C. Energy efficiency

Energy efficiency means using less energy to perform the same task.

Strategies:

- Use energy-saving bulbs.
- Switch off unused electrical appliances.
- Use efficient industrial machinery.
- Improve building insulation and ventilation.
- Maintain vehicles and machinery.
- Use energy-efficient cooking technologies.

D. Sustainable transport

- Promote public transport.
- Encourage walking and cycling for suitable journeys.
- Improve railway transport.
- Support cleaner vehicle technologies.
- Reduce unnecessary journeys.
- Maintain vehicles to reduce fuel consumption.
- Improve traffic management.

E. Sustainable agriculture

- Practise agroforestry.
- Improve manure management.
- Avoid unnecessary burning of crop residues.
- Use fertilisers efficiently.
- Improve livestock feeding practices.
- Restore degraded farmland.
- Protect soil organic matter.
- Use climate-smart agricultural methods.

F. Waste management

- Reduce unnecessary consumption.
- Reuse materials.
- Recycle paper, plastics, metals and glass.
- Compost suitable organic waste.
- Avoid open burning of rubbish.
- Improve landfill management.
- Recover methane from suitable waste facilities.

G. Protection of wetlands and other ecosystems

- Restore wetlands.
- Protect mangrove forests.
- Conserve natural forests.
- Restore degraded grasslands.
- Protect seagrass beds.
- Prevent illegal logging.
- Control destructive land-use practices.

H. Environmental education and awareness

- Teach learners about climate change.
- Conduct community awareness campaigns.
- Encourage responsible energy use.
- Promote tree planting.
- Encourage waste reduction and recycling.
- Share reliable climate information.

11.3 Difference between adaptation and mitigation

Adaptation	Mitigation
Adjusts to actual or expected climate change.	Addresses the causes of climate change.
Reduces vulnerability to climate impacts.	Reduces greenhouse gas emissions or increases carbon removal.
Focuses on managing the effects of climate change.	Focuses on limiting future climate change.
Example: Planting drought-resistant crops.	Example: Replacing fossil-fuel electricity with solar power.
Example: Constructing flood-control systems.	Example: Restoring forests to absorb carbon dioxide.
Example: Harvesting rainwater.	Example: Using energy-efficient appliances.

Important: Adaptation and mitigation complement each other. Communities need both approaches to respond effectively to climate change.

11.4 Importance of climate change mitigation

1. Reduces the rate of global warming.
2. Helps protect ecosystems.
3. Improves air quality when cleaner energy replaces polluting fuels.
4. Reduces dependence on fossil fuels.
5. Promotes renewable energy development.
6. Supports sustainable economic growth.
7. Protects biodiversity.
8. Reduces future climate-related risks.
9. Promotes responsible use of natural resources.
10. Supports the well-being of future generations.

12.0 GLOBAL ATTENTION ON CLIMATE CHANGE

12.1 Why climate change attracts global attention

Climate change is a global concern because greenhouse gases mix throughout the atmosphere and their effects cross national boundaries.

No country can address climate change effectively on its own. International cooperation is necessary because the causes, impacts and solutions involve countries across the world.

Reasons for global attention

1. **Rising global temperatures**
   - Increasing greenhouse gas concentrations are warming the Earth.
   - Continued warming can increase climate risks.
2. **Threats to food security**
   - Droughts, floods and heat stress can reduce agricultural production.
   - Food shortages may increase poverty and malnutrition.
3. **Water insecurity**
   - Changing rainfall patterns affect rivers, lakes, reservoirs and groundwater.
   - Some communities may experience severe water shortages.
4. **Rising sea levels**
   - Low-lying coastal areas are threatened by sea-level rise.
   - Coastal settlements, ports and tourist facilities may be damaged.
5. **Loss of biodiversity**
   - Changes in temperature and rainfall threaten natural habitats.
   - Some species may fail to adapt to rapid environmental change.
6. **Human health risks**
   - Heat-related illness may increase.
   - Some disease patterns may change.

- Flooding may increase exposure to contaminated water.

7. **Economic losses**

- Climate-related disasters damage roads, farms, homes and industries.
- Governments spend more resources on emergency response and recovery.

8. **Displacement of people**

- Floods, droughts and coastal hazards may force people to leave their homes.
- Displacement may create pressure on services in receiving areas.

9. **Threats to vulnerable communities**

- Poor households often have fewer resources to prepare for and recover from disasters.
- Children, older people and persons with disabilities may face additional risks.

10. **Threats to future generations**

- Continued environmental degradation may reduce the resources available to future generations.
- Decisions made today influence the future climate and environmental conditions.

12.2 International efforts to address climate change

A. United Nations Framework Convention on Climate Change (UNFCCC)

- It is an international agreement adopted in 1992.
- It provides a framework for international cooperation on climate change.
- Countries meet through conferences known as Conferences of the Parties (COP).
- It promotes climate research, reporting, mitigation and adaptation.

B. Kyoto Protocol

- Adopted in 1997 under the UNFCCC.
- It established legally binding emission-reduction targets for many developed countries.
- It introduced mechanisms to support emission reduction and international cooperation.
- It entered into force in 2005.

C. Paris Agreement

- Adopted in 2015.
- It aims to keep the rise in global average temperature well below 2°C above pre-industrial levels and pursue efforts to limit it to 1.5°C.
- Countries submit and update national climate action plans known as Nationally Determined Contributions (NDCs).
- It addresses mitigation, adaptation and support for developing countries.
- It encourages international cooperation and transparency.

D. Sustainable Development Goals (SDGs)

The United Nations Sustainable Development Goals include several goals that relate directly to climate action.

- **SDG 13:** Climate Action.

- **SDG 7:** Affordable and Clean Energy.
- **SDG 6:** Clean Water and Sanitation.
- **SDG 11:** Sustainable Cities and Communities.
- **SDG 12:** Responsible Consumption and Production.
- **SDG 14:** Life Below Water.
- **SDG 15:** Life on Land.

E. Intergovernmental Panel on Climate Change (IPCC)

- The IPCC was established in 1988.
- It assesses scientific knowledge on climate change.
- It publishes reports on climate science, impacts, adaptation and mitigation.
- It provides scientific information to governments and policymakers.
- It does not itself carry out climate research or enforce climate policies.

12.3 Kenya's role in addressing climate change

Kenya participates in international climate agreements and implements national and community-level climate action.

Important areas of action include:

1. Promoting renewable energy.
2. Protecting forests and water catchments.
3. Encouraging tree growing and landscape restoration.
4. Promoting climate-smart agriculture.
5. Improving early-warning systems.
6. Developing national and county climate action plans.
7. Supporting drought preparedness in arid and semi-arid lands.
8. Improving flood-risk management.
9. Encouraging energy efficiency.
10. Promoting environmental education.

Examples of climate action in Kenya

- Geothermal electricity generation in the Rift Valley.
- Wind power development around Lake Turkana.
- Solar power use in rural communities.
- Forest conservation in major water catchment areas.
- Community rainwater harvesting.
- Climate-smart farming and agroforestry.

- County-level climate adaptation initiatives.

12.4 Role of different groups in climate action

Group	Role in addressing climate change
National government	Develops climate policies, laws and national programmes
County governments	Implement local adaptation and environmental programmes
Schools	Teach climate literacy and conduct environmental projects
Farmers	Practise climate-smart agriculture and conserve soil and water
Industries	Improve energy efficiency and reduce emissions
Community groups	Restore local ecosystems and raise awareness
Households	Conserve energy, reduce waste and plant trees
Non-governmental organisations	Support research, awareness and community programmes
International organisations	Provide scientific, technical and financial support

13.0 COMMUNITY-BASED CLIMATE CHANGE STRATEGIES

13.1 Meaning of community-based climate action

Community-based climate action refers to activities planned and carried out by local people, groups and institutions to reduce greenhouse gas emissions and respond to the effects of climate change.

Local communities are important because they understand their environmental challenges and can identify practical solutions.

13.2 Strategies that can be implemented in a Kenyan community

A. Establishing community tree nurseries

- Identify suitable indigenous and other appropriate tree species.
- Collect or purchase quality seeds.
- Prepare nursery beds or containers.
- Water seedlings appropriately.
- Protect seedlings from pests and animals.
- Distribute seedlings to households, schools and farms.
- Monitor survival rates after planting.

B. Establishing rainwater-harvesting systems

- Install gutters on roofs.

- Direct rainwater into storage tanks.
- Fit suitable filters.
- Keep tanks covered.
- Clean gutters and tanks regularly.
- Use harvested water carefully.

C. Promoting climate-smart farming

- Use drought-tolerant crops.
- Practise crop rotation.
- Apply organic manure where suitable.
- Use mulching to conserve moisture.
- Practise agroforestry.
- Adopt water-efficient irrigation.
- Obtain and use seasonal weather forecasts.

D. Improving waste management

- Separate waste at the source.
- Compost biodegradable waste.
- Recycle reusable materials.
- Avoid burning rubbish.
- Organise community clean-up activities.
- Dispose of hazardous waste safely.

E. Conserving local water sources

- Protect riverbanks and springs.
- Avoid dumping waste into rivers.
- Restore vegetation around water sources.
- Prevent unnecessary destruction of wetlands.
- Establish community rules for sustainable water use.

F. Creating climate awareness

- Organise school and community talks.
- Use posters and public announcements.
- Invite agricultural extension officers and environmental experts.
- Share reliable weather and climate information.
- Conduct environmental competitions.
- Encourage learners to participate in local projects.

13.3 Steps in developing a community climate action project

1. **Identify the problem:** Find a climate-related challenge affecting the community.
2. **Collect information:** Interview residents and consult relevant experts.
3. **Set objectives:** State what the project intends to achieve.
4. **Identify resources:** Determine the materials, skills and funds required.
5. **Plan activities:** Prepare a schedule of activities.
6. **Allocate responsibilities:** Assign duties to members of the project team.
7. **Implement the project:** Carry out the planned activities.
8. **Monitor progress:** Check whether activities are being completed as planned.
9. **Evaluate results:** Assess the project's achievements and challenges.
10. **Prepare a report:** Document the activities, findings and recommendations.

13.4 Sample community climate action project

Project title: Establishing a school and community tree nursery.

Problem identified: Loss of tree cover and increasing pressure on local water sources.

Main objective: To raise suitable tree seedlings for planting in the school and surrounding community.

Materials required:

- Tree seeds.
- Seedling containers or polythene pots.
- Soil.
- Compost manure.
- Watering cans.
- Water.
- Shade materials.
- Garden tools.
- Record book.

Activities:

1. Identify suitable tree species with advice from forestry officers.
2. Collect and prepare seeds.
3. Prepare nursery containers.
4. Sow seeds.
5. Water and care for seedlings.
6. Record germination and seedling growth.

7. Distribute healthy seedlings.
8. Plant seedlings at suitable sites.
9. Monitor survival and growth.
10. Prepare a project report.

Expected outcomes:

- Improved tree-growing skills.
- Increased tree cover.
- Greater awareness of climate change.
- Improved environmental responsibility.
- Contribution to carbon storage.
- Better protection of soil and water resources.

13.5 Challenges facing community climate action projects

1. Inadequate funds.
2. Shortage of water.
3. Limited technical knowledge.
4. Poor community participation.
5. Destruction of seedlings by livestock.
6. Inadequate tools and equipment.
7. Unreliable rainfall.
8. Conflicts over land use.
9. Poor maintenance of completed projects.
10. Lack of long-term monitoring.

Possible solutions

- Seek support from county governments and development partners.
- Involve local environmental experts.
- Use locally available materials.
- Establish community project committees.
- Select suitable indigenous tree species.
- Provide regular training.
- Develop clear project budgets.
- Monitor and evaluate project progress.
- Encourage community ownership.

14.0 CLIMATE CHANGE, SUSTAINABLE DEVELOPMENT AND VALUES

14.1 Climate change and sustainable development

Sustainable development is development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs.

Climate change threatens sustainable development because it can damage natural resources, livelihoods, infrastructure and human well-being.

How climate action supports sustainable development

- Forest conservation protects biodiversity and water catchments.
- Renewable energy supports cleaner energy production.
- Sustainable agriculture improves food security.
- Water conservation supports households and industries.
- Climate-resilient infrastructure reduces disaster losses.
- Environmental education promotes responsible resource use.
- Community participation strengthens local development.

14.2 Values developed through the study of climate

1. **Responsibility:** Learners take responsibility for protecting the environment.
2. **Respect:** Learners respect the rights of other people and future generations to a healthy environment.
3. **Unity:** Learners work together in environmental conservation projects.
4. **Integrity:** Learners use reliable climate information and report findings honestly.
5. **Patriotism:** Learners participate in protecting Kenya's natural resources.
6. **Peace:** Learners promote peaceful sharing of scarce water and pasture resources.
7. **Social justice:** Learners recognise that vulnerable communities may face greater climate risks.

14.3 Pertinent and contemporary issues (PCIs)

The study of climate supports learning about:

- Climate change and environmental conservation.
- Disaster risk reduction.
- Food and nutrition security.
- Water and sanitation.
- Public health.
- Sustainable energy.
- Responsible consumption.
- Community resilience.
- Biodiversity conservation.
- Sustainable livelihoods.

15.0 FIELDWORK AND RESEARCH ON CLIMATE CHANGE

15.1 Importance of fieldwork

Fieldwork helps learners connect classroom knowledge with real environmental conditions.

Learners may investigate:

- Changes in rainfall patterns.
- Local drought experiences.
- Flood-prone areas.
- Water conservation methods.
- Tree cover and land degradation.
- Community adaptation practices.
- Climate-related effects on farming.

15.2 Suggested fieldwork activity

Title: Investigating the effects of climate change on human activities in the local community.

Objectives

By the end of the fieldwork, learners should be able to:

1. Identify climate-related challenges in the community.
2. Collect information from local residents.
3. Describe the effects of climatic changes on livelihoods.
4. Identify adaptation and mitigation measures.
5. Prepare and present a fieldwork report.

Preparations

- Select a suitable study area.
- Obtain permission from relevant authorities.
- Identify resource persons.
- Prepare interview questions.
- Prepare notebooks and recording sheets.
- Identify safe routes.
- Observe safety and environmental protection requirements.

Sample questions for community members

1. What climatic changes have you observed in this area?
2. Have you noticed changes in the timing of rainy seasons?
3. How have these changes affected farming?
4. Have droughts or floods affected your household?
5. Which water conservation methods are used in this community?
6. What crops are preferred during periods of unreliable rainfall?
7. What measures are used to protect livestock during drought?

8. How does the community prepare for floods?
9. What tree-planting or conservation activities are carried out?
10. What additional support would help the community respond to climate change?

Data collection methods

- Interviews.
- Observation.
- Questionnaires.
- Photography, with permission.
- Discussions with resource persons.
- Review of available local climate records.

Sample fieldwork report format

1. Title.
2. Date of fieldwork.
3. Study area.
4. Objectives.
5. Methods of data collection.
6. Findings.
7. Effects of climate change identified.
8. Adaptation and mitigation measures.
9. Challenges encountered.
10. Recommendations.
11. Conclusion.

16.2 Important geographical terms

Term	Meaning
Climate	Average weather conditions of a place over a long period
Climate classification	Grouping of places according to their climatic characteristics
Global warming	Long-term increase in the Earth's average surface temperature
Climate change	Long-term changes in temperature, rainfall and other climate patterns
Greenhouse effect	Natural warming process involving greenhouse gases
Greenhouse gases	Atmospheric gases that absorb and re-emit infrared radiation
Evapotranspiration	Combined loss of water through evaporation and plant transpiration
Arid	Very dry, with severe moisture shortage
Semi-arid	Relatively dry, with limited and often unreliable rainfall

Permafrost	Ground that remains frozen for at least two consecutive years
Deforestation	Removal of forest cover
Afforestation	Establishing forests on land not recently under forest cover
Reforestation	Re-establishing trees in areas where forest has been removed
Adaptation	Adjusting to actual or expected climate impacts
Mitigation	Reducing greenhouse gas emissions or increasing their removal
Climate resilience	Ability to prepare for, withstand, recover from and adapt to climate impacts
Drought	Prolonged period of unusually low rainfall causing water shortages
Heatwave	A period of unusually high temperatures relative to the local climate
Desertification	Land degradation in drylands, resulting from climatic variations and human activities
Climate-smart agriculture	Agricultural approaches that aim to improve productivity, resilience and, where possible, reduce emissions

REVISION QUESTIONS

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Instructions: Answer all the questions. Choose the correct answer from the alternatives A, B, C and D.

1. What is the best definition of climate?

A. The atmospheric condition of a place at a particular moment
B. The average weather conditions of a place over a long period
C. The amount of rainfall received in one day
D. The temperature recorded at noon

2. What is the normal period commonly used when calculating climate averages?

A. 5 years
B. 10 years
C. 20 years
D. 30 years

3. Which of the following is NOT an element of climate?

A. Temperature
B. Rainfall
C. Humidity
D. Soil fertility

4. Which factor mainly explains why highland areas are cooler than lowland areas?

A. Latitude
B. Altitude
C. Ocean currents
D. Longitude

5. Which climate classification system was developed by Wladimir Köppen?

A. Thornthwaite system
B. Köppen system
C. Bergeron system
D. Trewartha system

6. Which factors are mainly used in the Köppen climate classification system?

A. Soil and vegetation only
B. Temperature and precipitation patterns
C. Population and settlement
D. Relief and drainage only

7. Which climate classification system gives considerable attention to potential evapotranspiration?

A. Köppen system
B. Thornthwaite system
C. Davis system
D. Wegener system

8. Which climatic region is mainly found between the Tropic of Cancer and the Tropic of Capricorn?

A. Polar region
B. Continental region
C. Tropical region
D. Highland region

9. Which of the following areas is associated with a tropical rainforest climate?

A. Sahara Desert
B. Congo Basin
C. Antarctica
D. Gobi Desert

10. Which of the following is a characteristic feature of the tropical savanna climate?

A. Permanent snow cover
B. Distinct wet and dry seasons

C. Extremely low temperatures throughout the year
D. Absence of rainfall throughout the year

11. What is the major characteristic of a hot desert climate?

A. Heavy rainfall throughout the year
B. Low and unreliable rainfall
C. Permanent ice cover
D. Mild temperatures throughout the year

12. Which of the following is an example of a Mediterranean climatic region?

A. Antarctica
B. Sahara Desert
C. Mediterranean Basin
D. Congo Basin

13. Which climatic region is characterised by long, cold winters and warm or cool summers?

A. Continental region
B. Equatorial region
C. Tropical rainforest region
D. Hot desert region

14. Which type of vegetation is commonly associated with the tundra climate?

A. Tall evergreen tropical trees
B. Mosses and lichens
C. Dense mangrove forests
D. Tall savanna grasses only

15. Which major climatic factor causes temperature to decrease with increasing height above sea level?

A. Altitude
B. Ocean currents
C. Distance from the Equator
D. Vegetation

16. Which of the following is a major human cause of climate change?

A. Changes in the Earth's orbit
B. Volcanic eruptions
C. Burning fossil fuels
D. Natural ocean circulation

17. Which greenhouse gas is released in large quantities when coal and petroleum are burnt?

A. Oxygen
B. Carbon dioxide
C. Nitrogen
D. Hydrogen

18. Why is the greenhouse effect important to the Earth?

A. It prevents all solar radiation from reaching the Earth
B. It keeps the Earth warm enough to support life
C. It removes all water vapour from the atmosphere
D. It stops all atmospheric circulation

19. Which human activity reduces the amount of carbon dioxide absorbed from the atmosphere by vegetation?

A. Afforestation
B. Reforestation
C. Deforestation
D. Agroforestry

20. Which of the following is a natural factor influencing climate?

A. Industrialisation
B. Burning petroleum
C. Volcanic eruptions
D. Deforestation

21. What is a likely effect of prolonged drought on livestock keeping?

A. Increased pasture availability
B. Reduced livestock mortality
C. Livestock deaths due to lack of water and pasture
D. Increased river flow

22. Which of the following is a possible effect of climate change on water resources?

A. Permanent increase in all river flows
B. Changes in water availability
C. Elimination of all floods
D. Complete prevention of drought

23. A farmer who plants drought-tolerant crops is practising:

A. Climate mitigation only
B. Climate adaptation
C. Industrialisation
D. Deforestation

24. Which of the following is an example of climate change mitigation?

A. Constructing flood shelters
B. Moving households away from floodplains
C. Planting trees to absorb carbon dioxide
D. Storing emergency food

25. What is the main purpose of rainwater harvesting?

A. To increase evaporation
B. To conserve water for future use
C. To increase soil erosion
D. To reduce groundwater recharge in all cases

26. Which international agreement was adopted in 2015 to address climate change?

A. Kyoto Protocol
B. Paris Agreement
C. Montreal Protocol
D. Ramsar Convention

27. Which United Nations Sustainable Development Goal directly focuses on climate action?

A. SDG 4
B. SDG 7

C. SDG 13
D. SDG 16

28. Which international organisation assesses scientific information on climate change?

A. World Trade Organization
B. Intergovernmental Panel on Climate Change
C. International Monetary Fund
D. World Tourism Organization

29. What is the safest action to take when approaching a flooded road?

A. Drive through quickly
B. Follow another vehicle through the water
C. Stop and follow official safety instructions
D. Walk through fast-flowing water

30. Why does climate change require international cooperation?

A. Climate change affects only developing countries
B. Greenhouse gases and climate impacts cross national boundaries
C. Every country has identical climatic conditions
D. Climate change can be solved by one community alone

SECTION B: STRUCTURED QUESTIONS 50 marks

Instructions: Answer all questions. Show your work clearly where calculations or illustrations are required.

Question 1: Climate classification (8 marks)

a) Define the term climate. (2 marks)

b) State three elements used to describe the climate of a place. (3 marks)

c) Give three differences between the Köppen and Thornthwaite climate classification systems. (3 marks)

Question 2: Major climatic regions (8 marks)

a) Name four major climatic regions of the world. (4 marks)

b) State four characteristics of the tropical rainforest climate. (4 marks)

Question 3: Climate and human activities (8 marks)

a) Explain four ways in which climate influences agricultural activities. (4 marks)

b) Explain four ways in which climate influences human settlement and transport. (4 marks)

Question 4: Climate change (8 marks)

a) Define climate change. (2 marks)

b) Explain three human activities that contribute to climate change. (3 marks)

c) State three effects of climate change on human activities in Kenya. (3 marks)

Question 5: Adaptation and mitigation (10 marks)

a) Differentiate between climate change adaptation and mitigation. (4 marks)

b) Explain three ways through which farmers in Kenya can adapt to climate change. (3 marks)

c) Explain three measures that communities can use to mitigate climate change. (3 marks)

Question 6: Climate action and disaster management (8 marks)

A community in an arid and semi-arid part of Kenya has experienced prolonged drought, declining pasture and water shortages.

a) Identify two effects of prolonged drought on the community. (2 marks)

b) Explain three measures the community can take to adapt to drought. (3 marks)

c) State three ways in which the community can participate in mitigating climate change. (3 marks)

Total: 50 marks

SUGGESTED ANSWERS AND MARKING GUIDE

SECTION A: MULTIPLE-CHOICE ANSWERS

Question	Answer	Question	Answer
1	B	16	C
2	D	17	B
3	D	18	B

4	B	19	C
5	B	20	C
6	B	21	C
7	B	22	B
8	C	23	B
9	B	24	C
10	B	25	B
11	B	26	B
12	C	27	C
13	A	28	B
14	B	29	C
15	A	30	B

SECTION B: SUGGESTED ANSWERS

Question 1: Climate classification (8 marks)

a) Define climate. (2 marks)

Climate refers to the average weather conditions of a place over a long period, usually at least 30 years.

b) State three elements of climate. (3 marks)

Any three:

1. Temperature.
2. Rainfall.
3. Humidity.
4. Atmospheric pressure.
5. Wind.
6. Sunshine.
7. Cloud cover.

c) Give three differences between Köppen and Thornthwaite systems. (3 marks)

1. Köppen mainly uses temperature and precipitation, while Thornthwaite emphasises precipitation and potential evapotranspiration.

2. Köppen relates climatic categories to natural vegetation, while Thornthwaite focuses on moisture and thermal conditions.
3. Köppen uses letter symbols such as Af, BWh and Csa, while Thornthwaite uses moisture and thermal categories.

Question 2: Major climatic regions (8 marks)

a) Name four major climatic regions. (4 marks)

1. Tropical.
2. Dry.
3. Temperate.
4. Continental.
5. Polar.
6. Highland.

Award any four.

b) State four characteristics of tropical rainforest climate. (4 marks)

1. High temperatures throughout the year.
2. Heavy rainfall in most months.
3. Small annual temperature range.
4. High humidity.
5. Dense evergreen forests.
6. Little or no distinct dry season.

Award any four.

Question 3: Climate and human activities (8 marks)

a) Explain four ways climate influences agriculture. (4 marks)

1. **Rainfall:** Adequate rainfall supports crop growth, while drought may cause crop failure.
2. **Temperature:** Temperature determines the types of crops that can grow in a region.
3. **Length of growing season:** Determines the time available for crops to mature.
4. **Humidity:** Influences crop water loss and the development of certain crop diseases.
5. **Extreme weather:** Floods, hailstorms and heatwaves can destroy crops.

Award any four well-explained points.

b) Explain four ways climate influences human settlement and transport. (4 marks)

1. Favourable climatic conditions may attract settlement because of suitable living conditions.
2. Extremely cold or dry conditions may discourage permanent settlement.
3. Heavy rainfall may damage roads and bridges.
4. Flooding may interrupt road and railway transport.
5. Fog and heavy rainfall may reduce visibility and disrupt transport.

6. Snow and ice may block roads in cold regions.

Award any four well-explained points.

Question 4: Climate change (8 marks)

a) Define climate change. (2 marks)

Climate change refers to long-term changes in average temperature, rainfall and other climatic conditions of the Earth or a region.

b) Explain three human activities that contribute to climate change. (3 marks)

1. Burning fossil fuels releases carbon dioxide into the atmosphere.
2. Deforestation reduces the amount of carbon dioxide absorbed by trees and may release stored carbon.
3. Livestock production releases methane.
4. Industrial activities release greenhouse gases.
5. Poor waste management can release methane and other greenhouse gases.

Award any three correctly explained points.

c) State three effects of climate change on human activities in Kenya. (3 marks)

1. Reduced crop production due to drought and heat stress.
2. Livestock deaths due to shortage of pasture and water.
3. Flood damage to roads, bridges and settlements.
4. Reduced water supply.
5. Disruption of tourism activities.
6. Increased health risks.
7. Reduced hydroelectric power generation during drought.

Award any three.

Question 5: Adaptation and mitigation (10 marks)

a) Differentiate between adaptation and mitigation. (4 marks)

- Adaptation involves adjusting to actual or expected climate change to reduce its harmful effects.
- Mitigation involves reducing greenhouse gas emissions or increasing the removal of greenhouse gases from the atmosphere.

Award 2 marks for each correct explanation.

b) Explain three ways farmers in Kenya can adapt to climate change. (3 marks)

1. Growing drought-resistant crops such as sorghum and millet.
2. Practising irrigation to supplement inadequate rainfall.
3. Using seasonal weather forecasts to plan planting.
4. Practising agroforestry.
5. Conserving pasture and storing animal feeds.
6. Diversifying crops and livestock.

Award any three explained points.

c) State three measures communities can use to mitigate climate change. (3 marks)

1. Planting trees and restoring forests.
2. Using renewable energy such as solar and wind power.
3. Improving waste management through recycling and composting.
4. Reducing unnecessary use of fossil fuels.
5. Promoting energy-efficient appliances.
6. Protecting wetlands and other carbon-storing ecosystems.

Award any three.

Question 6: Climate action and disaster management (8 marks)

a) Identify two effects of prolonged drought on the community. (2 marks)

1. Livestock deaths.
2. Crop failure.
3. Food shortages.
4. Water scarcity.
5. Migration in search of pasture and water.
6. Increased poverty.

Award any two.

b) Explain three measures the community can take to adapt to drought. (3 marks)

1. Harvest and store rainwater for use during dry periods.
2. Grow drought-resistant crops.
3. Store hay and other animal feeds.
4. Establish water pans and reservoirs where environmentally suitable.
5. Practise controlled grazing.
6. Use seasonal weather forecasts to prepare for dry periods.

Award any three explained points.

c) State three ways the community can participate in mitigating climate change. (3 marks)

1. Planting and protecting trees.
2. Using solar energy.
3. Avoiding unnecessary burning of vegetation and waste.
4. Recycling and composting waste.
5. Protecting wetlands and natural vegetation.
6. Promoting energy conservation.

Award any three.

19.0 COMPETENCY-BASED LEARNING PROJECT

Project title: Developing a community climate change action plan

Project situation

A community in Kenya has experienced changing rainfall patterns, prolonged dry seasons, water shortages and declining agricultural production. The community has requested learners to help identify practical solutions.

Project task

Working in groups, learners should investigate the effects of climate change in their community and develop a practical action plan.

Project objectives

By the end of the project, learners should be able to:

1. Identify climate-related challenges in the community.
2. Collect and analyse information on climate change.
3. Distinguish between adaptation and mitigation.
4. Suggest practical community-based solutions.
5. Develop a realistic climate action plan.
6. Appreciate the importance of environmental conservation.

Project activities

1. Identify a climate-related problem in the community.
2. Interview at least five community members.
3. Collect information on rainfall, drought, flooding or environmental degradation.
4. Identify existing adaptation and mitigation measures.
5. Select one practical intervention.
6. Prepare a budget and activity schedule.
7. Implement a small-scale activity where resources and permissions allow.
8. Record the results using photographs, drawings and written observations.
9. Evaluate the achievements and challenges.
10. Present a report to the class and community.

Expected project products

- A written community climate assessment.
- A climate change action plan.
- A labelled poster or map.
- A project budget.
- Photographic or drawn evidence of activities.
- A presentation and final report.

Assessment rubric

Assessment area	Marks
Identification of a climate-related problem	5
Collection and analysis of information	10
Understanding of adaptation and mitigation	5
Practicality of proposed solutions	10
Participation and teamwork	5
Presentation and reporting	5
Total	40

STRAND 2.0: NATURAL SYSTEMS AND PROCESSES

SUB-STRAND 2.3: VEGETATION

COMPREHENSIVE TEACHING AND LEARNING NOTES

Introduction to the sub-strand

Vegetation is an important component of the natural environment. It provides food, shelter, medicine, timber, fuel and other resources that support human life. Vegetation also plays a major role in maintaining ecological balance by absorbing carbon dioxide, releasing oxygen, protecting soils, regulating water cycles and providing habitats for wildlife.

The world has different types of vegetation because regions differ in temperature, rainfall, soils, altitude, relief and human activities. For example, dense tropical rainforests occur in areas with high temperatures and abundant rainfall, while desert vegetation is adapted to conditions of limited water availability.

In Kenya, vegetation ranges from tropical forests and savanna grasslands to semi-arid shrubs, mangrove forests and high-altitude vegetation. Examples include the Mau Forest Complex, Mount Kenya forests, the

Maasai Mara grasslands, the Tana River mangroves and the dryland vegetation of Turkana and northern Kenya.

The study of vegetation helps learners understand the relationship between plants, climate, soils, animals and human activities. It also develops awareness of the need to manage and conserve vegetation for present and future generations.

1.0 MEANING AND CONCEPT OF VEGETATION

1.1 Definition of vegetation

Vegetation refers to the total plant cover growing naturally or being cultivated in a particular geographical area.

It includes:

- Trees.
- Shrubs.
- Grasses.
- Herbs.
- Climbers.
- Mosses.
- Lichens.
- Ferns.
- Other plant communities.

Vegetation varies from one region to another depending on environmental conditions such as climate, soil, altitude, relief and human activities.

Examples:

- Dense evergreen trees in the Congo Basin.
- Grasslands in the Maasai Mara.
- Thorny shrubs in Turkana.
- Mangrove trees along the Kenyan coast.
- Mosses and lichens in tundra regions.

1.2 Meaning of natural vegetation

Natural vegetation refers to plant communities that grow naturally in an area without being deliberately planted or cultivated by people.

Examples include:

- Tropical rainforests.
- Natural savanna grasslands.
- Desert shrubs.
- Tundra vegetation.
- Natural mangrove forests.

1.3 Meaning of planted or cultivated vegetation

Planted vegetation refers to plants deliberately established and managed by people for particular purposes.

Examples:

- Tea plantations in Kericho.
- Coffee farms in central Kenya.
- Eucalyptus plantations in selected areas.
- Fruit orchards.
- School gardens.
- Commercial tree plantations.

1.4 Difference between natural and cultivated vegetation

Natural vegetation	Cultivated vegetation
Grows naturally without deliberate planting by people.	Is deliberately planted by people.
Usually consists of different plant species.	May consist of one or several selected species.
Is influenced mainly by natural environmental conditions.	Is influenced by human management and environmental conditions.
May require little direct human management.	Often requires activities such as planting, watering, pruning and weeding.
Example: Maasai Mara grasslands.	Example: Tea plantations in Kericho.

1.5 Related geographical terms

1. **Flora:** The plant species found in a particular region or period.
2. **Fauna:** The animal species found in a particular region.
3. **Biome:** A large ecological region characterised by particular climatic conditions and dominant vegetation and animal communities.
4. **Ecosystem:** A community of living organisms interacting with one another and with their physical environment.
5. **Habitat:** The natural home or environment in which an organism lives.
6. **Biodiversity:** The variety of living organisms, including plants, animals and microorganisms.
7. **Forest:** A large area dominated by trees and associated plant communities.
8. **Grassland:** An area where grasses are the dominant vegetation.
9. **Shrubland:** An area dominated by woody shrubs, often with scattered trees and grasses.
10. **Desert vegetation:** Plant life adapted to areas with very low and unreliable rainfall.

1.6 Difference between vegetation and flora

Although the terms are related, they have different meanings.

- Vegetation describes the general plant cover and structure of an area.
- Flora refers to the plant species present in a particular area.

For example, the vegetation of the Maasai Mara is mainly savanna grassland, while its flora includes different species of grasses, shrubs and trees.

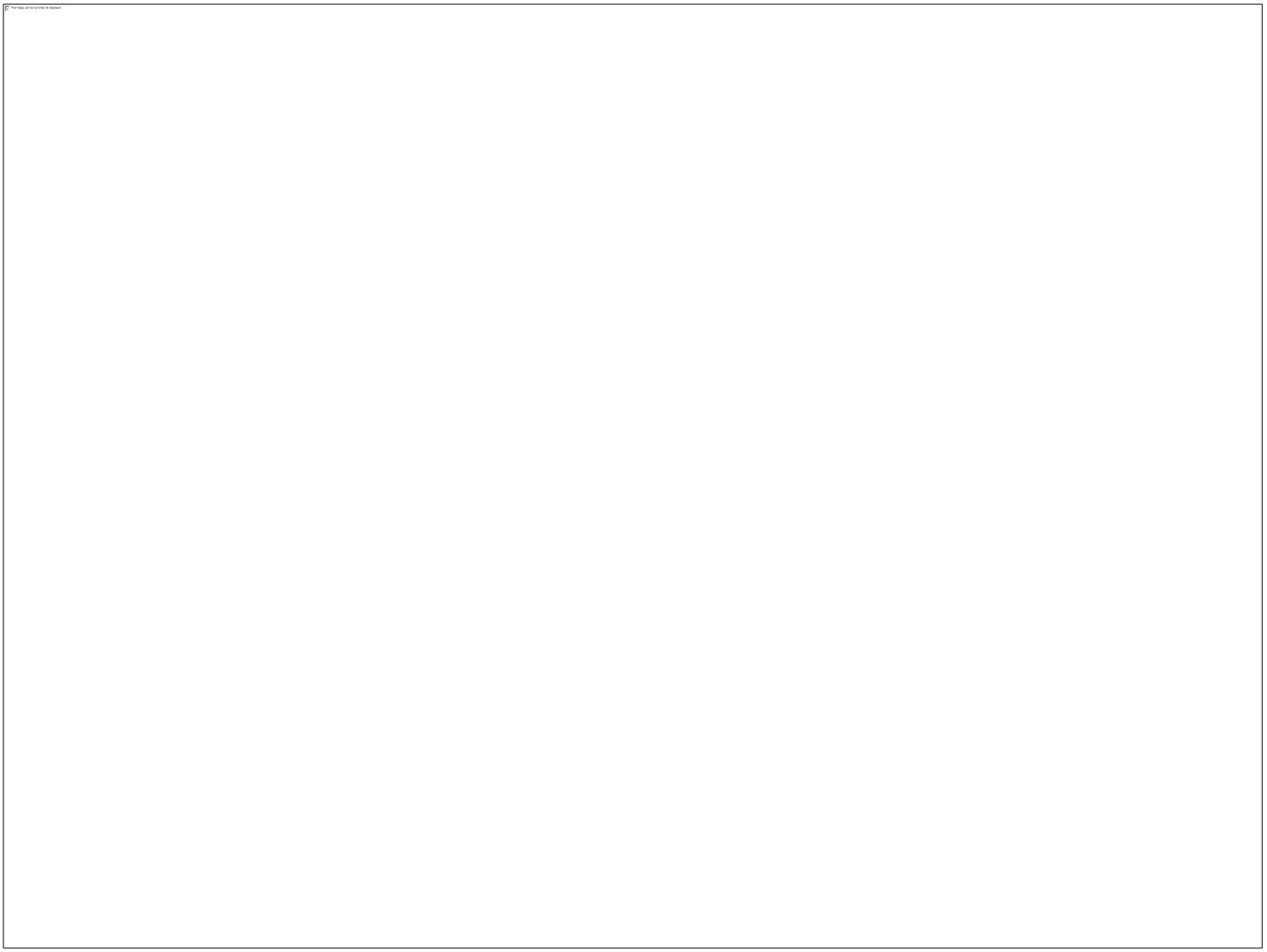
2.0 MAJOR TYPES OF VEGETATION IN THE WORLD

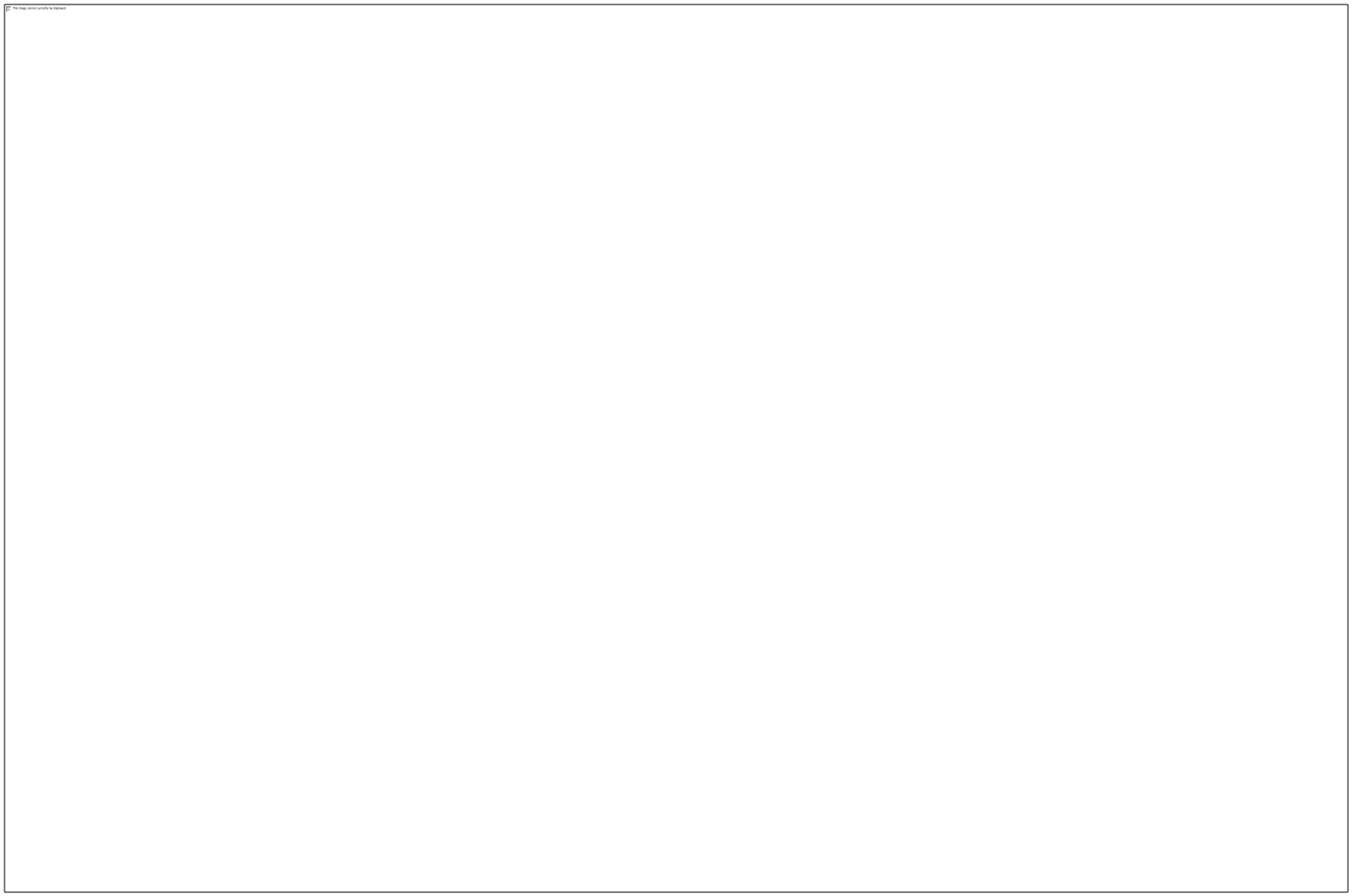
2.1 Introduction

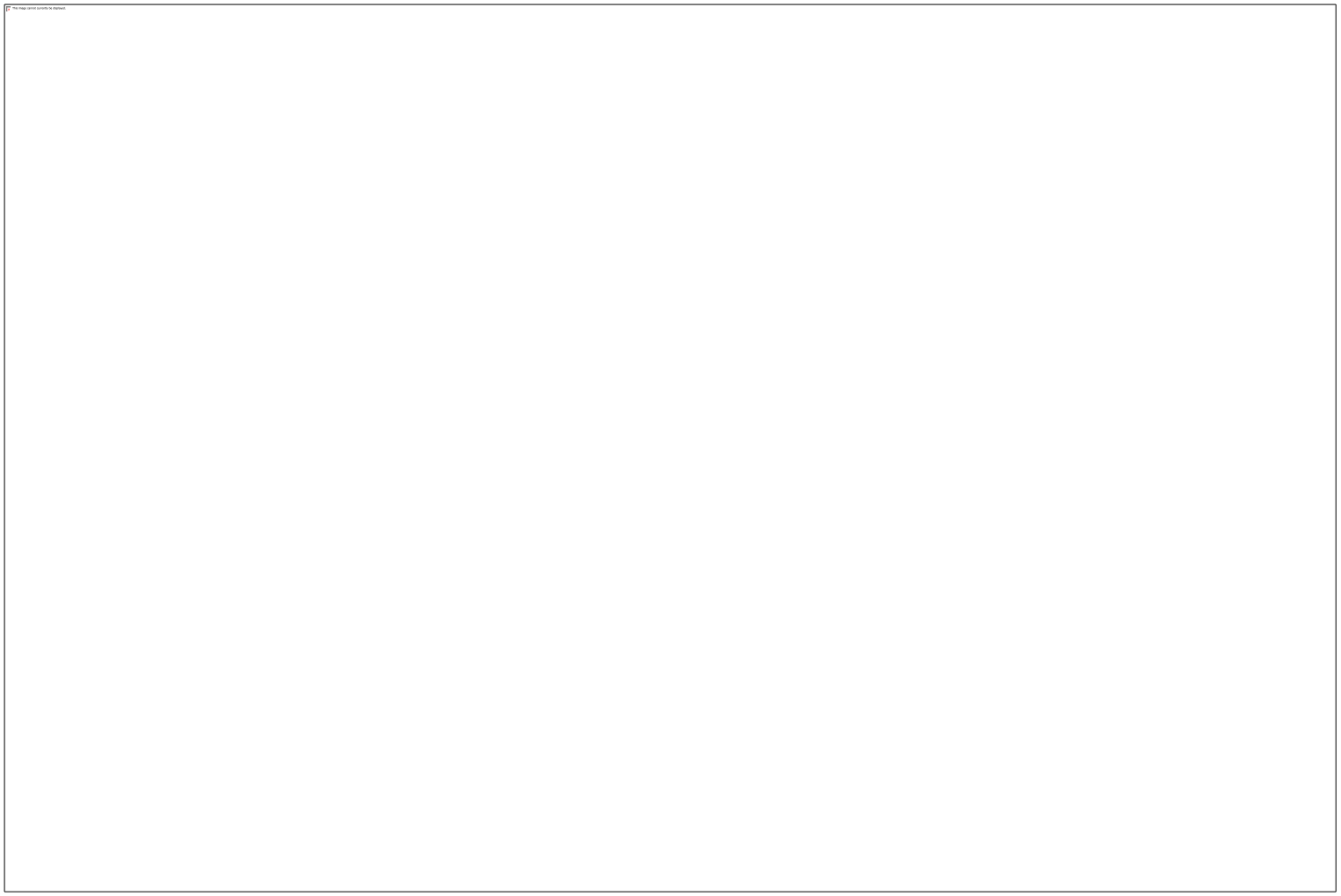
The world has different vegetation types because of variations in climatic and physical conditions.

The major vegetation types studied include:

1. Tropical rainforest vegetation.
2. Tropical deciduous or seasonal forest vegetation.
3. Temperate forest vegetation.
4. Coniferous forest vegetation.
5. Savanna grassland vegetation.
6. Temperate grassland vegetation.
7. Desert vegetation.
8. Mediterranean vegetation.
9. Tundra vegetation.
10. Highland or mountain vegetation.
11. Mangrove vegetation.





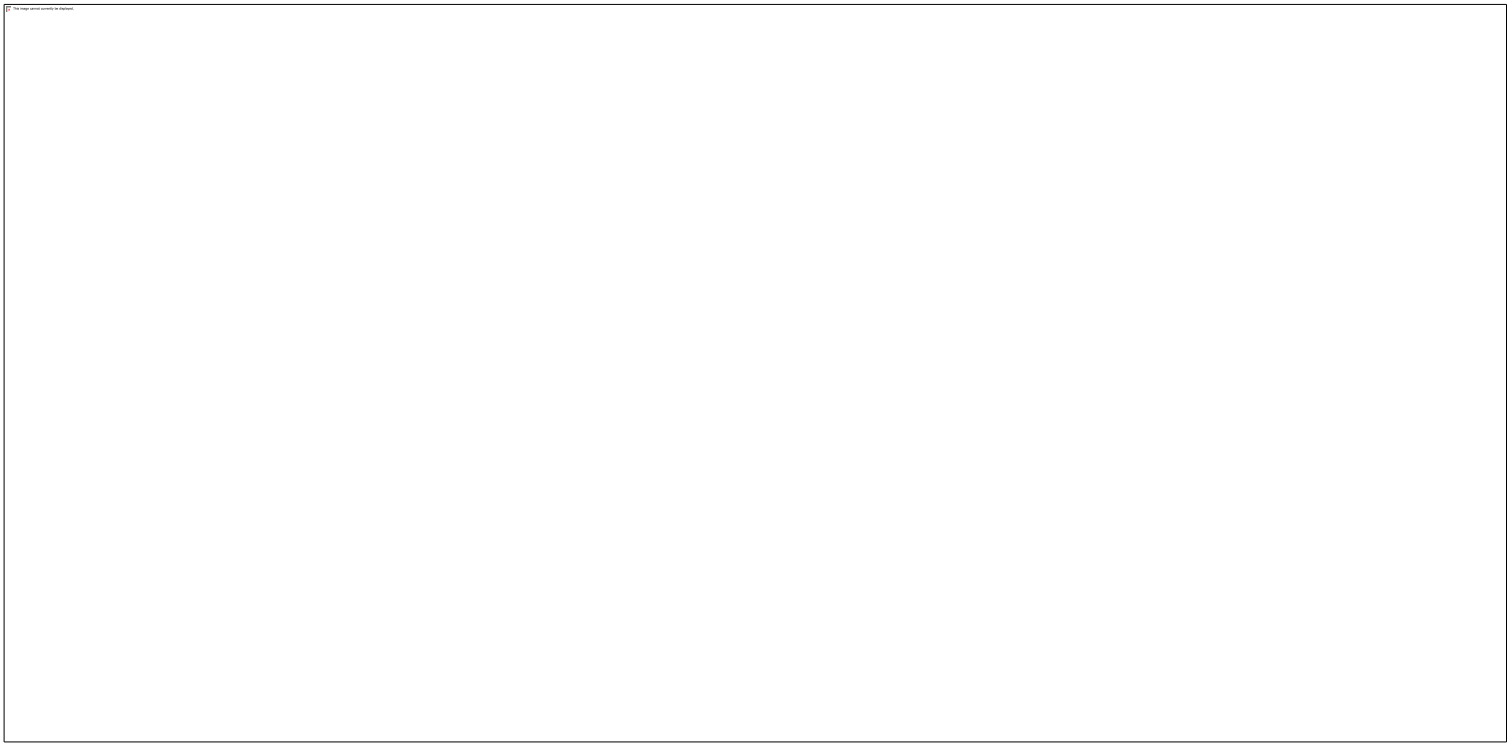


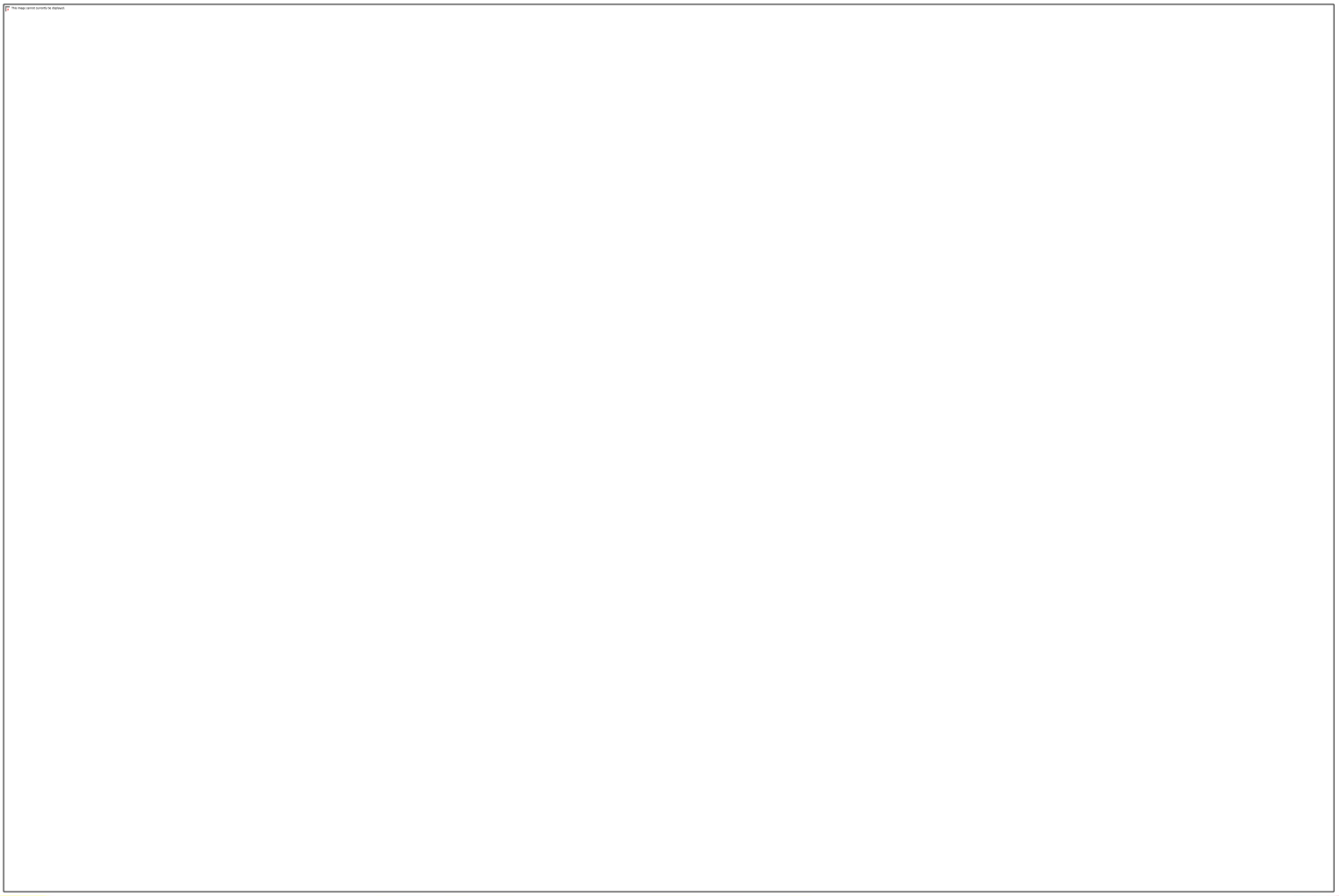
3.0 TROPICAL RAINFOREST VEGETATION

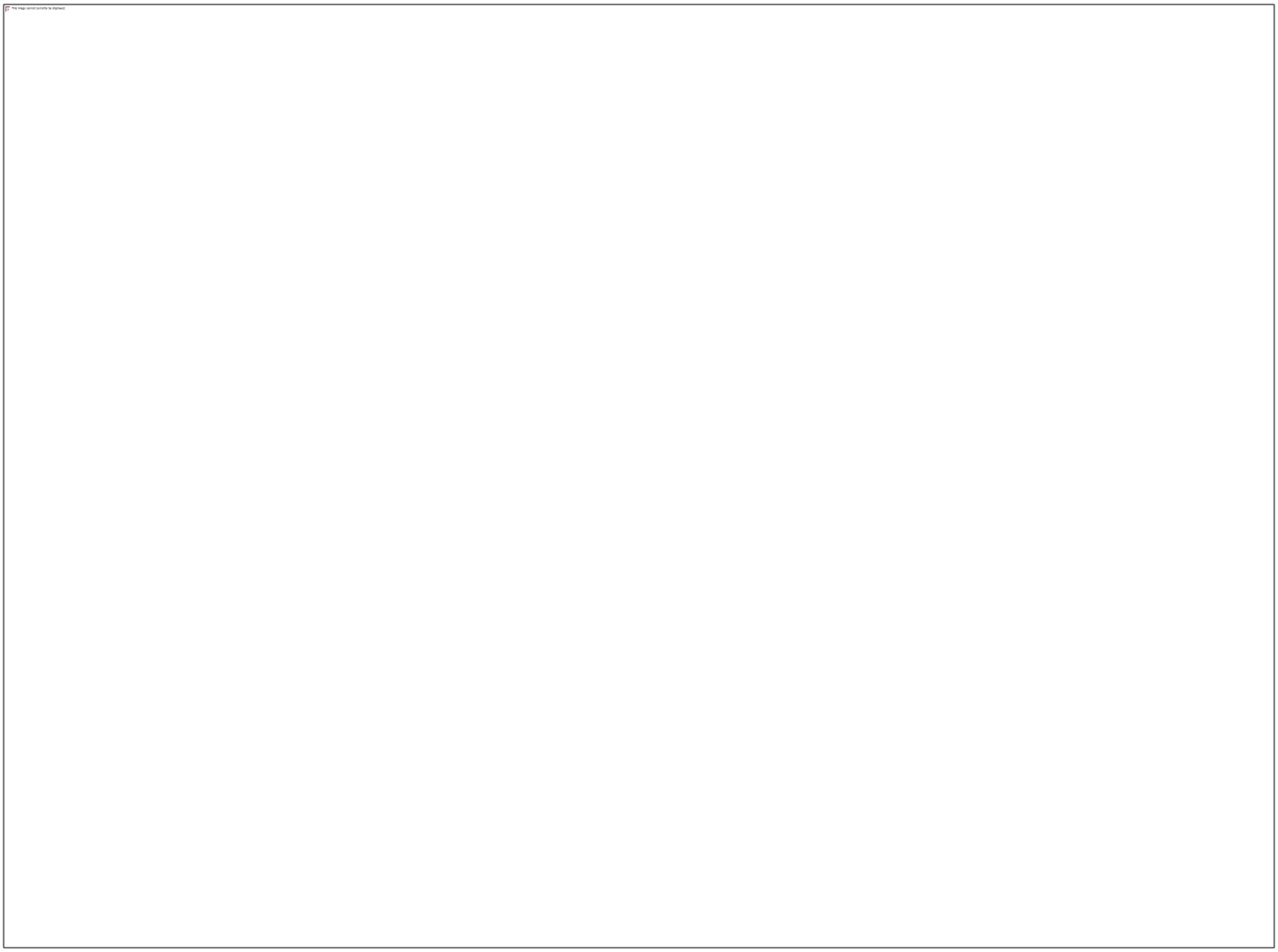
3.1 Definition

Tropical rainforest vegetation refers to dense, evergreen forests found mainly in hot and humid regions near the Equator, where rainfall is abundant throughout much of the year.

It is characterised by tall trees, several vegetation layers, high biodiversity and dense plant growth.





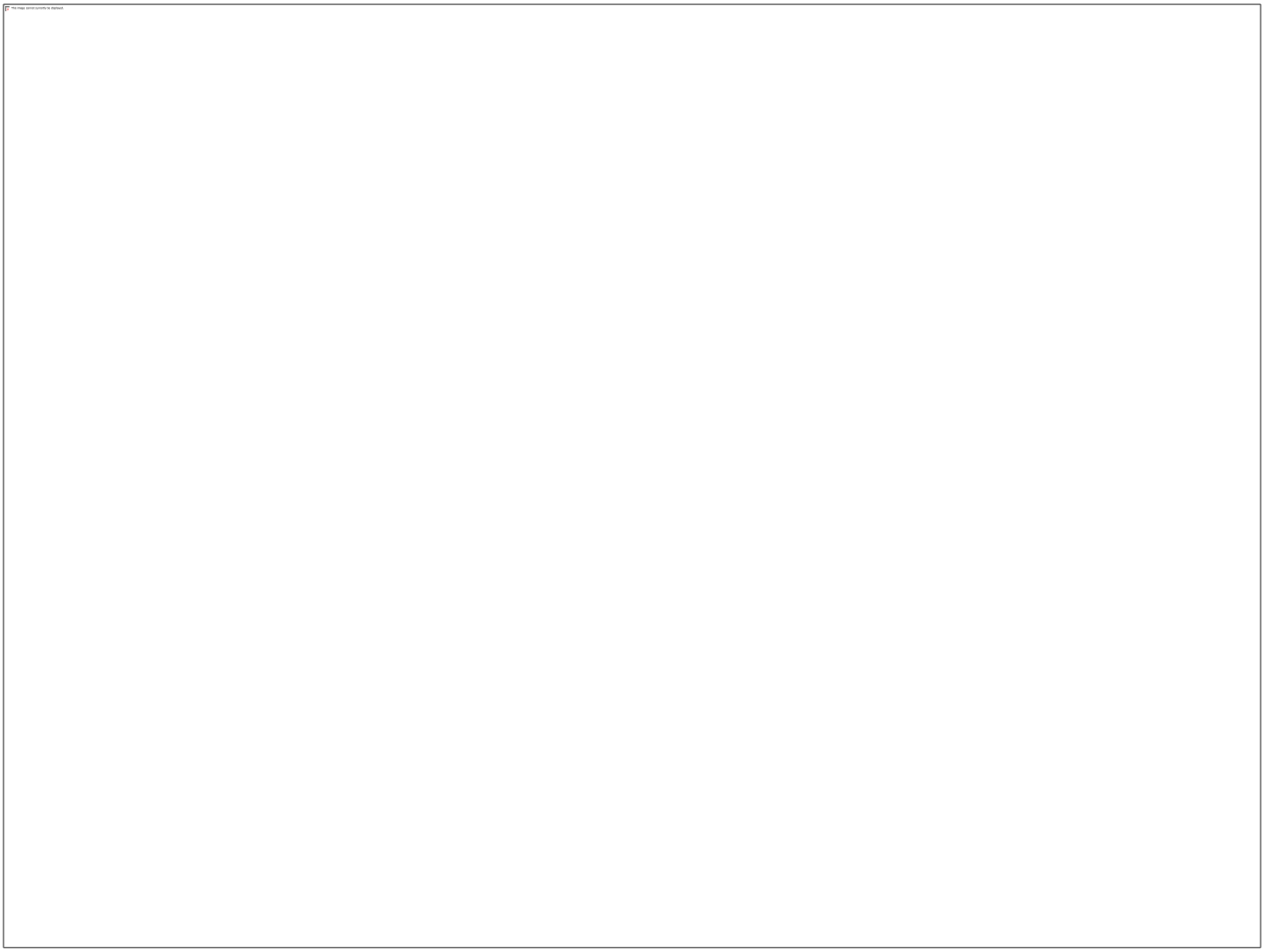


3.2 Distribution of tropical rainforest vegetation

Tropical rainforests are mainly found around the Equator, particularly between approximately 5° north and 5° south, although some extend beyond these latitudes.

Major areas include:

1. **Amazon Basin:** South America, especially Brazil, Peru and Colombia.
2. **Congo Basin:** Central Africa, especially the Democratic Republic of Congo, Republic of Congo and neighbouring countries.
3. **Southeast Asia:** Indonesia, Malaysia, Papua New Guinea and parts of the Philippines.
4. **Central America:** Parts of Panama and neighbouring countries.
5. **West Africa:** Small areas of tropical rainforest remain in countries such as Ghana, Liberia and Côte d'Ivoire.



3.3 Characteristics of tropical rainforest vegetation

1. **Evergreen trees**

- Most trees remain green throughout the year.
- Trees shed leaves gradually rather than all at once.
- This is supported by continuous moisture availability.

2. **Tall trees**

- Many trees grow to considerable heights.
- Some emergent trees rise above the general forest canopy.
- Competition for sunlight encourages upward growth.

3. **Dense vegetation**

- Trees grow close together.
- The forest has a thick canopy.
- Limited sunlight reaches the forest floor.

4. **Several vegetation layers**

- The forest is arranged into different vertical layers.

- These include the emergent layer, canopy, understory and forest floor.

5. **High biodiversity**
   - Many plant species occur within a relatively small area.
   - The forests provide habitats for numerous animal species.

6. **Broad leaves**
   - Many trees have broad leaves that help capture sunlight.
   - Some leaves have pointed drip tips that help water drain quickly.

7. **Buttress roots**
   - Some tall trees have large supporting roots at their bases.
   - These help stabilise trees in shallow or nutrient-poor soils.

8. **Climbers and lianas**
   - Climbing plants use trees for support to reach sunlight.
   - Some lianas have thick woody stems.

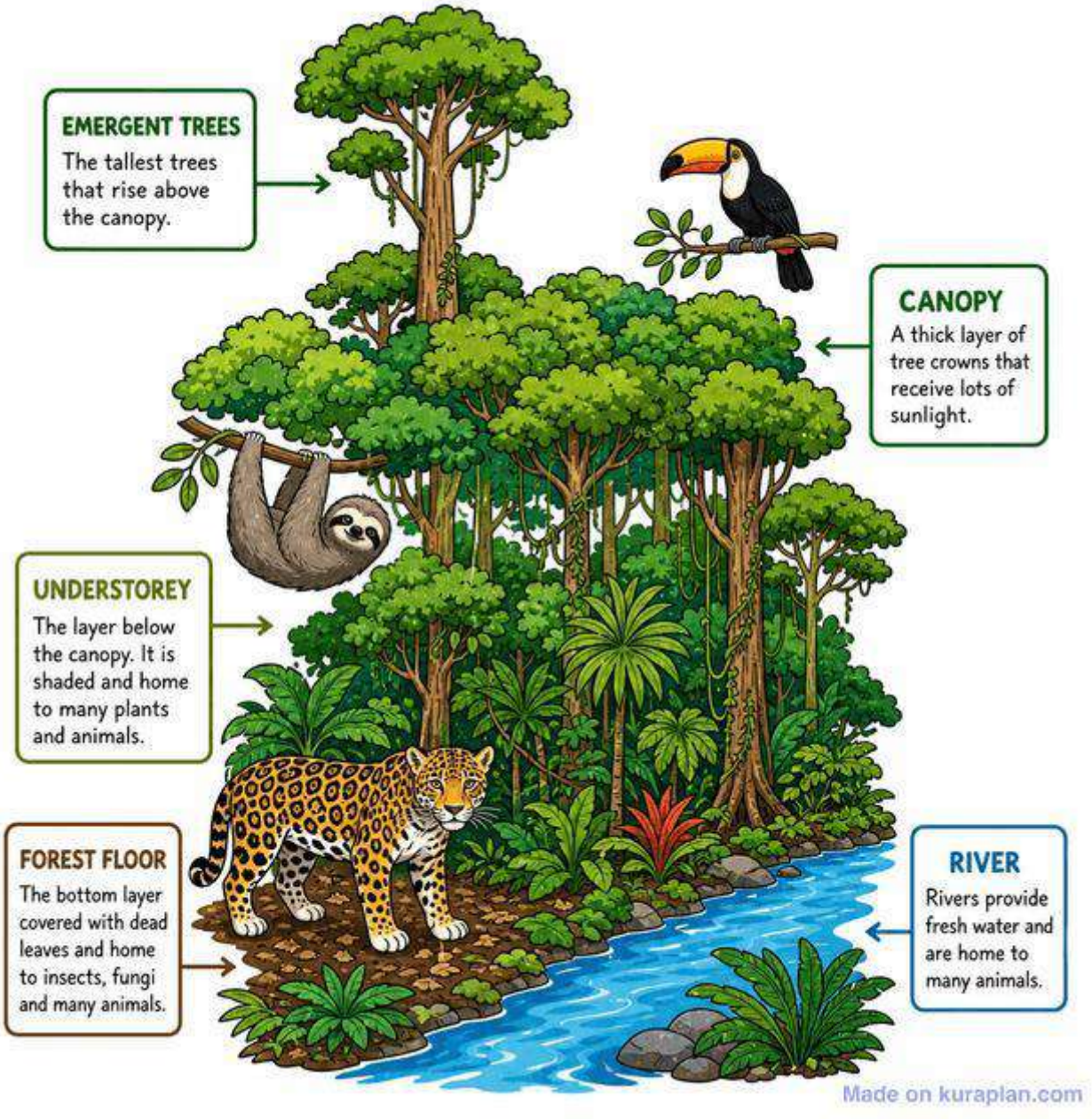
9. **Epiphytes**
   - Plants such as orchids and some ferns grow on other plants for physical support.
   - They do not necessarily obtain food from the supporting tree.

10. **Limited undergrowth in dense sections**
    - Thick canopies reduce sunlight reaching the forest floor.
    - This may limit the growth of grasses and small plants in some sections.

11. **Rapid decomposition**
    - Warm and moist conditions encourage the breakdown of dead organic matter.
    - Nutrients are rapidly recycled within the ecosystem.

3.4 Vertical structure of tropical rainforest vegetation

Tropical rainforests are organised into four major layers.



A. Emergent layer

- This is the uppermost layer.
- It consists of very tall trees that rise above the general canopy.
- Trees receive direct sunlight.
- They are exposed to strong winds.
- Birds and some insects may live in this layer.

B. Canopy layer

- It forms a continuous or nearly continuous roof of tree crowns.
- It receives abundant sunlight.
- It contains a large proportion of the forest's leaves, flowers and fruits.
- Many insects, birds and mammals live in this layer.
- It is important for photosynthesis.

C. Understory layer

- It lies below the canopy.
- It receives limited sunlight.
- It contains young trees, shrubs, ferns and shade-tolerant plants.
- Humidity is generally high.
- Plant growth is often slower because of limited light.

D. Forest floor

- This is the lowest layer.
- It receives very little sunlight in dense forests.
- It contains fallen leaves, dead branches and decomposing organic matter.
- Fungi, insects and microorganisms help break down organic materials.
- Nutrients are returned to the soil through decomposition.

3.5 Adaptations of tropical rainforest plants

Tropical rainforest plants have developed features that help them survive in warm and wet conditions.

Adaptation	Explanation
Drip-tip leaves	Allow excess rainwater to drain quickly
Broad leaves	Help plants capture available sunlight
Buttress roots	Support tall trees in shallow soils
Smooth bark	Helps water run off the trunk
Climbing stems	Enable plants to reach sunlight
Epiphytic growth	Allows plants to occupy spaces above the forest floor
Evergreen leaves	Allow continuous photosynthesis when conditions are favourable

3.6 Importance of tropical rainforest vegetation

- Provides habitats for diverse plants and animals.
- Stores large amounts of carbon in trees and soils.
- Helps regulate the water cycle.
- Protects soils from erosion.
- Provides timber and other forest products.
- Supports indigenous and local communities.
- Provides medicinal plants and food.

- Supports scientific research and tourism.

3.7 Human activities in tropical rainforest regions

- Logging.
- Farming.
- Collection of non-timber forest products.
- Hunting and fishing.
- Ecotourism.
- Scientific research.
- Settlement and infrastructure development.

3.8 Threats to tropical rainforest vegetation

- Deforestation.
- Illegal logging.
- Agricultural expansion.
- Mining.
- Road construction.
- Forest fires.
- Climate change.
- Overexploitation of forest resources.

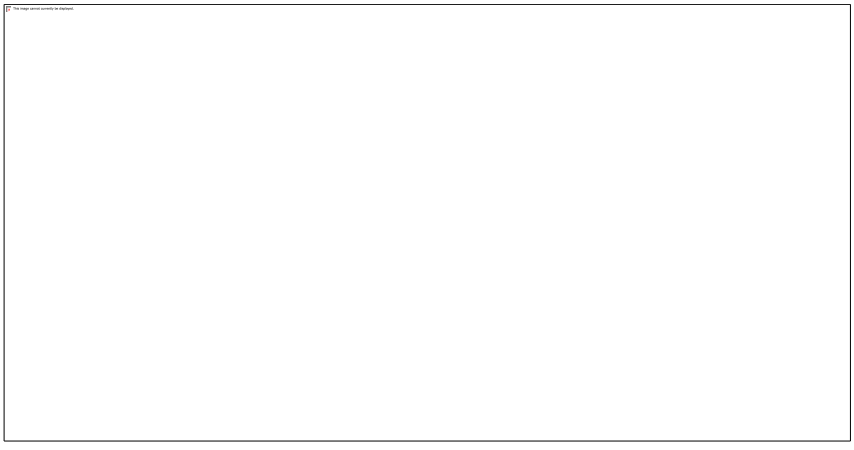
Kenyan connection: Kenya has tropical rainforest areas, although they are smaller than the Amazon and Congo rainforests. Examples include parts of Kakamega Forest, which is an important tropical rainforest ecosystem in western Kenya.

4.0 TROPICAL DECIDUOUS OR SEASONAL FOREST VEGETATION

4.1 Definition

Tropical deciduous vegetation consists of trees that shed most or some of their leaves during a particular dry season to reduce water loss.

It occurs mainly in tropical areas that experience distinct wet and dry seasons.







4.2 Distribution

It is found in:

- India.
- Myanmar.

- Thailand.
- Parts of southern China.
- Parts of East Africa.
- Parts of West Africa.
- Northern Australia.
- Central America.

4.3 Characteristics

1. Trees shed leaves during the dry season.
2. Trees are generally shorter and less dense than those in tropical rainforests.
3. The vegetation experiences distinct wet and dry seasons.
4. Trees often have deep roots to access underground water.
5. Many trees have thick bark to reduce water loss and withstand dry conditions.
6. The vegetation may include grasses, shrubs and scattered trees.
7. Some trees produce flowers and fruits during particular seasons.
8. The forest canopy is less continuous than in tropical rainforests.
9. Some areas contain broad-leaved deciduous trees.
10. Fire may influence vegetation structure in some regions.

4.4 Adaptations

- Shedding leaves reduces water loss during dry periods.
- Deep roots enable plants to obtain water from deeper soil layers.
- Thick bark protects trees against heat and some fires.
- Some plants store water in roots, stems or other plant parts.
- Seeds may remain dormant until favourable rainfall occurs.

4.5 Human activities

- Farming.
- Livestock keeping.
- Collection of fuelwood.
- Timber harvesting.
- Beekeeping.
- Wildlife tourism.

4.6 Importance

- Provides timber and fuelwood.
- Supports wildlife habitats.
- Protects soil from erosion.

- Supplies fruits, medicines and other products.
- Supports local livelihoods.

4.7 Threats

- Excessive cutting of trees.
- Uncontrolled fires.
- Overgrazing.
- Agricultural expansion.
- Settlement development.
- Climate change.

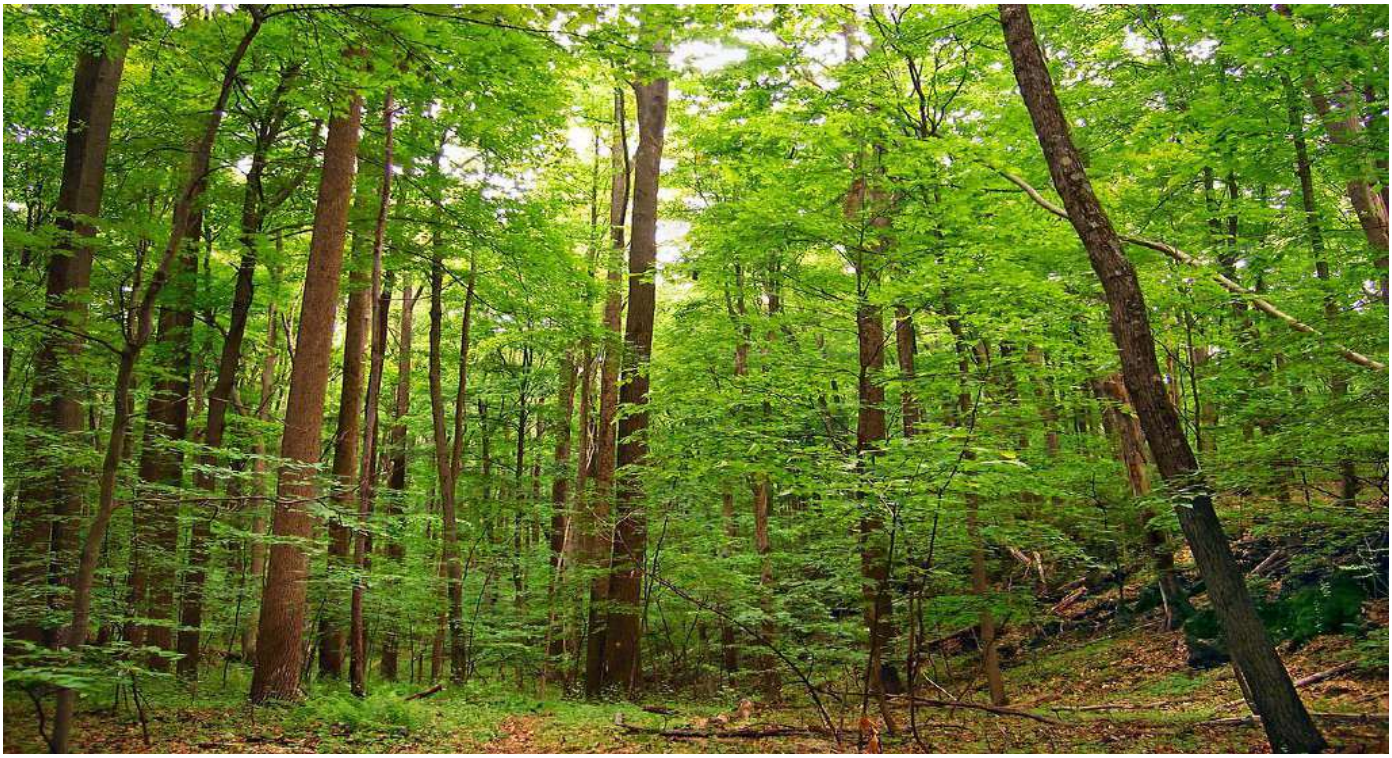
5.0 TEMPERATE FOREST VEGETATION

5.1 Definition

Temperate forest vegetation refers to forests found mainly in the middle latitudes, where temperatures are moderate and seasonal changes occur.

These forests may be deciduous, evergreen or mixed, depending on climatic conditions.





5.2 Distribution of temperate forests

Temperate forests are mainly found in:

- Western and central Europe.

- Eastern North America.
- Eastern Asia, especially China, Japan and Korea.
- Parts of southern Chile.
- Parts of southeastern Australia.
- New Zealand.

5.3 Characteristics of temperate forest vegetation

1. **Seasonal changes:** Trees respond to seasonal variations in temperature and moisture.
2. **Moderate tree height:** Trees are generally tall, but their height varies according to species and local conditions.
3. **Broad leaves in deciduous forests:** Many trees have broad leaves that capture sunlight during the growing season.
4. **Leaf shedding:** Deciduous trees shed leaves during autumn or a cold or dry season.
5. **Evergreen species:** Some temperate forests contain trees that retain their leaves throughout the year.
6. **Mixed vegetation:** Some forests contain both broad-leaved trees and conifers.
7. **Moderate undergrowth:** Shrubs, herbs, ferns and grasses may grow beneath the trees.
8. **Seasonal flowering and fruiting:** Many species produce flowers and fruits during favourable seasons.
9. **Well-developed soil:** Leaf litter decomposes and contributes organic matter to the soil.
10. **Wildlife habitats:** These forests support birds, insects, mammals and other organisms.

5.4 Types of temperate forest vegetation

A. Temperate deciduous forests

These are forests in which many trees shed their leaves during autumn or another unfavourable season.

Characteristics:

- Trees have broad leaves.
- Leaves may change colour before falling.
- Trees remain dormant during cold winter conditions.
- New leaves develop during spring.
- The forests may contain oak, beech, maple and birch trees.

Examples: Eastern United States, western and central Europe, and parts of eastern Asia.

B. Temperate evergreen forests

These forests contain trees that retain their foliage throughout the year.

Characteristics:

- Trees remain green throughout the year.
- Many species have leathery or tough leaves.
- Some trees are adapted to relatively dry or mild conditions.
- Vegetation density varies according to rainfall and soil conditions.

C. Temperate mixed forests

These forests contain both deciduous broad-leaved trees and evergreen coniferous trees.

Examples of trees include:

- Oak.
- Beech.
- Birch.
- Pine.
- Fir.
- Spruce.

5.5 Adaptations of temperate forest plants

- Deciduous trees shed leaves to reduce water loss or survive unfavourable cold seasons.
- Some trees develop thick bark for protection.
- Conifers have needle-shaped leaves that reduce water loss.
- Many trees have seasonal growth patterns.
- Seeds may remain dormant during unfavourable seasons.
- Deep or spreading roots help plants obtain water and nutrients.

5.6 Importance of temperate forests

1. Provide timber for construction and furniture.
2. Supply raw materials for paper production.
3. Support biodiversity.
4. Protect soil from erosion.
5. Store carbon.
6. Support recreation and tourism.
7. Provide fruits, nuts and medicinal products.
8. Regulate local water systems.

5.7 Threats to temperate forests

- Commercial logging.
- Urban expansion.
- Agricultural expansion.
- Forest fires.
- Air pollution.
- Invasive species.
- Pests and diseases.
- Climate change.

6.0 CONIFEROUS FOREST VEGETATION

6.1 Definition

Coniferous forest vegetation refers to forests dominated by cone-bearing trees, most of which have needle-like or scale-like leaves.

Many coniferous trees are evergreen and are adapted to cold climatic conditions.





6.2 Distribution

Coniferous forests are mainly found in:

- Canada.
- Alaska.
- Russia.
- Siberia.
- Scandinavia.
- Parts of northern Europe.
- Mountainous areas in Europe, Asia and North America.

The extensive northern coniferous forest is commonly called the **taiga** or **boreal forest**.

6.3 Characteristics of coniferous forest vegetation

1. **Needle-shaped leaves:** Many trees have narrow, needle-like leaves.
2. **Evergreen nature:** Most conifers retain their leaves throughout the year.
3. **Cone-shaped crowns:** Many trees have a pointed shape.
4. **Sloping branches:** Branches often slope downwards to allow snow to slide off.
5. **Thick bark:** Bark may provide protection against cold and fire.
6. **Straight trunks:** Many trees have straight trunks suitable for timber production.

7. **Limited species diversity:** Boreal forests often contain fewer tree species than tropical rainforests.
8. **Shallow roots:** Roots may spread near the surface where deep soil remains frozen or where nutrients are concentrated.
9. **Slow growth:** Low temperatures and short growing seasons limit the rate of plant growth.
10. **Acidic soils:** Decomposition may be slow, resulting in acidic soils with accumulated organic matter.

6.4 Adaptations of coniferous trees

- Needle-shaped leaves reduce water loss.
- A waxy leaf coating reduces moisture loss.
- Conical shape helps snow slide off.
- Flexible branches reduce the risk of breaking under snow.
- Evergreen leaves allow photosynthesis whenever conditions are favourable.
- Thick bark protects the trunk from cold and some fires.

6.5 Importance of coniferous forests

- Supply softwood timber.
- Provide pulp for paper manufacturing.
- Store carbon.
- Support wildlife habitats.
- Protect soils and water catchments.
- Support tourism and recreation.
- Provide resin and other forest products.

6.6 Human activities in coniferous forest regions

- Commercial logging.
- Paper and pulp manufacturing.
- Furniture production.
- Mining.
- Hunting and fishing.
- Tourism and recreation.
- Scientific research.

6.7 Threats to coniferous forests

- Excessive commercial logging.
- Forest fires.
- Insect outbreaks.
- Mining activities.
- Road construction.

- Climate change.
- Habitat fragmentation.

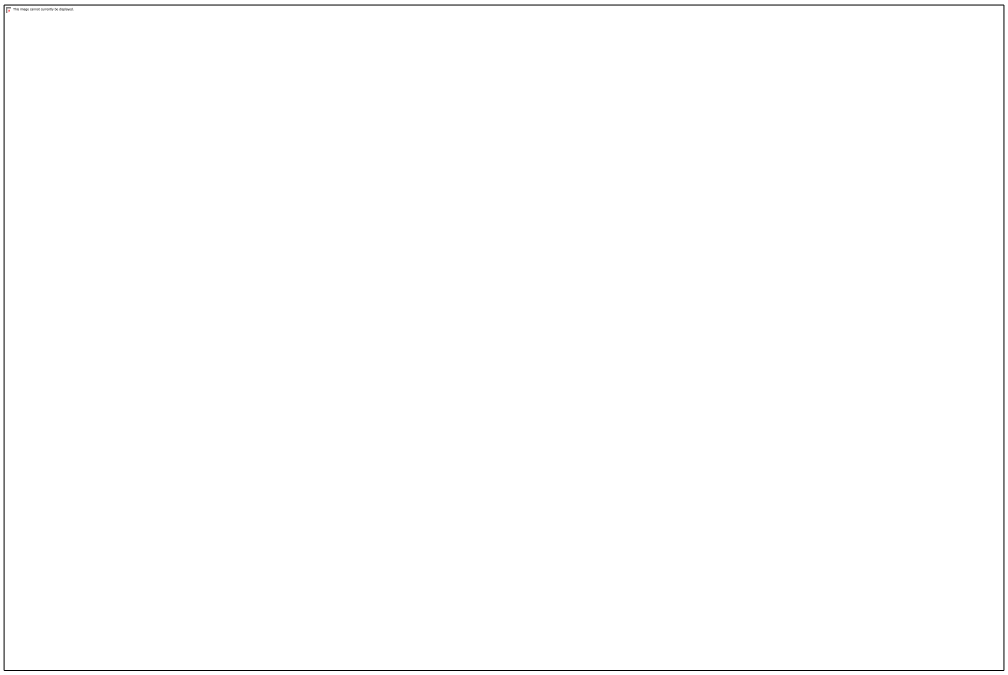
7.0 SAVANNA GRASSLAND VEGETATION

7.1 Definition

Savanna vegetation refers to tropical grassland vegetation characterised by extensive grass cover with scattered trees and shrubs.

It is commonly found in tropical regions experiencing distinct wet and dry seasons.





7.2 Distribution of savanna vegetation

Savanna vegetation occurs mainly in:

- East Africa.
- Central Africa.
- West Africa.
- Brazil.
- Venezuela.
- Northern Australia.
- Parts of India.

Kenyan examples:

- Maasai Mara.
- Amboseli.
- Tsavo.
- Laikipia.
- Parts of Samburu.
- Some areas of the Athi-Kapiti plains.

7.3 Characteristics of savanna vegetation

1. **Dominance of grasses:** Grasses are the most common plant type.
2. **Scattered trees:** Trees occur at intervals rather than forming a continuous canopy.
3. **Seasonal rainfall:** Rainfall is concentrated in particular months.
4. **Long dry season:** Many areas experience a prolonged period of limited rainfall.
5. **Variable grass height:** Grasses may be tall in wetter areas and short in drier areas.
6. **Drought-resistant plants:** Many plants have features that help them survive water shortages.
7. **Fire adaptation:** Some grasses and trees can recover after seasonal fires.
8. **Deep-rooted plants:** Roots may extend deep into the soil to obtain water.
9. **Thorny shrubs:** Thorny vegetation occurs in some areas as an adaptation to grazing and dry conditions.
10. **Wildlife diversity:** Savannas support large populations of herbivores and carnivores.

7.4 Types of savanna vegetation

A. Tree savanna

- Contains grasses and widely spaced trees.
- Trees may include acacia-type species and other drought-resistant trees.
- Grass cover is usually continuous or nearly continuous.

- It supports grazing animals.

B. Shrub savanna

- Contains grasses and numerous shrubs.
- Trees are fewer than in tree savanna.
- Shrubs may have small leaves or thorns.
- It is common in relatively dry areas.

C. Grass savanna

- Dominated by grasses.
- Trees and shrubs are few or absent in some locations.
- Grass height varies with rainfall.
- It provides pasture for livestock and wildlife.

D. Wet savanna

- Occurs in areas receiving relatively high seasonal rainfall.
- Supports tall grasses and more scattered trees.
- Some areas may experience seasonal flooding.

7.5 Adaptations of savanna plants

1. Deep roots enable plants to obtain water during dry seasons.
2. Some grasses die back above ground during dry periods but regenerate from underground roots.
3. Thick bark protects some trees against fire.
4. Small leaves reduce water loss.
5. Thorny branches discourage browsing animals.
6. Some trees shed leaves during the dry season.
7. Some seeds remain dormant until adequate moisture is available.
8. Grasses often grow rapidly after the onset of rains.

7.6 Importance of savanna vegetation

- Provides pasture for livestock.
- Supports wildlife and tourism.
- Provides fuelwood and construction materials.
- Protects soils from erosion.
- Supports pollinators and other organisms.
- Stores carbon in vegetation and soils.
- Supports traditional livelihoods.
- Provides medicinal plants and other products.

7.7 Human activities in savanna regions

- Cattle keeping.
- Sheep and goat rearing.
- Wildlife tourism.
- Crop farming in suitable areas.
- Beekeeping.
- Collection of fuelwood.
- Conservation activities.

7.8 Threats to savanna vegetation

- Overgrazing.
- Excessive tree cutting.
- Uncontrolled burning.
- Agricultural expansion.
- Settlement expansion.
- Poaching and habitat destruction.
- Invasive plant species.
- Prolonged drought.
- Climate change.

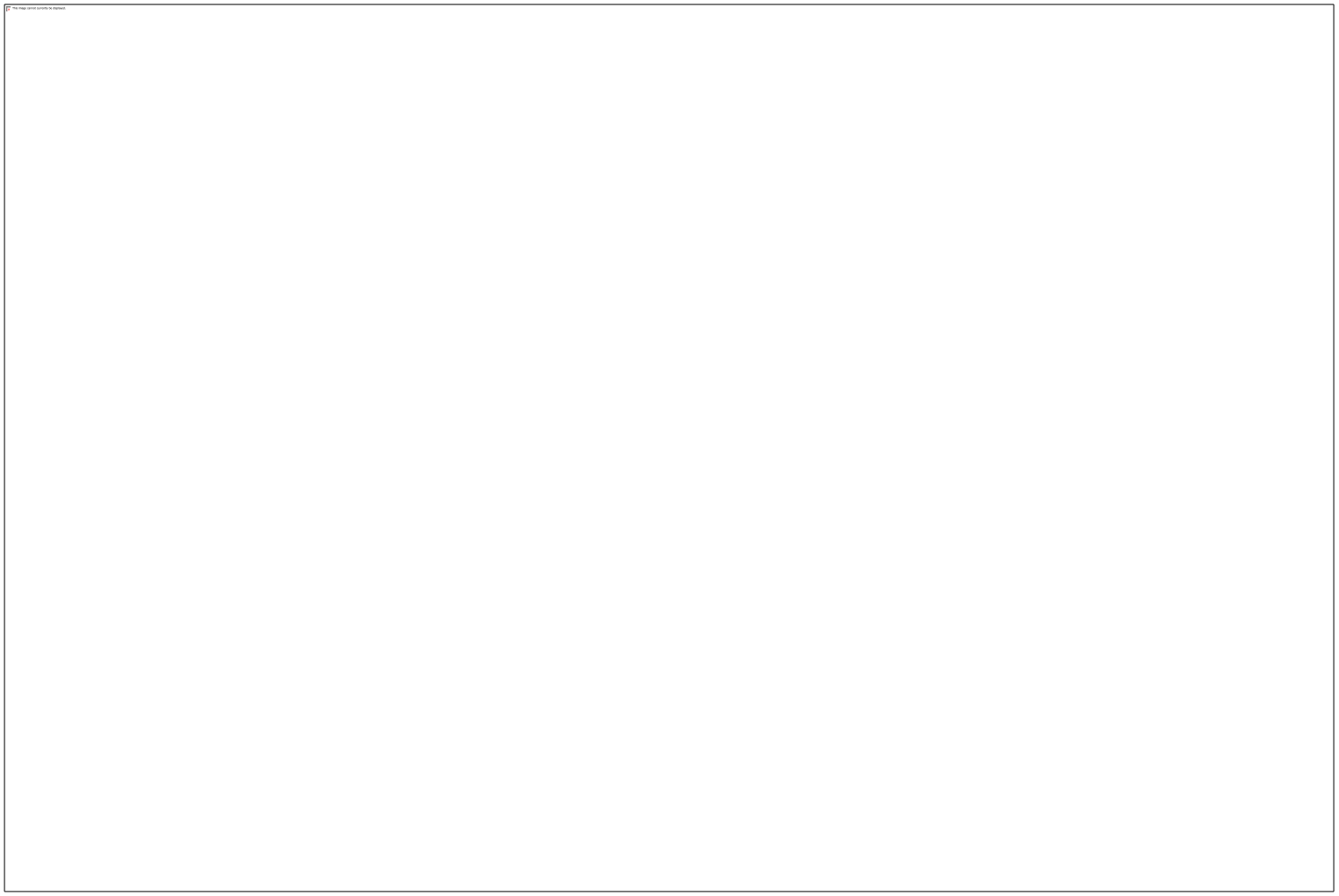
Kenyan application: Savanna vegetation is important in the Maasai Mara ecosystem because it supports wildebeest, zebras, gazelles and other wildlife. It also provides pasture for livestock in surrounding pastoral communities.

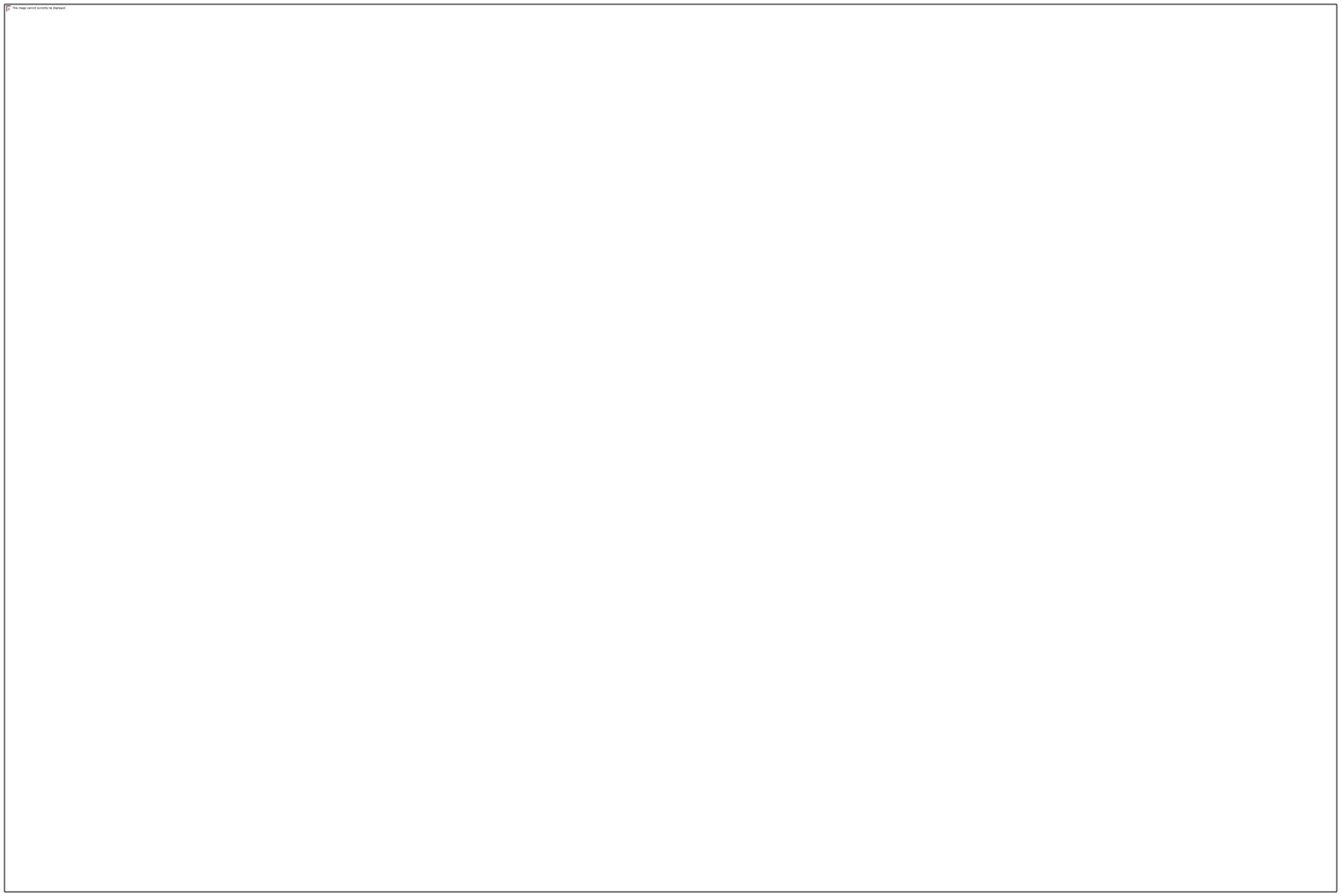
8.0 TEMPERATE GRASSLAND VEGETATION

8.1 Definition

Temperate grassland vegetation refers to natural grasslands found in the middle latitudes, where rainfall is generally insufficient to support extensive forests but adequate to support grasses.







8.2 Distribution

Temperate grasslands occur in:

- North America: Prairies.
- South America: Pampas.
- Eurasia: Steppes.
- South Africa: Veld.
- Australia: Downs.

8.3 Characteristics of temperate grassland vegetation

1. Grasses are the dominant vegetation.
2. Trees are generally few because of limited rainfall or other environmental conditions.
3. Grasses may grow tall in wetter areas.
4. Short grasses dominate drier areas.
5. Seasonal changes in temperature are pronounced.
6. Many areas experience hot summers and cold winters.
7. Some grasslands have deep, fertile soils.
8. Natural fires may help maintain grassland vegetation.
9. Many plants have extensive root systems.
10. Grasslands support grazing animals.

8.4 Major types of temperate grasslands

Grassland	Location
Prairies	North America
Pampas	Argentina and neighbouring parts of South America
Steppes	Eurasia
Veld	South Africa
Downs	Australia

8.5 Adaptations of temperate grassland plants

- Deep roots enable grasses to obtain water.
- Narrow leaves reduce water loss.
- Underground buds enable grasses to regrow after grazing or fire.
- Seeds may survive periods of unfavourable conditions.
- Extensive root systems help bind the soil.

8.6 Importance of temperate grasslands

- Support commercial livestock farming.
- Provide land for wheat and other cereal production.
- Support wildlife.
- Provide grazing resources.
- Support tourism and recreation.
- Help maintain soil fertility.
- Store carbon in deep grassland soils.

8.7 Human activities

- Commercial wheat farming.
- Beef cattle ranching.
- Sheep farming.
- Dairy farming in suitable areas.
- Mechanised agriculture.
- Wildlife conservation.
- Tourism.

8.8 Threats

- Conversion to farmland.
- Overgrazing.
- Soil erosion.
- Excessive use of agrochemicals.
- Urbanisation.
- Invasive species.
- Climate change.

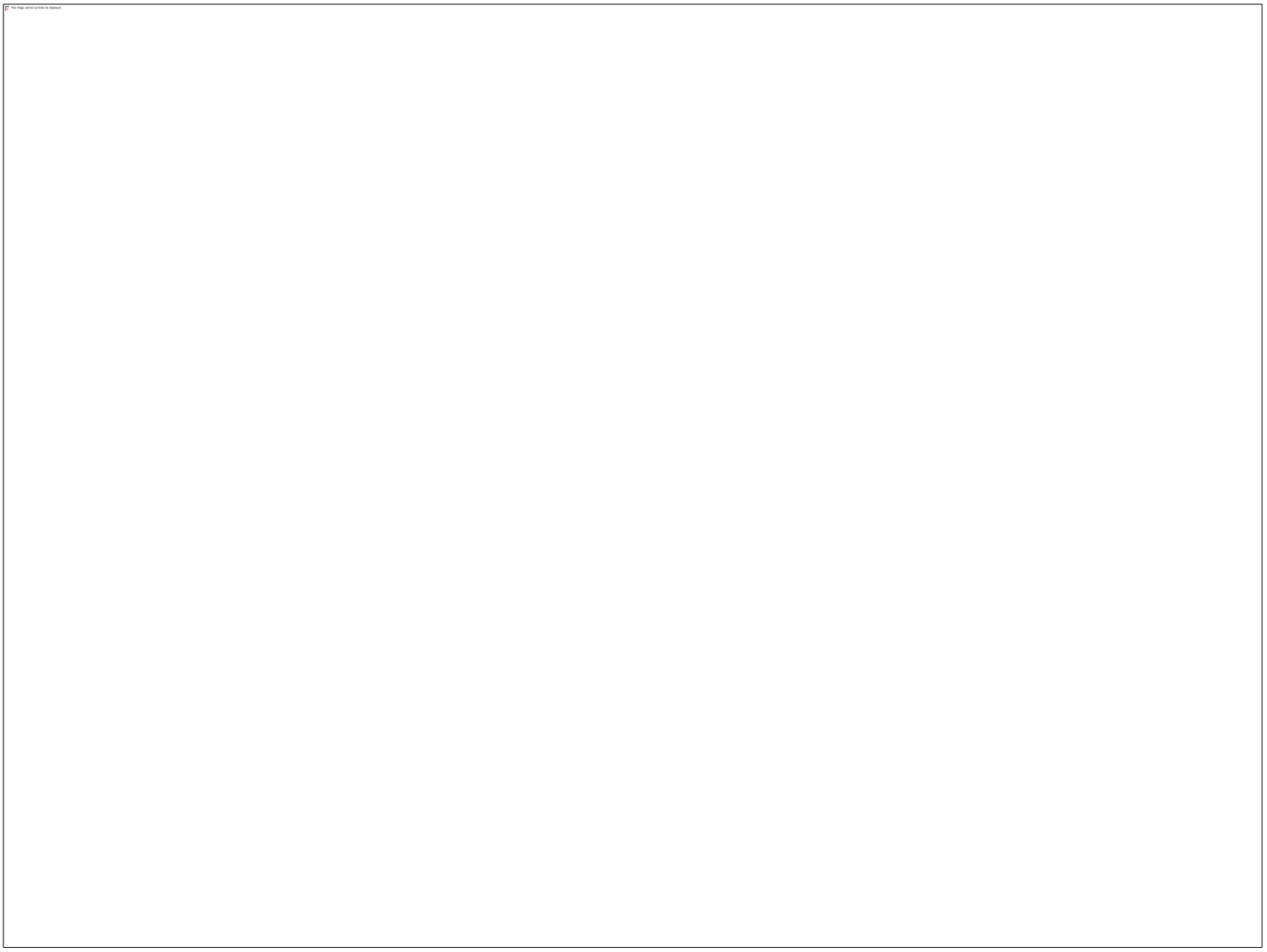
9.0 DESERT VEGETATION

9.1 Definition

Desert vegetation refers to plant life adapted to areas with very low and unreliable rainfall and high potential evaporation.

Desert plants are specially adapted to conserve and obtain water.

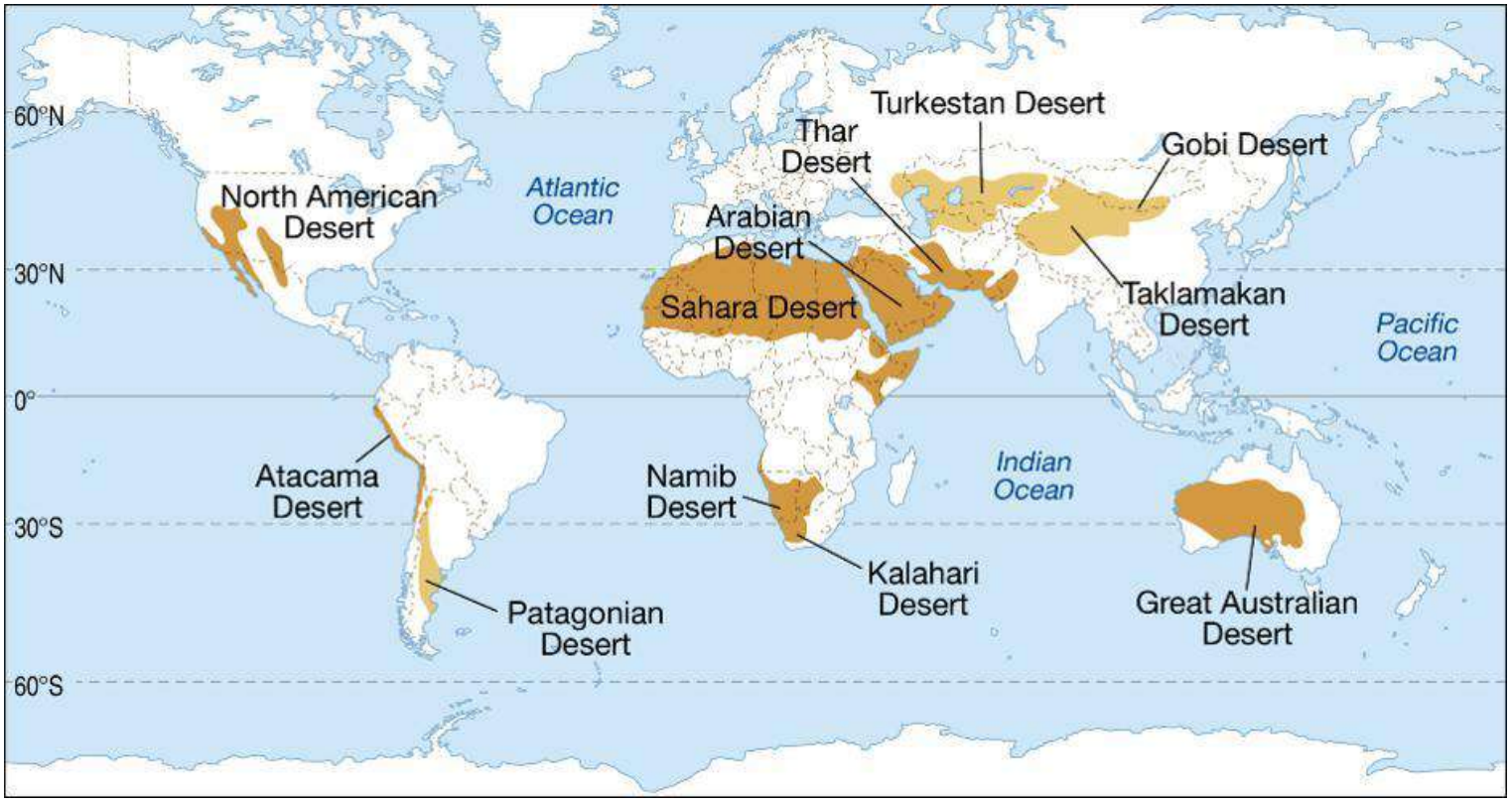




9.2 Distribution of desert vegetation

Desert vegetation is mainly found in:

- Sahara Desert in North Africa.
- Arabian Desert in Southwest Asia.
- Namib Desert in Namibia.
- Kalahari Desert in southern Africa.
- Atacama Desert in South America.
- Australian deserts.
- Gobi Desert in Asia.
- Sonoran Desert in North America.



9.3 Characteristics of desert vegetation

1. **Sparse plant cover:** Plants are widely spaced because of limited water.
2. **Small leaves:** Many plants have reduced leaf surfaces to limit water loss.
3. **Deep root systems:** Some plants have deep roots to reach underground water.
4. **Wide-spreading roots:** Other plants have shallow, extensive roots to absorb brief rainfall.
5. **Water storage:** Some plants store water in stems, roots or leaves.
6. **Thick cuticles:** Waxy surfaces reduce water loss.
7. **Spines and thorns:** Some plants have modified leaves that reduce water loss and discourage herbivores.
8. **Short life cycles:** Some annual plants grow rapidly after rainfall and complete their life cycles before the soil dries.
9. **Dormant seeds:** Seeds may remain inactive during prolonged dry conditions.
10. **Slow growth:** Many desert plants grow slowly because of limited water.

9.4 Types of desert plants

A. Xerophytes

Xerophytes are plants adapted to survive in dry conditions.

Examples:

- Cacti.
- Some acacia-type trees.
- Aloe species.
- Some desert shrubs.

B. Succulents

Succulents are plants that store water in thick leaves, stems or roots.

Examples:

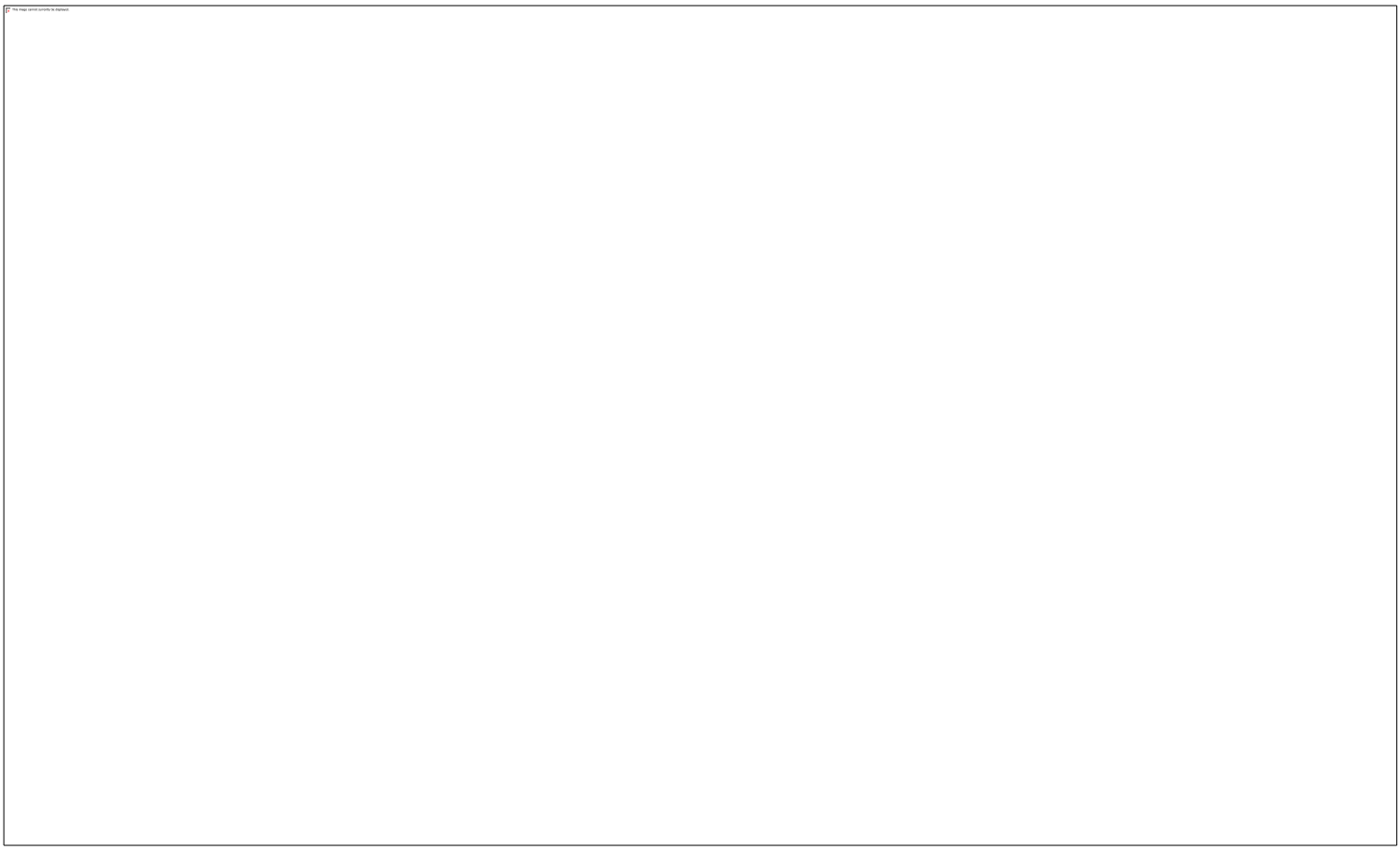
- Aloe.
- Some cacti.
- Some desert euphorbias.

C. Ephemeral plants

These are short-lived plants that grow rapidly after rainfall.

- They germinate when sufficient moisture is available.
- They flower and produce seeds quickly.
- Their seeds may remain dormant during long dry periods.

9.5 Adaptations of desert vegetation



1. **Reduced leaves:** Leaves may be small, rolled or modified into spines to reduce water loss.
2. **Water-storage tissues:** Thick stems or leaves store water.
3. **Thick waxy cuticle:** Reduces evaporation from plant surfaces.
4. **Deep roots:** Enable plants to reach underground water.
5. **Extensive shallow roots:** Absorb water quickly after light rainfall.
6. **Leaf shedding:** Some plants shed leaves during severe drought.
7. **Dormancy:** Seeds and some plant parts remain inactive during unfavourable periods.

8. **Rapid growth:** Some plants complete their life cycle shortly after rainfall.

9.6 Importance of desert vegetation

- Provides fodder for livestock.
- Supplies medicinal plants.
- Provides fruits and other food products.
- Stabilises sand and soil.
- Supports desert wildlife.
- Provides fuel and other useful materials.
- Supports traditional livelihoods.
- Helps maintain desert ecosystems.

9.7 Human activities in desert vegetation regions

- Nomadic pastoralism.
- Oasis farming.
- Collection of medicinal plants.
- Tourism.
- Mining.
- Solar energy production.
- Research and conservation.

9.8 Threats to desert vegetation

- Overgrazing.
- Excessive cutting of shrubs.
- Desertification.
- Mining.
- Uncontrolled off-road vehicle use.
- Climate change.
- Invasive species.
- Excessive extraction of groundwater.

Kenyan application: Dryland vegetation in Turkana, Marsabit, Wajir and Garissa includes drought-resistant shrubs, grasses and scattered trees. These plants provide browse and pasture for pastoral livestock.

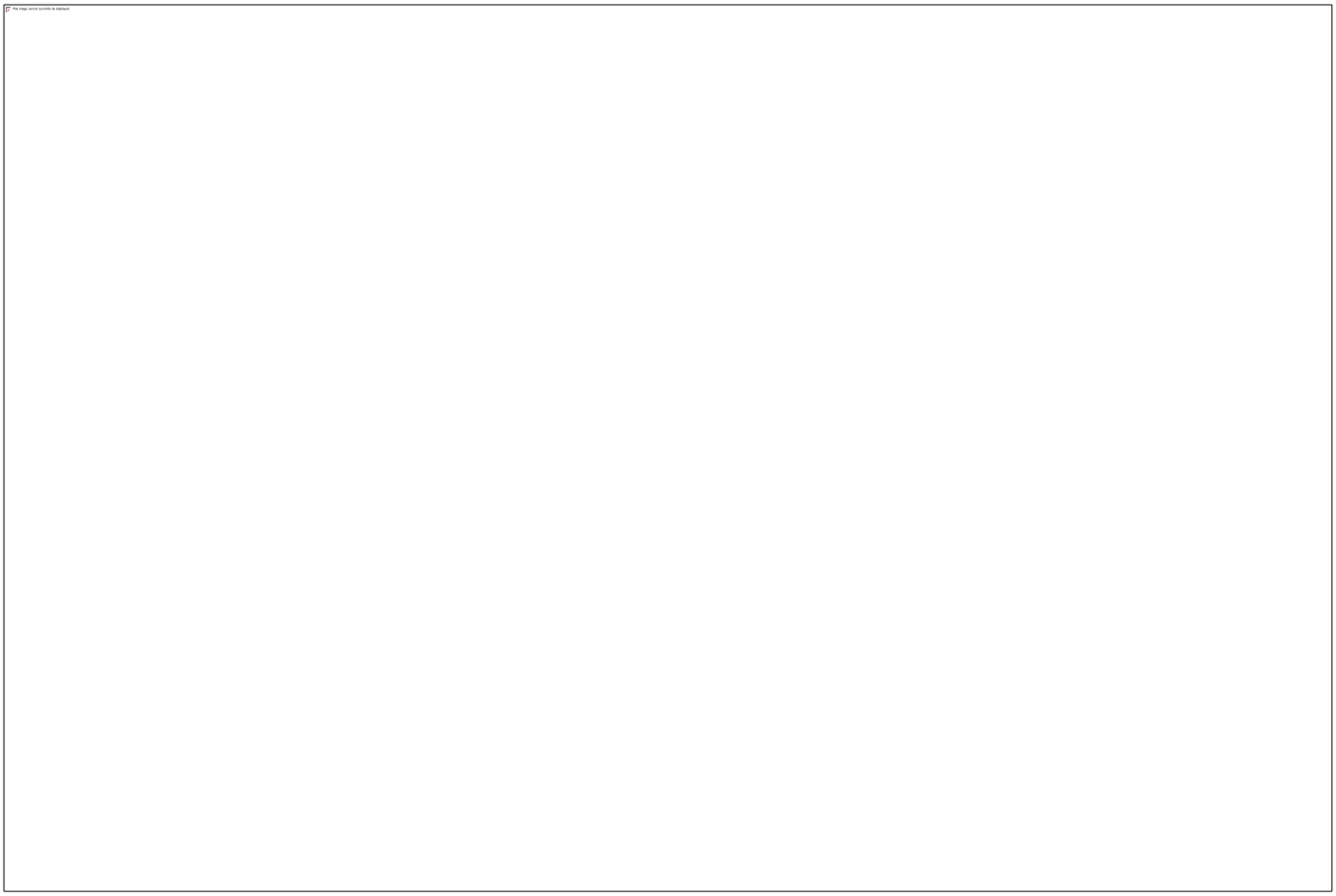
10.0 MEDITERRANEAN VEGETATION

10.1 Definition

Mediterranean vegetation refers to vegetation adapted to regions with hot, dry summers and mild, wet winters.

It is dominated by evergreen shrubs, small trees and drought-resistant plants.





10.2 Distribution

Mediterranean vegetation occurs in:

- Countries bordering the Mediterranean Sea.
- Central Chile.
- California in the United States.
- Southwestern Australia.
- Parts of South Africa's Western Cape.

10.3 Characteristics

1. Dominated by evergreen shrubs and small trees.
2. Plants have small, tough and leathery leaves.
3. Many plants have thick waxy leaf surfaces.
4. Trees and shrubs are adapted to summer drought.
5. Roots may extend deeply into the soil.
6. Vegetation is often scattered and relatively low.
7. Many plants produce aromatic oils.
8. Some species regenerate after fire.
9. Grass and herb cover may increase during the wet winter season.
10. Plant growth is strongly influenced by seasonal moisture availability.

10.4 Adaptations

- Small leaves reduce water loss.
- Thick leaves reduce excessive transpiration.
- Deep roots enable plants to obtain water.
- Waxy leaf surfaces reduce evaporation.
- Some plants have fire-resistant features or regenerate after fire.
- Some species have dormant seeds that germinate after favourable conditions.

10.5 Importance

- Supports tourism and recreation.
- Provides fruits such as olives and grapes.
- Supplies medicinal and aromatic plants.
- Supports beekeeping.
- Protects soil on hillsides.
- Provides wildlife habitats.
- Supports commercial agriculture.

10.6 Threats

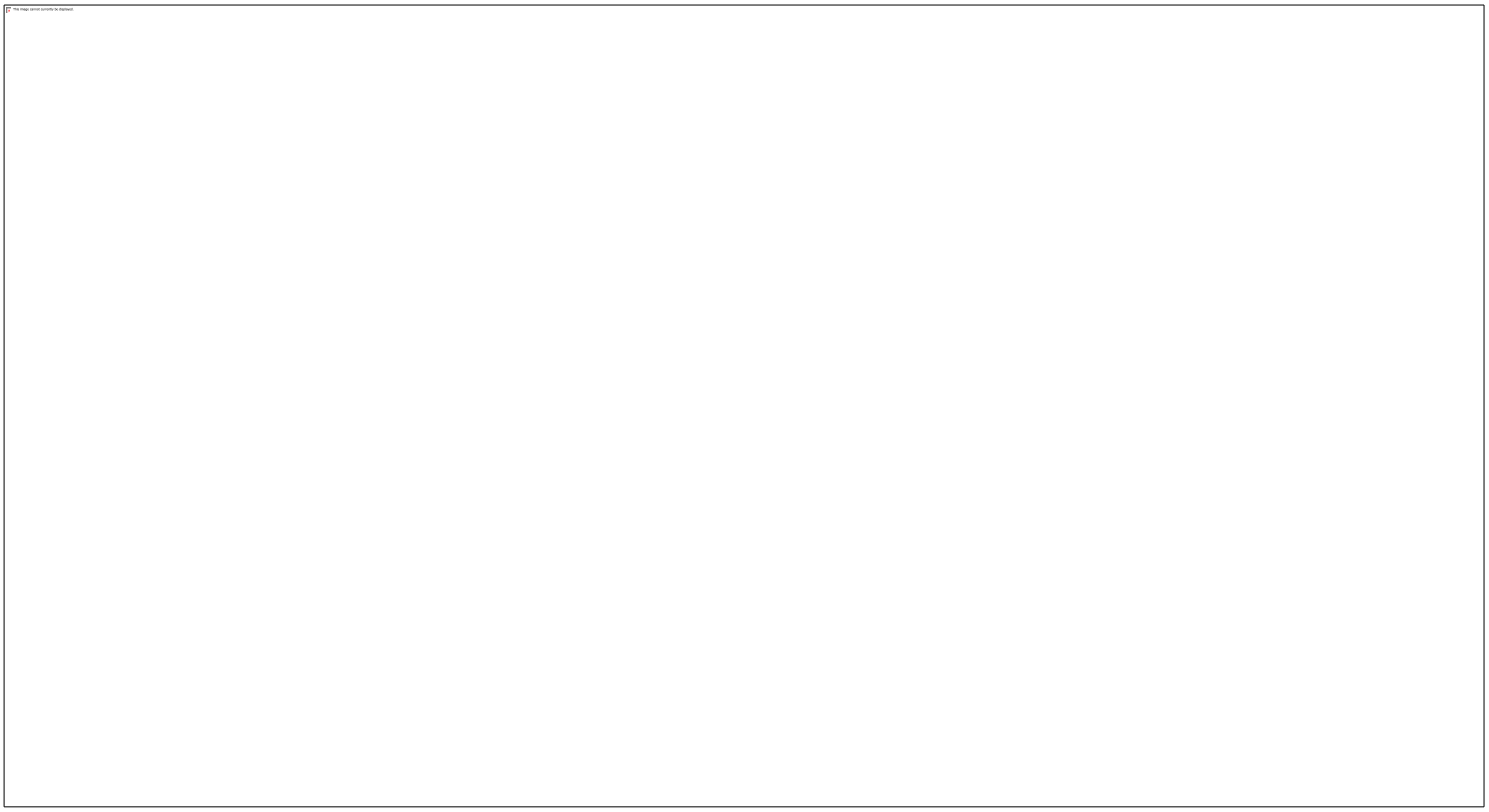
- Frequent and intense wildfires.
- Urban expansion.
- Agricultural expansion.
- Overgrazing.
- Soil erosion.
- Climate change.
- Invasive plant species.

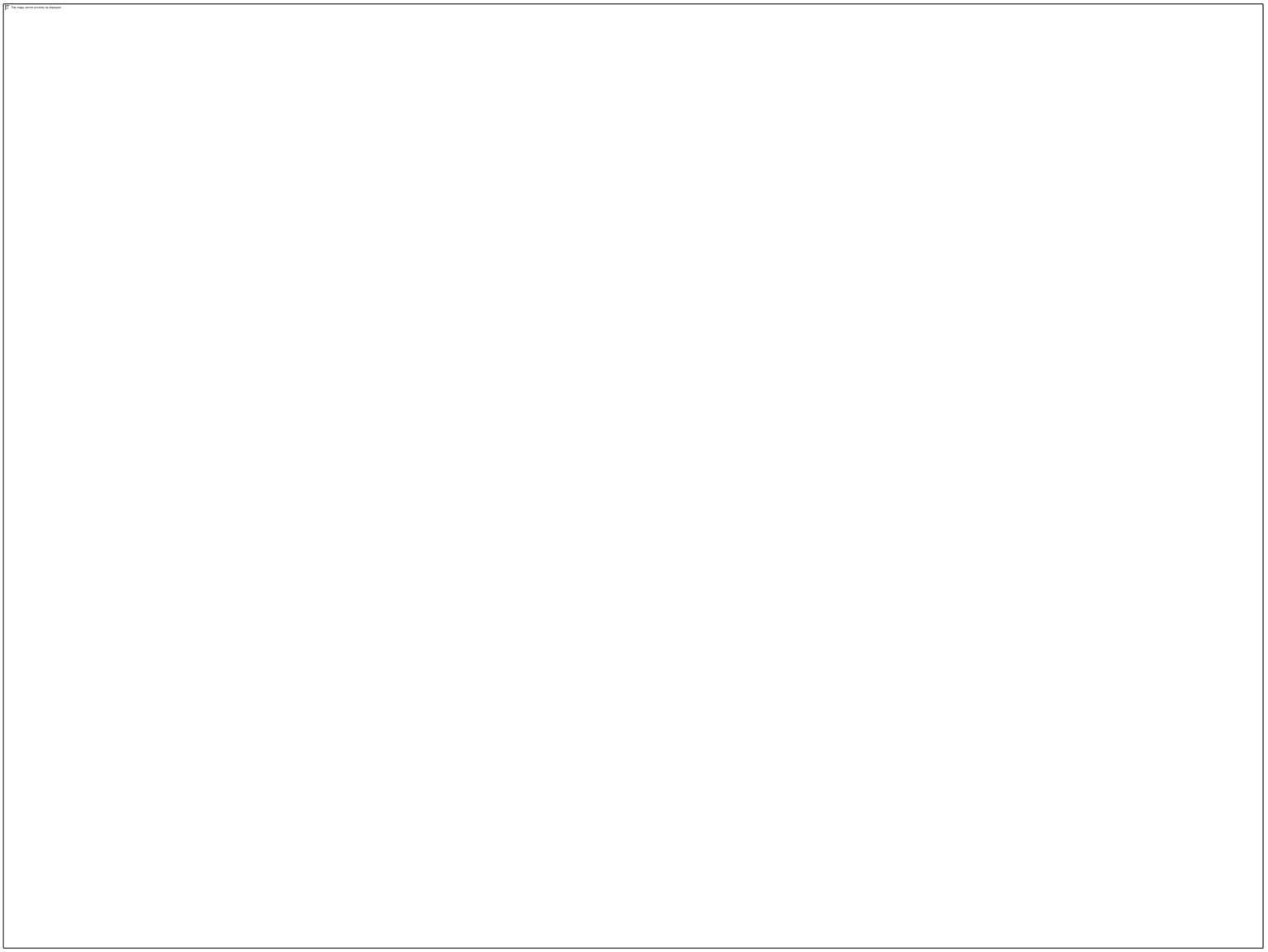
11.0 TUNDRA VEGETATION

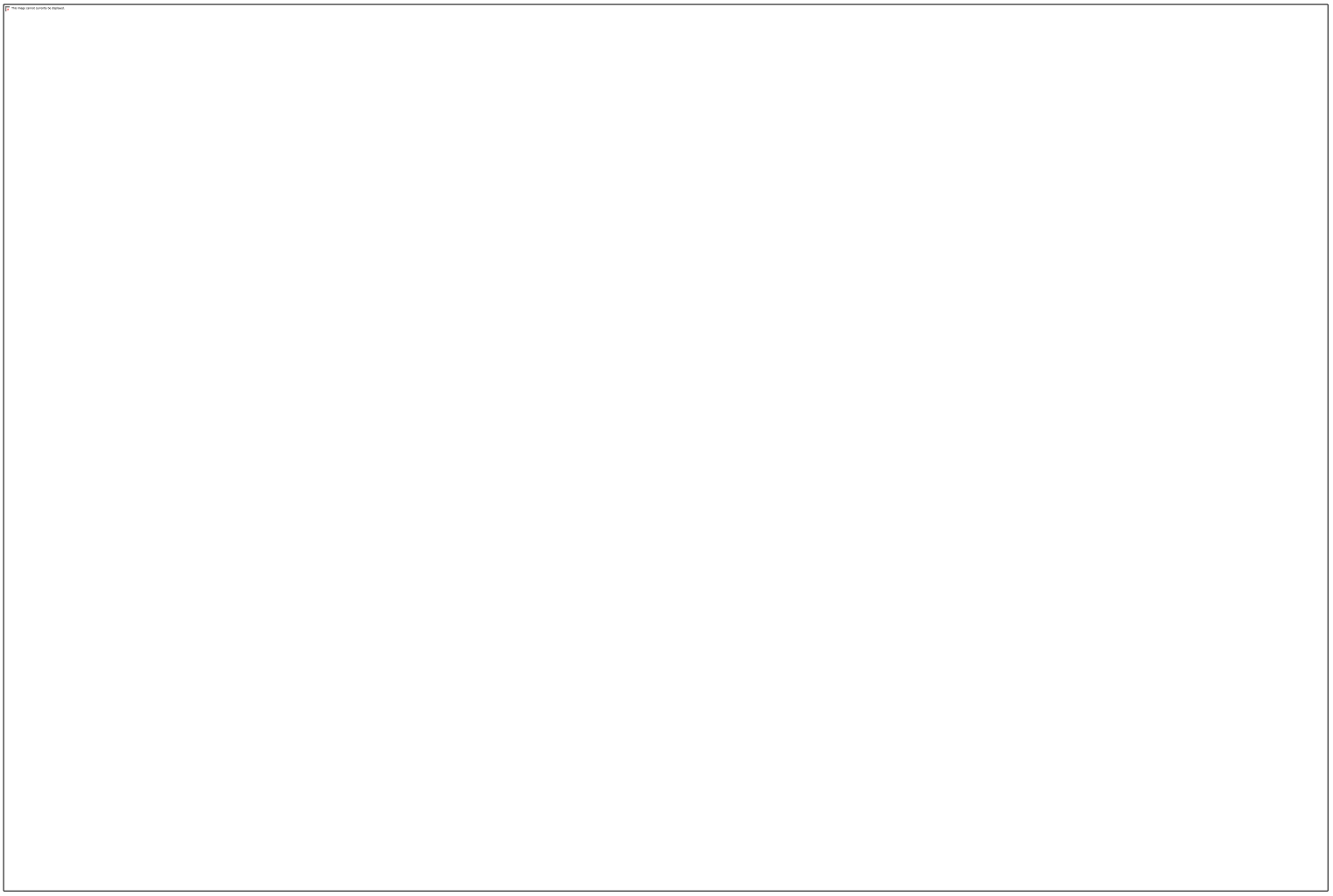
11.1 Definition

Tundra vegetation refers to low-growing plant communities found in very cold regions, particularly around the Arctic and on some high mountains above the tree line.

It is characterised by mosses, lichens, grasses, sedges and dwarf shrubs.







11.2 Distribution of tundra vegetation

Tundra vegetation is mainly found in:

- Northern Canada.
- Northern Alaska.
- Greenland.
- Northern Scandinavia.
- Northern Russia.
- Arctic islands.
- High mountain areas above the tree line.

11.3 Characteristics of tundra vegetation

1. **Low-growing plants:** Most plants grow close to the ground.
2. **Absence of tall trees:** Very low temperatures and short growing seasons limit tree growth.
3. **Mosses and lichens:** These are common plant forms.
4. **Short growing season:** Plants grow during a short summer period.
5. **Shallow roots:** Permanently frozen subsoil limits deep root development.
6. **Small leaves:** Many plants have small leaves that reduce exposure to cold and moisture loss.
7. **Low plant diversity:** Fewer plant species occur compared with tropical forests.

8. **Slow growth:** Cold conditions limit the rate of plant growth.
9. **Permafrost:** Permanently frozen ground occurs in many tundra areas.
10. **Seasonal flowering:** Some plants flower rapidly during the short summer.

11.4 Types of tundra vegetation

A. Arctic tundra

- Occurs in high-latitude regions around the Arctic.
- Contains mosses, lichens, grasses, sedges and dwarf shrubs.
- Has very cold winters.
- Has a short growing season.
- Permafrost is widespread.

B. Alpine tundra

- Occurs on high mountains above the tree line.
- Experiences low temperatures due to high altitude.
- Contains low grasses, herbs, mosses and small shrubs.
- May experience strong winds.
- Does not necessarily have the same extensive permafrost conditions as Arctic tundra.

11.5 Adaptations of tundra plants

- Low growth reduces exposure to strong winds.
- Small leaves help reduce water loss.
- Shallow roots grow in the active soil layer above permafrost.
- Some plants grow in compact cushions to conserve heat.
- Dark-coloured plant surfaces may absorb more solar energy.
- Rapid flowering and seed production enable reproduction within the short summer.
- Some plants reproduce vegetatively to increase survival.

11.6 Importance of tundra vegetation

- Provides food for grazing animals such as reindeer and caribou.
- Supports Arctic wildlife habitats.
- Stores carbon in vegetation and frozen soils.
- Protects the surface from erosion.
- Supports indigenous livelihoods.
- Provides opportunities for scientific research.

11.7 Threats to tundra vegetation

- Rising temperatures.
- Thawing permafrost.

- Industrial development.
- Mining and oil exploration.
- Infrastructure construction.
- Disturbance by vehicles.
- Changes in wildlife populations.
- Pollution.

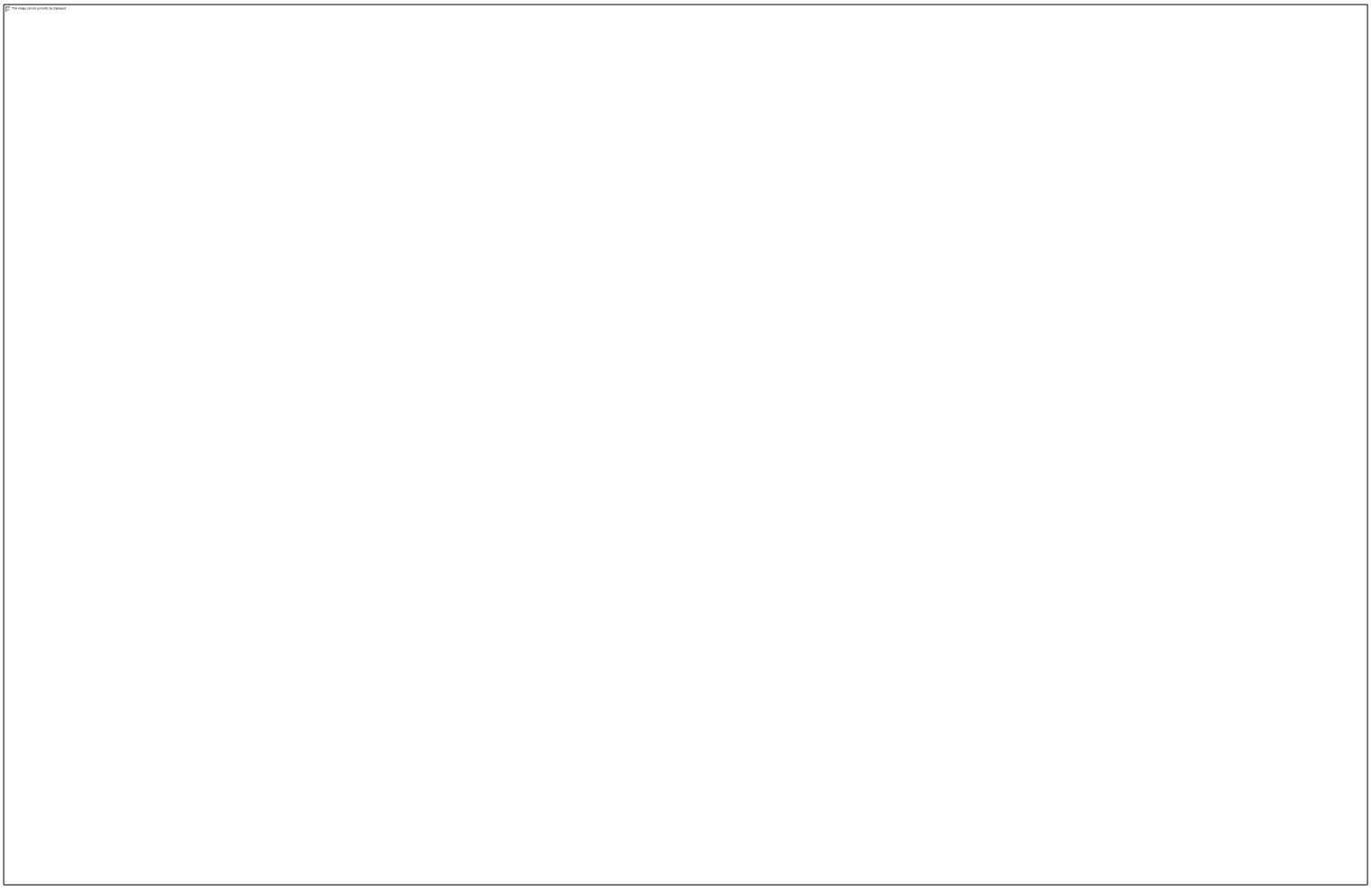
12.0 HIGHLAND OR MOUNTAIN VEGETATION

12.1 Definition

Highland vegetation refers to plant communities found in mountainous areas, where vegetation changes with increasing altitude due to variations in temperature, rainfall, soil and exposure.







12.2 Distribution

Highland vegetation occurs in:

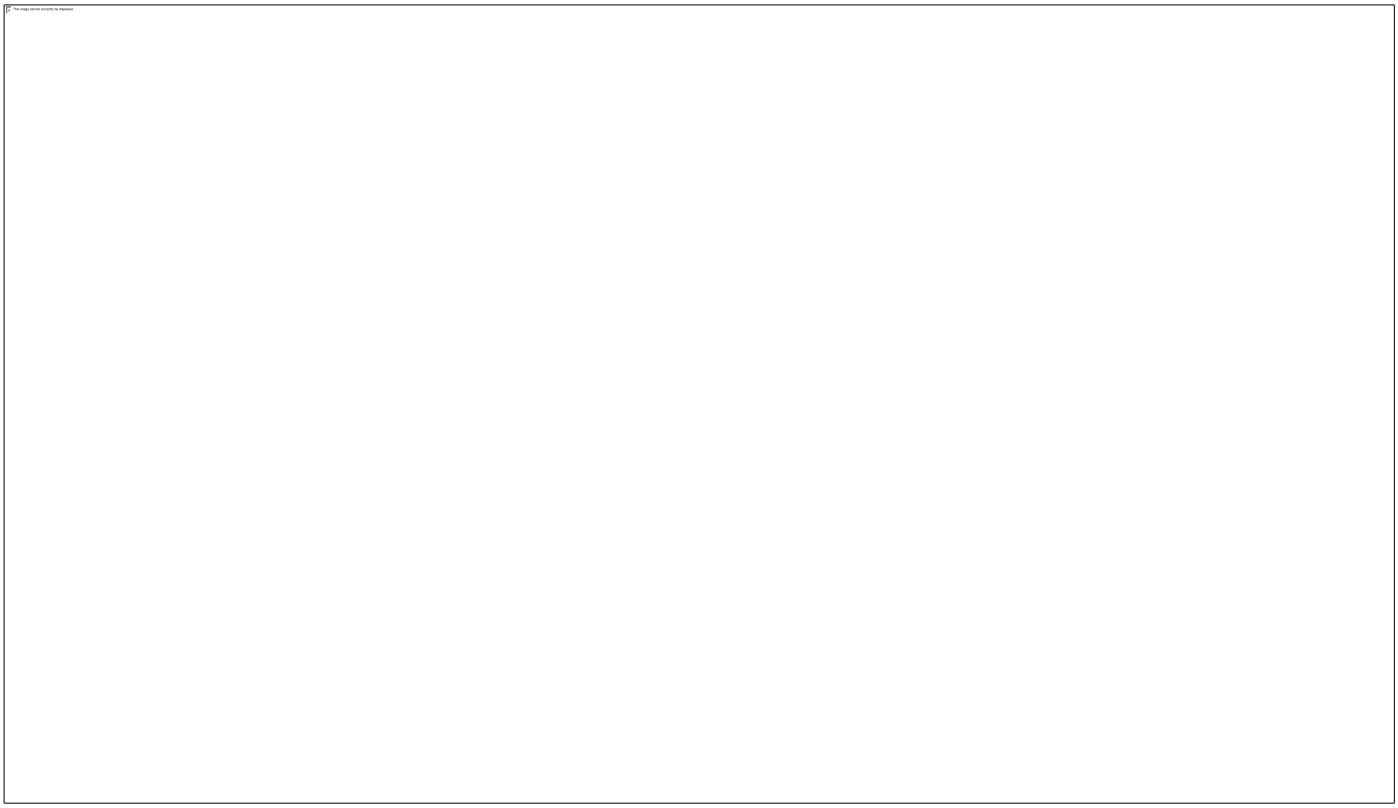
- Mount Kenya.
- Mount Kilimanjaro.
- Ruwenzori Mountains.
- Ethiopian Highlands.
- Atlas Mountains.
- Alps.
- Himalayas.
- Andes.
- Rocky Mountains.

12.3 Characteristics of highland vegetation

1. Vegetation changes with altitude.
2. Temperature generally decreases as altitude increases.
3. Lower slopes may support forests.
4. Middle slopes may contain bamboo, mixed forests or montane vegetation.
5. Higher slopes may support heath, moorland and grassland.

6. The highest areas may have sparse alpine vegetation.
7. Plant species are adapted to cooler temperatures.
8. Strong winds may influence plant growth at high altitudes.
9. Rainfall may vary between windward and leeward slopes.
10. Some high mountains support glaciers or permanent snow near their summits, although this is not vegetation.

12.4 Vegetation zones on Mount Kenya



The vegetation on Mount Kenya changes with altitude. The zones may overlap and vary according to slope, aspect and local conditions.

A. Lower montane forest zone

- Found on the lower mountain slopes.
- Contains tall trees.
- May include species such as cedar and podo in suitable locations.
- Supports many birds, insects and mammals.
- Receives considerable moisture in suitable areas.

B. Bamboo zone

- Occurs above sections of the montane forest.
- Dominated by bamboo in suitable locations.
- Bamboo grows in dense stands.
- Provides habitats and food for wildlife.
- Helps protect mountain soils.

C. Upper montane forest zone

- Contains trees adapted to cooler conditions.
- May include species such as Hagenia and other montane trees.
- Vegetation is generally shorter than in lower forest zones.
- Supports diverse mountain wildlife.

D. Heath and moorland zone

- Contains shrubs, grasses and distinctive mountain plants.
- Vegetation is generally low-growing.
- Giant lobelias and giant groundsels occur in some East African high mountains.
- Temperatures are low, and frost may occur.

E. Alpine zone

- Contains sparse grasses, herbs and specialised plants.
- Conditions are cold and exposed.
- Plant growth is limited by low temperatures and strong winds.

F. Nival zone

- Found near the highest peaks.
- Characterised mainly by bare rock, snow and ice where present.
- Vegetation is extremely sparse or absent.

12.5 Importance of highland vegetation

- Protects mountain water catchments.
- Supports biodiversity.
- Provides timber and other products under regulated management.
- Supports tourism and recreation.
- Reduces soil erosion.
- Helps regulate river flow.
- Provides habitats for specialised plant species.
- Supports local livelihoods.

12.6 Threats

- Deforestation.
- Encroachment into forests.
- Uncontrolled fires.
- Overgrazing.
- Unsustainable tourism.
- Invasive species.

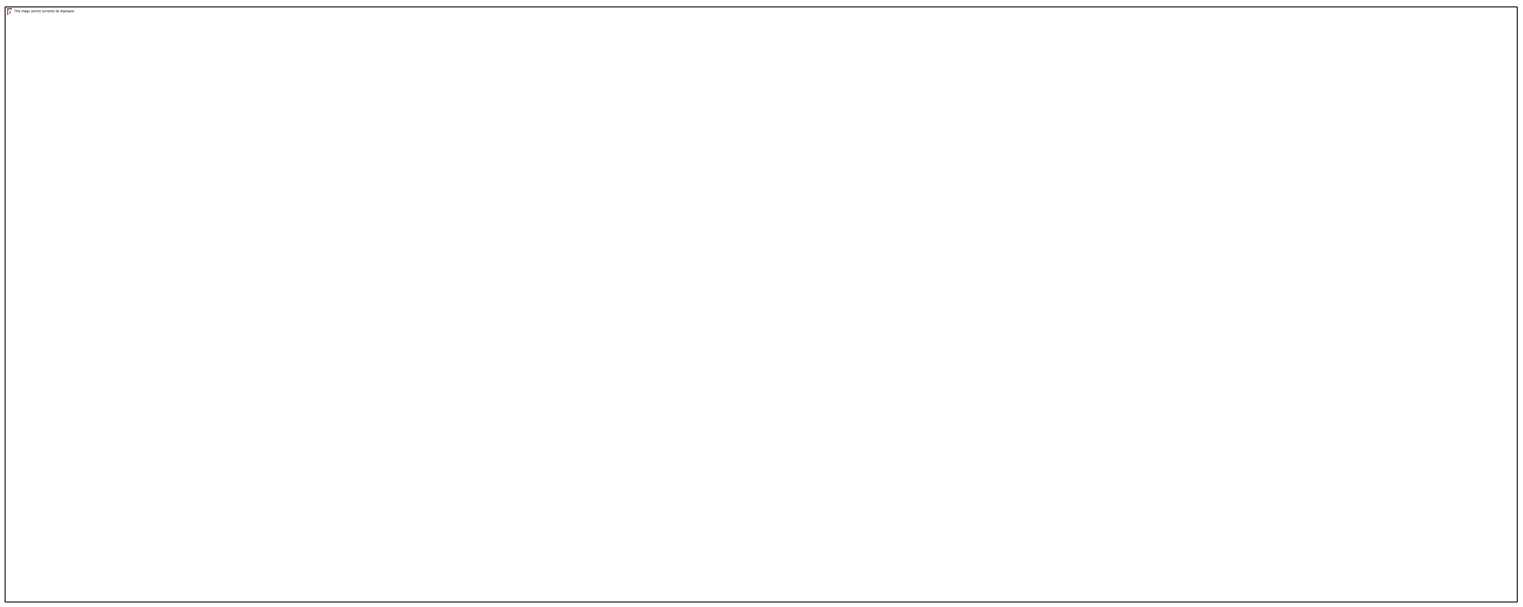
- Climate change.
- Soil erosion and landslides.

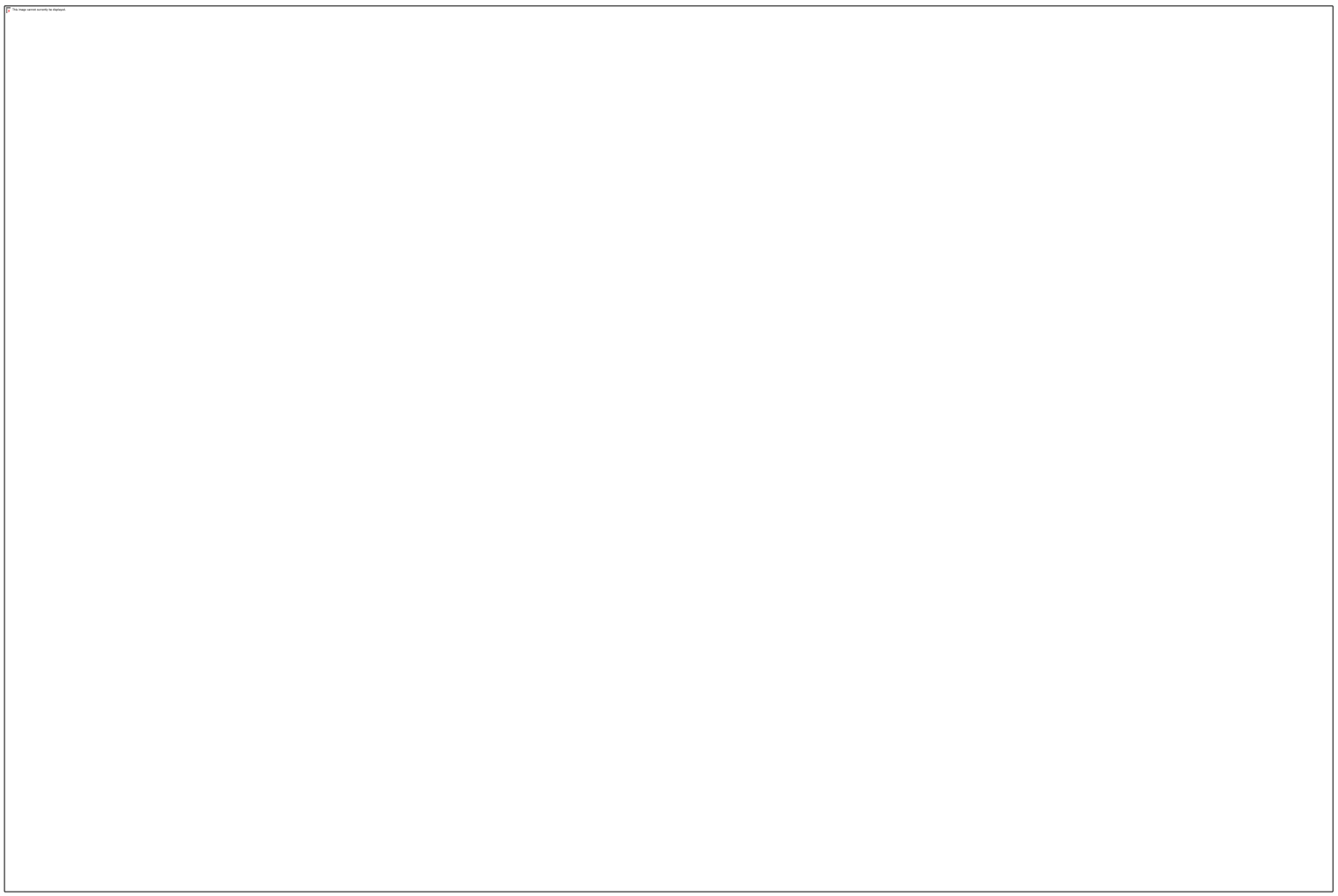
13.0 MANGROVE VEGETATION

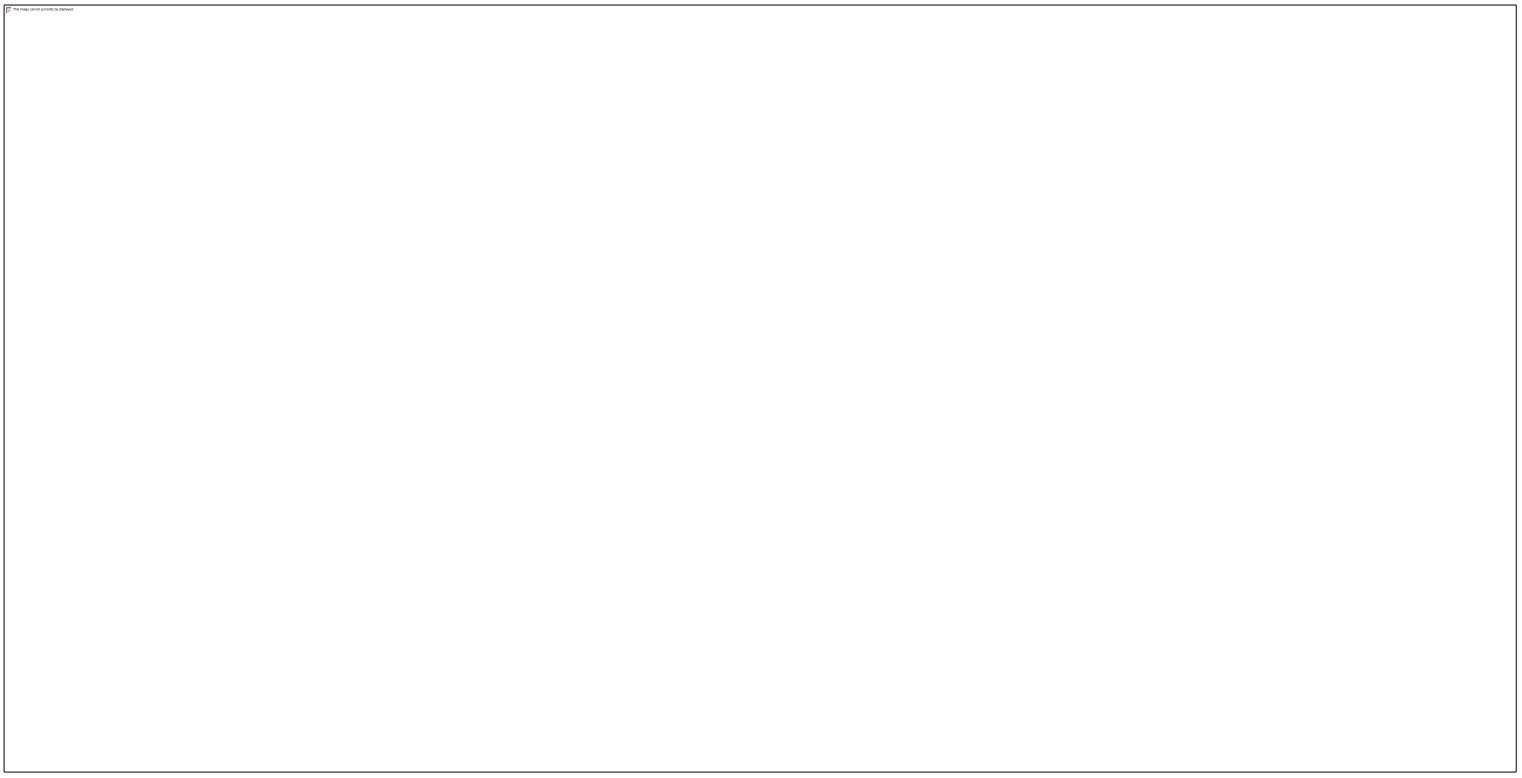
13.1 Definition

Mangrove vegetation refers to salt-tolerant trees and shrubs that grow along sheltered tropical and subtropical coastlines, especially in tidal mudflats, estuaries, lagoons and river mouths.

Mangroves are specially adapted to survive in salty, waterlogged and oxygen-poor soils.







13.2 Distribution of mangrove vegetation

Mangroves occur along tropical and subtropical coastlines, including:

- East African coast.
- West African coast.
- Indian Ocean coastlines.
- Southeast Asia.
- Northern Australia.
- Caribbean coastlines.
- Tropical American coastlines.

Kenyan examples:

- Lamu.
- Mida Creek in Kilifi County.
- Gazi Bay in Kwale County.
- Tudor Creek in Mombasa.
- Vanga in Kwale County.
- Other sheltered coastal estuaries and creeks.

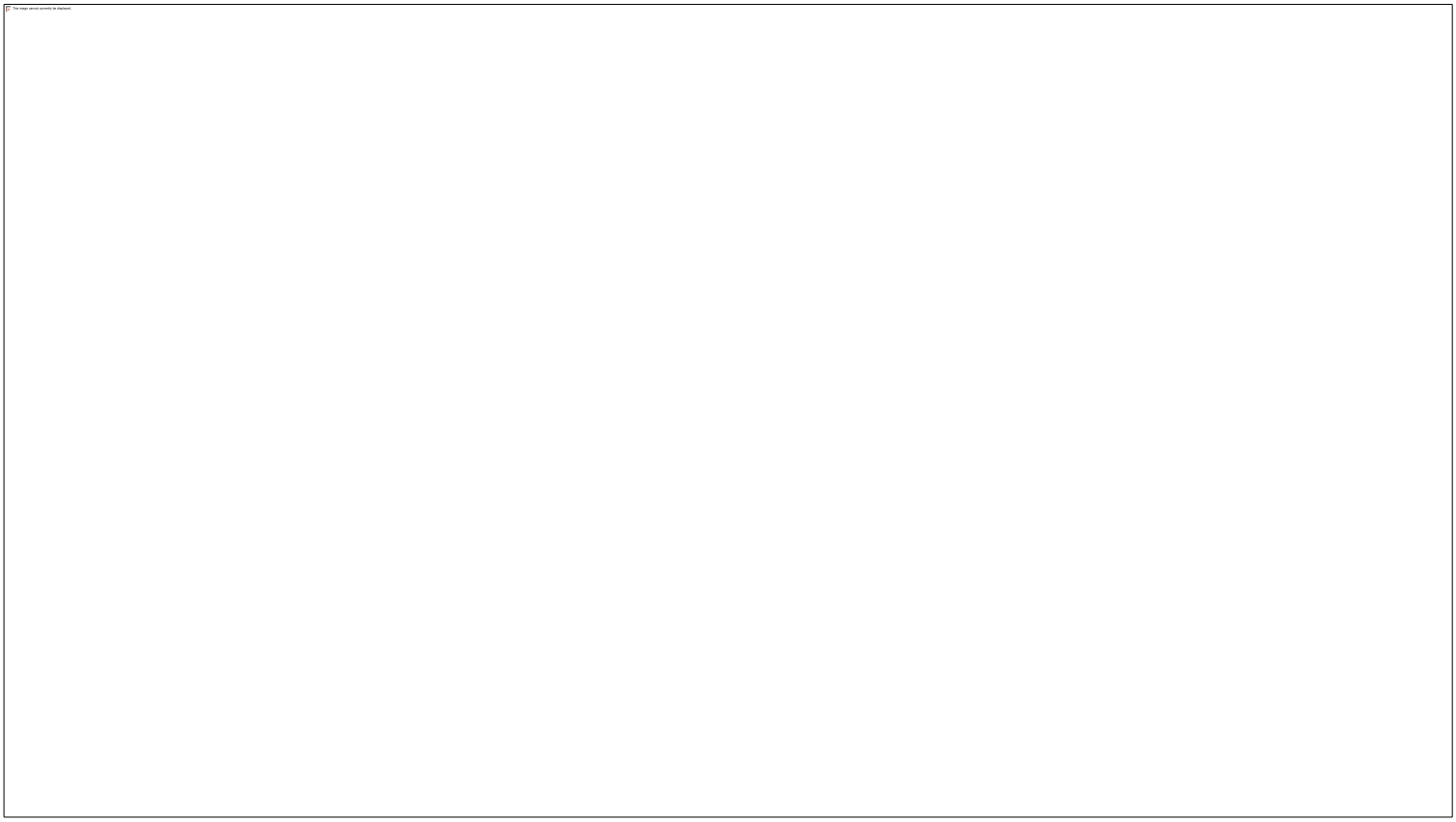
13.3 Characteristics of mangrove vegetation

1. **Salt tolerance:** Mangrove plants can survive in saline environments.
2. **Aerial roots:** Some species have roots that extend above the soil or water.
3. **Prop roots:** These provide support in soft, muddy soils.
4. **Pneumatophores:** These are specialised breathing roots that extend above the soil to obtain oxygen.

5. **Vivipary in some species:** Seeds may begin developing while still attached to the parent plant.
6. **Thick leaves:** Some species have leaf structures that help regulate water loss.
7. **Tidal environment:** Mangroves are regularly affected by changing water levels.
8. **Mud-rich soils:** They grow in soft, waterlogged sediments.
9. **Specialised root systems:** Roots help the plants remain stable and obtain oxygen.
10. **High ecological productivity:** Mangrove forests support many marine and coastal organisms.

13.4 Adaptations of mangrove plants

- Prop roots support trees in soft mud.
- Pneumatophores enable gaseous exchange in waterlogged soils.
- Salt-filtering roots reduce the amount of salt entering the plant.
- Some species remove excess salt through their leaves.
- Thick or waxy leaves reduce water loss.
- Viviparous seedlings increase the chances of successful establishment in tidal environments.
- Extensive root systems trap sediments.



13.5 Importance of mangrove vegetation

1. Protects coastlines against erosion.
2. Reduces the impact of waves and storm surges.
3. Provides breeding and nursery grounds for fish and other marine organisms.
4. Supports crabs, molluscs and other coastal wildlife.
5. Stores carbon in trees and sediments.

6. Provides timber and poles when harvested sustainably.
7. Supports fishing communities.
8. Promotes ecotourism.
9. Traps sediments and helps maintain coastal water quality.
10. Supports research and environmental education.

13.6 Threats to mangrove vegetation

- Cutting of mangrove trees.
- Coastal development.
- Pollution.
- Dredging and reclamation.
- Unsustainable aquaculture.
- Changes in freshwater supply.
- Climate change and sea-level rise.
- Destruction of tidal habitats.

13.7 Mangrove conservation in Kenya

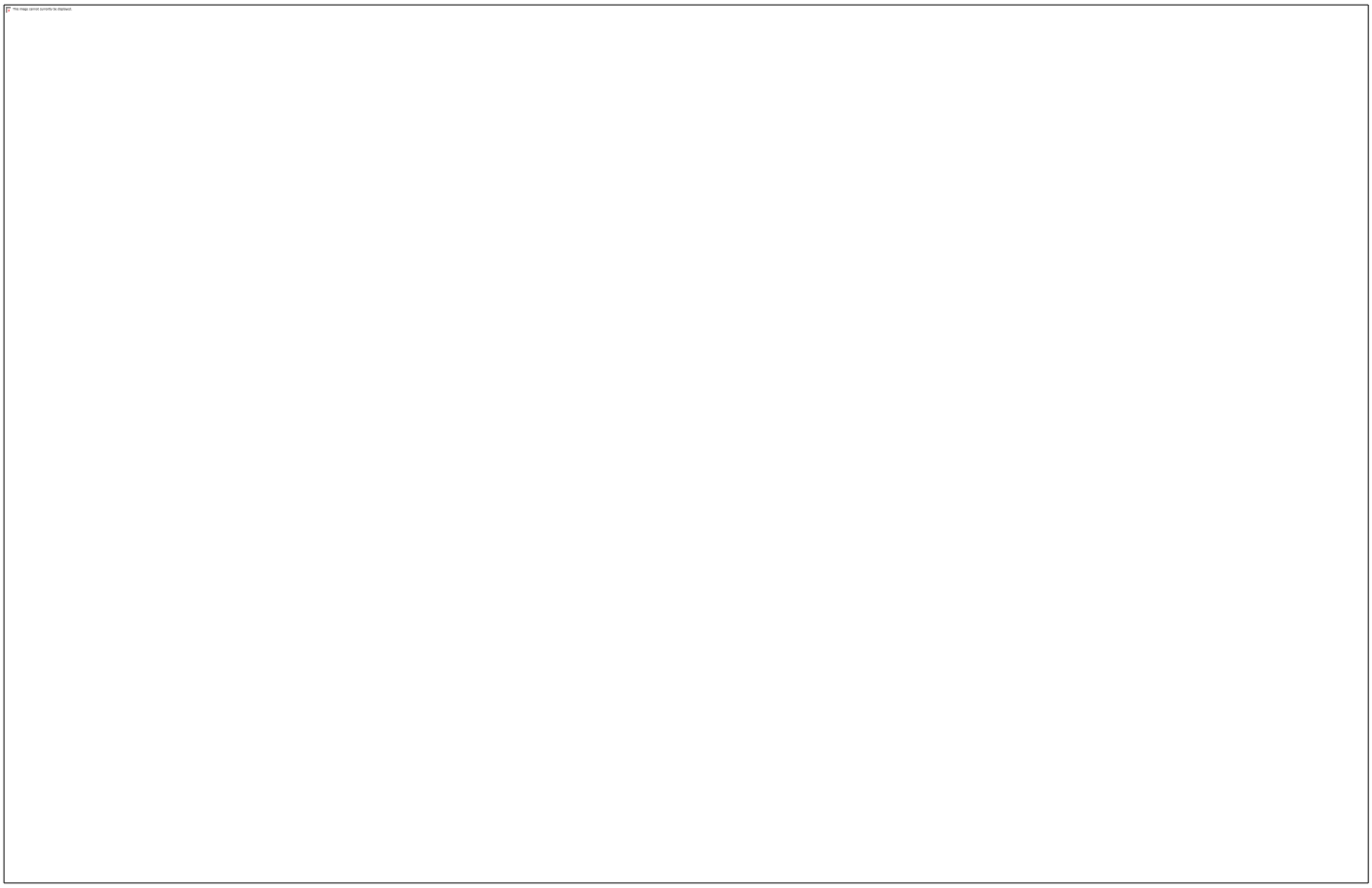
Conservation measures include:

- Community-led mangrove restoration.
- Regulating harvesting.
- Establishing and enforcing protected areas.
- Monitoring mangrove health.
- Controlling coastal pollution.
- Promoting sustainable fishing.
- Supporting community conservation groups.
- Raising public awareness.

14.0 LOCATION OF THE MAJOR VEGETATION TYPES ON THE WORLD MAP

14.1 World distribution of vegetation

Vegetation distribution is strongly related to climate, particularly temperature and rainfall. However, soil, relief, altitude, drainage and human activities also influence where particular vegetation types occur.



14.2 Major vegetation types and their locations

Vegetation type	Major world locations	Examples
Tropical rainforest	Equatorial South America, Central Africa, Southeast Asia	Amazon, Congo Basin
Tropical seasonal forest	South and Southeast Asia, parts of Africa	India, Myanmar
Savanna	Tropical Africa, Brazil, northern Australia	Maasai Mara, Cerrado
Temperate deciduous forest	Europe, eastern North America, eastern Asia	Germany, eastern USA, China
Coniferous forest	Canada, Alaska, Scandinavia, Russia	Taiga of Siberia
Temperate grassland	Central North America, Argentina, Eurasia, South Africa	Prairies, Pampas, Steppes, Veld
Desert vegetation	North Africa, Southwest Asia, Australia, South America	Sahara, Namib, Atacama
Mediterranean vegetation	Mediterranean Basin, California, central Chile, southwestern Australia, Western Cape	Mediterranean scrub

Tundra	Arctic areas of North America, Europe and Asia	Northern Canada, Siberia
Highland vegetation	High mountain areas worldwide	Mount Kenya, Himalayas
Mangroves	Tropical and subtropical coastlines	Kenyan coast, Indonesia

14.3 Factors explaining the distribution of world vegetation

1. Tropical rainforests occur mainly near the Equator because of high temperatures and abundant rainfall.
2. Savanna grasslands occur in areas with seasonal rainfall and a prolonged dry season.
3. Desert vegetation occurs in regions with severe moisture shortages.
4. Temperate forests occur in areas with moderate temperatures and sufficient moisture.
5. Coniferous forests occur mainly in cold regions with long winters.
6. Tundra vegetation occurs in extremely cold areas with short growing seasons.
7. Highland vegetation changes with altitude and mountain exposure.
8. Mangrove vegetation occurs along sheltered tropical and subtropical coasts where tidal conditions and saline water are present.

14.4 Practical activity: Drawing a world vegetation map

Instructions

Using an outline map of the world:

1. Draw and label the Equator, Tropic of Cancer and Tropic of Capricorn.
2. Locate the Amazon Basin and shade the tropical rainforest region.
3. Locate the Congo Basin and shade the tropical rainforest region.
4. Mark the major savanna regions of Africa, Brazil and northern Australia.
5. Locate the Sahara, Namib, Kalahari, Atacama and Australian deserts.
6. Mark the temperate forests of Europe, eastern North America and eastern Asia.
7. Locate the coniferous forests of Canada, Scandinavia and Russia.
8. Mark the grasslands of North America, South America, Eurasia and South Africa.
9. Locate the tundra regions around the Arctic.
10. Mark the major highland vegetation areas such as Mount Kenya, the Himalayas and Andes.
11. Mark mangrove vegetation along suitable tropical coastlines.
12. Prepare a key showing each vegetation type.

Expected outcome: A correctly labelled world vegetation map showing the distribution of major vegetation types.

14.5 Classroom activity: Vegetation collage

In groups:

- Collect photographs from textbooks, newspapers and approved digital sources.
- Arrange the photographs according to vegetation type.
- Write the name of each vegetation type.
- Indicate the continent where it is found.
- Add two characteristics below each photograph.
- Display the completed collage in the classroom.
- Explain the factors responsible for the distribution of the vegetation types.

15.0 FACTORS INFLUENCING THE DISTRIBUTION OF VEGETATION IN THE WORLD

15.1 Meaning of vegetation distribution

Vegetation distribution refers to the geographical pattern showing where different plant communities occur on the Earth's surface.

Different regions have different types of vegetation because plants require particular environmental conditions for germination, growth, survival and reproduction.

The main factors influencing vegetation distribution include:

1. Climate.
2. Soil.
3. Relief.
4. Altitude.
5. Drainage and water availability.
6. Latitude.
7. Human activities.
8. Biotic factors.
9. Natural disturbances.
10. Geological conditions.

15.2 Climatic factors

Climate is one of the most important influences on vegetation distribution.

A. Rainfall

Rainfall provides water required for plant growth.

- High rainfall supports dense forests.
- Moderate rainfall supports grasslands and some woodland.
- Low rainfall supports shrubs and desert plants.
- Seasonal rainfall encourages plants to develop drought-survival adaptations.
- Unreliable rainfall may limit the establishment of certain plant species.

Examples:

- The Amazon Basin supports dense rainforest because of abundant rainfall.

- The Sahara supports sparse desert vegetation because of limited rainfall.
- The Maasai Mara supports savanna grasslands under seasonal rainfall conditions.

B. Temperature

Temperature influences germination, photosynthesis, respiration and plant growth.

- High temperatures support tropical vegetation where water is sufficient.
- Low temperatures limit plant growth in polar regions.
- Very high temperatures may increase water loss.
- Seasonal temperature changes influence leaf shedding.
- Frost may damage plants that are not adapted to cold conditions.

Examples:

- Tropical rainforests thrive under warm conditions.
- Tundra vegetation consists mainly of low-growing plants because of extreme cold.
- Some temperate trees shed their leaves during cold seasons.

C. Sunshine

Sunlight provides energy for photosynthesis.

- Adequate sunlight encourages plant growth.
- Dense forest canopies reduce the amount of light reaching the forest floor.
- Plants in shaded conditions may develop broad leaves.
- Limited sunshine may slow plant growth.
- Differences in sunlight duration influence seasonal growth patterns.

D. Humidity

Humidity refers to the amount of water vapour in the atmosphere.

- High humidity may reduce the rate of water loss from plant leaves.
- Low humidity can increase transpiration.
- Some plants in dry areas develop thick leaves and waxy surfaces to conserve water.
- Humidity influences the distribution of moisture-sensitive plant species.

E. Wind

Wind affects vegetation in several ways.

- Strong winds may damage branches and uproot trees.
- Wind increases water loss from leaves.
- Wind transports seeds and pollen.
- Coastal winds may carry salt spray that affects sensitive plants.
- Persistent strong winds may encourage low-growing vegetation.

F. Length of growing season

The growing season is the period when environmental conditions are suitable for active plant growth.

- Tropical rainforests may have long growing seasons because warmth and moisture are available for much of the year.
- Temperate regions have seasonal growing periods.
- Tundra areas have very short growing seasons.
- Dry areas may have short periods of plant growth following rainfall.

15.3 Soil factors

Soil provides plants with water, air, minerals and physical support.

A. Soil fertility

- Fertile soils contain nutrients required for plant growth.
- Nutrient-rich soils support a wider range of plant species.
- Poor soils may limit plant growth.
- Some plants are specially adapted to nutrient-poor soils.

B. Soil texture

Soil texture refers to the relative proportions of sand, silt and clay.

- Sandy soils drain quickly and may hold little water.
- Clay soils hold more water but may become waterlogged.
- Loamy soils generally provide favourable conditions for many plants.
- Different plants are adapted to different soil textures.

C. Soil depth

- Deep soils provide more space for root development.
- Shallow soils may restrict the growth of large trees.
- Deep-rooted plants may survive in areas where surface moisture is limited.

D. Soil pH

- Soil pH determines how acidic or alkaline the soil is.
- Some plants prefer acidic soils.
- Other plants grow better in neutral or alkaline soils.
- Extreme soil pH may limit nutrient availability.

E. Soil drainage

- Well-drained soils provide air for plant roots.
- Poor drainage may cause waterlogging.
- Some plants, such as mangroves, are adapted to waterlogged soils.
- Excessive waterlogging may damage plants that require well-aerated soils.

15.4 Relief

Relief refers to the shape and height of the Earth's surface.

Relief influences vegetation through differences in slope, aspect, drainage and exposure.

A. Slope

- Steep slopes often have shallow soils.
- Soil erosion may be severe on steep slopes.
- Gentle slopes may retain deeper soils.
- Deep soils may support taller and denser vegetation.

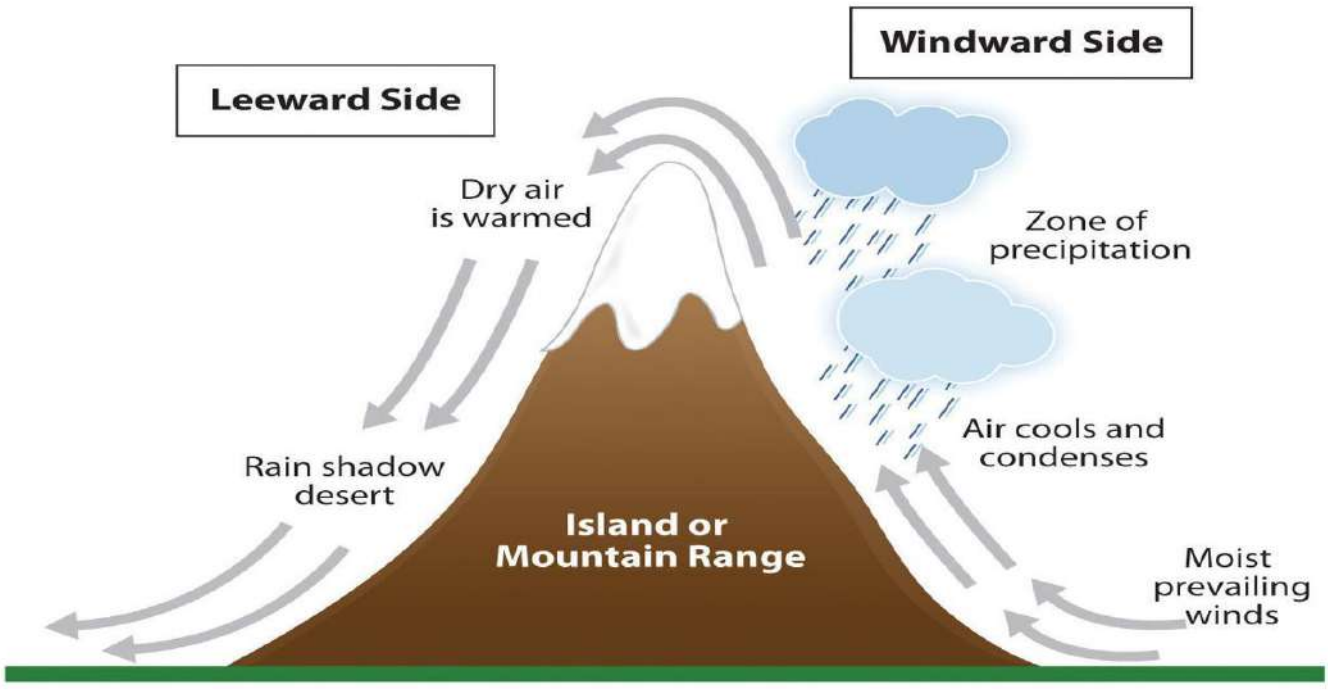
B. Aspect

Aspect refers to the direction a slope faces.

- Slopes facing the sun may receive more solar radiation.
- Slopes facing away from the sun may be cooler.
- Differences in temperature and moisture influence plant species.
- Vegetation may therefore differ on opposite sides of a mountain.

C. Windward and leeward slopes

- Windward slopes receive moist winds and may experience high rainfall.
- Leeward slopes may receive less rainfall because of the rain-shadow effect.
- Dense forests may occur on wet windward slopes.
- Grasslands and shrubs may occur on relatively dry leeward slopes.



15.5 Altitude

Altitude refers to the height of a place above sea level.

- Temperature generally decreases as altitude increases.
- Vegetation changes according to altitude.

- Lower slopes may support tropical or montane forests.
- Higher slopes may support bamboo, heath and moorland.
- The highest slopes may have alpine vegetation or bare rock and ice.

Example: On Mount Kenya, vegetation changes from montane forest on lower slopes to heath, moorland and sparse alpine vegetation at higher elevations.

15.6 Latitude

Latitude influences the amount and duration of solar radiation received in different regions.

- Equatorial regions generally experience high temperatures.
- Tropical regions support rainforests, seasonal forests and savanna.
- Middle latitudes support temperate forests and grasslands.
- High latitudes support coniferous forests and tundra.
- Polar areas have extremely cold conditions that limit plant growth.

15.7 Drainage and water availability

- Areas with adequate soil moisture support greater plant growth.
- Waterlogged areas support plants adapted to saturated conditions.
- Riverbanks may support dense vegetation.
- Wetlands support specialised plant communities.
- Areas far from reliable water sources may support drought-resistant plants.

15.8 Human activities

Human activities can increase, reduce or change vegetation cover.

Activities that reduce vegetation

- Deforestation.
- Overgrazing.
- Settlement expansion.
- Agricultural expansion.
- Mining.
- Road construction.
- Uncontrolled burning.
- Unsustainable harvesting of trees.

Activities that increase or improve vegetation

- Afforestation.
- Reforestation.
- Agroforestry.
- Forest protection.

- Controlled grazing.
- Wetland restoration.
- Community tree planting.
- Rehabilitation of degraded land.

15.9 Biotic factors

Biotic factors are influences arising from living organisms.

A. Grazing animals

- Herbivores feed on grasses, leaves and shrubs.
- Excessive grazing reduces plant cover.
- Grazing may encourage the growth of some grass species.
- Selective feeding can change plant composition.

B. Insects and pests

- Some insects feed on leaves, stems and roots.
- Severe pest attacks may damage or kill plants.
- Pollinating insects support plant reproduction.

C. Microorganisms

- Soil bacteria and fungi decompose organic matter.
- Some microorganisms improve nutrient availability.
- Certain fungi form beneficial associations with plant roots.
- Some microorganisms cause plant diseases.

D. Competition

- Plants compete for sunlight, water, nutrients and space.
- Taller plants may shade smaller plants.
- Strongly competitive species may dominate an area.
- Competition influences the structure of plant communities.

15.10 Natural disturbances

Natural events may alter vegetation distribution.

Examples include:

- Forest fires.
- Floods.
- Droughts.
- Volcanic eruptions.
- Landslides.
- Severe storms.

- Pest outbreaks.

These events may destroy vegetation, create new habitats or encourage the regeneration of certain plant communities.

15.11 Geological factors

- Parent rock influences the minerals available in soil.
- Volcanic rocks may produce fertile soils in some environments.
- Limestone areas may support plants adapted to alkaline soils.
- Rocky surfaces may restrict root development.
- Geological structure may influence drainage and groundwater availability.

15.12 Summary table of factors influencing vegetation distribution

Factor	**Influence on vegetation**
Rainfall	Determines water availability and plant density
Temperature	Influences plant growth and survival
Sunshine	Provides energy for photosynthesis
Humidity	Influences transpiration and water loss
Wind	Affects seed dispersal, water loss and plant structure
Soil fertility	Determines nutrient availability
Soil texture	Influences water retention and drainage
Relief	Influences slope, exposure and soil depth
Altitude	Influences temperature and vegetation zones
Latitude	Influences solar radiation and temperature
Drainage	Determines soil moisture conditions
Human activities	Can destroy, modify or restore vegetation
Biotic factors	Influence plant growth through competition, grazing and disease
Natural disturbances	Can destroy or encourage vegetation regeneration

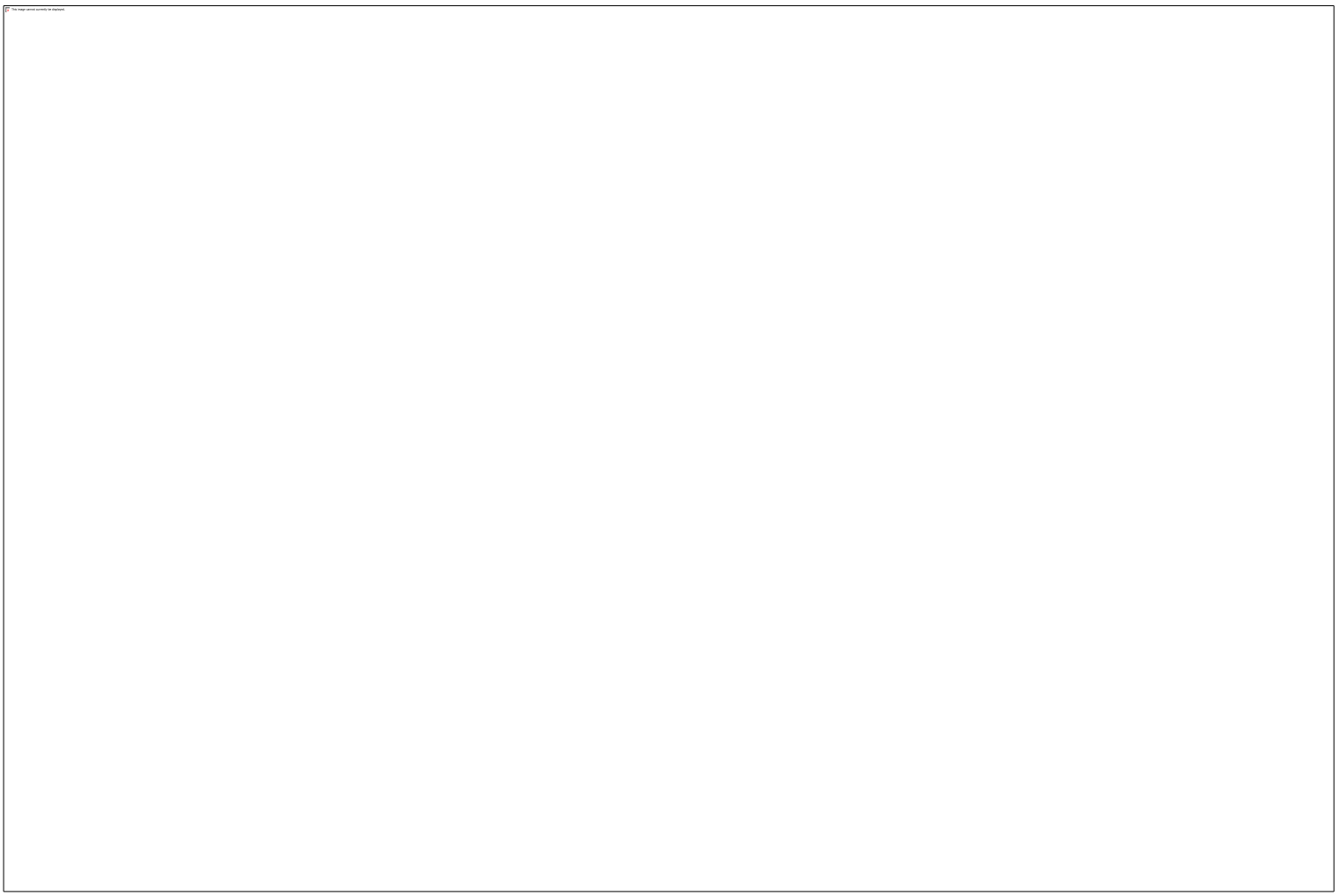
Geology	Influences soil formation, nutrients and drainage

16.0 SIGNIFICANCE OF VEGETATION TO HUMANKIND AND THE ENVIRONMENT

16.1 Meaning of significance of vegetation

The significance of vegetation refers to the importance and benefits of plant cover to human beings, animals and the natural environment.

Vegetation is essential for maintaining ecological balance and supporting economic and social development.





16.2 Ecological significance of vegetation

A. Absorption of carbon dioxide

- Green plants absorb carbon dioxide during photosynthesis.
- Carbon is stored in plant tissues and, in many ecosystems, in soils.
- Forests and other vegetated areas help regulate the carbon cycle.
- Conserving vegetation helps reduce the loss of stored carbon.

B. Release of oxygen

- Green plants release oxygen during photosynthesis.
- Oxygen supports respiration in humans and animals.
- Vegetation contributes to maintaining the balance of atmospheric gases.

C. Regulation of the water cycle

- Plants absorb water from the soil through their roots.
- Water is released into the atmosphere through transpiration.
- Vegetation helps maintain moisture circulation.
- Forests influence rainfall and local humidity patterns.
- Tree cover helps regulate the movement of water within catchments.

D. Protection against soil erosion

- Roots bind soil particles together.
- Leaves and branches reduce the direct impact of raindrops.
- Plant cover slows surface runoff.
- Vegetation reduces soil loss by wind.
- Ground cover helps protect exposed soil.

E. Regulation of temperature

- Trees provide shade.
- Vegetation cools the surrounding environment through evapotranspiration.
- Forests moderate local temperature conditions.
- Urban trees reduce heat exposure in built-up areas.

F. Maintenance of biodiversity

- Vegetation provides habitats for animals, birds and insects.
- Plants provide food and shelter.
- Forests support pollinators and seed-dispersing animals.
- Different plant communities maintain ecological relationships.

G. Maintenance of soil fertility

- Fallen leaves and plant remains decompose.
- Decomposition adds organic matter to the soil.

- Plant roots help maintain soil structure.
- Leguminous plants may improve nitrogen availability through associations with nitrogen-fixing microorganisms.

H. Flood control

- Vegetation intercepts rainfall.
- Roots improve soil structure and water infiltration.
- Plant cover can reduce surface runoff.
- Wetlands and riparian vegetation help store and slow water movement.
- Healthy catchments can reduce some flood risks, although they cannot prevent all major floods.

I. Windbreaks

- Trees reduce wind speed.
- Windbreaks protect crops from strong winds.
- They reduce wind erosion.
- They provide shade and shelter for livestock.

J. Carbon storage

- Trees store carbon in their trunks, branches and roots.
- Grassland and wetland soils can also store substantial amounts of carbon.
- Mangroves are particularly important coastal carbon stores.
- Conservation prevents the release of carbon stored in vegetation and soils.

16.3 Economic significance of vegetation

A. Source of timber

- Forests provide timber for building and construction.
- Timber is used to make furniture.
- It is used in doors, windows and flooring.
- It supports sawmilling and wood-processing industries.

B. Source of fuel

- Wood is used as a source of energy.
- Charcoal is used for cooking in many households.
- Sustainable woodlots can reduce pressure on natural forests.
- Improved cooking technologies can reduce fuelwood consumption.

C. Source of food

Vegetation provides:

- Fruits.
- Nuts.

- Seeds.
- Vegetables.
- Tubers.
- Leaves used as vegetables.
- Edible roots and other plant products.

D. Source of medicine

- Some plants contain substances used in traditional medicine.
- Some plant compounds are used in the pharmaceutical industry.
- Medicinal plants support research and the development of new medicines.
- Sustainable harvesting is important to prevent extinction.

E. Source of employment

Vegetation supports employment in:

- Forestry.
- Sawmilling.
- Furniture making.
- Beekeeping.
- Ecotourism.
- Herbal medicine production.
- Fruit processing.
- Landscaping and nursery management.

F. Raw materials for industries

Vegetation provides raw materials for:

- Paper manufacturing.
- Textile production.
- Rubber production.
- Furniture manufacturing.
- Essential oil production.
- Food processing.
- Pharmaceutical industries.

G. Tourism development

- Forests attract tourists interested in nature.
- Grasslands support wildlife tourism.
- Mangroves attract birdwatchers and ecotourists.
- Mountain vegetation attracts hikers and researchers.

- Tourism generates income and employment.

Kenyan examples: Forest and savanna ecosystems support tourism in places such as Kakamega Forest, Maasai Mara, Mount Kenya and other conservation areas.

H. Livestock production

- Grasslands provide pasture.
- Trees provide browse for goats, camels and other livestock.
- Vegetation provides fodder.
- Some plants are used as animal medicines.
- Tree shade protects animals from excessive heat.

I. Beekeeping

- Trees and flowering plants provide nectar and pollen.
- Bees use vegetation as a source of food.
- Honey production provides income.
- Bees also support pollination.

J. Water-resource protection

- Forests protect river catchments.
- Riparian vegetation reduces sediment entering rivers.
- Wetlands help store and filter water.
- Vegetation helps maintain the quality of water sources.

16.4 Social and cultural significance of vegetation

1. **Traditional medicine:** Communities use plants in traditional healthcare practices.
2. **Cultural identity:** Certain trees and forests have cultural and historical importance.
3. **Recreation:** Parks, forests and gardens provide spaces for relaxation.
4. **Education:** Vegetation provides learning materials for environmental and biological studies.
5. **Spiritual value:** Some communities consider particular trees and forests culturally or spiritually significant.
6. **Community identity:** Forests and other natural landscapes may be important symbols of local heritage.
7. **Food security:** Wild fruits, vegetables and other plant products supplement household diets.
8. **Traditional materials:** Plants provide materials for baskets, ropes, mats, dyes and household tools.

16.5 Significance of specific vegetation types

Vegetation type	Main significance
Tropical rainforest	Biodiversity conservation, carbon storage, timber and medicinal products

Savanna grassland	Wildlife habitats, pasture and tourism
Temperate forest	Timber, paper, recreation and carbon storage
Coniferous forest	Softwood timber, paper production and wildlife habitats
Desert vegetation	Pasture, medicinal plants and soil stabilisation
Tundra vegetation	Wildlife habitats, traditional livelihoods and carbon storage in ecosystems
Highland vegetation	Water catchment protection, tourism and biodiversity
Mangrove vegetation	Coastal protection, fish breeding grounds and carbon storage
Temperate grassland	Livestock grazing and commercial crop farming
Mediterranean vegetation	Fruits, tourism, soil protection and aromatic products

16.6 Significance of vegetation to the Kenyan community

Vegetation is important to Kenyan communities in the following ways:

1. Forests such as Mau and Mount Kenya support important water catchments.
2. Savanna grasslands support livestock and wildlife.
3. Coastal mangroves support fishing and protect shorelines.
4. Trees provide fuelwood and construction materials.
5. Forests and grasslands attract tourists.
6. Trees provide shade in homes, schools and public spaces.
7. Indigenous plants provide traditional medicines.
8. Vegetation protects farms against soil erosion.
9. Trees provide fruits, fodder and other useful products.
10. Forests and wetlands help maintain environmental balance.

17.0 MANAGEMENT OF VEGETATION

17.1 Meaning of vegetation management

Vegetation management refers to the planned use, protection, maintenance and improvement of plant resources to ensure that they remain productive and healthy.

It involves controlling harmful activities, promoting regeneration and ensuring that vegetation is used sustainably.

17.2 Methods of managing vegetation

A. Controlled harvesting

- Trees should be harvested according to approved management plans.

- Cutting should not exceed the capacity of the forest to regenerate.
- Mature trees may be harvested selectively.
- Sensitive habitats should be protected.
- Illegal logging should be controlled.

B. Selective logging

Selective logging involves removing selected trees rather than clearing an entire forest.

Importance:

- Reduces extensive forest destruction.
- Allows younger trees to continue growing.
- Maintains some forest structure.
- Reduces damage when carefully planned and implemented.

C. Controlled grazing

- Livestock numbers should match available pasture.
- Grazing areas should be rested to allow vegetation recovery.
- Rotational grazing can reduce pressure on individual grazing areas.
- Grazing near fragile water sources should be controlled.
- Degraded grazing land should be rehabilitated.

D. Controlled burning

- Fire may be used in some ecosystems as part of planned vegetation management.
- Burning must be based on ecological knowledge and legal requirements.
- It should be carried out under appropriate weather conditions.
- Firebreaks should be established.
- Uncontrolled burning should be prevented.

E. Weed and invasive species control

- Identify invasive plant species.
- Remove invasive plants using suitable methods.
- Prevent the introduction of harmful species.
- Monitor areas after removal.
- Restore native vegetation where necessary.

F. Forest regeneration

- Allow natural regeneration where suitable.
- Protect young seedlings from livestock and destruction.
- Replant trees in degraded sections.
- Use suitable indigenous species.

- Monitor the survival of planted seedlings.

G. Soil and water conservation

- Establish terraces on suitable slopes.
- Plant grass strips.
- Protect riverbanks.
- Use mulching.
- Avoid cultivating fragile slopes.
- Establish cover crops.
- Maintain wetland vegetation.

H. Establishment of woodlots

- Plant trees on designated land.
- Use suitable species.
- Maintain the woodlots through pruning and weeding.
- Harvest trees sustainably.
- Establish new trees to replace those harvested.

I. Community participation

- Involve local residents in vegetation management.
- Establish community forest associations where appropriate.
- Promote environmental education.
- Encourage community monitoring.
- Share benefits from sustainable resource use.
- Involve schools, youth groups and local institutions.

J. Enforcement of environmental laws

- Prevent illegal logging.
- Regulate forest exploitation.
- Protect endangered plant species.
- Control encroachment into protected areas.
- Enforce laws against illegal charcoal production.
- Ensure environmental impact assessments are conducted where required.

18.0 CONSERVATION OF VEGETATION

18.1 Definition of vegetation conservation

Vegetation conservation refers to the protection, restoration and sustainable use of plant resources to prevent their destruction and ensure their availability for present and future generations.

Conservation aims to maintain vegetation cover, biodiversity and the ecological services provided by plants.

18.2 Difference between vegetation management and conservation

Vegetation management	Vegetation conservation
Involves planning and controlling the use of vegetation resources.	Focuses on protecting and maintaining vegetation and its biodiversity.
May include harvesting, pruning and controlled grazing.	May include protection, restoration and restriction of destructive activities.
Aims to maintain productive and healthy vegetation.	Aims to prevent degradation and loss of vegetation.
Example: Selective logging under an approved management plan.	Example: Protecting an endangered forest ecosystem.

18.3 Methods of conserving vegetation

A. Afforestation

Afforestation is the establishment of a forest on land that has not recently been under forest cover.

Importance:

- Increases tree cover.
- Absorbs carbon dioxide.
- Protects soil.
- Provides habitats.
- Supports sustainable timber production when properly planned.

B. Reforestation

Reforestation is the re-establishment of trees in areas where forests have been removed or degraded.

Importance:

- Restores forest cover.
- Helps recover degraded ecosystems.
- Improves habitat availability.
- Supports water catchment protection.
- Increases carbon storage.

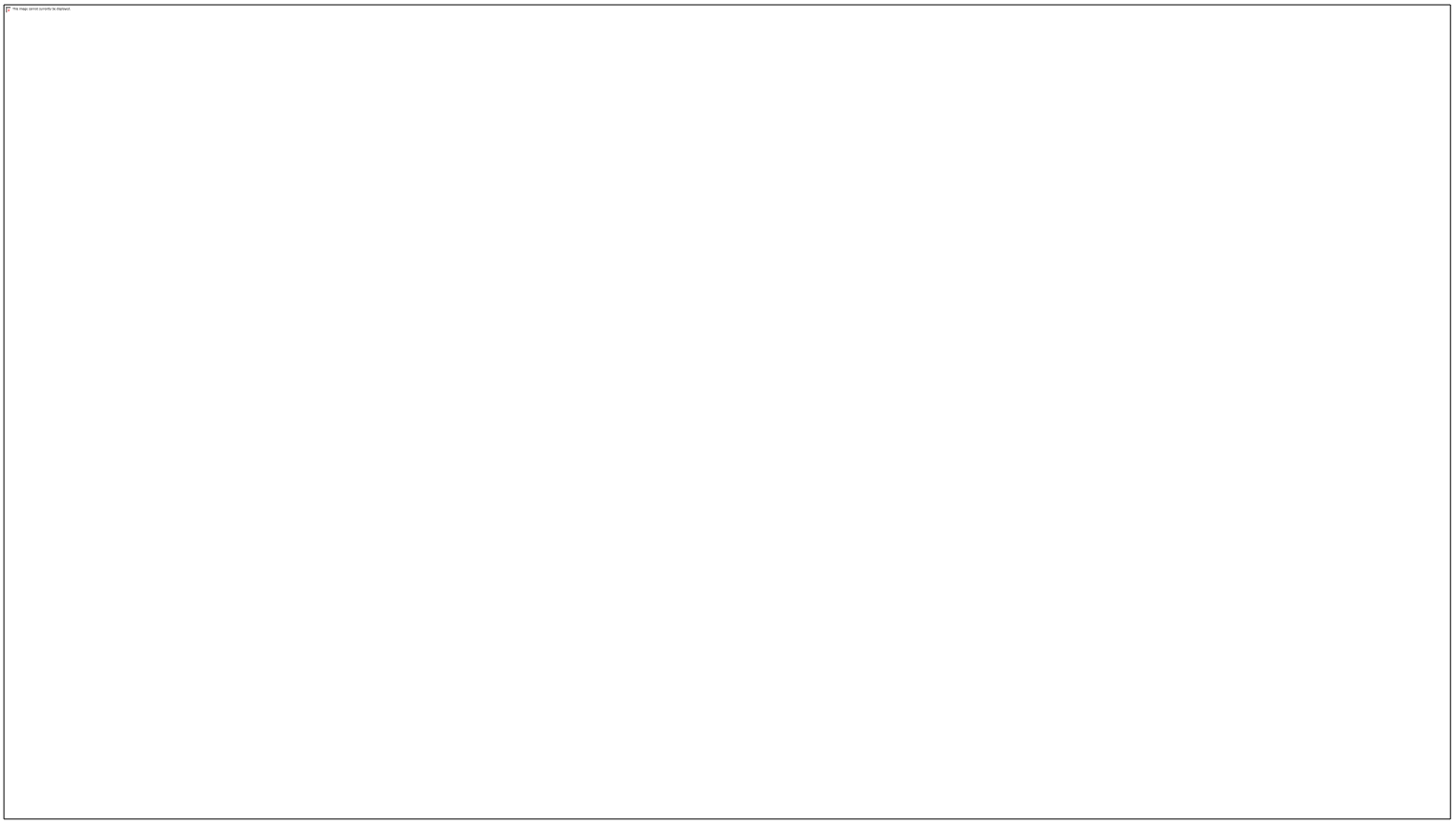
C. Agroforestry

Agroforestry is the deliberate integration of trees and shrubs with crops and/or livestock on the same land-management unit.

Benefits:

- Improves soil protection.
- Provides shade.

- Supplies fodder.
- Produces fruits and timber.
- Helps conserve moisture.
- Diversifies farm income.



D. Establishment of forest reserves and protected areas

- Designate important vegetation areas for protection.
- Prevent unauthorised clearing.
- Monitor activities within protected areas.
- Protect rare and endangered species.
- Support scientific research and education.

E. Community-based conservation

- Involve local people in conservation decisions.
- Support community forest associations.
- Promote sustainable use of forest products.
- Encourage community tree nurseries.
- Share conservation benefits fairly.

F. Protection of indigenous vegetation

- Identify and protect native plant species.
- Prevent uncontrolled removal of indigenous trees.

- Encourage the planting of suitable native species.
- Protect natural habitats.
- Control invasive species.

G. Wetland and mangrove conservation

- Protect wetland vegetation.
- Restore damaged mangroves.
- Prevent pollution.
- Control destructive coastal development.
- Maintain natural water flow.
- Encourage sustainable harvesting.

H. Creation of botanical gardens

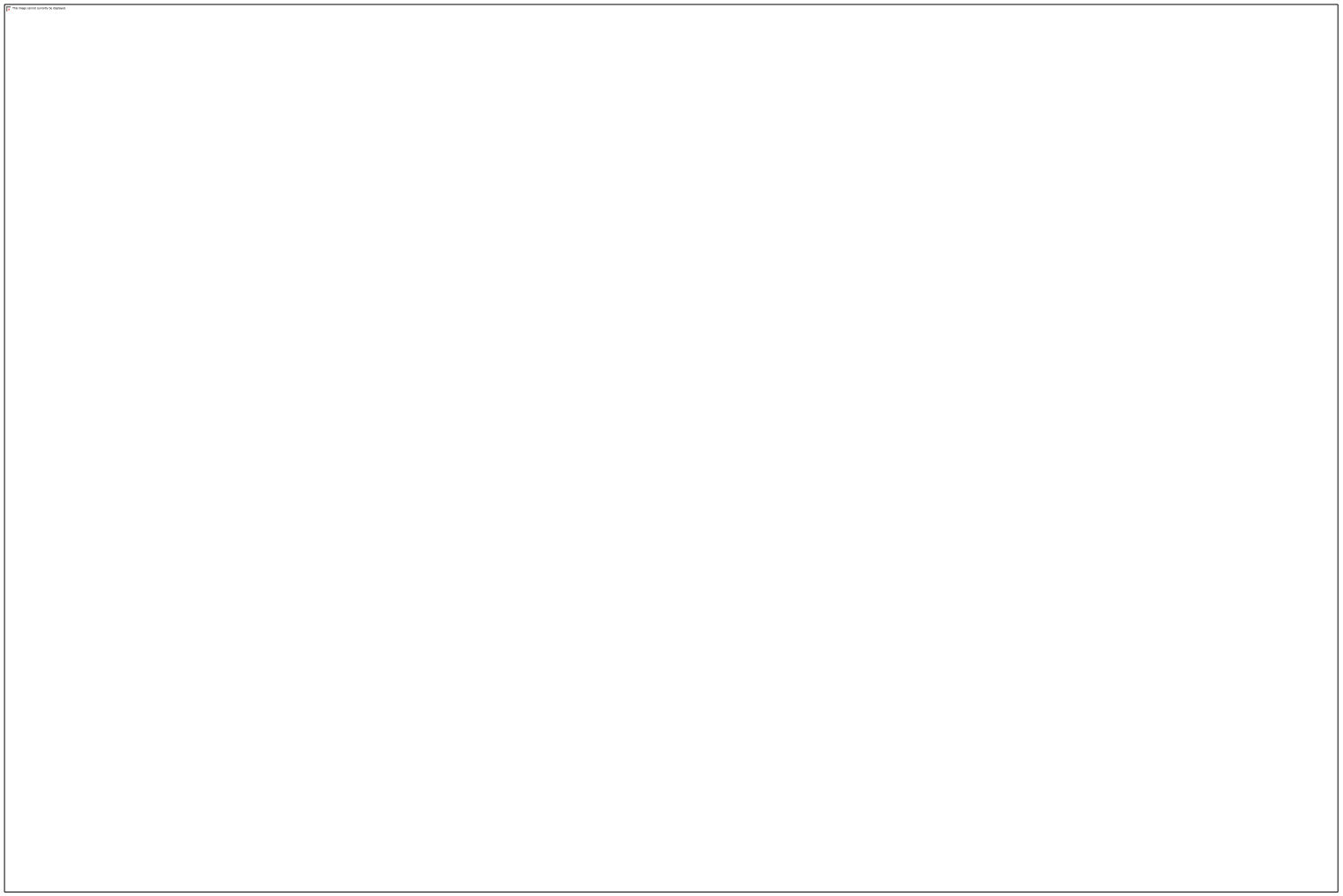
- Establish gardens containing different plant species.
- Label plants correctly.
- Maintain suitable growing conditions.
- Use gardens for education and research.
- Protect rare or locally important plant species.

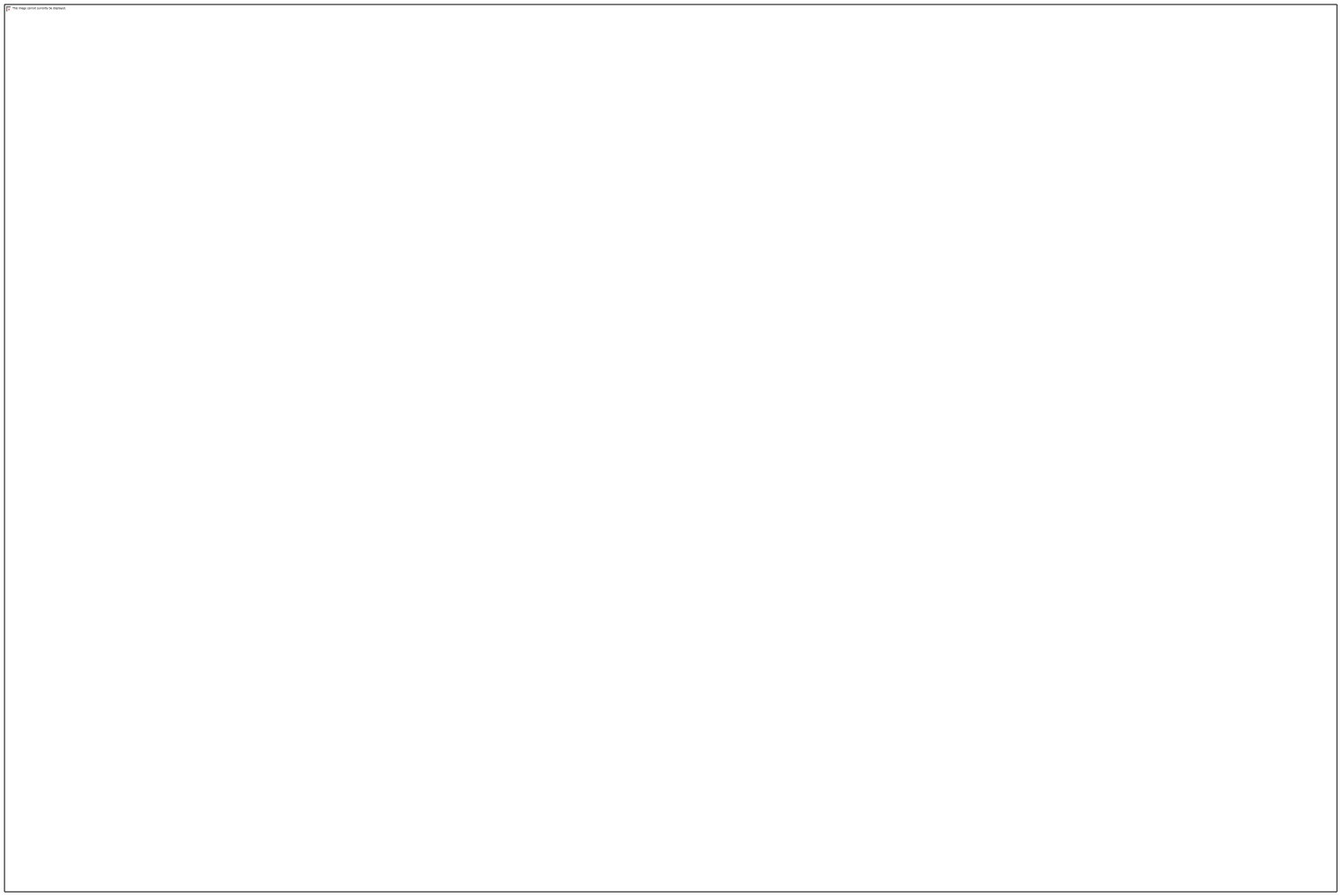
I. Environmental education

- Teach communities about the importance of vegetation.
- Organise school environmental clubs.
- Conduct tree-planting campaigns.
- Use posters and public awareness activities.
- Encourage responsible use of forest resources.

J. Rehabilitation of degraded land

- Plant suitable vegetation.
- Stabilise eroded slopes.
- Restore wetlands.
- Control overgrazing.
- Rehabilitate abandoned mining areas.
- Protect newly restored areas from further damage.





18.4 Importance of vegetation conservation

1. Prevents extinction of plant species.
2. Maintains biodiversity.
3. Protects water catchments.
4. Reduces soil erosion.
5. Helps regulate the carbon cycle.
6. Supports climate resilience.
7. Maintains wildlife habitats.
8. Supports sustainable tourism.
9. Protects the livelihoods of local communities.
10. Preserves resources for future generations.

18.5 Challenges facing vegetation conservation in Kenya

1. **Deforestation:** Cutting down trees reduces forest cover.
2. **Population pressure:** Increasing demand for land may encourage forest clearance.
3. **Agricultural expansion:** Natural vegetation may be cleared to create farmland.

4. **Illegal logging:** Unauthorised tree harvesting damages forests.
5. **Charcoal production:** Unsustainable charcoal production may lead to loss of woodland.
6. **Overgrazing:** Excessive livestock numbers reduce vegetation cover.
7. **Forest fires:** Uncontrolled fires destroy vegetation.
8. **Invasive species:** Some introduced plants displace native species.
9. **Climate change:** Changes in rainfall and temperature affect plant survival.
10. **Inadequate funding:** Conservation agencies and community groups may lack resources.
11. **Limited awareness:** Some communities may not fully understand the long-term value of vegetation.
12. **Human-wildlife conflict:** Conflict may affect conservation activities and land-use decisions.

18.6 Solutions to challenges facing vegetation conservation

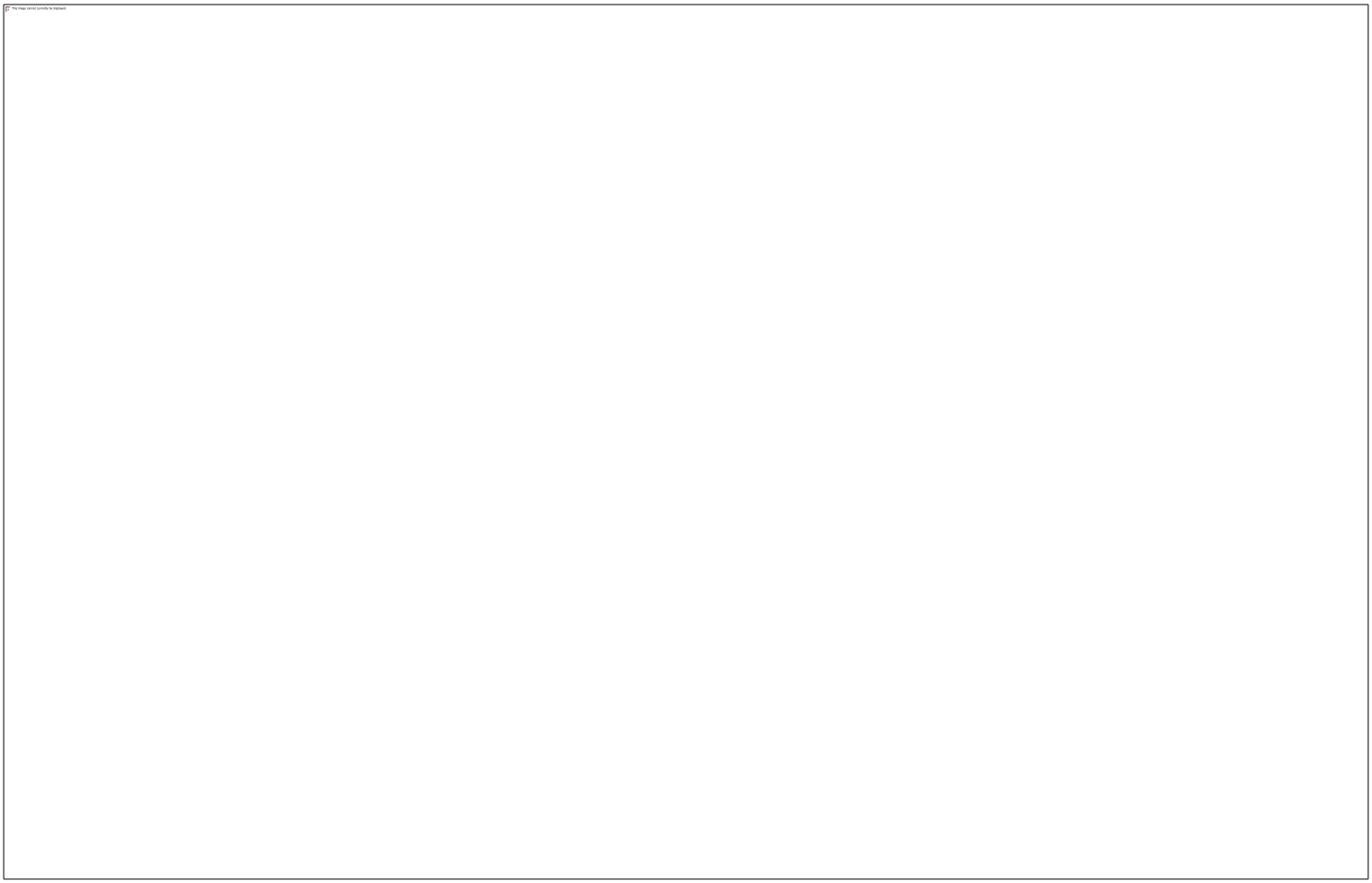
- Strengthen enforcement of environmental laws.
- Promote community participation.
- Establish alternative sources of energy.
- Encourage sustainable farming.
- Promote agroforestry.
- Restore degraded forests and wetlands.
- Improve environmental education.
- Provide adequate funding for conservation.
- Encourage research and monitoring.
- Promote sustainable tourism.
- Control invasive plant species.
- Develop land-use plans that protect important ecosystems.

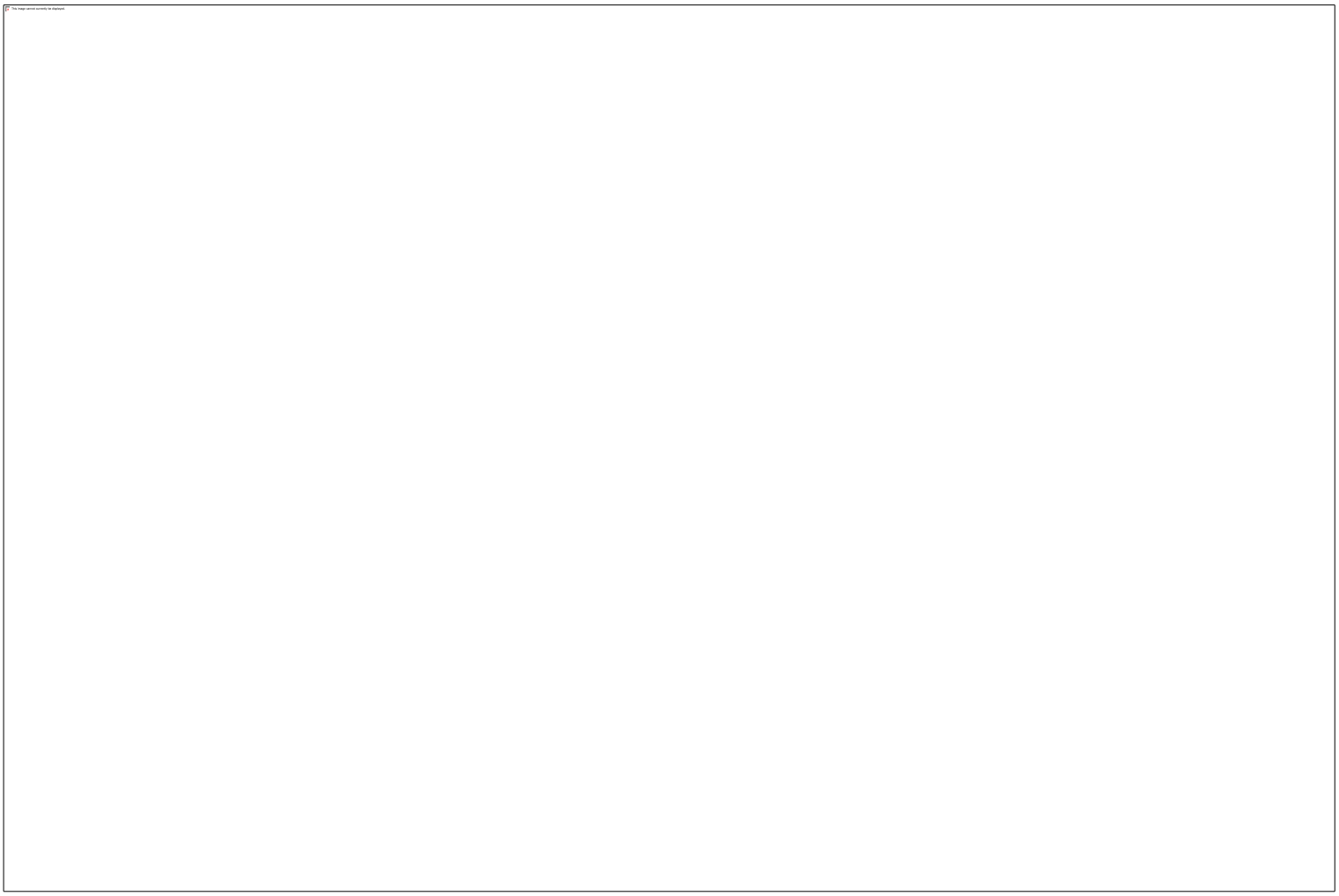
19.0 ESTABLISHING A SCHOOL BOTANICAL GARDEN

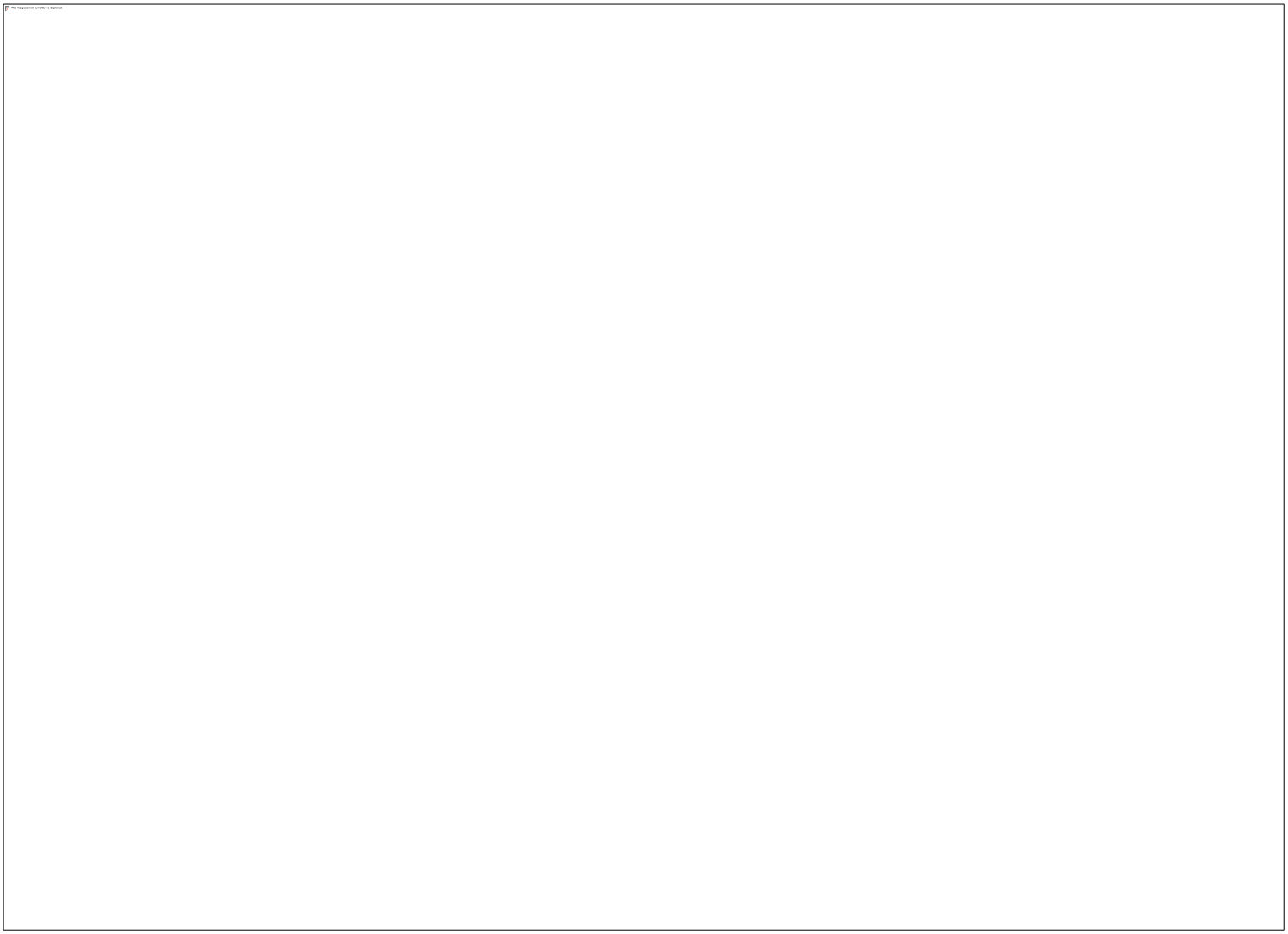
19.1 Meaning of a botanical garden

A botanical garden is a planned area where different plant species are grown, labelled, studied, displayed and conserved for education, research and recreation.

A school botanical garden is an area within the school compound set aside for growing and studying different plants.







19.2 Importance of a school botanical garden

1. Provides practical learning opportunities.
2. Helps learners identify different plant species.
3. Promotes environmental awareness.
4. Supports conservation of indigenous plants.
5. Improves the appearance of the school compound.
6. Provides shade.
7. Supports biodiversity.
8. Encourages teamwork and responsibility.
9. Provides opportunities for scientific observation.
10. May supply useful plants such as herbs and fruit trees.

19.3 Requirements for establishing a school botanical garden

- Suitable land.
- Water supply.
- Seeds and seedlings.

- Suitable soil.
- Garden tools.
- Compost manure.
- Plant labels.
- Fencing materials where necessary.
- Record book.
- Guidance from teachers or horticultural experts.

19.4 Steps in establishing a school botanical garden

Step 1: Identify a suitable site

- Select accessible land within the school compound.
- Choose an area with suitable sunlight.
- Avoid waterlogged or highly exposed sites unless the garden is designed for those conditions.
- Ensure the site does not interfere with school activities.

Step 2: Assess the site

- Examine the soil.
- Determine water availability.
- Observe the amount of sunlight.
- Identify drainage conditions.
- Assess security and protection from animals.

Step 3: Plan the garden layout

- Divide the garden into sections.
- Group plants according to their types or uses.
- Provide walking paths.
- Include areas for indigenous plants, medicinal plants, herbs and ornamental plants.
- Provide space for labels and information boards.

Step 4: Select plant species

Choose species according to:

- Local climate.
- Soil conditions.
- Water availability.
- Educational value.
- Conservation importance.
- Suitability for the school environment.

Step 5: Prepare the land

- Clear unwanted weeds carefully.
- Remove harmful waste.
- Prepare planting beds.
- Add compost manure where suitable.
- Establish drainage channels if necessary.

Step 6: Plant seedlings and seeds

- Plant at appropriate spacing.
- Follow correct planting procedures.
- Water newly planted seedlings.
- Label each species.
- Protect young plants from damage.

Step 7: Maintain the garden

- Water plants appropriately.
- Remove weeds.
- Apply suitable organic manure.
- Prune where necessary.
- Control pests and diseases.
- Replace dead plants.
- Maintain paths and labels.

Step 8: Keep records

Record:

- Plant name.
- Local name.
- Scientific name where known.
- Date planted.
- Source of seed or seedling.
- Growth observations.
- Uses.
- Conservation status where verified.

Step 9: Use the garden for learning

- Identify plant structures.
- Compare leaf shapes.
- Study root systems.
- Observe plant adaptations.

- Investigate pollination.
- Compare indigenous and introduced species.
- Study plant growth under different conditions.

19.5 Sample botanical garden record

Plant name	Type	Main features	Uses
Croton	Indigenous tree	Broad leaves	Shade and habitat
Aloe	Succulent	Thick water-storing leaves	Ornamental and traditional uses
Grevillea	Introduced tree	Evergreen foliage	Agroforestry and shade
Bamboo	Grass	Jointed stems	Construction and crafts
Neem	Tree	Compound leaves	Shade and various traditional uses

Note: Plant selection should be based on ecological suitability and expert guidance. Some introduced species can become invasive or use excessive water.

20.0 PRACTICAL FIELDWORK AND RESEARCH ON VEGETATION

20.1 Importance of studying vegetation through fieldwork

Fieldwork enables learners to observe vegetation directly and relate classroom knowledge to the environment.

Through fieldwork, learners can:

- Identify different vegetation types.
- Describe plant characteristics.
- Investigate factors influencing vegetation distribution.
- Identify human activities affecting vegetation.
- Examine vegetation management practices.
- Propose conservation measures.

20.2 Suggested fieldwork activity

Title: Investigating vegetation types and their importance in the local community.

Objectives

By the end of the activity, learners should be able to:

1. Identify vegetation types found in the local environment.
2. Describe the characteristics of selected plants.
3. Explain factors influencing the distribution of vegetation.
4. Identify the importance of vegetation to the community.
5. Examine threats to vegetation.

6. Suggest appropriate management and conservation measures.

Preparation

- Select a suitable study area.
- Obtain permission from the school and relevant landowners.
- Prepare an observation guide.
- Identify resource persons.
- Prepare notebooks, pencils and recording sheets.
- Carry appropriate safety equipment.
- Plan safe routes and activities.

Activities during fieldwork

1. Observe the general vegetation cover.
2. Identify trees, shrubs, grasses and herbs.
3. Record the names of common plants where known.
4. Observe the height and spacing of trees.
5. Examine leaf shapes and root structures without damaging plants.
6. Identify areas affected by grazing, cutting or burning.
7. Observe soil and drainage conditions.
8. Interview community members about the uses of vegetation.
9. Identify conservation activities in the area.
10. Take photographs where permission has been granted.

Sample fieldwork observation table

Observation	**Findings**
Study area	To be completed by learners
Main vegetation type	To be identified
Dominant plant forms	Trees, shrubs, grasses or herbs
General plant height	Tall, medium or short
Vegetation density	Dense, moderate or sparse
Soil condition	Sandy, clayey, loamy or rocky
Human activities	Farming, grazing, logging or conservation

Main threats	To be identified
Conservation measures	To be identified

20.3 Sample questions for interviews

1. Which types of vegetation are common in this area?
2. Which plants are most useful to the community?
3. What factors influence the distribution of plants here?
4. Have you noticed changes in vegetation cover over the years?
5. What human activities threaten vegetation in this area?
6. How does vegetation support livestock keeping?
7. Which plants are used for traditional medicine?
8. What measures are used to conserve vegetation?
9. Are there community tree-planting activities?
10. What challenges affect conservation efforts?
11. Which indigenous trees are found in the area?
12. How can learners participate in vegetation conservation?

20.4 Sample fieldwork report format

A good fieldwork report should contain:

1. Title of the study.
2. Date of fieldwork.
3. Study area.
4. Objectives.
5. Methods used to collect information.
6. Description of vegetation types observed.
7. Factors influencing vegetation distribution.
8. Importance of vegetation.
9. Threats identified.
10. Management and conservation measures.
11. Challenges encountered.
12. Recommendations.
13. Conclusion.

21.0 VEGETATION, CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT

21.1 Relationship between vegetation and climate change

Vegetation and climate influence each other.

- Climate determines the types of plants that can grow in a region.
- Vegetation influences the carbon cycle.
- Plants absorb carbon dioxide through photosynthesis.
- Forests and other ecosystems store carbon in plant tissues and soils.
- Deforestation releases stored carbon and reduces future carbon absorption.
- Vegetation influences local temperatures through shade and evapotranspiration.
- Climate change can alter the geographical distribution of plant species.
- Rising temperatures and changing rainfall may increase stress on some ecosystems.

21.2 Effects of climate change on vegetation

1. **Changes in plant distribution:** Some plant species may move towards cooler areas or higher altitudes.
2. **Increased drought stress:** Prolonged dry periods may cause plant death.
3. **Changes in flowering seasons:** Some plants may flower earlier or later.
4. **Increased wildfire risk:** Hot and dry conditions can increase fire danger in some ecosystems.
5. **Changes in forest composition:** Some tree species may decline while others become more common.
6. **Pest and disease outbreaks:** Warmer conditions may favour certain pests and plant diseases.
7. **Loss of biodiversity:** Species unable to adapt may become locally extinct.
8. **Changes in grassland productivity:** Rainfall and temperature changes may affect pasture availability.
9. **Mangrove stress:** Sea-level rise and changes in salinity may affect coastal vegetation.
10. **Thawing permafrost:** Warming can alter tundra soils and vegetation communities.

21.3 How vegetation helps reduce climate change

- Forests absorb carbon dioxide.
- Mangroves store carbon in vegetation and sediments.
- Grassland soils store organic carbon.
- Trees provide shade and reduce local heat exposure.
- Wetland vegetation stores carbon and supports water regulation.
- Agroforestry increases tree cover on agricultural land.
- Restoration of degraded land increases carbon storage in suitable ecosystems.

21.4 Vegetation and sustainable development

Sustainable development involves using natural resources responsibly so that present needs are met without compromising the ability of future generations to meet their own needs.

Vegetation supports sustainable development through:

- Provision of renewable resources.
- Protection of water catchments.
- Conservation of biodiversity.

- Support for food production.
- Creation of employment.
- Reduction of soil erosion.
- Support for ecotourism.
- Storage of carbon.
- Maintenance of ecosystem services.
- Protection of community livelihoods.

21.5 Values promoted through the study of vegetation

Value	**How it is developed**
Responsibility	Caring for trees, gardens and natural habitats
Respect	Appreciating different plant species and the environment
Unity	Working together in tree-planting and conservation projects
Integrity	Recording and reporting field observations accurately
Patriotism	Protecting Kenya's natural heritage
Peace	Cooperating in the sustainable use of natural resources
Social justice	Recognising the rights of communities to benefit fairly from natural resources

21.6 Pertinent and contemporary issues

The sub-strand addresses:

- Environmental conservation.
- Climate change.
- Biodiversity loss.
- Sustainable land use.
- Food security.
- Water conservation.
- Community participation.
- Disaster risk reduction.
- Sustainable livelihoods.
- Intergenerational responsibility.

22.2 Important geographical terms

Term	Meaning
Vegetation	Total plant cover of an area
Flora	Plant species found in an area
Fauna	Animal species found in an area
Biome	Large ecological region with characteristic climate and plant and animal communities
Ecosystem	Living organisms interacting with one another and their physical environment
Habitat	Natural home of an organism
Biodiversity	Variety of living organisms
Deciduous	Describes plants that shed their leaves seasonally
Evergreen	Describes plants that retain leaves throughout the year
Xerophyte	Plant adapted to dry conditions
Succulent	Plant that stores water in its tissues
Epiphyte	Plant growing on another plant for physical support
Liana	Woody climbing plant
Mangrove	Salt-tolerant tree or shrub growing in coastal tidal environments
Tundra	Cold region with low-growing vegetation and a short growing season
Savanna	Tropical grassland with scattered trees and shrubs
Taiga	Extensive northern coniferous forest
Permafrost	Ground that remains frozen for at least two consecutive years
Afforestation	Establishment of forest on land not recently under forest cover
Reforestation	Re-establishment of trees in an area where forest has been removed
Agroforestry	Integration of trees with crops and/or livestock

Deforestation	Removal of forest cover
Desertification	Land degradation in drylands due to climatic variations and human activities
Conservation	Protection and sustainable management of natural resources
Botanical garden	Planned area for growing, studying, displaying and conserving plants

REVISION QUESTIONS

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Instructions: Answer all the questions. Choose the correct answer from the alternatives A, B, C and D.

1. What is meant by vegetation?

A. All animals living in an area
B. Total plant cover of a geographical area
C. The amount of rainfall received in an area
D. The types of soils found in an area

2. Which of the following is an example of natural vegetation in Kenya?

A. Tea plantation in Kericho
B. Coffee plantation in Kiambu
C. Natural savanna grassland in Maasai Mara
D. Eucalyptus woodlot on a farm

3. Which type of vegetation is mainly associated with areas that receive high rainfall throughout the year?

A. Desert vegetation
B. Tropical rainforest
C. Tundra vegetation
D. Temperate grassland

4. Where is the largest tropical rainforest in the world found?

A. Sahara Basin
B. Amazon Basin
C. Gobi Basin
D. Mediterranean Basin

5. Which of the following is a characteristic feature of tropical rainforest vegetation?

A. Widely spaced trees
B. Low-growing lichens
C. Dense evergreen trees
D. Permanent snow cover

6. What is the name given to the uppermost continuous layer of a tropical rainforest?

A. Forest floor
B. Understory
C. Canopy
D. Emergent layer

7. Trees that shed their leaves during an unfavourable season are described as:

A. Evergreen
B. Deciduous
C. Xerophytic
D. Epiphytic

8. Which type of vegetation is dominated by cone-bearing trees?

A. Savanna
B. Coniferous forest

C. Tropical rainforest
D. Desert vegetation

9. What is the extensive coniferous forest found in northern Canada and Siberia commonly known as?

A. Pampas
B. Taiga
C. Veld
D. Tundra

10. Which of the following is a characteristic feature of savanna vegetation?

A. Dense evergreen canopy
B. Scattered trees and grasses
C. Permanent ice cover
D. Complete absence of grasses

11. What is the name given to the temperate grasslands of North America?

A. Pampas
B. Steppes
C. Prairies
D. Veld

12. The temperate grasslands of Argentina are commonly known as:

A. Pampas
B. Taiga
C. Tundra
D. Downs

13. Which type of vegetation is best adapted to conditions of very low and unreliable rainfall?

A. Tropical rainforest
B. Desert vegetation
C. Mangrove vegetation
D. Temperate rainforest

14. What are plants adapted to survive in dry environments called?

A. Hydrophytes
B. Xerophytes
C. Epiphytes
D. Mesophytes

15. Which of the following is a common adaptation of desert plants?

A. Large, thin leaves
B. Extensive water storage
C. Shallow roots only
D. High water demand

16. Which climatic conditions is Mediterranean vegetation mainly adapted to?

A. Hot, dry summers and mild, wet winters
B. Permanent ice and snow

C. Heavy rainfall throughout the year
D. Extremely cold winters and short summers

17. Which type of vegetation is commonly found in Arctic regions?

A. Tropical rainforest
B. Savanna
C. Tundra
D. Mangrove

18. Which of the following plants is commonly associated with tundra vegetation?

A. Tall tropical hardwood trees
B. Mosses and lichens
C. Mangrove trees
D. Cactus forests

19. Which geographical factor mainly influences the variation of vegetation on highlands?

A. Longitude
B. Altitude
C. Population
D. Mineral resources

20. Which type of vegetation is commonly found along sheltered tropical coastlines?

A. Tundra
B. Coniferous forest
C. Mangrove
D. Temperate grassland

21. Which of the following is a breathing root found in some mangrove plants?

A. Buttress root
B. Pneumatophore
C. Taproot
D. Propagule

22. Which climatic factor is most important in determining the amount of water available for plant growth?

A. Rainfall
B. Longitude
C. Rock structure only
D. Population density

23. Which soil property refers to the relative proportions of sand, silt and clay?

A. Soil depth
B. Soil texture
C. Soil pH
D. Soil fertility

24. Why is vegetation on the windward side of a mountain often denser than that on the leeward side?

A. It receives less rainfall
B. It receives moist winds and more rainfall
C. It is always lower than the leeward side
D. It experiences no soil erosion

25. Which of the following human activities is likely to reduce natural vegetation cover?

A. Afforestation
B. Reforestation
C. Deforestation
D. Agroforestry

26. What is one major ecological importance of vegetation?

A. It increases soil erosion
B. It protects soil from erosion
C. It prevents all rainfall
D. It increases desertification

27. Which of the following activities is an example of agroforestry?

A. Removing all trees from a farm
B. Growing trees together with crops and livestock
C. Clearing forests for settlement
D. Burning all crop residues

28. What is the establishment of a forest on land that has not recently been under forest cover called?

A. Deforestation
B. Afforestation
C. Desertification
D. Overgrazing

29. What is the name given to a planned area where different plant species are grown, labelled and studied?

A. National park
B. Botanical garden
C. Desert reserve
D. Mining field

30. Why is vegetation conservation important?

A. To encourage uncontrolled logging
B. To increase soil degradation
C. To protect biodiversity and maintain ecological balance
D. To eliminate natural plant communities

SECTION B: STRUCTURED QUESTIONS

50 MARKS

Instructions: Answer all questions. Give clear geographical explanations and use relevant examples where appropriate.

QUESTION 1: Meaning and types of vegetation (8 marks)

a) Define the term vegetation. (2 marks)

b) State four major types of vegetation found in the world. (4 marks)

c) Give two differences between natural vegetation and cultivated vegetation. (2 marks)

QUESTION 2: Tropical and temperate vegetation (8 marks)

a) State four characteristics of tropical rainforest vegetation. (4 marks)

b) Explain four characteristics of temperate forest vegetation. (4 marks)

QUESTION 3: Grassland and desert vegetation (8 marks)

a) Identify four characteristics of savanna vegetation. (4 marks)

b) Explain four adaptations of desert plants to dry conditions. (4 marks)

QUESTION 4: Distribution of vegetation (8 marks)

a) Name four factors influencing the distribution of vegetation in the world. (4 marks)

b) Explain four ways in which climate influences the distribution of vegetation. (4 marks)

QUESTION 5: Significance of vegetation (10 marks)

a) Explain five ways in which vegetation is important to human beings and the environment. (5 marks)

b) Explain five ways in which human activities may threaten vegetation. (5 marks)

QUESTION 6: Management and conservation of vegetation (8 marks)

A school in Kenya intends to establish a botanical garden and participate in the conservation of local vegetation.

a) Define the term botanical garden. (2 marks)

b) Explain three activities the school should undertake when establishing and maintaining the botanical garden. (3 marks)

c) State three measures the community can use to conserve vegetation. (3 marks)

ANSWERS AND MARKING GUIDE

SECTION A: MULTIPLE-CHOICE ANSWERS

Question	Answer	Question	Answer

1	B	16	A
2	C	17	C
3	B	18	B
4	B	19	B
5	C	20	C
6	D	21	B
7	B	22	A
8	B	23	B
9	B	24	B
10	B	25	C
11	C	26	B
12	A	27	B
13	B	28	B
14	B	29	B
15	B	30	C

SECTION B: SUGGESTED ANSWERS

QUESTION 1: Meaning and types of vegetation (8 marks)

a) Define vegetation. (2 marks)

Vegetation refers to the total plant cover growing naturally or being cultivated in a particular geographical area.

b) State four major types of vegetation. (4 marks)

Any four:

1. Tropical rainforest.
2. Savanna grassland.
3. Temperate forest.
4. Coniferous forest.

5. Desert vegetation.
6. Tundra vegetation.
7. Mediterranean vegetation.
8. Highland vegetation.
9. Mangrove vegetation.
10. Temperate grassland.

c) Give two differences between natural and cultivated vegetation. (2 marks)

1. Natural vegetation grows without deliberate planting, while cultivated vegetation is deliberately planted by people.
2. Natural vegetation is mainly influenced by natural environmental conditions, while cultivated vegetation is also influenced by human management.

QUESTION 2: Tropical and temperate vegetation (8 marks)

a) State four characteristics of tropical rainforest vegetation. (4 marks)

1. Tall evergreen trees.
2. Dense vegetation.
3. High biodiversity.
4. Several vegetation layers.
5. Presence of climbers and lianas.
6. Broad leaves.
7. High humidity.
8. Limited sunlight reaching the forest floor.

Award any four.

b) Explain four characteristics of temperate forest vegetation. (4 marks)

1. Many trees shed their leaves during autumn or an unfavourable season.
2. Trees experience seasonal changes in growth.
3. Forests may contain deciduous and evergreen species.
4. Shrubs, herbs and ferns may grow beneath the trees.
5. Leaf litter contributes organic matter to the soil.
6. Trees include oak, beech, maple and birch in some regions.

Award any four explained points.

QUESTION 3: Grassland and desert vegetation (8 marks)

a) Identify four characteristics of savanna vegetation. (4 marks)

1. Dominated by grasses.
2. Contains scattered trees and shrubs.
3. Experiences seasonal rainfall.

4. Has a prolonged dry season in many areas.
5. Supports wildlife and grazing animals.
6. Contains drought-resistant plants.
7. Grass height varies according to rainfall.

Award any four.

b) Explain four adaptations of desert plants. (4 marks)

1. **Small leaves:** Reduce the surface area through which water is lost.
2. **Thick waxy cuticle:** Reduces evaporation from plant surfaces.
3. **Deep roots:** Enable plants to obtain underground water.
4. **Water-storage tissues:** Enable plants to store water for use during dry periods.
5. **Spines:** Some plants have modified leaves that reduce water loss.
6. **Dormant seeds:** Enable plants to survive unfavourable dry periods.
7. **Wide-spreading roots:** Allow rapid absorption of water after rainfall.

Award any four explained points.

QUESTION 4: Distribution of vegetation (8 marks)

a) Name four factors influencing vegetation distribution. (4 marks)

1. Climate.
2. Soil.
3. Relief.
4. Altitude.
5. Latitude.
6. Drainage.
7. Human activities.
8. Biotic factors.
9. Geological conditions.
10. Natural disturbances.

Award any four.

b) Explain four ways climate influences vegetation distribution. (4 marks)

1. **Rainfall:** Areas receiving abundant rainfall support dense forests, while dry areas support sparse vegetation.
2. **Temperature:** Warm conditions favour tropical plants, while cold conditions favour tundra and coniferous vegetation.
3. **Sunshine:** Adequate sunlight supports photosynthesis and plant growth.
4. **Humidity:** Influences water loss through transpiration and the survival of moisture-sensitive plants.
5. **Wind:** Strong winds may damage plants and increase water loss, while also dispersing seeds.

Award any four explained points.

QUESTION 5: Significance of vegetation (10 marks)

a) Explain five ways vegetation is important. (5 marks)

1. **Soil protection:** Roots bind soil particles and reduce erosion.
2. **Climate regulation:** Vegetation absorbs carbon dioxide and provides shade.
3. **Water-cycle regulation:** Plants release water vapour through transpiration.
4. **Food supply:** Vegetation provides fruits, seeds, vegetables and other food products.
5. **Medicine:** Some plants provide substances used in traditional and modern medicine.
6. **Timber:** Forests supply wood for construction and furniture.
7. **Employment:** Forestry, tourism and related industries create jobs.
8. **Wildlife habitats:** Vegetation provides food and shelter for animals.
9. **Tourism:** Forests and grasslands attract visitors.
10. **Water catchment protection:** Vegetation helps protect rivers, springs and wetlands.

Award any five explained points.

b) Explain five ways human activities may threaten vegetation. (5 marks)

1. **Deforestation:** Cutting trees reduces forest cover.
2. **Overgrazing:** Excessive grazing destroys grass and other plant cover.
3. **Agricultural expansion:** Clearing land for farming destroys natural vegetation.
4. **Urbanisation:** Settlement and infrastructure development replace natural plant communities.
5. **Mining:** Excavation and waste disposal destroy vegetation.
6. **Uncontrolled burning:** Fires destroy plants and may prevent regeneration.
7. **Pollution:** Harmful substances may damage plants and their habitats.
8. **Overharvesting:** Excessive collection of plant products reduces plant populations.

Award any five explained points.

QUESTION 6: Management and conservation of vegetation (8 marks)

a) Define botanical garden. (2 marks)

A botanical garden is a planned area where different plant species are grown, labelled, studied, displayed and conserved for education, research and recreation.

b) Explain three activities involved in establishing and maintaining a school botanical garden. (3 marks)

1. **Site selection:** Choose suitable land with appropriate soil, sunlight and water access.
2. **Plant selection and planting:** Select suitable plant species, prepare beds and plant seedlings at appropriate spacing.
3. **Maintenance:** Water plants, remove weeds, apply suitable manure, control pests and replace dead seedlings.

4. **Labelling:** Label plants with their local and scientific names where known.
5. **Record keeping:** Record planting dates, plant growth and observations.

Award any three explained activities.

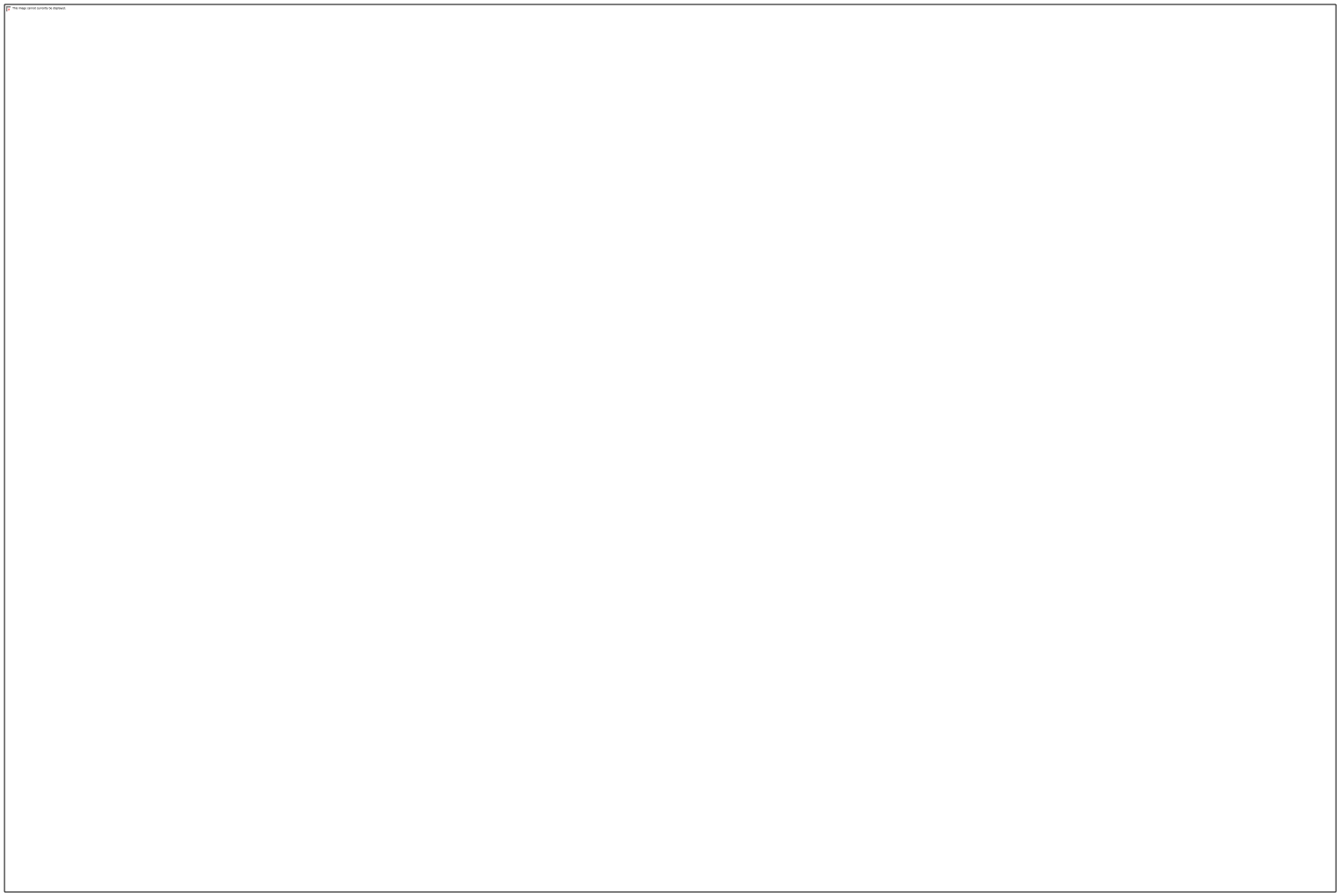
c) State three measures communities can use to conserve vegetation. (3 marks)

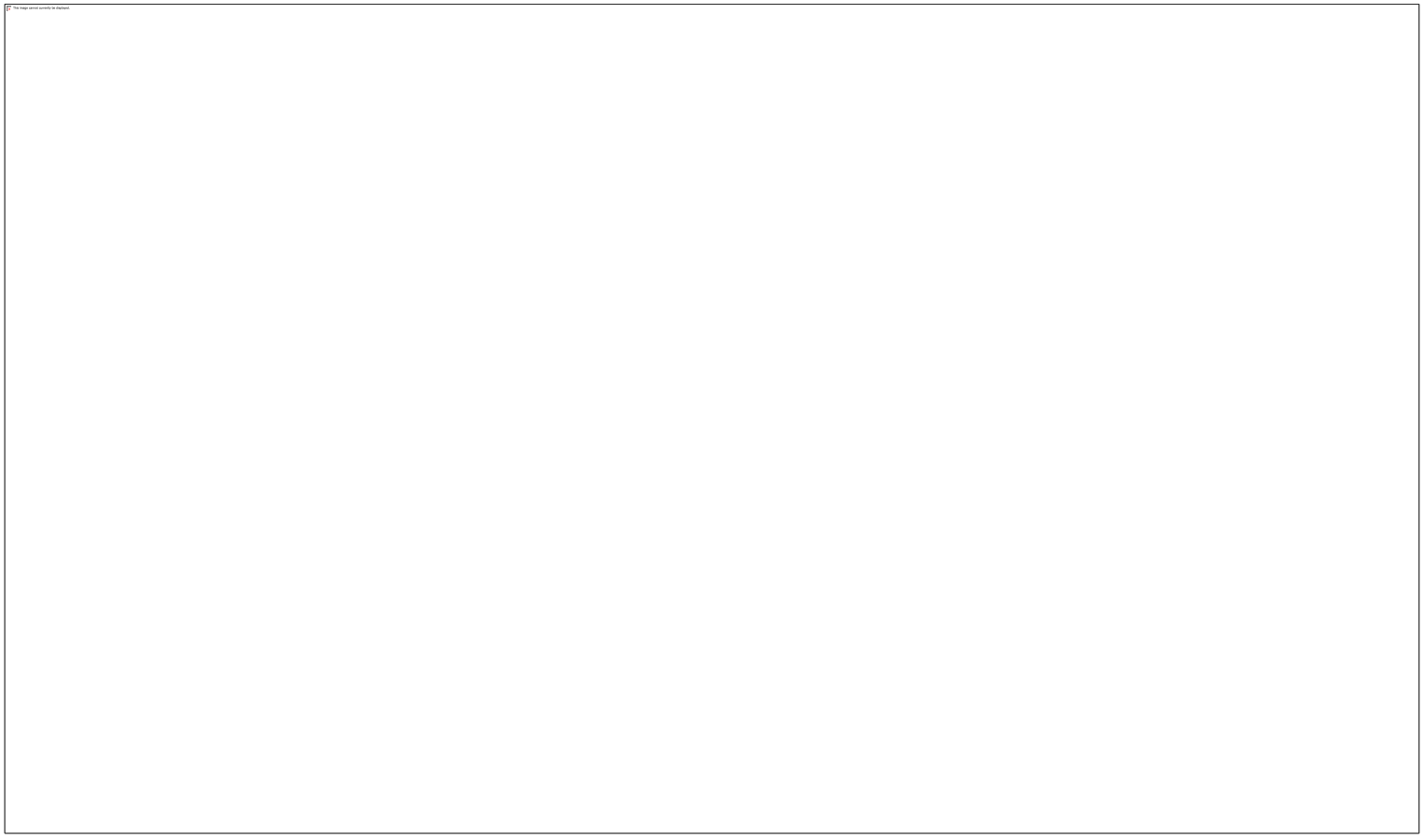
1. Afforestation and reforestation.
2. Agroforestry.
3. Controlled grazing.
4. Protection of indigenous forests.
5. Community tree nurseries.
6. Establishment of protected areas.
7. Prevention of illegal logging.
8. Environmental education.
9. Restoration of degraded land.
10. Mangrove and wetland conservation.

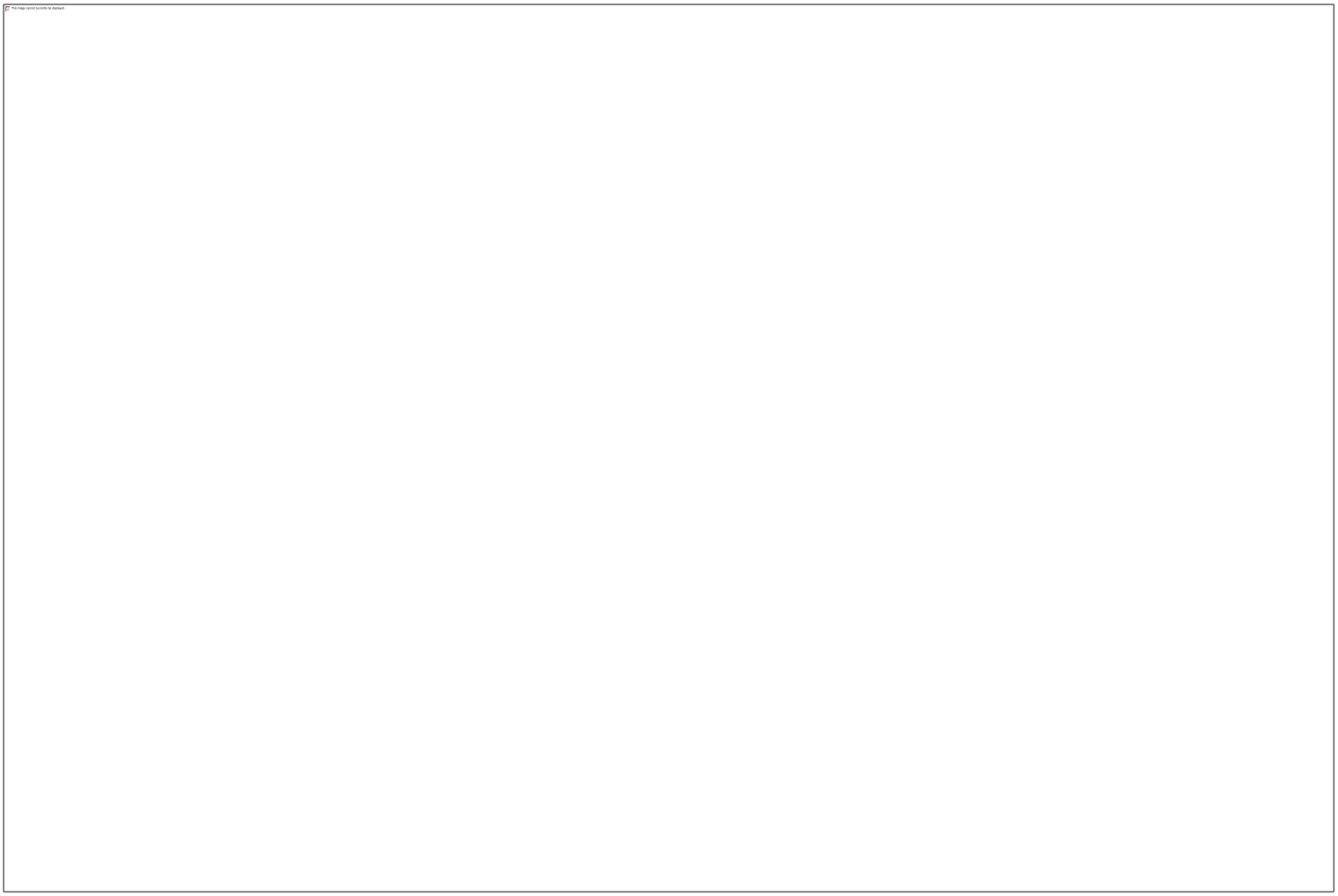
Award any three.

COMPETENCY-BASED LEARNING PROJECT

Project title: Establishing a school botanical garden and vegetation conservation corner







Project situation

Your school has identified an unused section of its compound. The school administration would like learners to establish a botanical garden that will display different plant species, support practical learning and promote vegetation conservation.

Project task

Working in groups, learners should plan, establish and maintain a school botanical garden using suitable plant species.

Project objectives

Learners should be able to:

1. Identify suitable plant species for the school environment.
2. Investigate the uses and characteristics of selected plants.
3. Prepare a suitable garden layout.
4. Plant and label selected species.
5. Maintain the garden.
6. Document the growth of plants.
7. Explain the importance of conserving vegetation.

Project materials

- Indigenous tree seedlings.

- Fruit tree seedlings.
- Suitable shrubs and herbs.
- Gardening tools.
- Watering cans.
- Compost manure.
- Plant labels.
- Record books.
- Fencing materials where necessary.

Project activities

1. Identify a suitable site.
2. Assess soil and water conditions.
3. Prepare a garden layout.
4. Research suitable plant species.
5. Obtain seeds and seedlings.
6. Prepare planting beds.
7. Plant and label the selected species.
8. Water and maintain the garden.
9. Record plant growth.
10. Prepare a report and present findings.

Expected project products

- A school botanical garden.
- A labelled plant collection.
- A garden layout.
- A plant identification chart.
- A record of plant growth.
- A written project report.
- A class presentation.

Suggested project assessment rubric

Assessment area	Marks
Identification and selection of plant species	5
Research on plant characteristics and uses	5
Garden layout and site preparation	5
Planting and labelling	10
Maintenance and record keeping	5
Teamwork and participation	5

Project report and presentation	5
Total	40

STRAND 2.0: NATURAL SYSTEMS AND PROCESSES

SUB-STRAND 2.4: WEATHERING

PART 1: INTRODUCTION TO WEATHERING

1.1 Meaning of Weathering

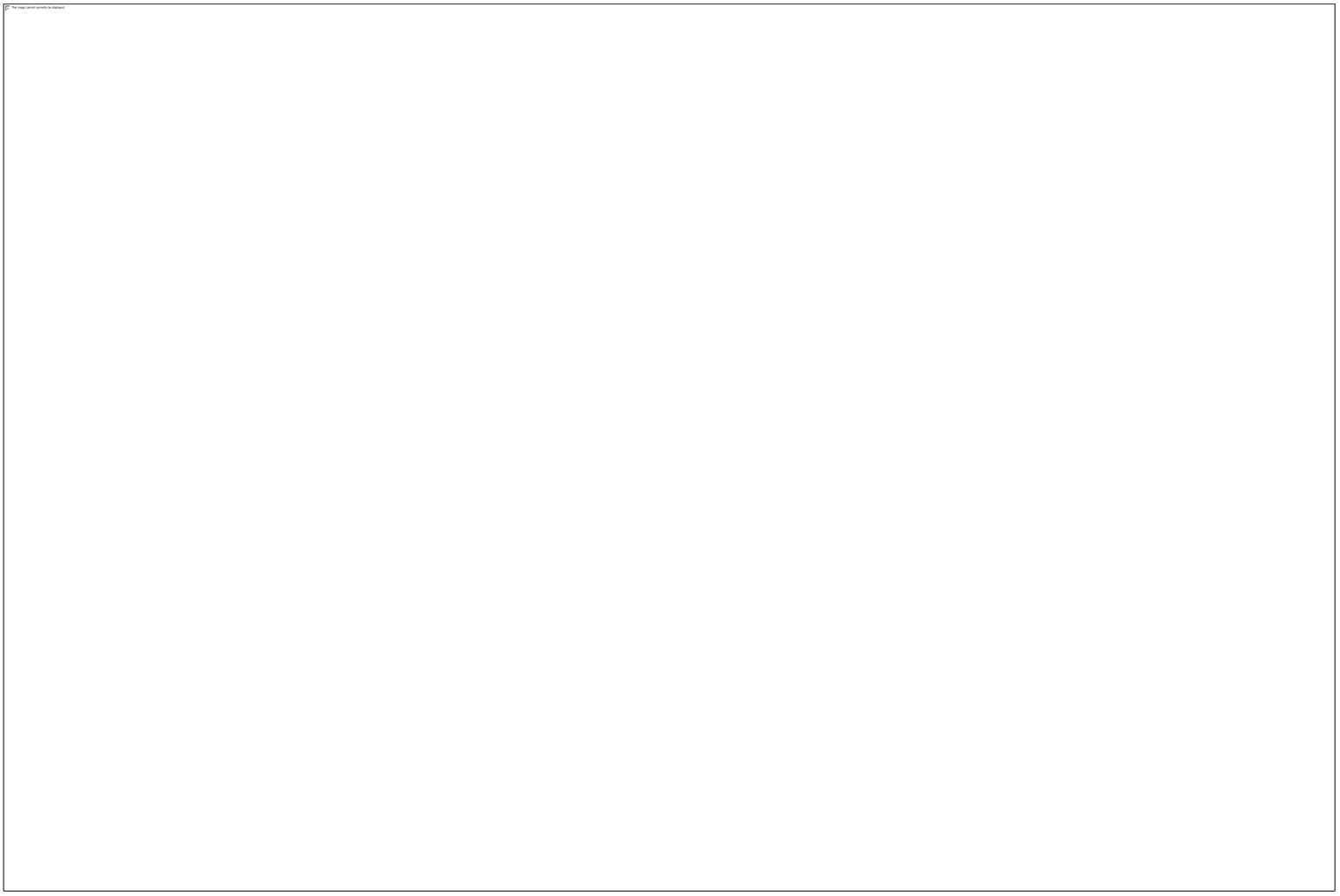
Weathering is the natural process through which rocks are broken down, disintegrated or decomposed into smaller particles at or near the Earth's surface without being transported from their original position.

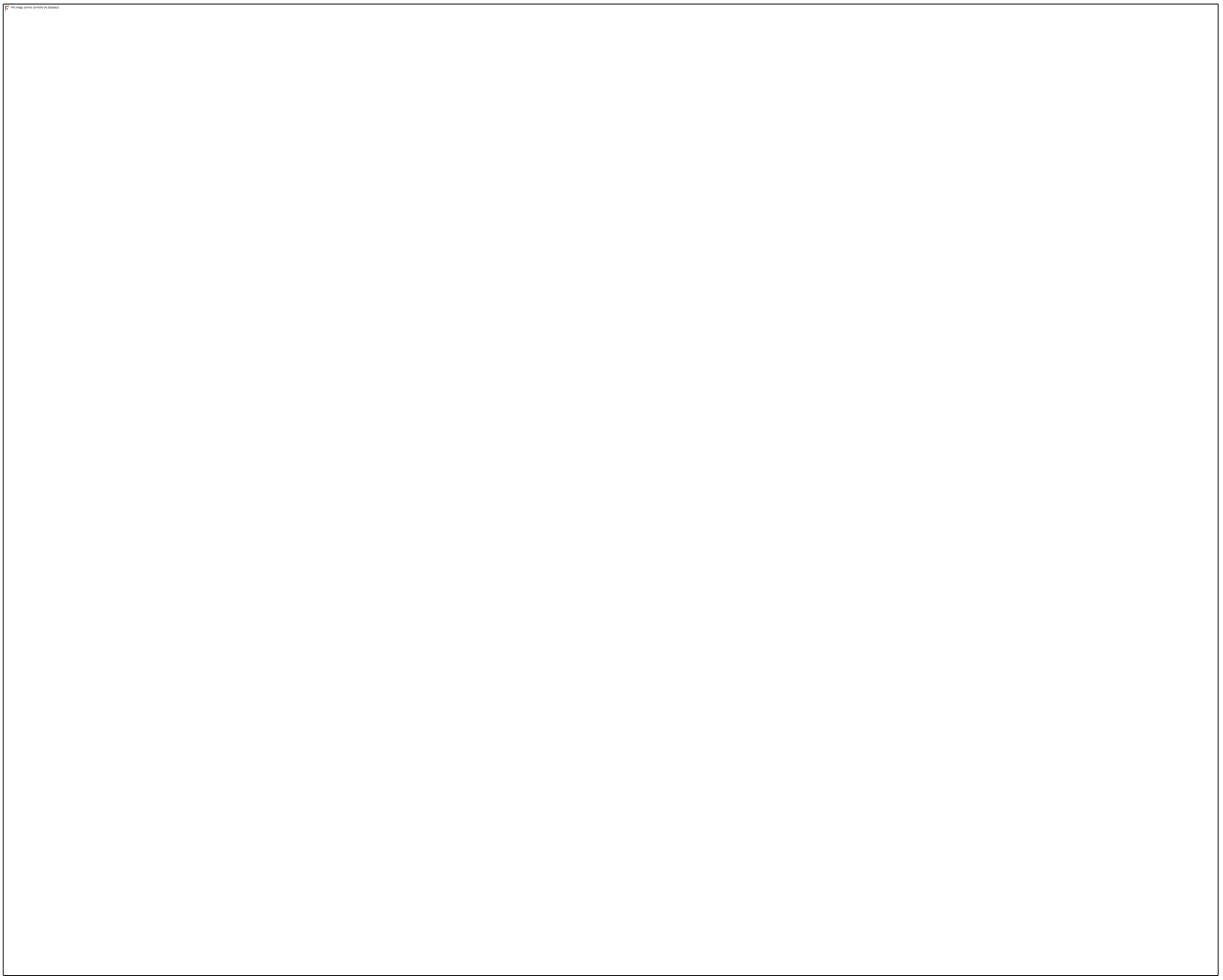
It is an important geographical process that continuously changes the appearance of the Earth's surface.

Weathering takes place when rocks are exposed to various environmental conditions, including:

- Changes in temperature.
- Rainfall and moisture.
- Atmospheric gases.
- Freezing and thawing.
- Chemical reactions.
- Activities of plants and animals.

Weathering can take place over a long period of time or relatively quickly depending on the environmental conditions and the nature of the rocks.







Examples of weathering in the Kenyan environment

1. Cracking of exposed rocks due to repeated heating and cooling in arid and semi-arid areas such as Kajiado and parts of Turkana.
2. Breakdown of rocks through plant roots growing into cracks in forested areas such as Mau Forest.
3. Chemical decomposition of rocks in areas experiencing high rainfall.
4. Weathering of exposed rocks along road cuttings in the Kenyan highlands.
5. Decomposition of volcanic rocks in parts of the Rift Valley.

1.2 Characteristics of Weathering

Weathering has the following characteristics:

1. **It occurs in situ:** Weathering takes place at or near the original position of the rock. The broken materials are not transported away by the weathering process itself.

2. **It breaks down rocks:** Large rock masses are gradually reduced into smaller fragments and mineral particles.

3. **It may be physical, chemical or biological:** Different agents and processes contribute to the breakdown of rocks.

4. **It is influenced by climate:** Temperature, rainfall and moisture determine the type and rate of weathering.

5. **It contributes to soil formation:** Weathering produces mineral particles that form an important component of soil.

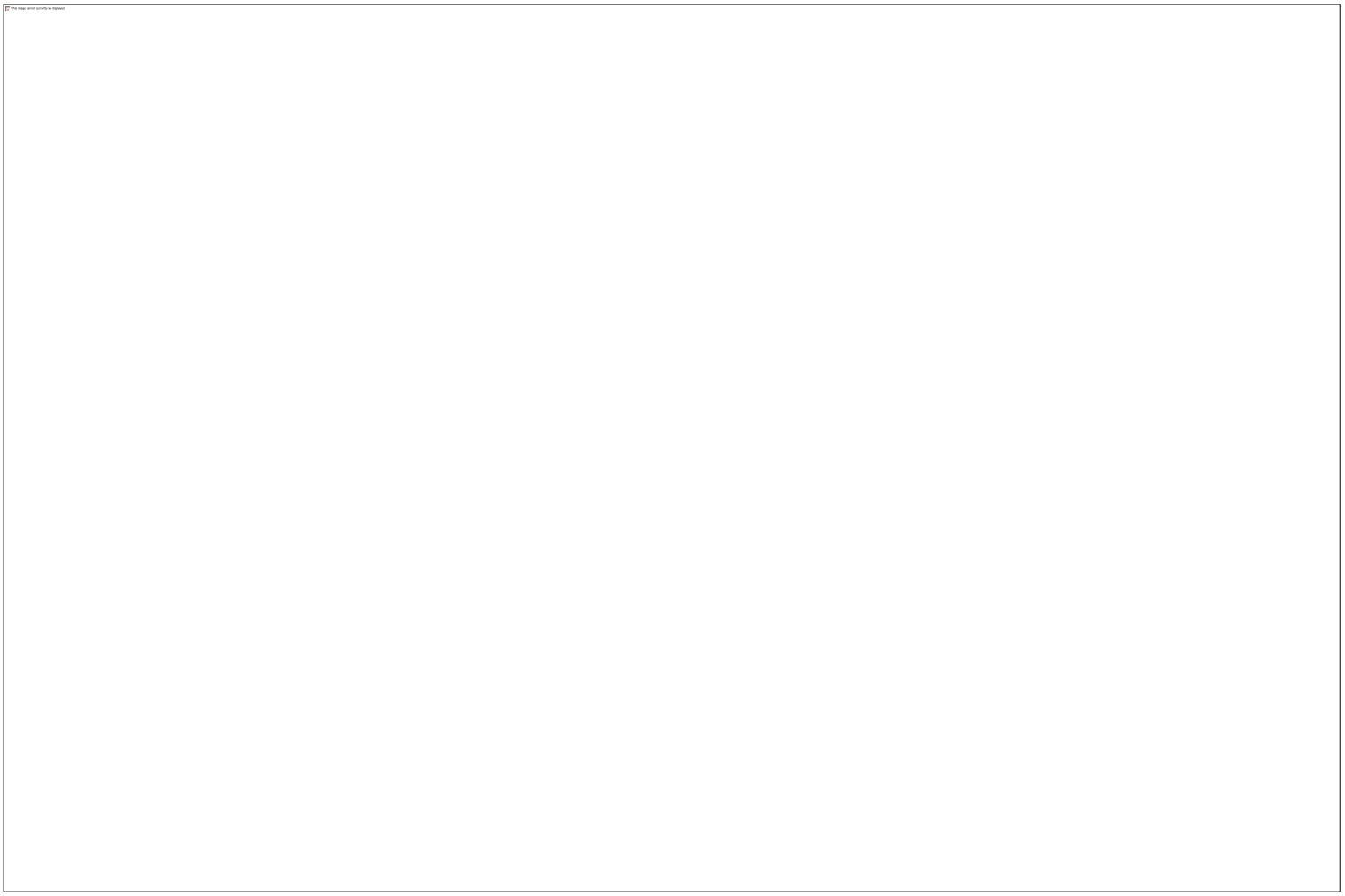
6. **It changes landscapes:** Weathering creates different landforms, including caves, rock domes, weathering hollows and loose rock deposits.

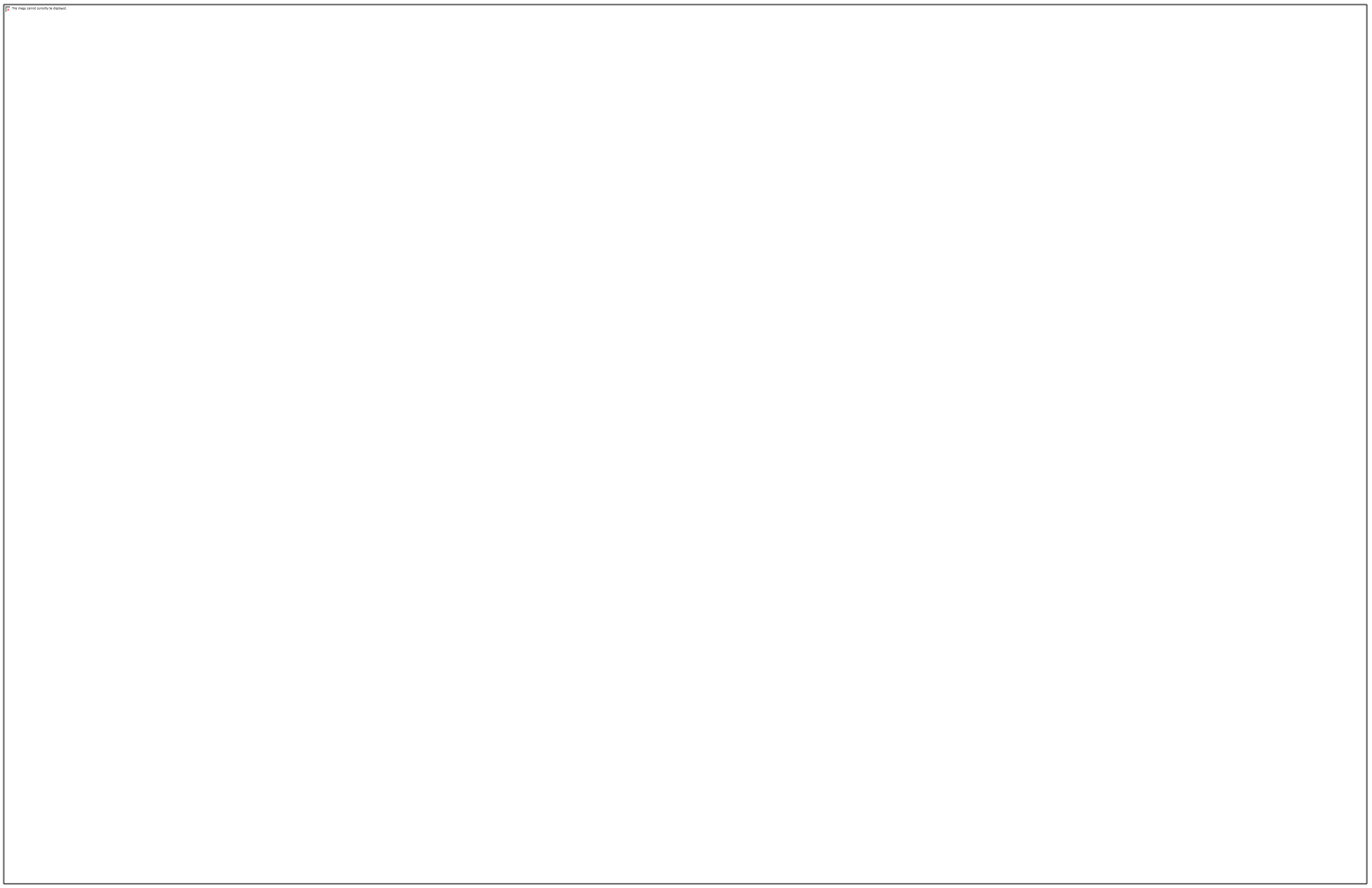
7. **It varies in intensity:** Different rocks experience different rates of weathering depending on their composition and structure.

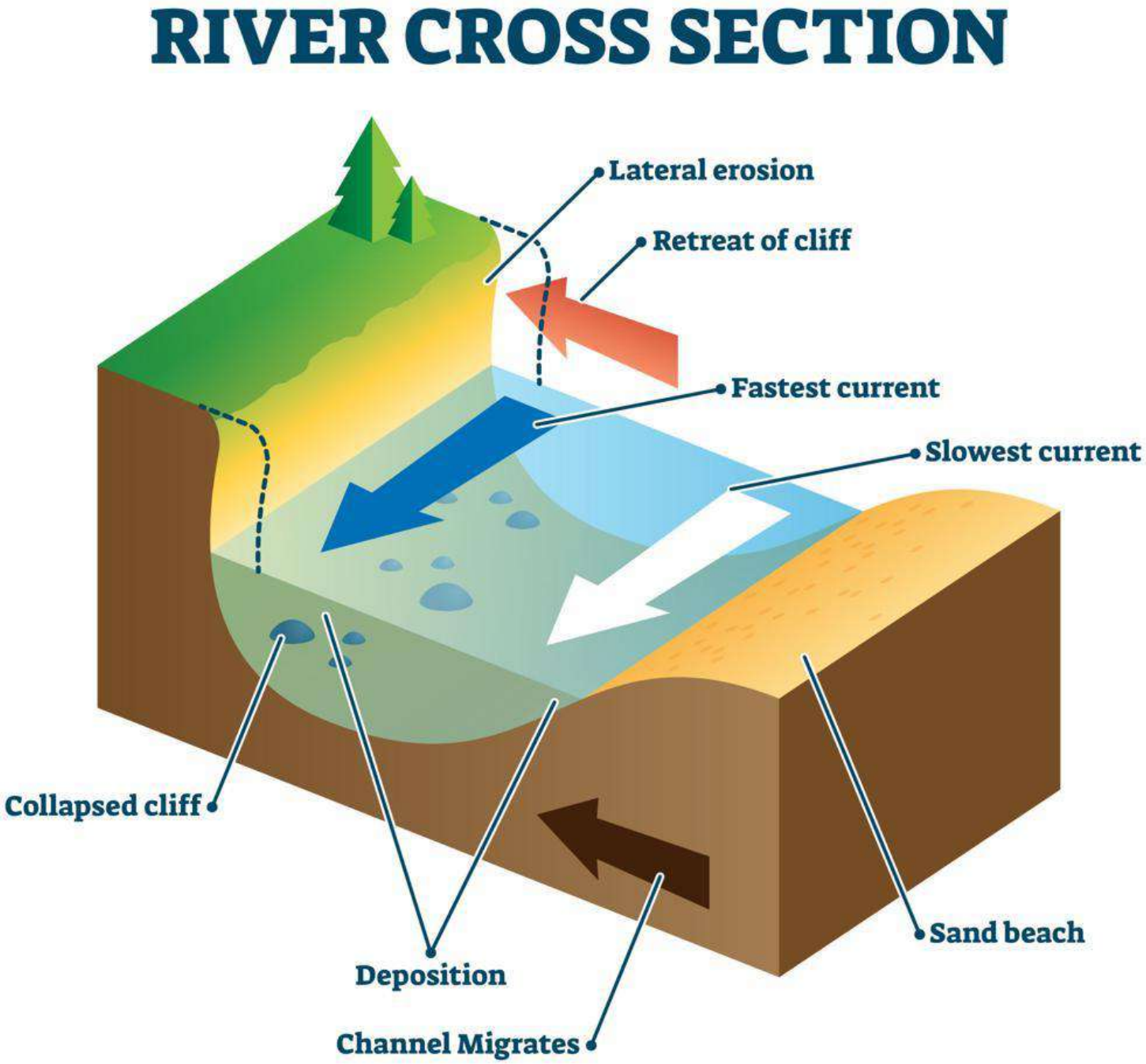
1.3 Difference Between Weathering and Erosion

Weathering and erosion are related geographical processes, but they are not the same.

Weathering	**Erosion**
Breakdown of rocks in their original position.	Wearing away and removal of materials.
Does not involve transportation.	Involves transportation of materials.
Mainly weakens and decomposes rocks.	Removes and transports loosened materials.
Can be physical, chemical or biological.	Mainly caused by running water, wind, ice, waves and gravity.
Example: cracking of granite.	Example: removal of soil by a river.







Important: Weathering prepares rocks for erosion by breaking them down and weakening their structure.

PART 2: AGENTS OF WEATHERING

2.1 Meaning of Agents of Weathering

Agents of weathering are natural elements, forces and organisms that cause the breakdown or decomposition of rocks at or near the Earth's surface.

The major agents include:

1. Temperature changes.
2. Water.
3. Ice and frost.

4. Wind.
5. Oxygen.
6. Carbon dioxide.
7. Acids.
8. Living organisms.
9. Pressure changes.

2.2 Temperature Changes

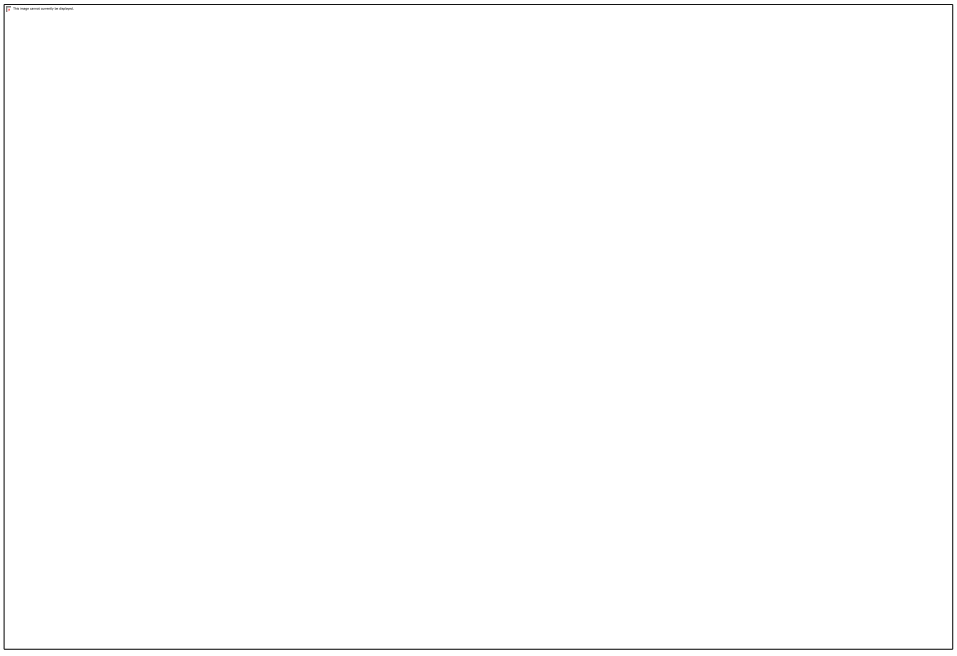
Temperature changes contribute to the breakdown of rocks through repeated heating and cooling.

How temperature changes cause weathering

1. During the day, exposed rocks absorb heat from the sun.
2. The heat causes the rocks to expand.
3. At night, temperatures fall and the rocks lose heat.
4. The rocks contract as they cool.
5. Repeated expansion and contraction create stress within the rocks.
6. Cracks gradually develop.
7. Eventually, parts of the rocks break away.

Areas where temperature changes are important

- Turkana.
- Marsabit.
- Garissa.
- Kajiado.
- Other arid and semi-arid regions.



2.3 Water

Water is one of the most important agents of weathering because it participates in both physical and chemical processes.

How water causes weathering

- Rainwater enters cracks and joints in rocks.
- Water dissolves soluble minerals.
- Water reacts with minerals to produce new substances.
- Water facilitates oxidation and hydrolysis.
- Water may freeze inside rock cracks in cold environments.
- Water contributes to the expansion of certain minerals through hydration.

Importance of water in weathering

1. Provides a medium for chemical reactions.
2. Dissolves soluble rock minerals.
3. Facilitates the formation of carbonic acid.
4. Enables frost action in cold regions.
5. Supports biological weathering by maintaining moisture.

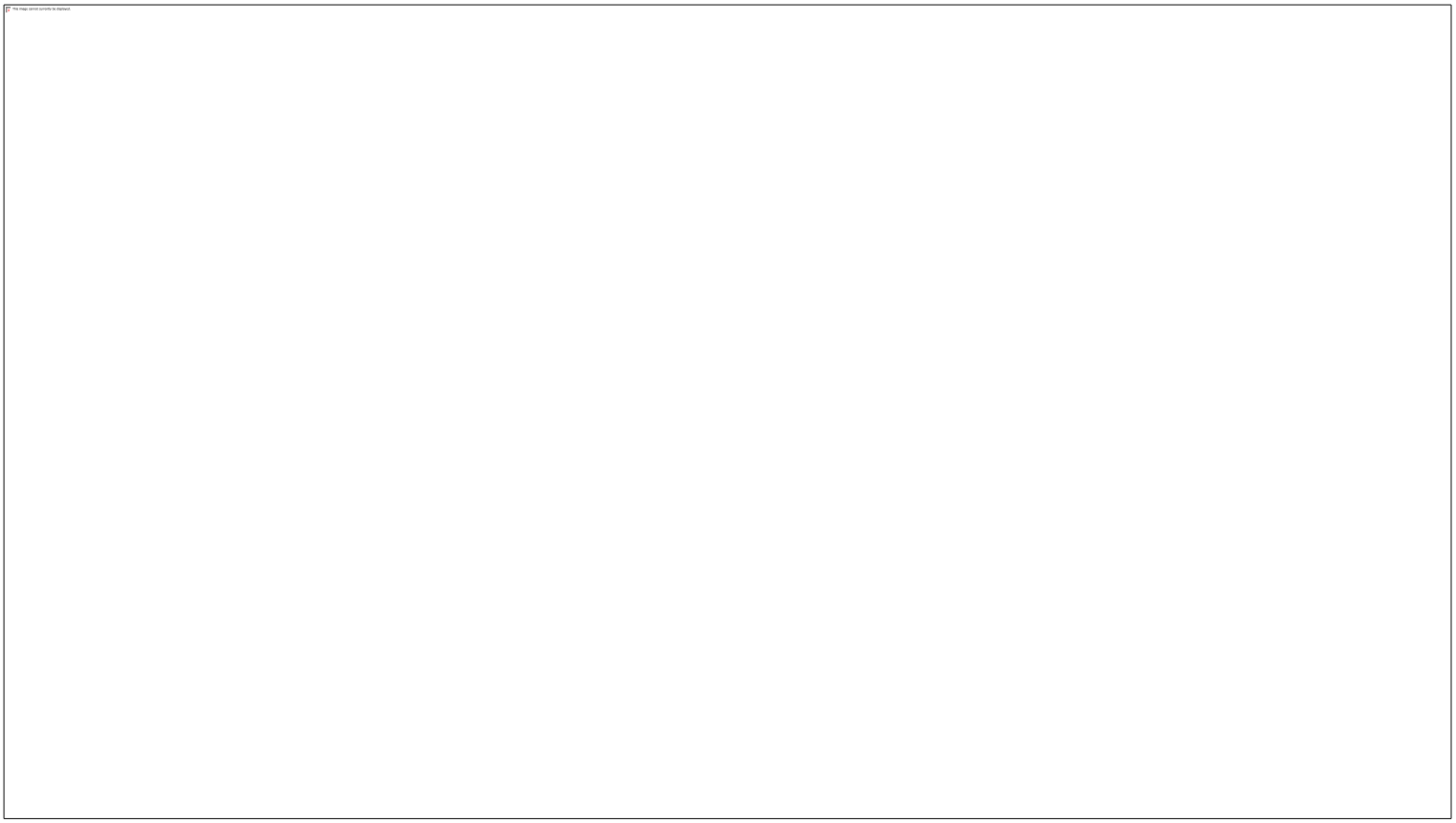
2.4 Ice and Frost

Ice contributes to weathering through freezing and thawing.

When water freezes, it expands and exerts pressure on the surrounding rock.

How ice causes weathering

1. Water enters cracks and joints in rocks.
2. Temperatures fall below freezing point.
3. Water freezes and expands.
4. The expanding ice exerts pressure on the rock.
5. When temperatures rise, the ice melts.
6. More water enters the enlarged cracks.
7. Repeated freezing and thawing eventually breaks the rock.



This process is common in cold mountain environments and high-altitude areas where temperatures frequently fluctuate around the freezing point.

2.5 Wind

Wind contributes to weathering through the movement of sand and other small particles.

- Wind carries sand particles.
- The particles strike exposed rock surfaces.
- Repeated impacts wear away the rock surface.
- Small fragments are gradually loosened.
- The exposed rock develops worn and sometimes polished surfaces.

This process is known as **wind abrasion**.

It is particularly important in dry environments where loose sand is abundant.

2.6 Oxygen

Oxygen contributes to chemical weathering through oxidation.

- Oxygen comes into contact with minerals containing iron.
- In the presence of moisture, chemical reactions occur.
- Iron oxides are formed.
- The rock may develop reddish-brown or yellowish stains.
- The altered minerals may become weaker and more easily decomposed.

2.7 Carbon Dioxide

Carbon dioxide contributes to chemical weathering through carbonation.

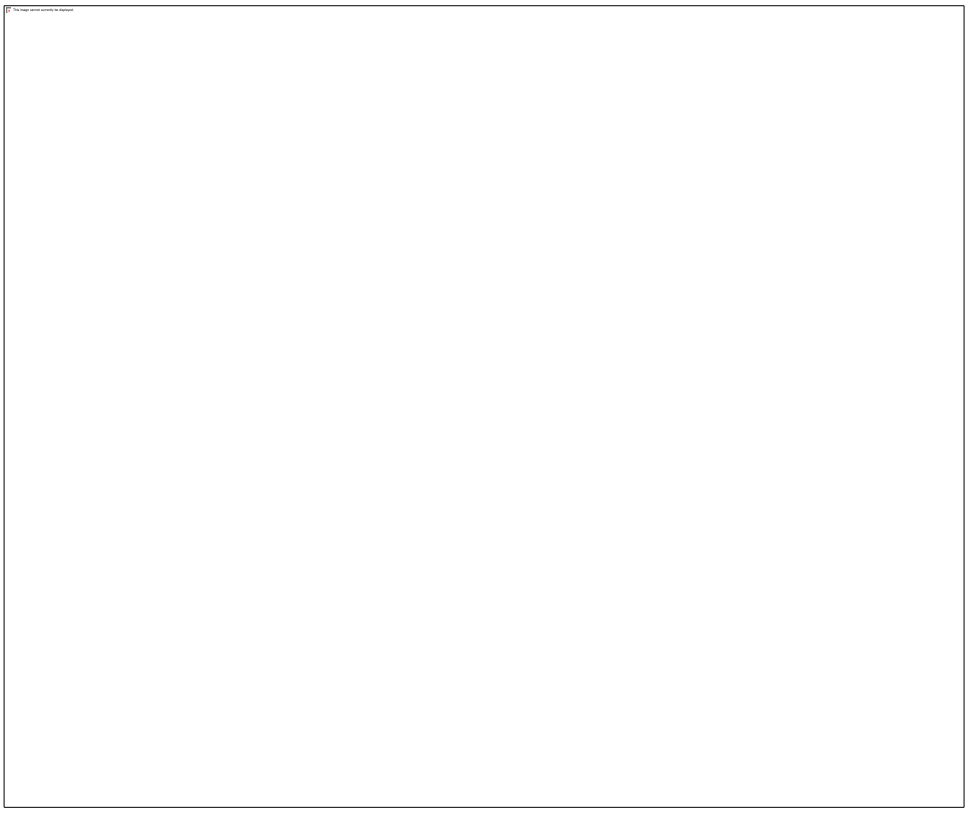
- Carbon dioxide from the atmosphere dissolves in rainwater.
- It forms weak carbonic acid.
- The acid reacts with calcium carbonate in limestone.
- Soluble calcium bicarbonate is produced.
- The dissolved material is gradually removed by water.

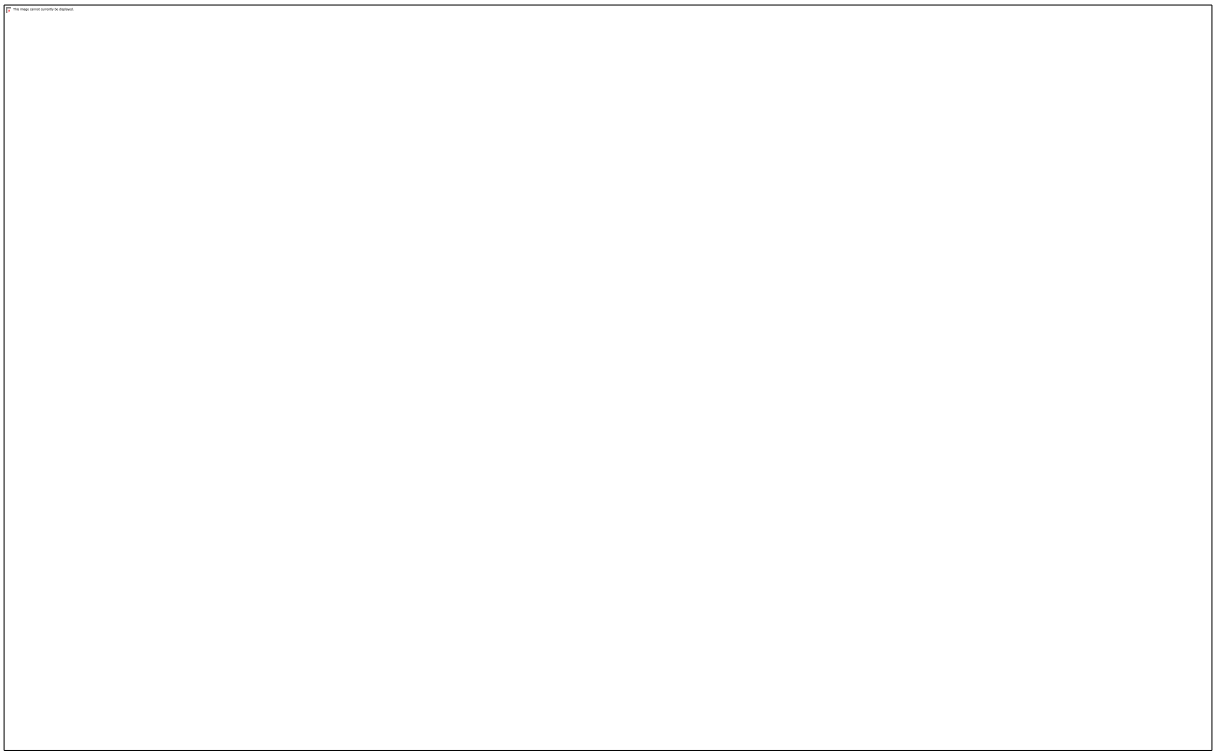
2.8 Living Organisms

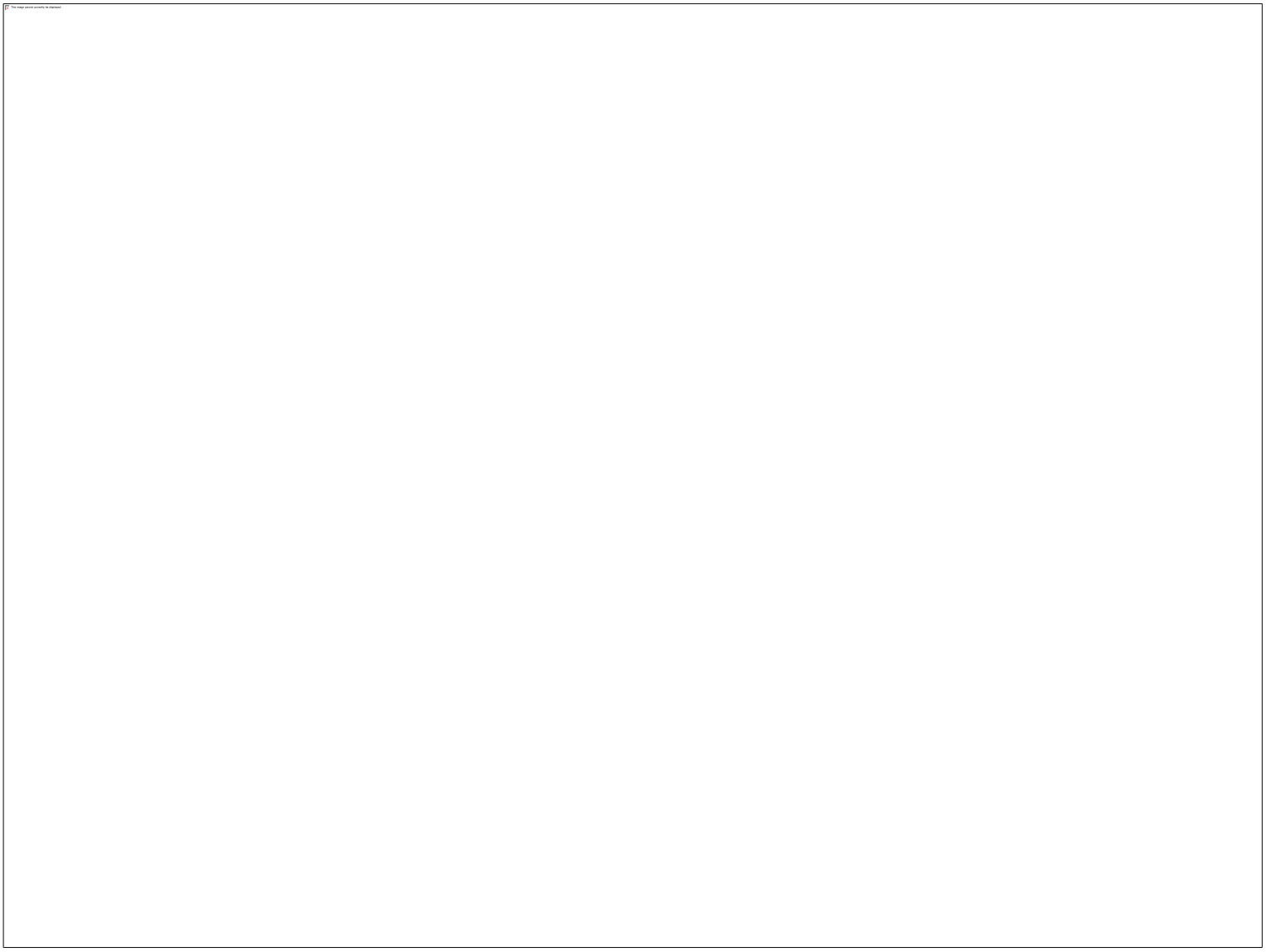
Plants, animals and microorganisms contribute to weathering.

Examples include:

- Tree roots growing into cracks.
- Earthworms loosening soil and weathered materials.
- Termites excavating underground tunnels.
- Lichens producing organic acids.
- Human beings breaking rocks during quarrying and construction.



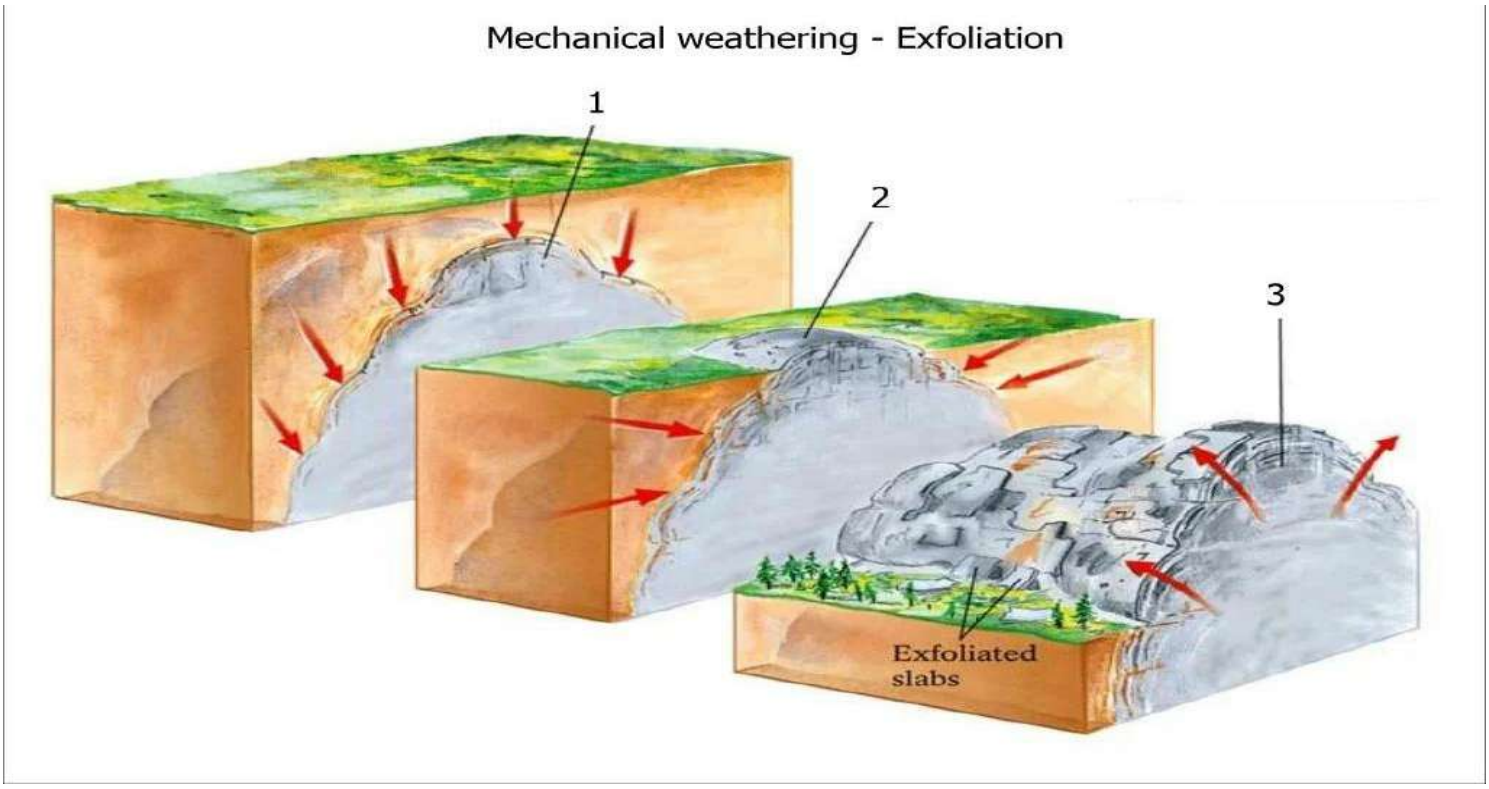


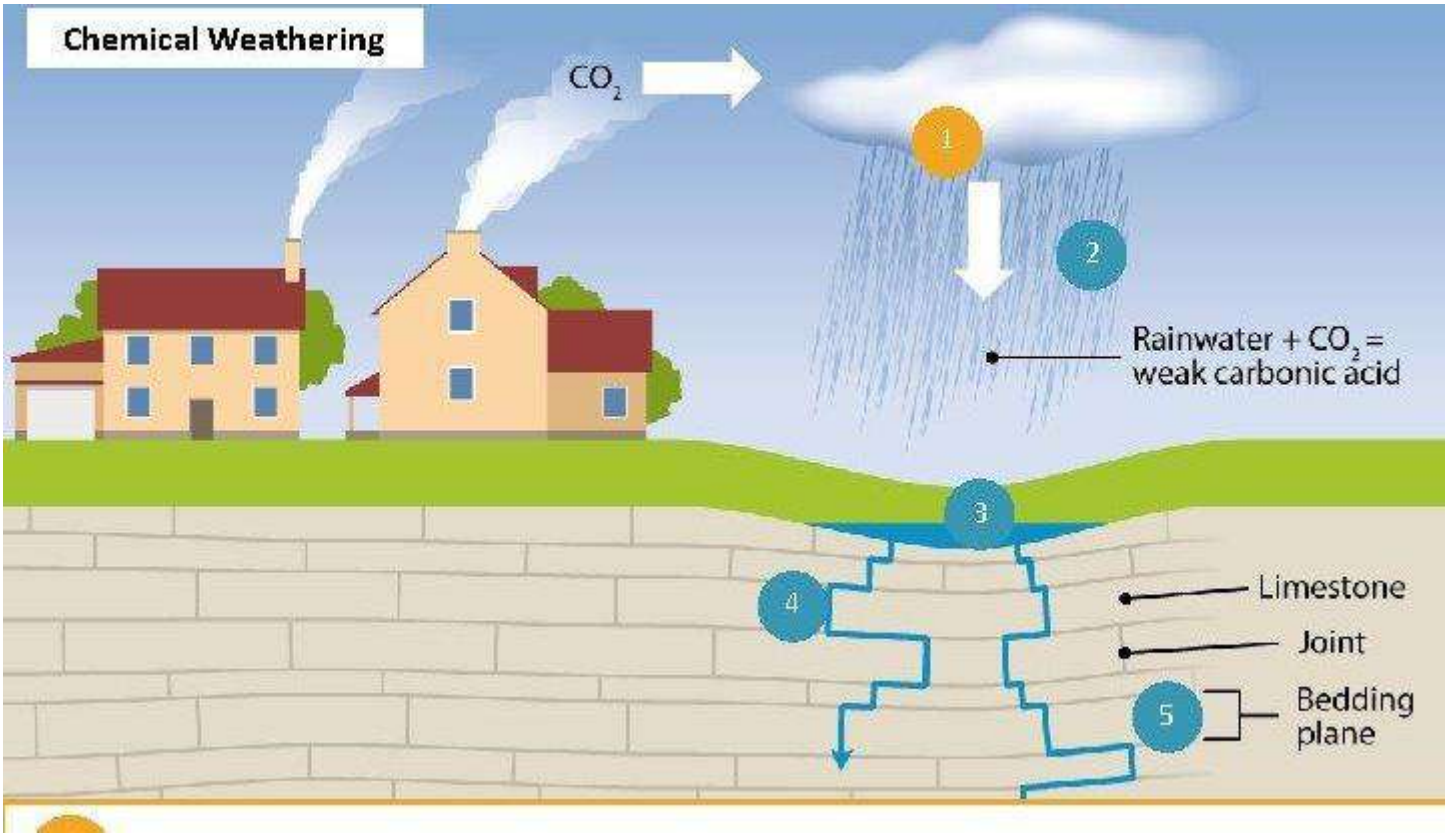


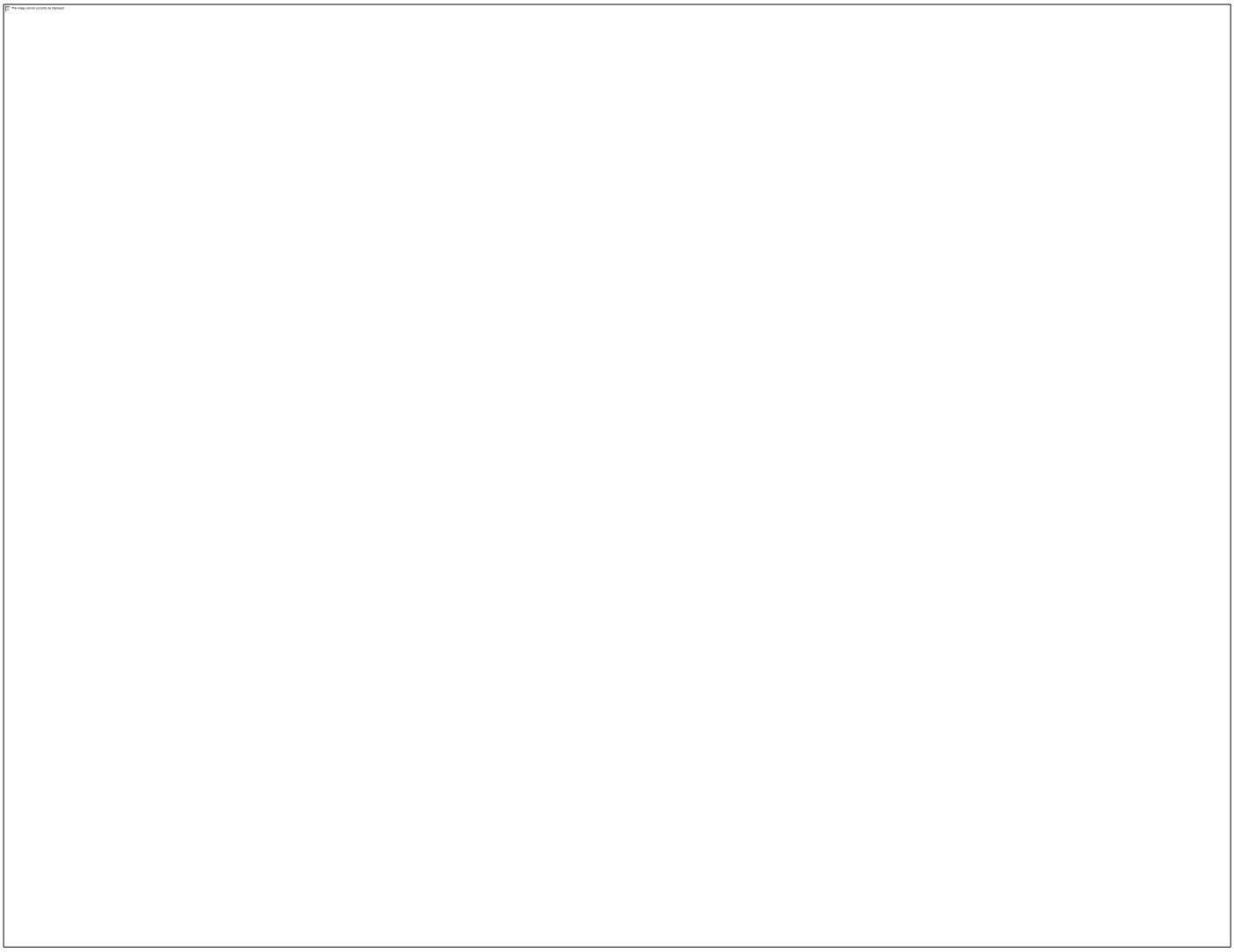
PART 3: TYPES OF WEATHERING

Weathering is classified into three major types:

1. Physical or mechanical weathering.
2. Chemical weathering.
3. Biological weathering.







3.1 PHYSICAL OR MECHANICAL WEATHERING

Meaning

Physical weathering is the breakdown of rocks into smaller fragments without changing their chemical composition.

It occurs when physical forces weaken and break rocks.

The original minerals making up the rocks remain chemically unchanged.

Characteristics of Physical Weathering

1. It breaks large rocks into smaller fragments.
2. It does not alter the chemical composition of the rock.
3. It involves physical forces rather than chemical reactions.
4. It is common in areas experiencing extreme temperature variations.
5. It increases the surface area exposed to further weathering.
6. It may occur in hot, cold and semi-arid environments.

Main Processes of Physical Weathering

A. Exfoliation

Exfoliation is the physical weathering process through which the outer layers of a rock peel off in curved sheets.

It is also called onion-skin weathering because the layers peel away in a manner similar to the layers of an onion.



How exfoliation occurs

1. Massive rocks are exposed at the Earth's surface.
2. The outer layers absorb heat during the day.
3. The outer layers expand due to increased temperatures.
4. During cooler periods, the rocks contract.
5. Repeated expansion and contraction create stress.
6. Cracks develop parallel to the rock surface.
7. Outer layers gradually separate from the main rock mass.
8. Curved sheets of rock eventually peel away.

Exfoliation may also occur through pressure release when overlying rocks are removed and the underlying rocks expand.

Conditions favouring exfoliation

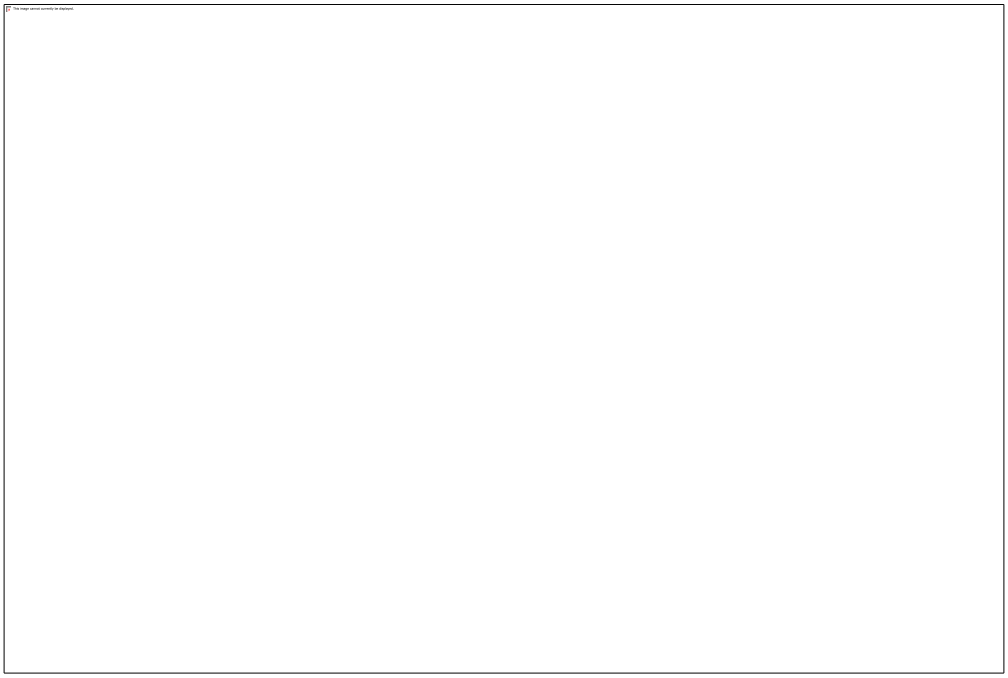
- Large temperature variations.
- Exposure of massive rocks.
- Repeated heating and cooling.
- Reduction of pressure on deeply buried rocks.
- Presence of suitable rock joints.

Effects of exfoliation

1. Produces rounded rock surfaces.
2. Contributes to the formation of granite domes.
3. Produces loose rock fragments.
4. Exposes fresh rock surfaces.
5. Contributes to landscape development.

B. Block Disintegration

Block disintegration is the breakdown of rocks into large angular blocks along existing joints and cracks.



How block disintegration occurs

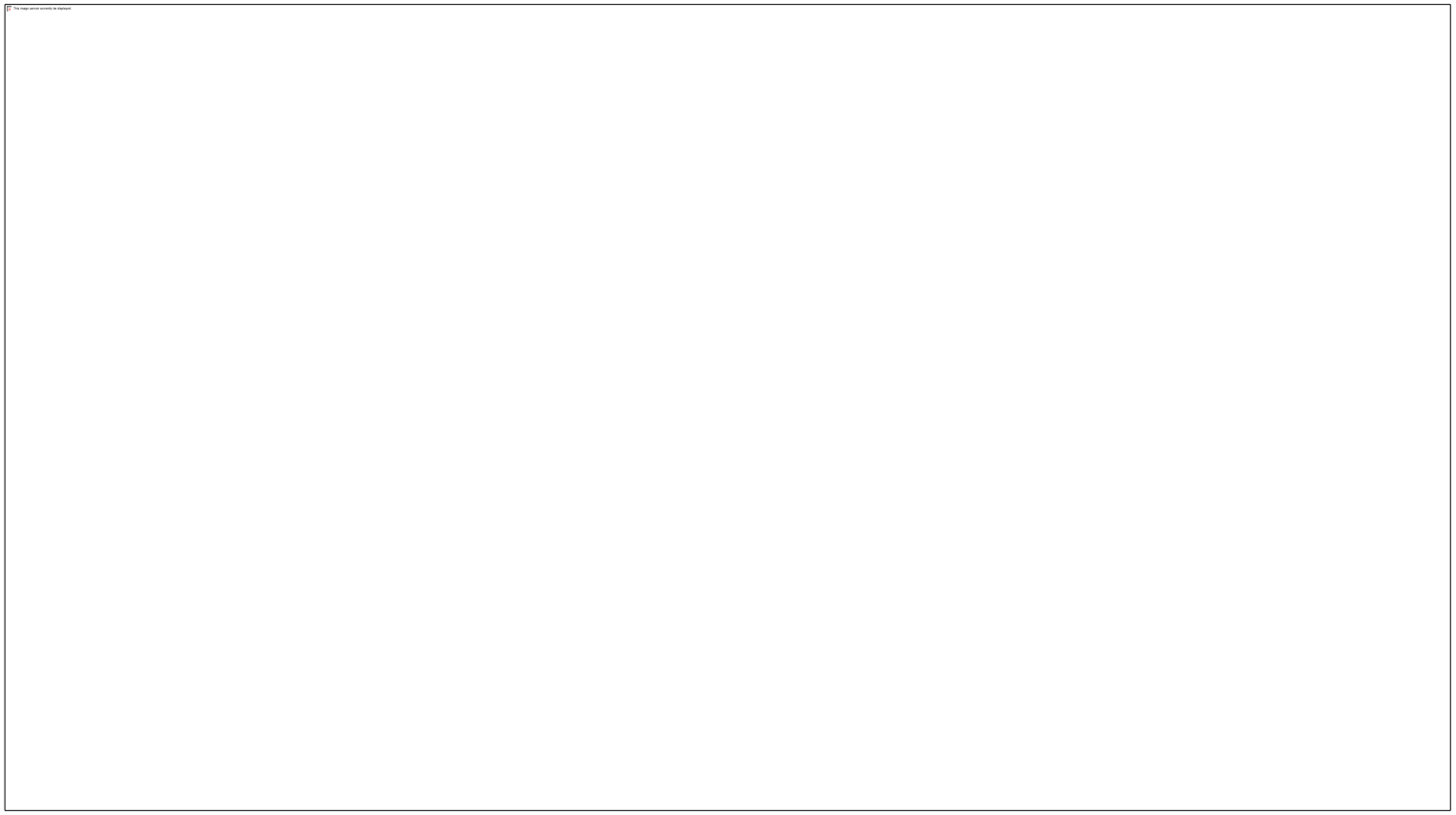
1. Rocks contain natural joints and cracks.
2. Temperature changes cause repeated expansion and contraction.
3. Water enters the cracks.
4. In cold environments, freezing water may exert pressure on the joints.
5. The cracks gradually widen.
6. Sections of rock separate along the joints.
7. Large angular blocks are formed.

Characteristics

- Produces angular rock blocks.
- Common in jointed rocks.
- Can be accelerated by frost action.
- Exposes additional surfaces to weathering.

C. Granular Disintegration

Granular disintegration is the breakdown of rocks into individual mineral grains due to differences in the expansion and contraction of their constituent minerals.



How granular disintegration occurs

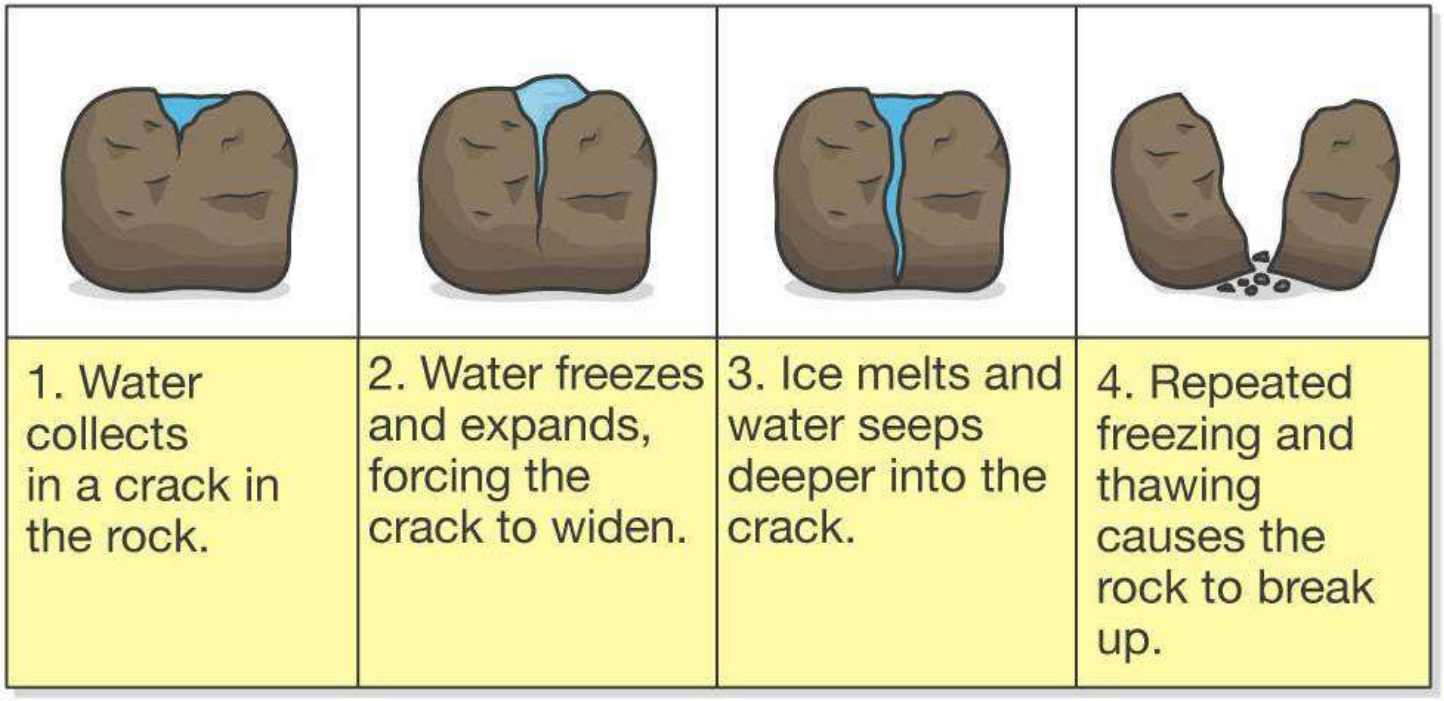
1. Rocks are made up of different mineral grains.
2. Different minerals expand and contract at different rates.
3. Repeated heating and cooling creates stress between the grains.
4. The bonds holding the grains together gradually weaken.
5. Individual mineral grains become detached.
6. The rock breaks down into loose particles.

Examples

- Disintegration of exposed granite.
- Formation of coarse mineral particles.
- Breakdown of rocks containing minerals with different thermal properties.

D. Frost Wedging

Frost wedging is the breakdown of rocks caused by the freezing and expansion of water inside rock cracks.



Stages involved

1. Water enters cracks and joints.
2. Temperatures fall below freezing point.
3. Water freezes and expands.
4. Ice exerts pressure on the surrounding rock.
5. The ice melts when temperatures rise.
6. More water enters the enlarged cracks.
7. Repeated freezing and thawing widens the cracks.
8. Pieces of rock eventually break away.

Conditions favouring frost wedging

- Availability of water.
- Frequent freezing and thawing.
- Presence of joints and cracks.
- Temperatures fluctuating around 0°C.

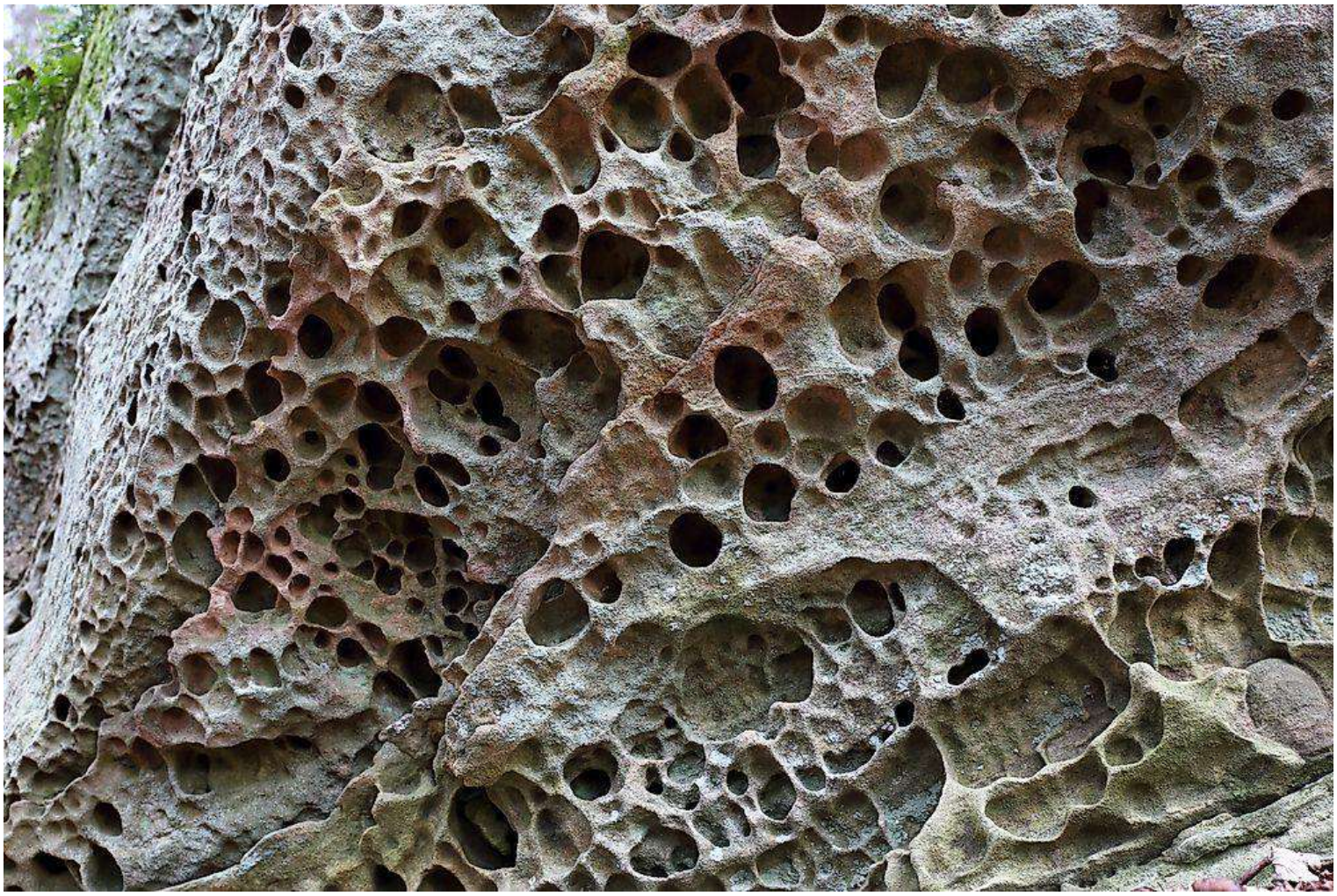
Areas where it occurs

- Mount Kenya.
- Mount Kilimanjaro.
- Other high-altitude mountain environments.
- Polar regions.

E. Salt Crystallisation

Salt crystallisation is the breakdown of rocks caused by the growth of salt crystals within cracks and pores.

It is also known as salt weathering or haloclasty.



How salt crystallisation occurs

1. Salty water enters cracks and pores in rocks.
2. High temperatures cause water to evaporate.
3. Dissolved salts remain behind.
4. Salt crystals begin to grow.
5. Growing crystals exert pressure on the walls of the pores.
6. Repeated crystallisation increases the pressure.
7. The rock gradually weakens.
8. Pieces of rock eventually break away.

Conditions favouring salt crystallisation

- High evaporation rates.
- Availability of salty water.
- Porous rocks.
- Dry climatic conditions.

- Alternating wetting and drying.

Areas where salt crystallisation is common

- Coastal regions.
- Desert environments.
- Semi-arid regions.
- Areas with saline groundwater.

F. Wetting and Drying

Wetting and drying is the physical breakdown of rocks caused by repeated absorption and loss of moisture.

How it occurs

1. Rocks absorb water during rainy periods.
2. Certain minerals, especially clay minerals, expand.
3. During dry periods, the water evaporates.
4. The minerals contract.
5. Repeated expansion and contraction create stress.
6. Cracks develop and the rock gradually breaks down.

This process is particularly important in rocks containing clay minerals.

G. Pressure Release or Unloading

Pressure release is the physical weathering process that occurs when overlying rocks are removed, reducing the pressure on underlying rocks.



How pressure release occurs

1. Rocks are buried beneath thick layers of other materials.
2. The overlying materials exert pressure on the underlying rocks.

3. Erosion removes the overlying materials.
4. Pressure on the underlying rocks decreases.
5. The rocks expand.
6. Cracks develop parallel to the exposed surface.
7. Outer layers may eventually separate and peel off.

Importance

- Contributes to exfoliation.
- Produces sheet joints.
- Exposes fresh rock surfaces.
- Helps create rounded granite domes.

3.2 CHEMICAL WEATHERING

Meaning of Chemical Weathering

Chemical weathering is the breakdown and decomposition of rocks through chemical reactions that change the chemical composition of the original minerals.

During chemical weathering, minerals may dissolve, combine with other substances or change into new minerals.

Characteristics of Chemical Weathering

1. It changes the chemical composition of rocks.
2. It involves chemical reactions between minerals and environmental substances.
3. It is favoured by warm and moist conditions.
4. It may produce new minerals such as clay.
5. It contributes to soil formation.
6. It is particularly effective in areas with abundant rainfall.
7. It may occur alongside physical weathering.

Major Processes of Chemical Weathering

A. Solution

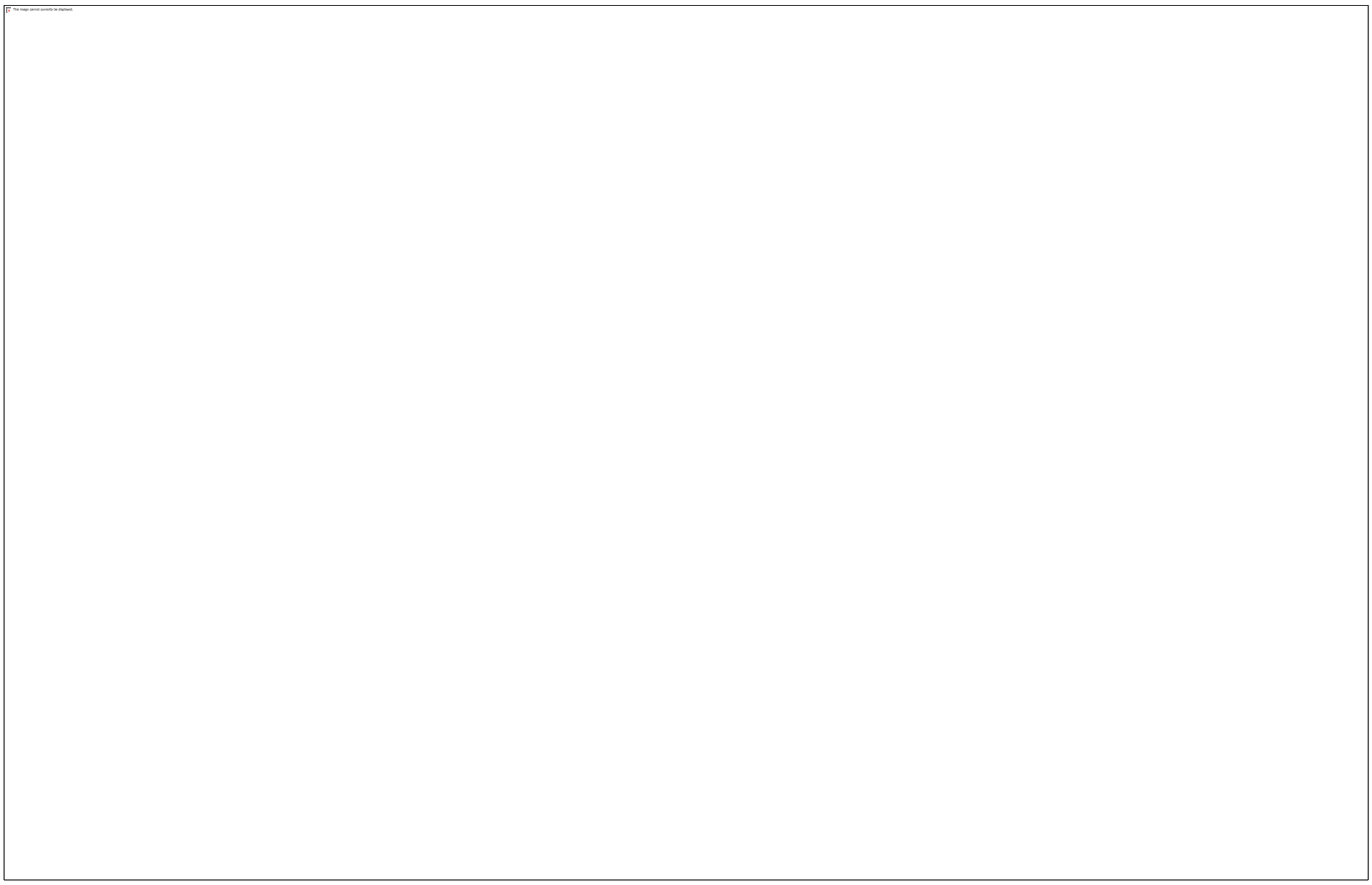
Solution is the chemical weathering process through which soluble minerals in rocks dissolve directly in water.

How solution occurs

1. Rainwater comes into contact with rocks containing soluble minerals.
2. Water dissolves the minerals.
3. The dissolved substances form a solution.
4. The solution is gradually removed by flowing or underground water.
5. The remaining rock becomes weaker and may disintegrate.

Examples of soluble minerals

- Rock salt.
- Gypsum.
- Certain carbonate minerals.



Significance of solution

- Weakens rocks.
- Contributes to the formation of underground cavities.
- Removes soluble minerals from rocks.
- Contributes to landscape development.

B. Carbonation

Carbonation is the chemical weathering process through which carbon dioxide dissolves in water to form weak carbonic acid, which reacts with minerals in rocks, especially calcium carbonate in limestone.

Formation of carbonic acid

$CO_2 + H_2O \rightarrow H_2CO_3$

Where:

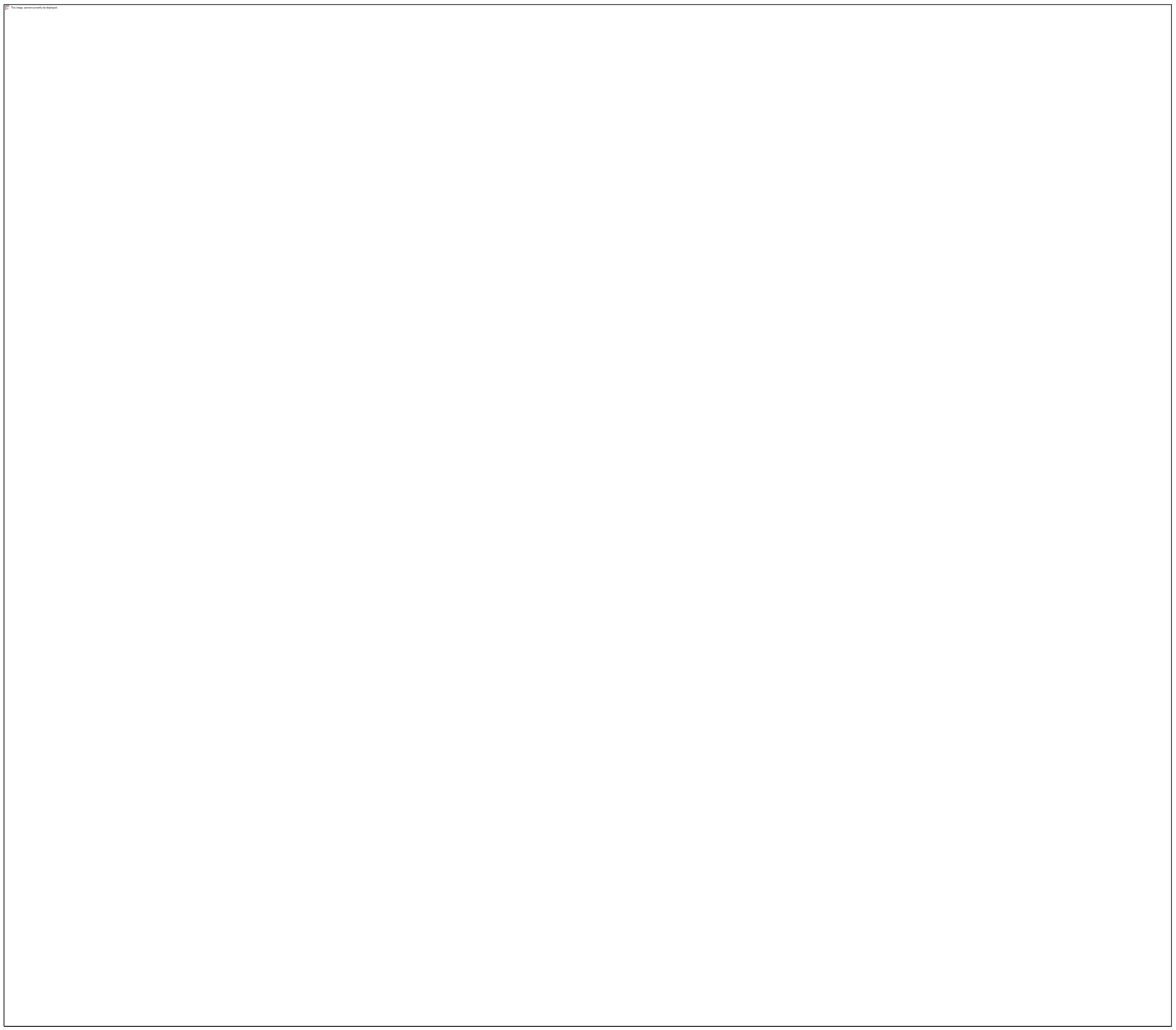
- CO_2 = Carbon dioxide.
- H_2O = Water.
- H_2CO_3= Carbonic acid.

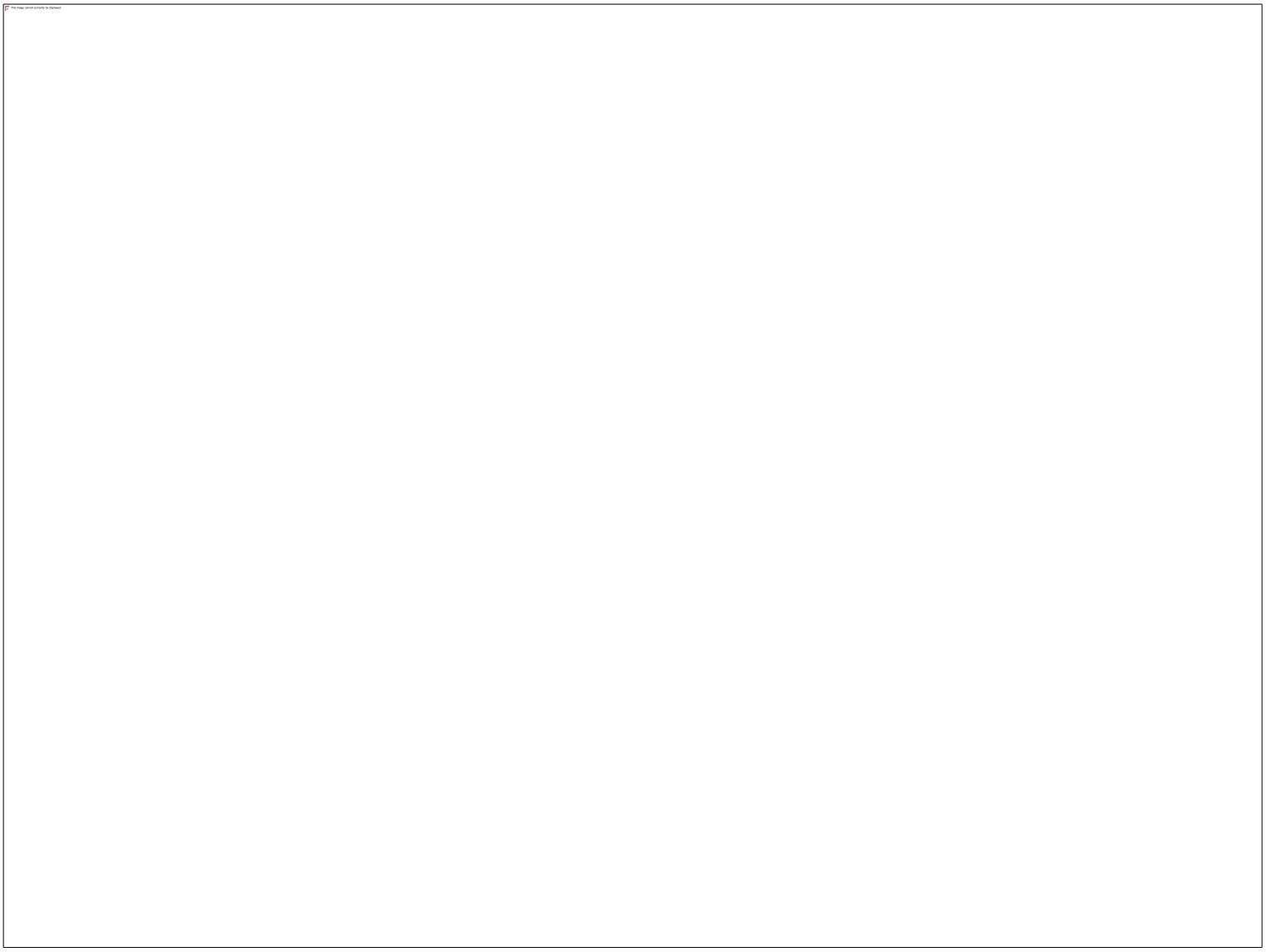
How carbonation occurs

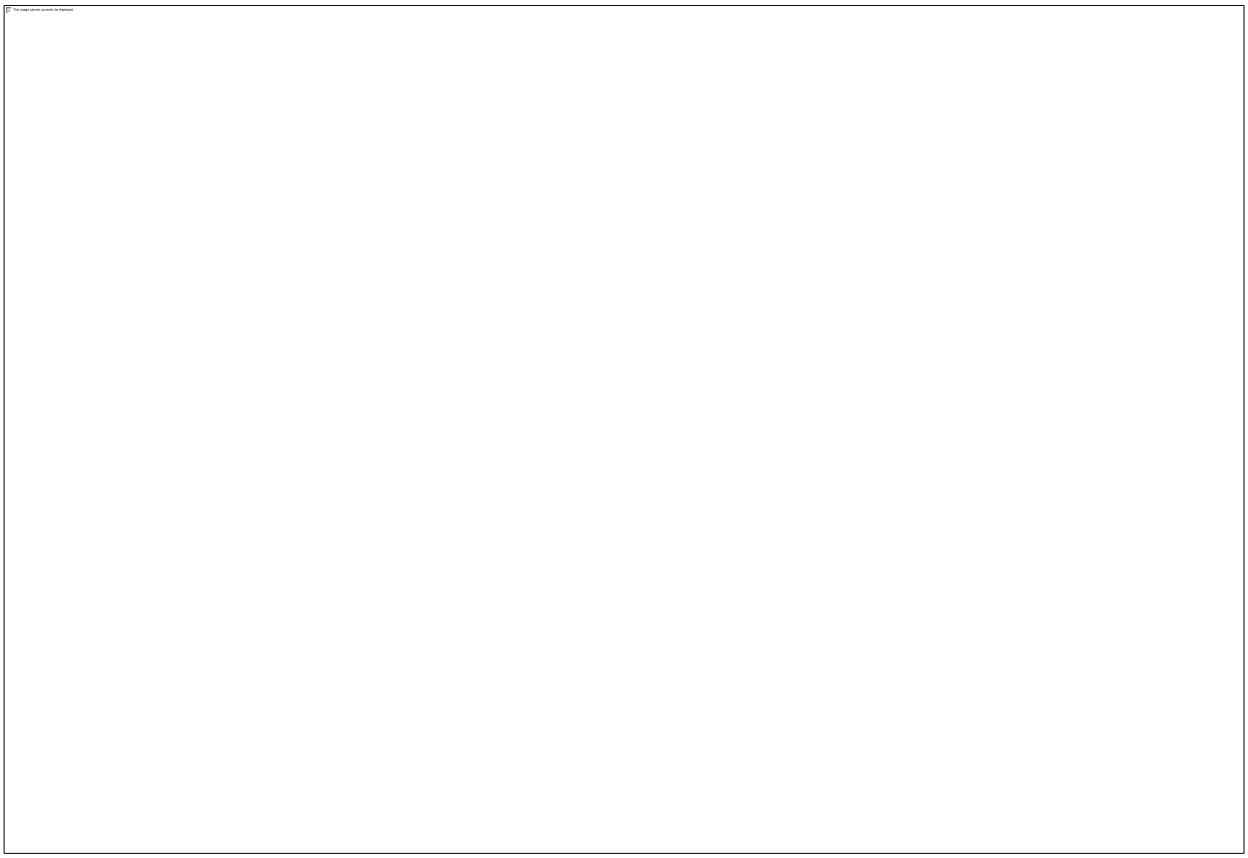
1. Rainwater absorbs carbon dioxide from the atmosphere and soil.
2. Carbon dioxide combines with water to form weak carbonic acid.
3. Acidic water comes into contact with limestone.
4. Carbonic acid reacts with calcium carbonate.
5. Soluble calcium bicarbonate is formed.
6. The dissolved material is carried away by water.
7. Limestone gradually dissolves.

The simplified chemical reaction is:

$CaCO_3 + H_2CO_3 \rightarrow Ca(HCO_3)_2$







Landforms associated with carbonation

1. Limestone pavements.
2. Clints and grikes.
3. Sinkholes or dolines.
4. Caves and caverns.
5. Underground drainage systems.
6. Enlarged joints and fissures.

Importance of carbonation

- Produces distinctive limestone landscapes.
- Contributes to cave formation.
- Creates underground drainage systems.
- Provides tourist attractions.
- Influences groundwater movement.

C. Oxidation

Oxidation is the chemical weathering process in which oxygen combines with certain minerals in rocks, particularly iron-bearing minerals, to form oxides.

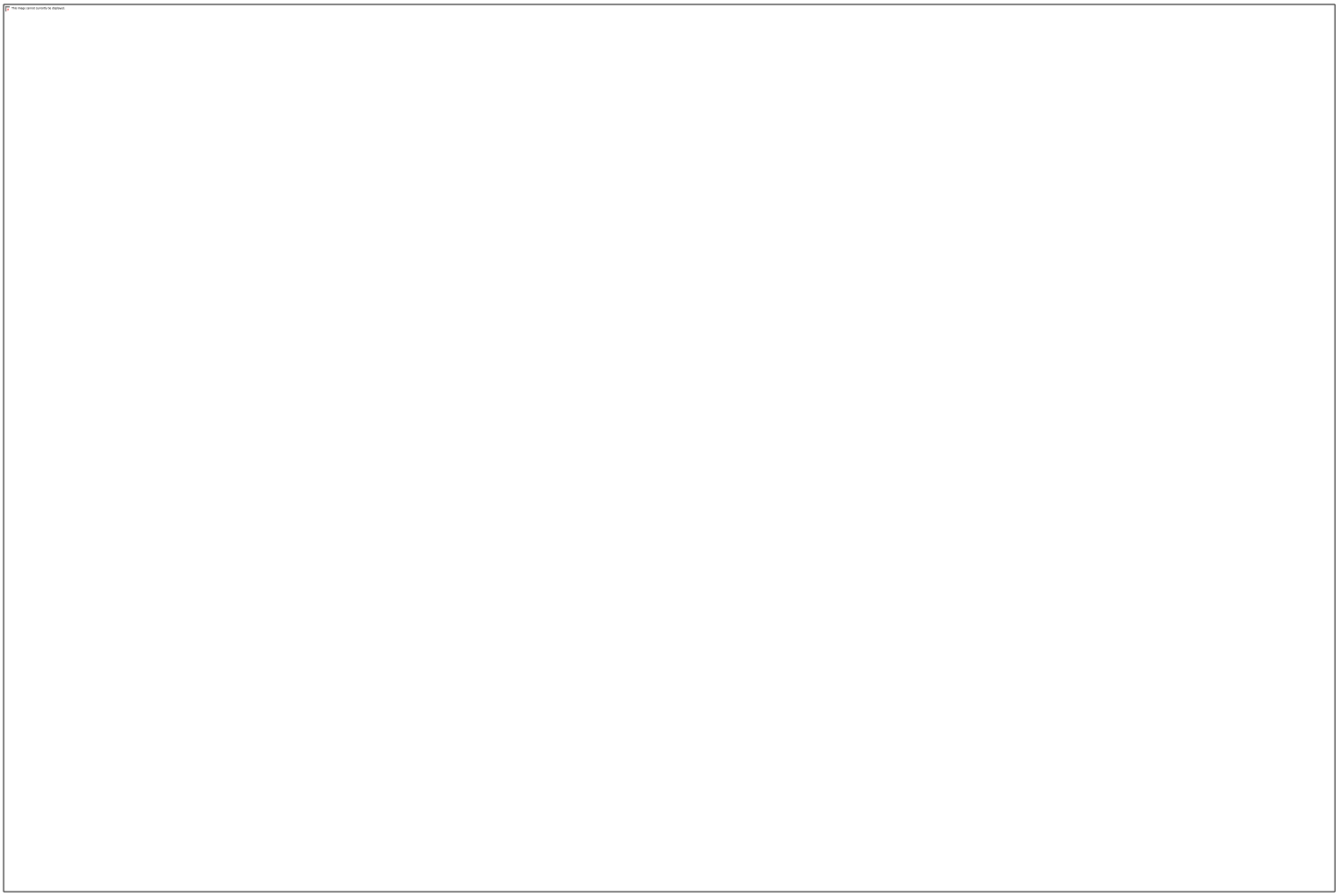
It is similar to the rusting of iron.

How oxidation occurs

1. Oxygen in the atmosphere comes into contact with iron-bearing minerals.
2. Water facilitates the reaction.
3. Iron reacts with oxygen.
4. Iron oxides are formed.
5. The rock may develop reddish-brown or yellowish stains.
6. The altered minerals may become weaker and contribute to rock decomposition.

A simplified chemical equation is:

$4Fe+3O_2 \rightarrow 2Fe_2O_34$



Conditions favouring oxidation

- Availability of oxygen.
- Presence of iron-bearing minerals.
- Moist conditions.
- Warm temperatures.

Examples

- Reddish-brown weathered rocks.
- Rust-coloured surfaces on iron-rich rocks.
- Decomposition of iron-bearing minerals.

D. Hydration

Hydration is the chemical weathering process through which water molecules are absorbed into the structure of certain minerals, causing them to expand and undergo chemical changes.

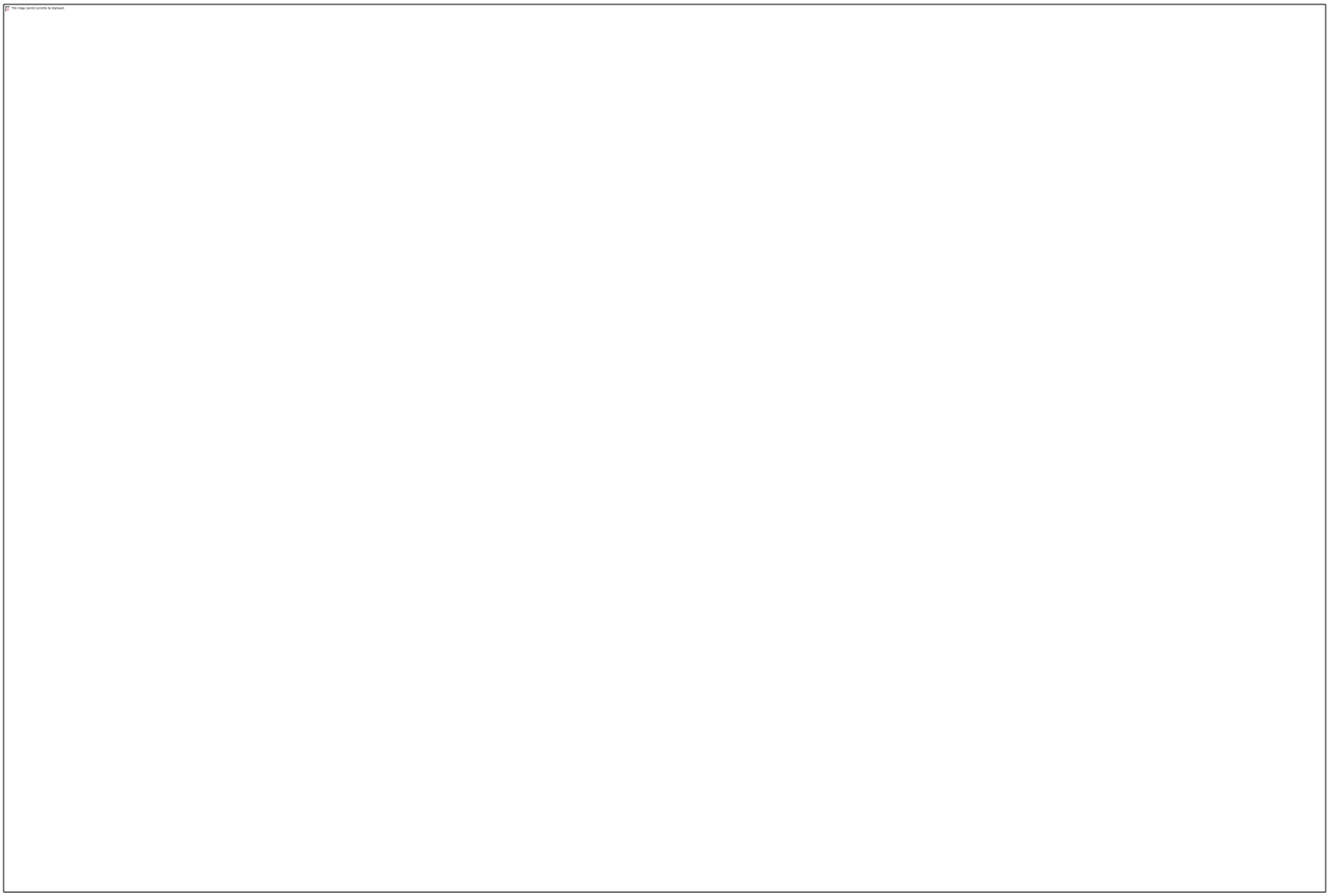
How hydration occurs

1. Water comes into contact with certain minerals.
2. The minerals absorb water molecules.
3. Their chemical structure changes.
4. The minerals increase in volume.

5. Internal pressure may develop within the rock.
6. The rock gradually weakens and breaks down.

Example: Conversion of anhydrite into gypsum

$CaSO_4 + 2H_2O \rightarrow CaSO_4 \cdot 2H_2O$



Importance of hydration

- Weakens rocks.
- Changes the structure of certain minerals.
- Contributes to mineral decomposition.
- Facilitates the formation of new minerals.

E. Hydrolysis

Hydrolysis is the chemical weathering process in which water reacts with minerals in rocks, causing them to decompose and form new minerals.

It is particularly important in the weathering of feldspar minerals found in granite.

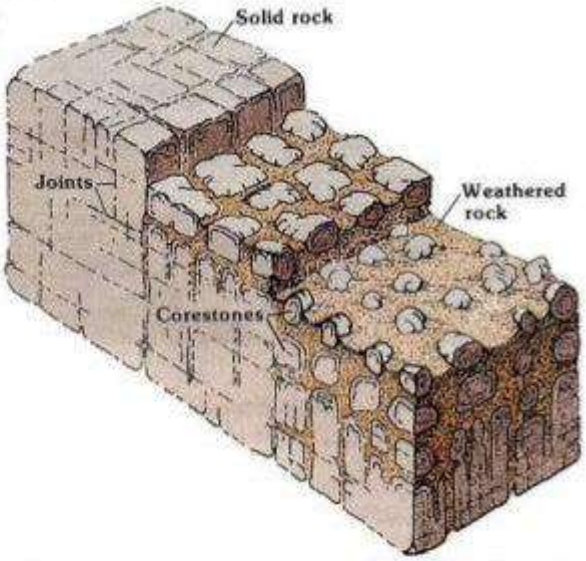
How hydrolysis occurs

1. Rainwater comes into contact with rocks containing feldspar.
2. Water reacts with feldspar minerals.
3. Hydrogen ions in water replace certain elements in the mineral structure.

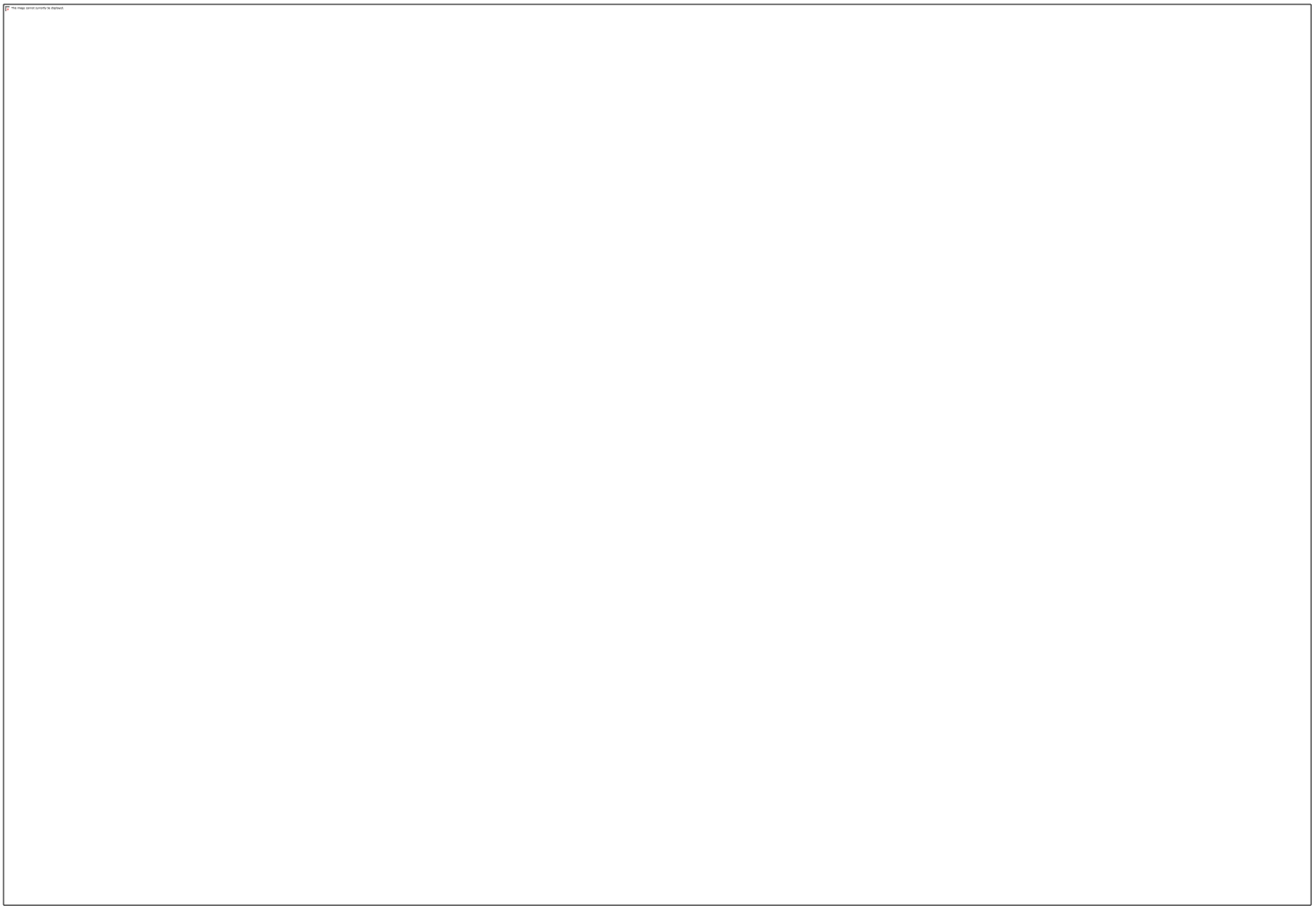
4. The original feldspar decomposes.
5. New clay minerals, such as kaolinite, may form.
6. Soluble substances are removed by water.
7. The rock gradually decomposes into softer materials.

Hydrolysis of granite





Hydrolysis processes take place when slightly acid rainwater dissolves some minerals like feldspars and transforms them into clay minerals. Granite is a hard and resistant rock, but becomes weakened and disintegrated when feldspars are broken down by hydrolysis and quartz crystals remain as loose debris, unaffected.



Example: Feldspar in granite may decompose to form kaolinite clay.

Conditions favouring hydrolysis

- High rainfall.
- Warm temperatures.
- Availability of water.
- Presence of feldspar minerals.
- Long periods of exposure to weathering.

Significance of hydrolysis

- Contributes to soil formation.
- Produces clay minerals.
- Releases soluble mineral nutrients.
- Weakens and decomposes granite rocks.

F. Organic Acid Weathering

Organic acid weathering occurs when weak acids produced by living organisms react with minerals found in rocks.

Sources of organic acids

- Plant roots.

- Decaying leaves.
- Lichens.
- Microorganisms.
- Decomposing organic matter.

How it occurs

1. Organic materials decompose.
2. Weak organic acids are released.
3. The acids come into contact with rock minerals.
4. Chemical reactions occur.
5. Some minerals dissolve or change chemically.
6. The rocks gradually weaken and decompose.



3.3 BIOLOGICAL WEATHERING

Meaning of Biological Weathering

Biological weathering is the breakdown or decomposition of rocks through the activities of living organisms.

It involves both physical and chemical processes.

Living organisms contribute to weathering through:

- Mechanical pressure.
- Burrowing activities.
- Production of organic acids.
- Decomposition of organic matter.
- Human activities.

Characteristics of Biological Weathering

1. It involves living organisms.
2. It can cause physical or chemical breakdown of rocks.
3. It occurs in environments where living organisms interact with rocks.

4. It may be accelerated by vegetation growth.
5. It contributes to soil formation.
6. It may increase the rate of physical and chemical weathering.

Processes of Biological Weathering

A. Root Wedging

Root wedging is the physical breakdown of rocks caused by plant roots growing into cracks and joints.



How root wedging occurs

1. Seeds germinate in cracks found in rocks.
2. Plant roots grow into the cracks.
3. The roots increase in length and thickness.
4. Growing roots exert pressure on the walls of the cracks.
5. The cracks gradually become wider.
6. Eventually, pieces of rock break away.

Examples in Kenya

- Trees growing on rocky slopes.
- Grass growing in cracks in pavements.
- Shrubs growing on exposed rocky surfaces.
- Trees growing between rock joints in forested environments.

Effects of root wedging

- Breaks rocks into smaller pieces.
- Creates spaces for water to enter rocks.
- Contributes to soil formation.
- Exposes fresh rock surfaces.
- Weakens rocky slopes.

B. Burrowing Animals

Burrowing animals contribute to physical weathering by digging holes and tunnels in soil and weathered rock materials.

Examples of burrowing animals

- Earthworms.
- Moles.
- Termites.
- Ants.
- Rabbits.
- Rodents.



How burrowing animals cause weathering

1. Animals dig holes and tunnels in the ground.
2. Their movements loosen soil and weathered rock materials.
3. Some animals expose buried rocks to air and water.
4. The exposed rocks become more vulnerable to physical and chemical weathering.
5. Repeated burrowing contributes to the breakdown of materials.

Importance of burrowing animals

- Loosen soil materials.
- Improve soil aeration.
- Increase water infiltration.
- Expose fresh rock surfaces.
- Contribute to soil development.

C. Weathering by Lichens and Mosses

Lichens are organisms formed through a close association between fungi and algae or cyanobacteria. Mosses are small non-vascular plants commonly found in moist environments.

They contribute to weathering through physical and chemical processes.





How lichens cause weathering

1. Lichens grow on exposed rock surfaces.
2. They attach themselves firmly to the rocks.

3. They produce weak organic acids.
4. The acids react with minerals in the rocks.
5. Some minerals dissolve or decompose.
6. Small particles are gradually released from the rock surface.

How mosses contribute to weathering

- Mosses grow in cracks and on damp rock surfaces.
- They retain moisture against the rocks.
- Their growth may contribute to physical weakening.
- They trap dust and organic matter.
- They create conditions favourable for further chemical weathering.

D. Weathering Through Human Activities

Human activities contribute to the breakdown of rocks and expose fresh rock surfaces to environmental conditions.

1. Mining

- Mining involves removing rocks and minerals from the ground.
- Blasting and excavation break rocks into smaller pieces.
- Exposed rocks become more vulnerable to further weathering.

2. Quarrying

- Quarrying involves extracting building stones and other materials.
- Cutting and blasting weaken rock structures.
- Exposed rock surfaces become vulnerable to weathering.

3. Construction

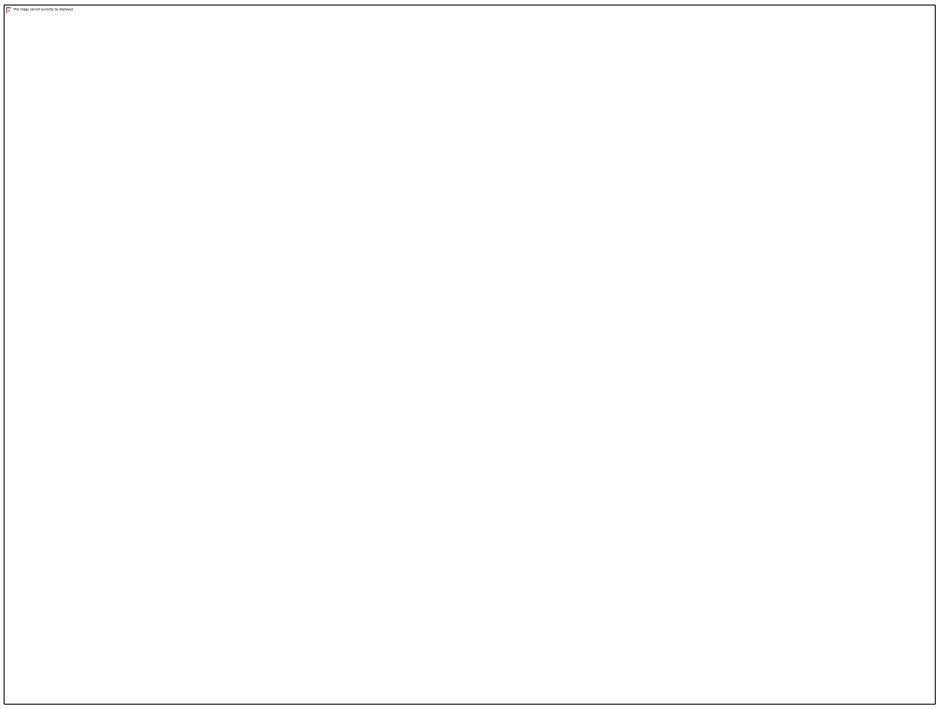
- Construction involves cutting, drilling and breaking rocks.
- These activities expose fresh rock surfaces.
- Exposed surfaces become vulnerable to temperature changes and chemical reactions.

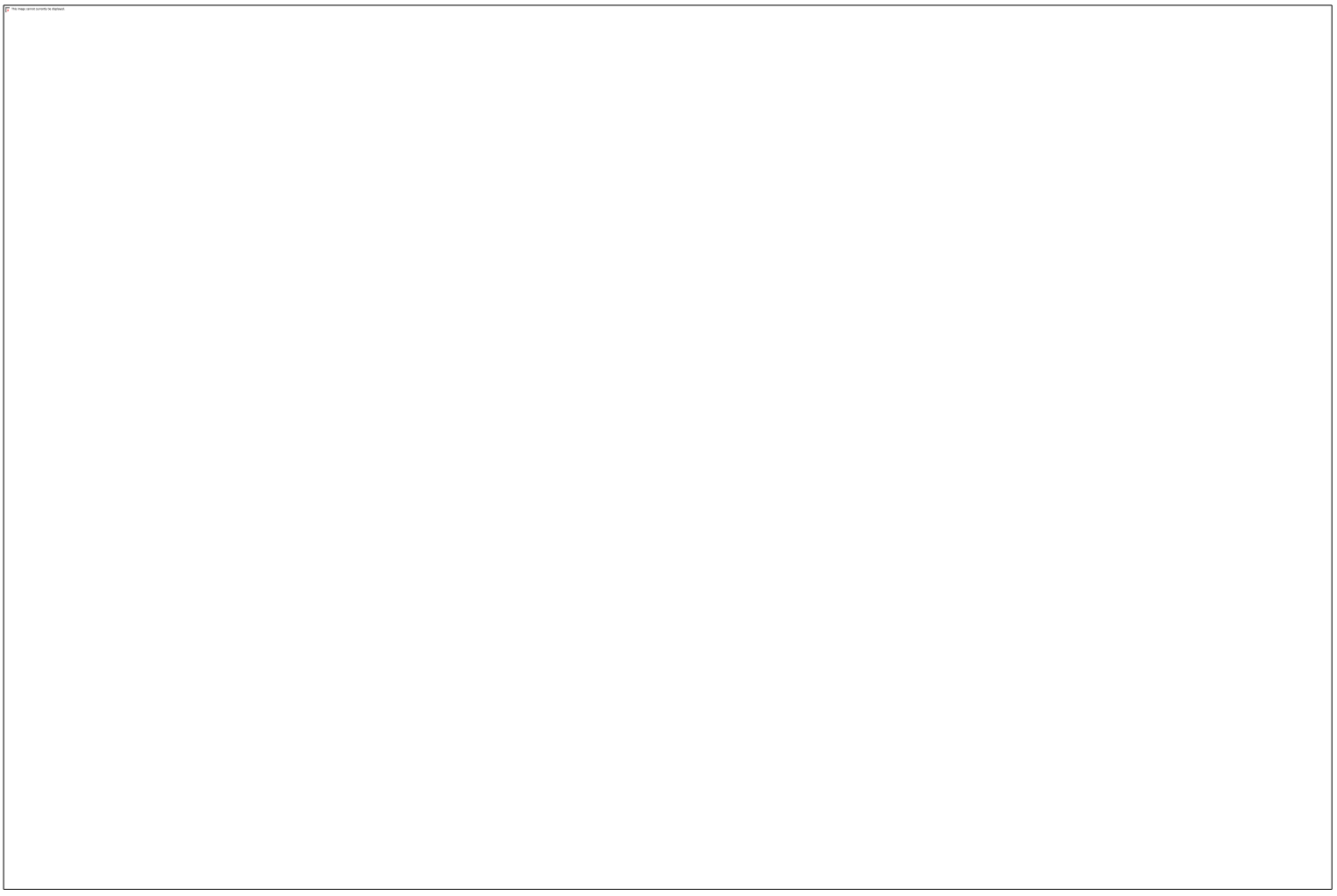
4. Agriculture

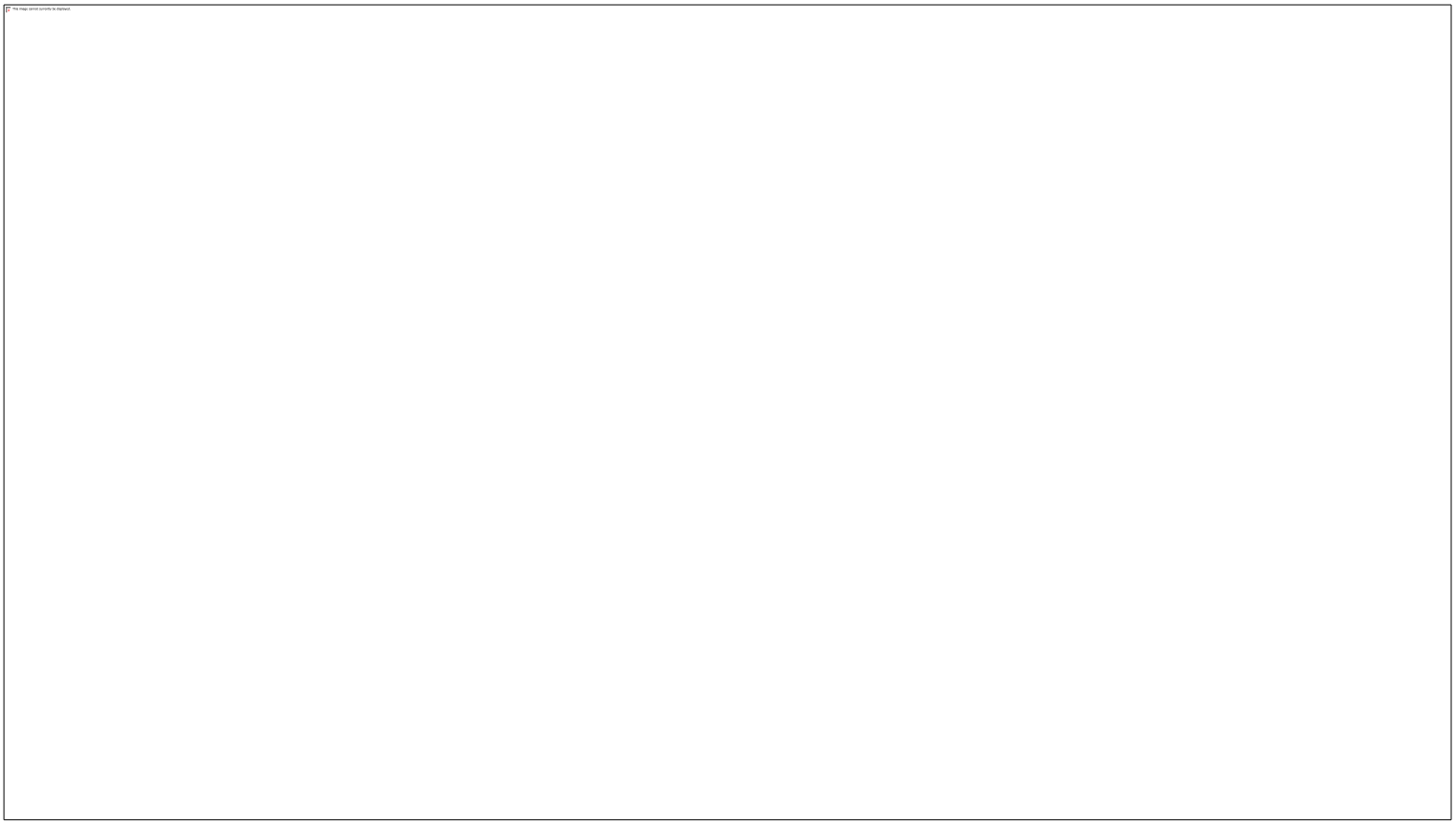
- Ploughing and digging disturb soil and weathered materials.
- Agricultural activities expose underlying materials to air and water.
- Heavy machinery may break and loosen rock materials.

5. Road construction

- Cutting through hills exposes fresh rock surfaces.
- Blasting creates cracks and fractures.
- Exposed rocks undergo further weathering.







PART 4: FACTORS INFLUENCING THE RATE OF WEATHERING

4.1 Meaning of Rate of Weathering

The rate of weathering refers to the speed at which rocks are broken down or decomposed by natural weathering processes.

Different environmental and geological factors determine how quickly weathering takes place.

4.2 Climate

Climate is one of the most important factors influencing weathering.

It includes temperature, rainfall and humidity.

Temperature

- High temperatures encourage chemical reactions.
- Large temperature variations encourage physical weathering.
- Repeated heating and cooling weaken rocks.
- Freezing and thawing encourage frost weathering.

Rainfall

- High rainfall provides water for chemical reactions.
- Water facilitates hydrolysis, hydration and carbonation.
- Heavy rainfall increases moisture availability in rocks.

Humidity

- High humidity maintains moisture on rock surfaces.
- Moist conditions encourage chemical weathering.

- Dry conditions may favour salt crystallisation where salty water is available.

Kenyan examples

- Humid environments such as parts of the Aberdare region experience conditions favourable for chemical weathering.
- Arid environments such as Turkana experience conditions favourable for some forms of physical weathering and salt crystallisation.

4.3 Nature and Composition of Rocks

Different rocks respond differently to weathering depending on their mineral composition.

- Rocks containing soluble minerals are easily affected by solution.
- Limestone is particularly affected by carbonation.
- Granite may undergo hydrolysis because it contains feldspar.
- Iron-rich rocks are susceptible to oxidation.
- Hard, resistant minerals may withstand weathering for longer periods.
- Rocks containing clay minerals may be affected by wetting and drying.

4.4 Rock Structure

Rock structure refers to the arrangement of minerals, joints, cracks, bedding planes and other weaknesses within rocks.

- Jointed rocks are easily weathered because water enters the cracks.
- Massive rocks with few joints may resist weathering.
- Closely spaced joints expose more surfaces to weathering.
- Porous rocks allow water to enter more easily.
- Rocks with alternating hard and soft layers may weather unevenly.

4.5 Vegetation Cover

Vegetation influences weathering in different ways.

- Plant roots grow into rock cracks and widen them.
- Decaying vegetation produces organic acids.
- Vegetation retains moisture around rocks.
- Plant cover may protect rocks from direct temperature changes.
- Organisms living around plants contribute to biological weathering.

4.6 Relief and Slope

Relief refers to differences in elevation and the shape of the Earth's surface.

- Steep slopes expose rocks to environmental conditions.
- Weathered materials may be removed from steep slopes, exposing fresh surfaces.
- Gentle slopes may retain weathered materials for longer periods.
- Valleys may retain moisture, encouraging chemical weathering.

- Mountainous areas may experience frost action at high elevations.

4.7 Time

The length of time a rock is exposed to weathering influences the extent of its breakdown.

- Rocks exposed for long periods generally experience greater weathering.
- Newly exposed rocks may have experienced less weathering.
- Continuous exposure to water, air and temperature changes gradually weakens rocks.

4.8 Human Activities

Human activities can accelerate weathering.

- Mining exposes fresh rock surfaces.
- Quarrying breaks rocks into smaller pieces.
- Construction exposes rocks to atmospheric conditions.
- Deforestation exposes rock and soil surfaces.
- Industrial pollution may increase the acidity of rainwater.

4.9 Drainage Conditions

Drainage affects the availability and movement of water around rocks.

- Poor drainage may encourage prolonged contact between rocks and water.
- Water movement through rocks facilitates chemical reactions.
- Underground water can dissolve minerals.
- Waterlogged conditions may influence oxidation depending on oxygen availability.

PART 5: SIGNIFICANCE OF WEATHERING TO THE ENVIRONMENT

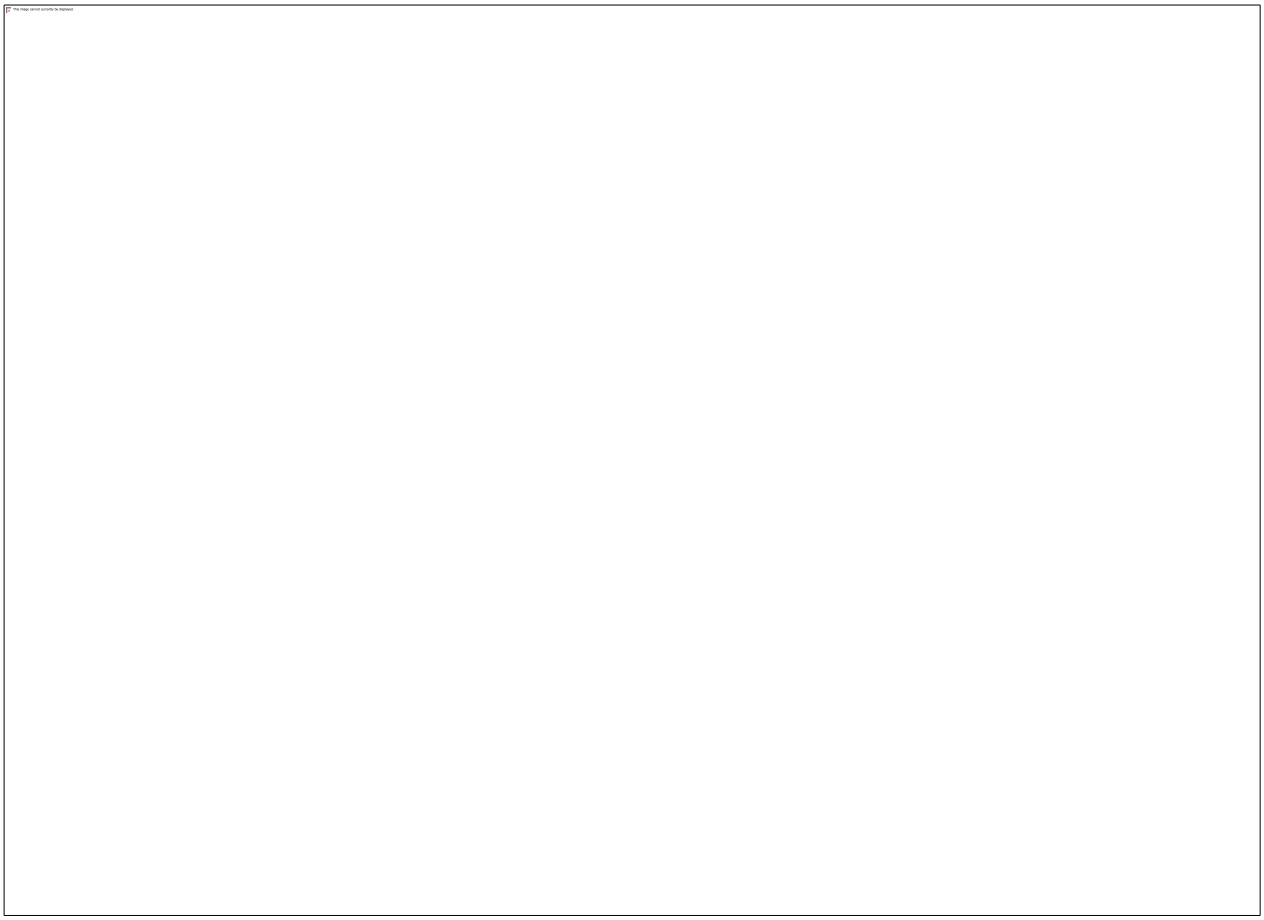
Weathering has both positive and negative effects on the physical and human environment.

5.1 Positive Significance of Weathering

A. Soil Formation

Weathering contributes to soil formation by breaking down rocks into smaller particles.

- Physical weathering produces rock fragments.
- Chemical weathering produces clay minerals and dissolved substances.
- Organic matter mixes with weathered materials.
- Over time, these materials contribute to soil development.
- The resulting soil supports plant growth and agriculture.



B. Formation of Fertile Soils

Chemical weathering releases mineral nutrients from rocks.

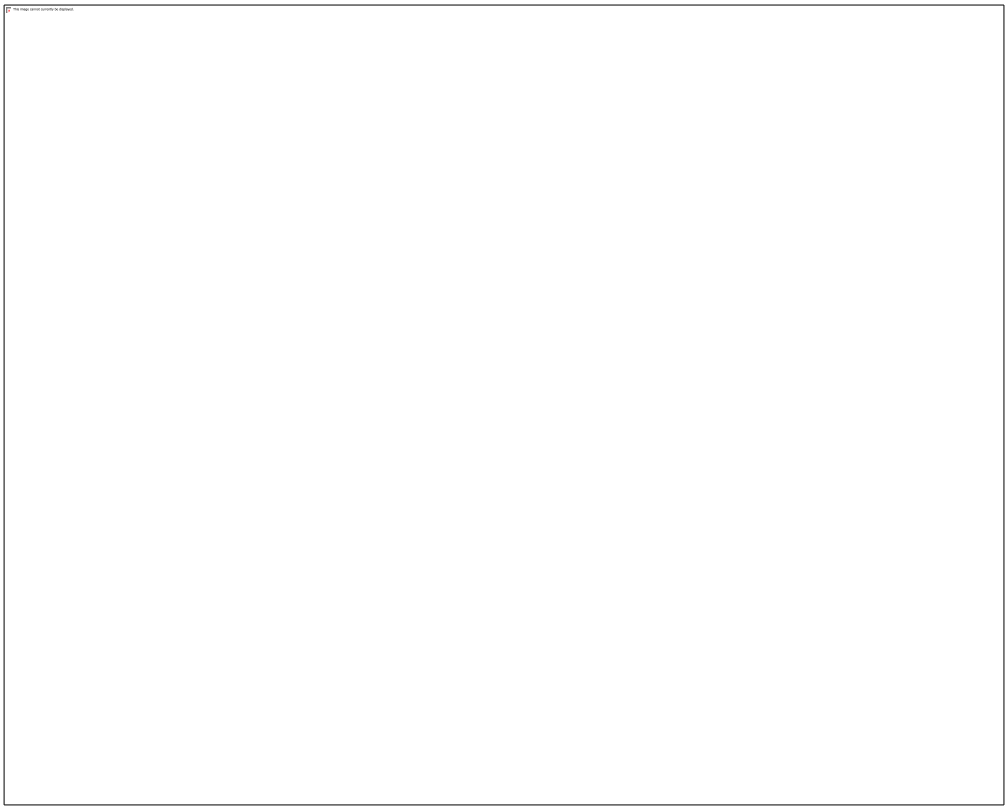
- Weathering releases elements such as potassium, calcium and magnesium.
- These minerals contribute to soil fertility.
- The nutrients support plant growth.
- Fertile soils support agricultural production.

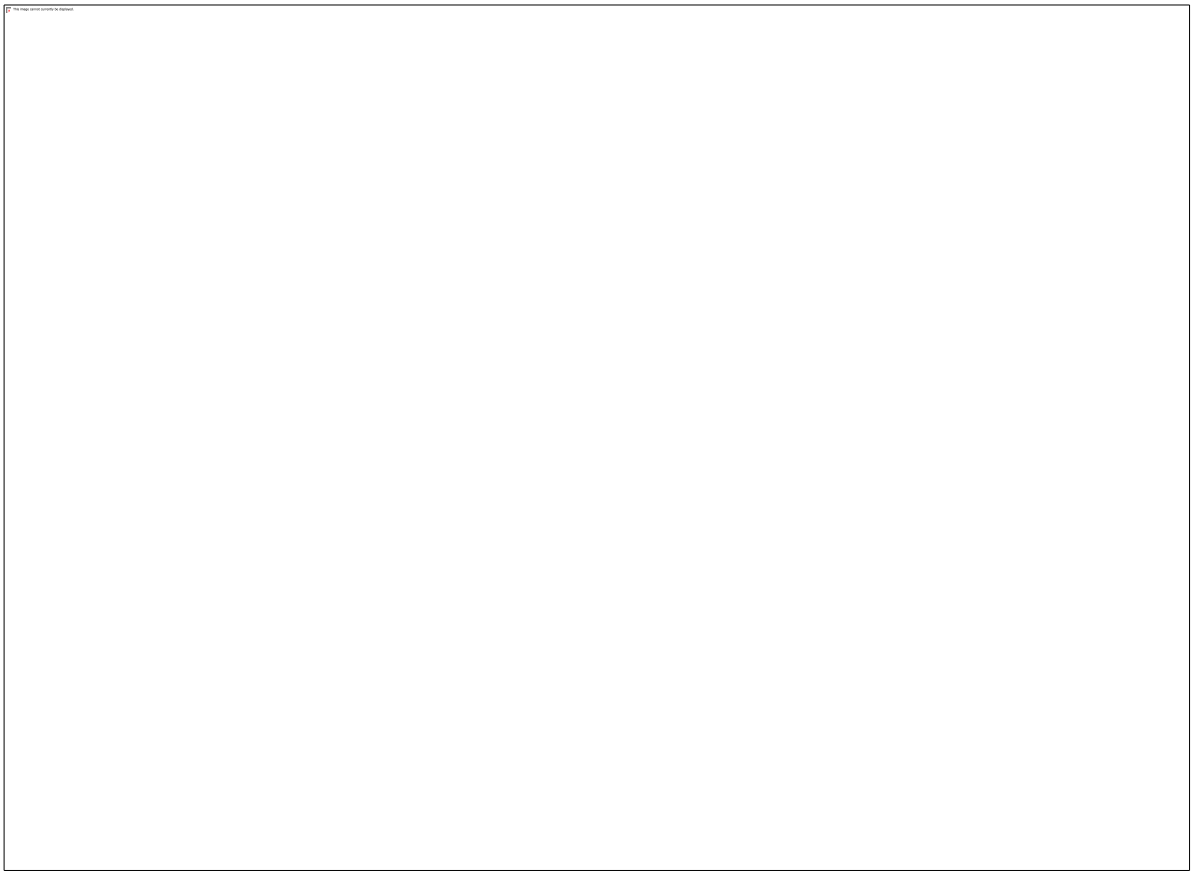
C. Formation of Unique Landforms

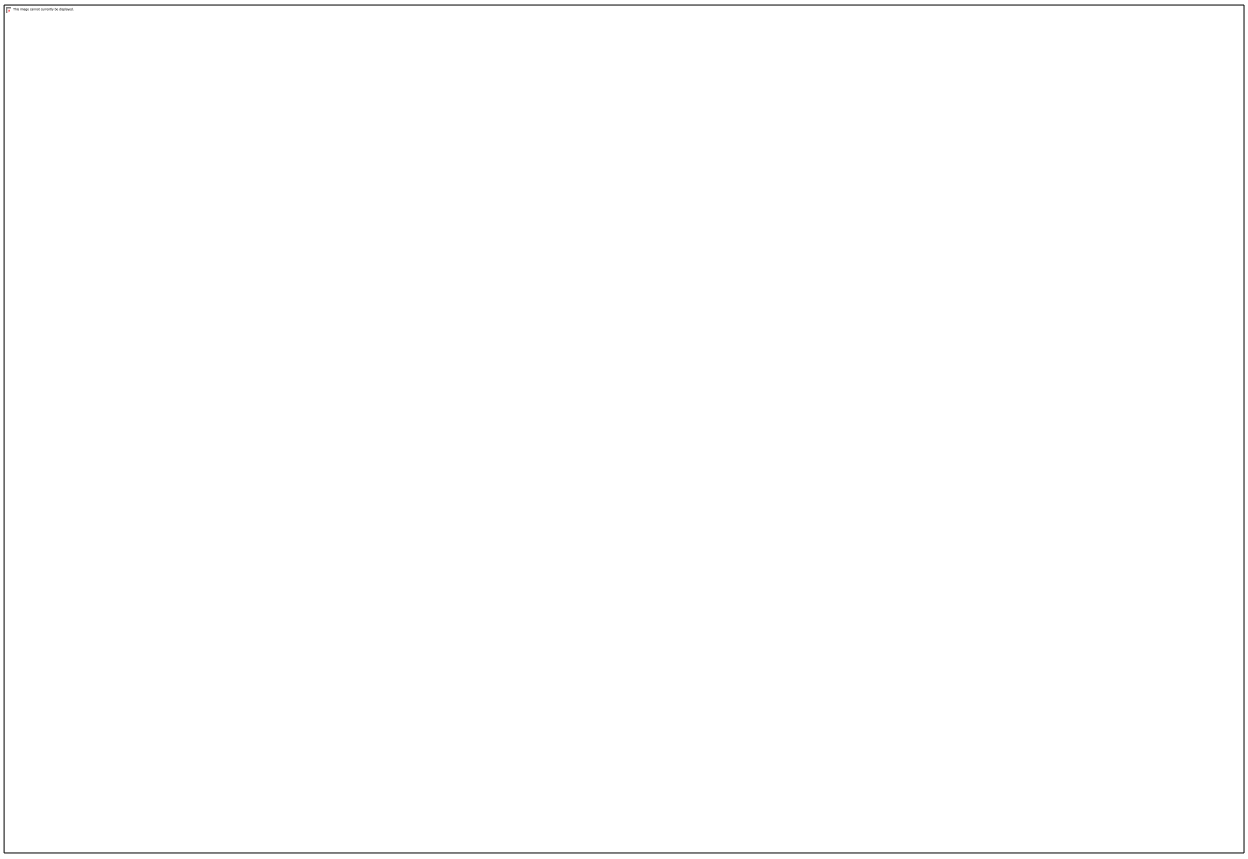
Weathering contributes to the development of different landscapes.

Examples include:

- Limestone caves.
- Sinkholes.
- Granite domes.
- Rock pillars.
- Weathering hollows.
- Limestone pavements.







D. Provision of Building Materials

Weathering produces materials used in construction.

Examples include:

- Sand.
- Gravel.
- Clay.
- Laterite.
- Weathered stone.

These materials are used in:

- Road construction.
- Brick making.
- Building foundations.
- Concrete production.
- Pottery and ceramics.

E. Formation and Concentration of Mineral Deposits

Weathering may contribute to the concentration of economically important minerals.

- Chemical weathering may remove soluble materials and leave behind less soluble minerals.
- Aluminium-rich weathering products may accumulate to form bauxite deposits under suitable conditions.
- Weathering may contribute to lateritic iron deposits.

- Some residual mineral deposits become economically valuable.

F. Support for Plant and Animal Life

Weathering contributes to the development of habitats.

- It produces soil for plant growth.
- It creates cracks and spaces where small organisms live.
- It releases nutrients needed by plants.
- It contributes to the development of ecosystems.

G. Development of Tourist Attractions

Weathering creates attractive natural features that attract tourists.

Examples include:

- Limestone caves.
- Granite domes.
- Rock arches.
- Weathering pits.
- Unusual rock formations.

Tourism creates employment and generates income for local communities.

H. Facilitates Water Infiltration

Weathering creates cracks, joints and pores in rocks.

- These openings allow water to enter the ground.
- Water may replenish underground water reserves.
- Weathered materials may increase the capacity of some surfaces to store water.
- Groundwater supports domestic, agricultural and industrial activities.

I. Releases Valuable Minerals

Chemical weathering releases minerals and nutrients from rocks.

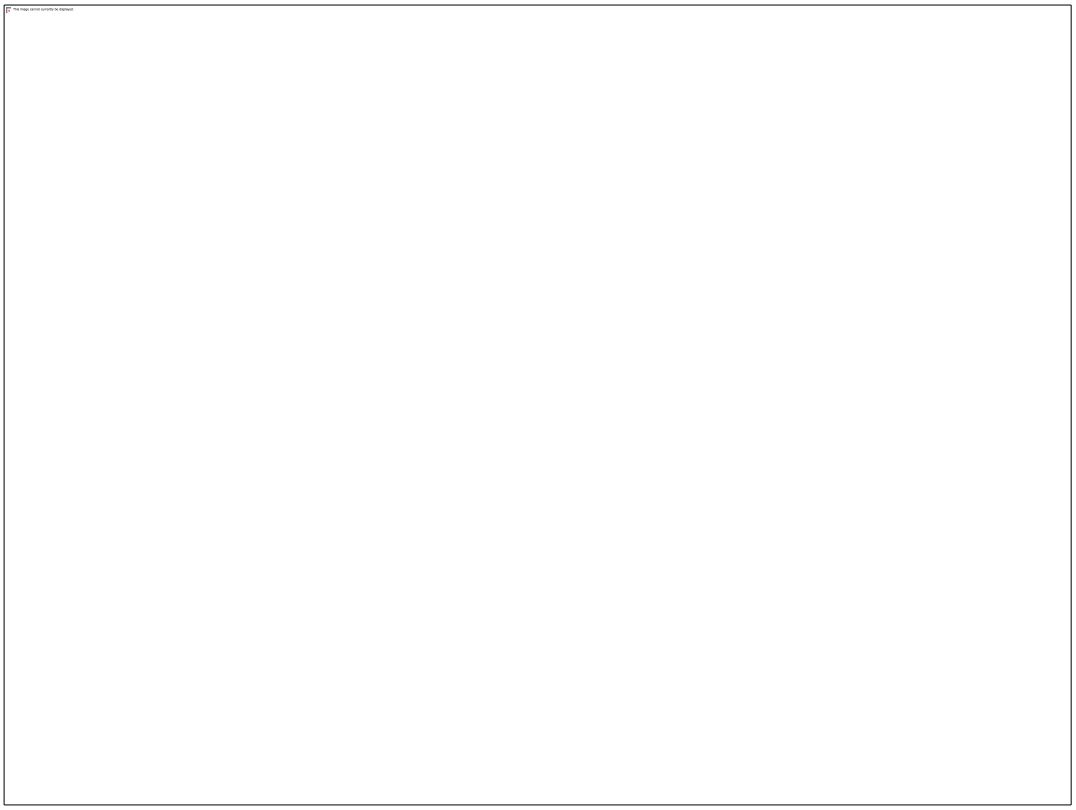
Some minerals may be transported and later deposited in other areas, contributing to the development of mineral resources.

5.2 Negative Significance of Weathering

A. Weakening of Building Structures

Weathering weakens rocks used in buildings and other structures.

- Stone walls may crack.
- Building stones may crumble.
- Foundations may become unstable.
- Historical monuments may lose their original appearance.



B. Damage to Roads and Bridges

- Chemical weathering weakens construction materials.
- Water enters cracks and may expand when frozen.
- Weathered road surfaces may develop potholes.
- Rock faces along roads may become unstable.
- Bridges and retaining structures may deteriorate.

C. Landslides and Rockfalls

Weathering weakens rocks along slopes.

- Cracks develop within rocks.
- Weathered materials become loose.
- Heavy rainfall may increase instability.
- Rock fragments may fall from steep slopes.
- Large masses of weathered materials may move downslope.

D. Damage to Historical Monuments

- Stone monuments may develop cracks.
- Carved surfaces may become weathered.
- Chemical reactions may discolour stones.
- Valuable historical features may be destroyed.

E. Loss of Valuable Rock Materials

Weathering may destroy or weaken valuable building stones and exposed mineral deposits, reducing their economic value.

F. Soil Instability

Excessive weathering may contribute to the development of loose and unstable materials, especially on steep slopes.

These materials may be easily washed away or displaced by gravity.

PART 6: WEATHERING AND SOIL FORMATION

6.1 Relationship Between Weathering and Soil Formation

Soil formation is closely related to weathering because weathering provides the mineral materials from which soils develop.

Soil develops through the interaction of weathered rock materials, organic matter, water, air and living organisms over time.

6.2 Stages of Soil Formation Through Weathering

Stage 1: Breakdown of Parent Rock

- Exposed rocks are subjected to physical, chemical and biological weathering.
- Large rocks break down into smaller fragments.

Stage 2: Decomposition of Minerals

- Water and other chemical agents react with rock minerals.
- Some minerals dissolve while others form new minerals such as clay.

Stage 3: Accumulation of Weathered Materials

- Weathered rock fragments accumulate on the Earth's surface.
- These materials form the mineral component of developing soil.

Stage 4: Addition of Organic Matter

- Plants and animals contribute organic remains.
- Dead plants and animals decompose.
- Humus develops and mixes with mineral materials.

Stage 5: Development of Soil Horizons

- Water moves materials through the soil.
- Different layers gradually develop.
- Soil horizons become more distinct over time.

6.3 Importance of Weathering in Soil Formation

1. Provides mineral particles for soil development.
2. Releases nutrients needed by plants.
3. Produces clay minerals that influence soil properties.
4. Creates spaces that allow water and air to enter the soil.
5. Provides parent material from which many soils develop.
6. Contributes to the development of soil profiles.

PART 7: FIELD STUDY OF WEATHERING IN THE LOCAL ENVIRONMENT

7.1 Meaning of a Field Study

A field study is a geographical investigation carried out in the actual environment to observe, collect and analyse information about geographical features and processes.

Learners can conduct a field study within the school compound or surrounding locality to identify different weathering processes.

7.2 Objectives of the Field Study

By the end of the field study, learners should be able to:

1. Identify different agents of weathering in the locality.
2. Identify physical, chemical and biological weathering.
3. Describe evidence of weathering on exposed rocks.
4. Explain factors influencing weathering.
5. Record and present observations about weathering.
6. Appreciate the significance of weathering to the environment.

7.3 Equipment and Materials Required

- Notebook.
- Pens and pencils.
- Camera or smartphone.
- Measuring tape.
- Hand lens.
- Field observation sheets.
- Protective gloves.
- Appropriate footwear.

7.4 Procedure for Conducting the Field Study

1. Select a suitable study area within the school locality.
2. Identify exposed rocks, rocky surfaces and weathered materials.
3. Observe cracks, joints and peeling rock surfaces.
4. Identify plants growing on or around rocks.
5. Observe the colour and texture of exposed rocks.
6. Look for evidence of chemical weathering, such as rust-like stains and dissolving limestone.
7. Record the agents responsible for the observed weathering.
8. Photograph important features where permitted.
9. Discuss findings with other learners.
10. Prepare a report based on the observations.

7.5 Sample Field Observation Table

Observed feature	Type of weathering	Agent responsible
Cracked granite rock	Physical	Temperature changes
Tree roots splitting rocks	Biological/physical	Plant roots
Reddish-brown rock surface	Chemical	Oxygen
Dissolving limestone	Chemical	Carbonic acid
Loose mineral grains	Physical	Temperature changes
Lichen growing on rocks	Biological/chemical	Organic acids
Rock fragments along a slope	Physical	Frost or temperature changes

7.6 Safety Precautions During Fieldwork

- Avoid climbing steep and unstable rocky surfaces.
- Do not touch sharp or loose rock fragments.
- Wear suitable footwear.
- Avoid collecting samples from dangerous locations.
- Stay with the assigned group.
- Follow the teacher's instructions.
- Avoid entering abandoned quarries and mines.
- Carry drinking water and appropriate protective clothing.

PART 8: DRAWING AND INTERPRETATION OF WEATHERING PROCESSES

Learners should be able to draw, label and explain different weathering processes.

The following illustrations are useful for classroom teaching, revision and assessment.

8.1 Exfoliation



Features to identify and label:

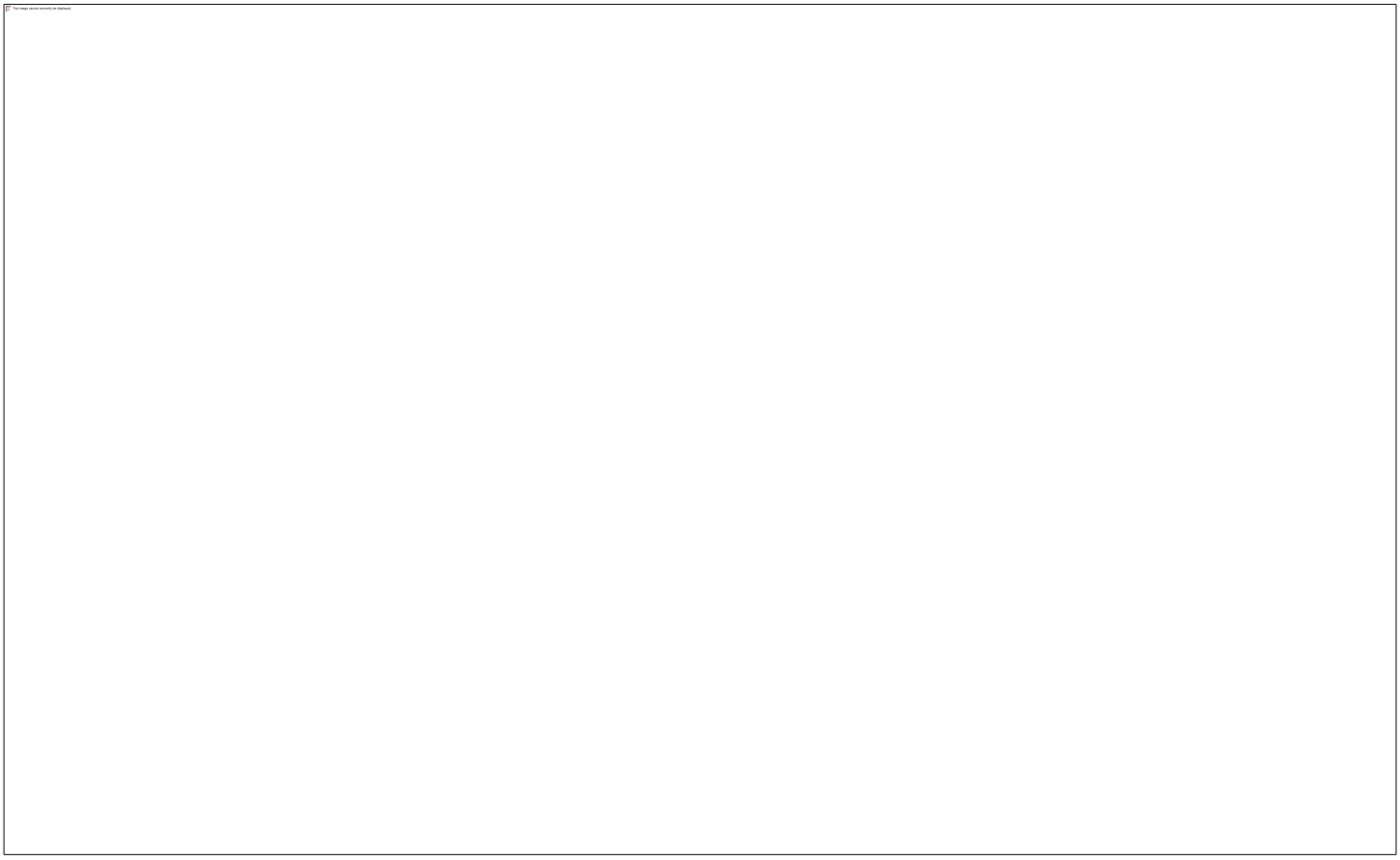
- Main rock mass.
- Outer rock layers.
- Peeling sheets.
- Cracks and joints.
- Weathered rock fragments.

8.2 Frost Wedging

Features to identify and label:

- Rock crack.
- Water entering the crack.
- Ice formation.
- Expansion of ice.
- Widened crack.
- Detached rock fragments.

8.3 Root Wedging

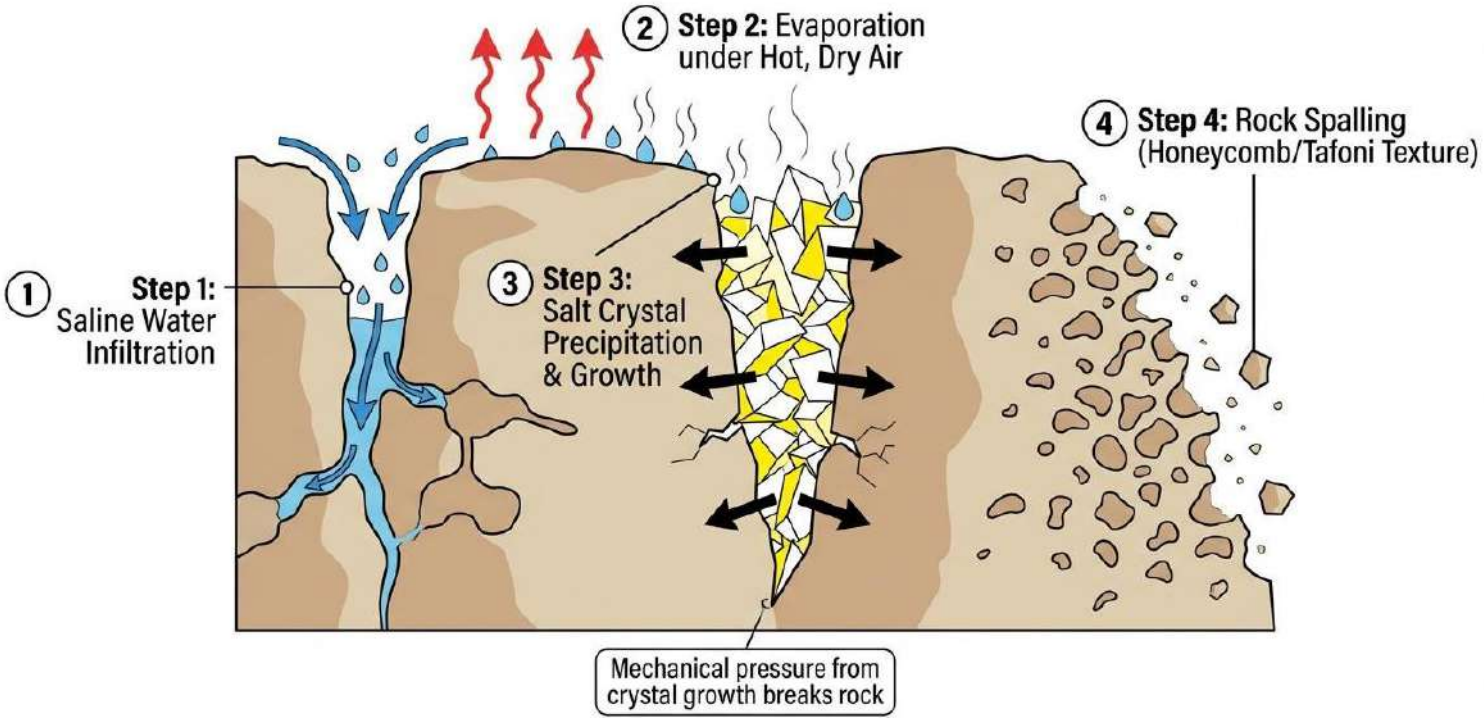


Features to identify and label:

- Plant.
- Growing roots.
- Rock cracks.
- Expanding roots.

- Broken rock fragments.

8.4 Salt Crystallisation



Features to identify and label:

- Salty water.
- Rock pores.
- Evaporation.
- Salt crystals.
- Cracking rock surface.

8.5 Limestone Weathering Through Carbonation

Features to identify and label:

- Rainwater.
- Carbon dioxide.
- Carbonic acid.
- Limestone rock.
- Dissolved calcium bicarbonate.
- Enlarged joints and cracks.

PART 9: COMPARISON OF THE THREE TYPES OF WEATHERING

Physical weathering	Chemical weathering	Biological weathering
Breaks rocks into smaller fragments.	Decomposes rocks through chemical reactions.	Breaks down rocks through living organisms.
Does not change chemical composition.	Changes chemical composition.	May be physical or chemical.
Mainly involves physical forces.	Mainly involves chemical reactions.	Involves biological activities.
Common in hot and cold environments.	Favoured by warm and moist conditions.	Occurs wherever organisms interact with rocks.
Examples include exfoliation and frost wedging.	Examples include carbonation and oxidation.	Examples include root wedging and lichen action.

Important examination point: Biological weathering may be physical or chemical depending on the process involved. Root wedging is physical, while the action of organic acids released by lichens is chemical.

PART 10: APPLICATION OF WEATHERING KNOWLEDGE IN KENYA

Understanding weathering helps people make informed decisions about environmental management and the use of natural resources.

10.1 Agriculture

- Farmers understand how weathering contributes to soil formation.
- Knowledge of weathering helps identify areas with different soil characteristics.
- It explains the release of nutrients from parent rocks.
- It supports appropriate soil conservation practices.
- It helps farmers understand the relationship between parent rock and soil fertility.

10.2 Construction and Engineering

- Engineers assess the weathering condition of rocks before construction.
- Buildings are designed using materials that can withstand weathering.
- Weak and highly weathered rocks may require stabilisation.
- Road construction projects consider the stability of exposed rock slopes.
- Appropriate drainage systems help minimise water-related deterioration.

10.3 Environmental Conservation

- Knowledge of weathering helps identify areas prone to rockfalls.
- It supports protection of fragile landscapes.

- It helps communities manage exposed slopes.
- It encourages proper land-use planning.
- It supports the conservation of natural geological features.

10.4 Tourism

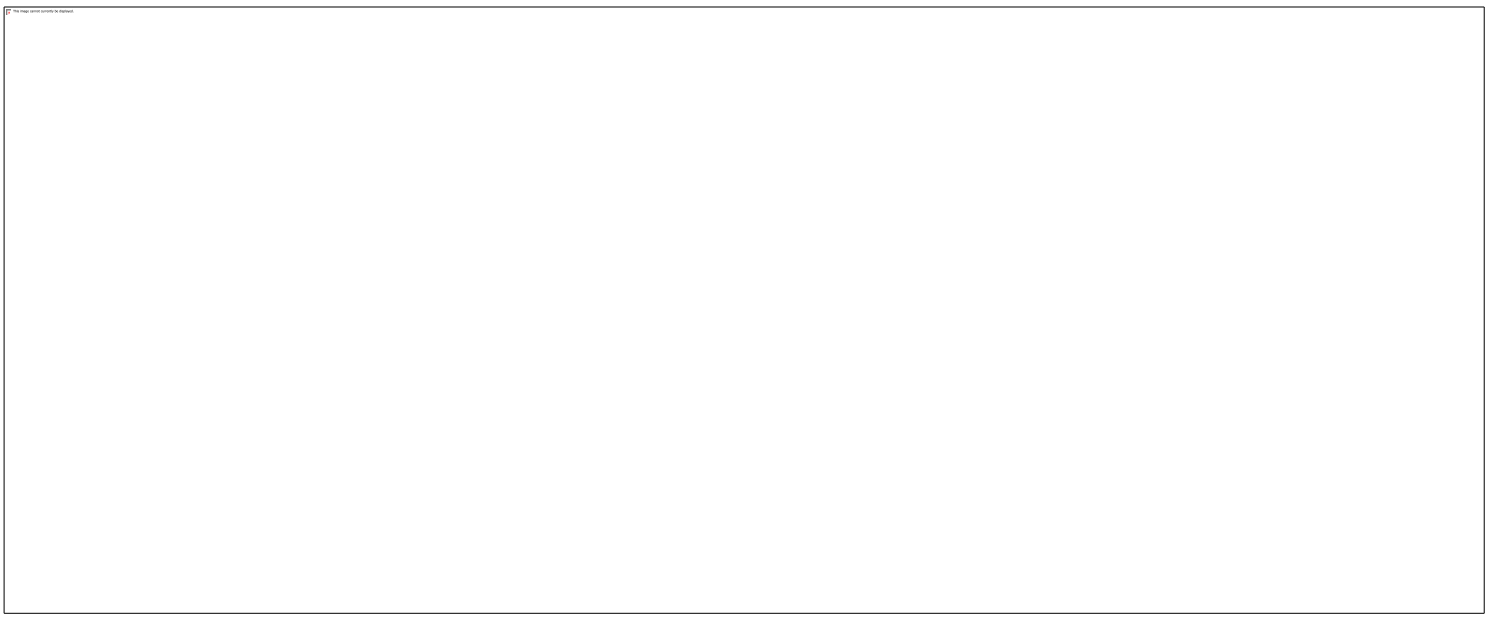
Weathering creates attractive natural features that attract tourists.

Examples in Kenya include:



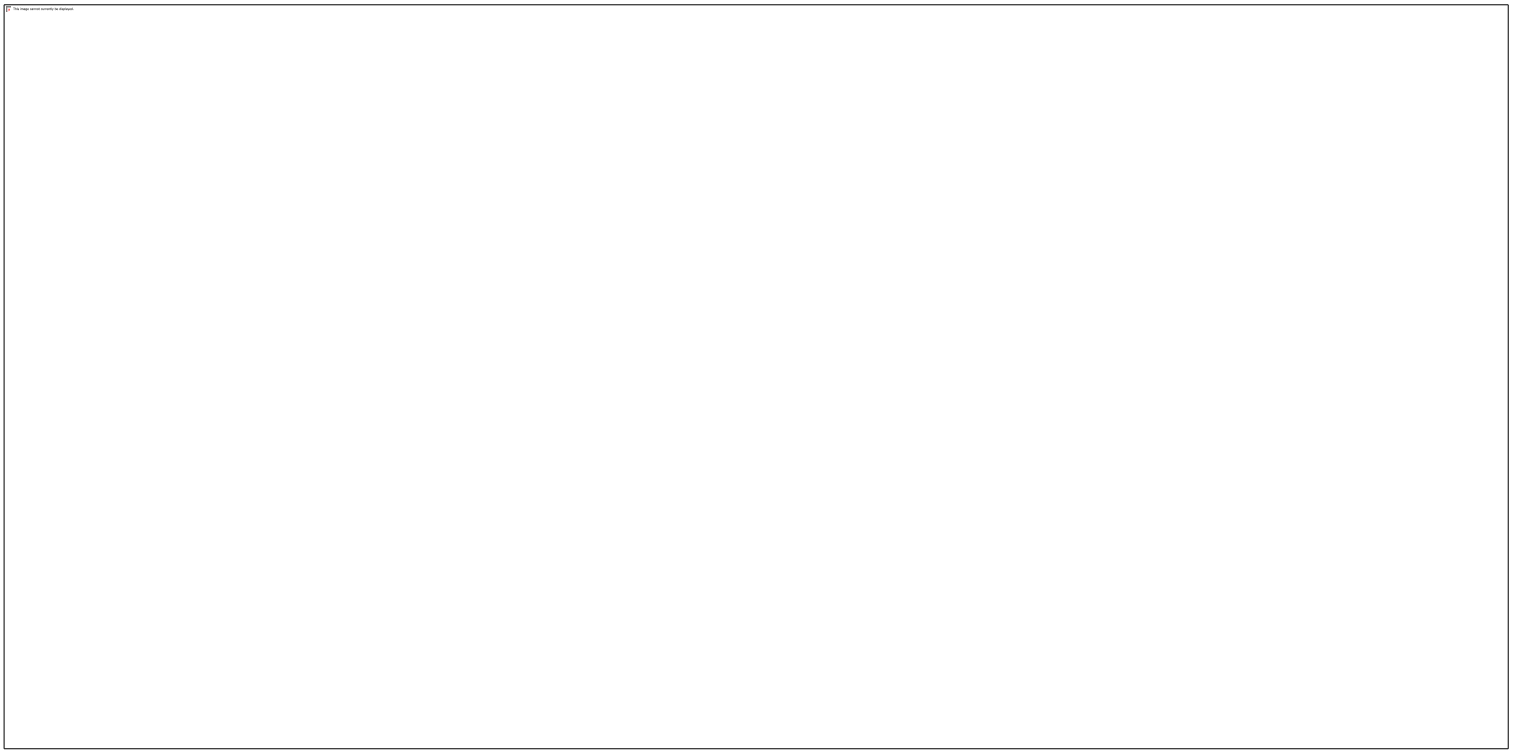
Hell's Gate National Park

Rocky landscapes and deeply cut gorges.



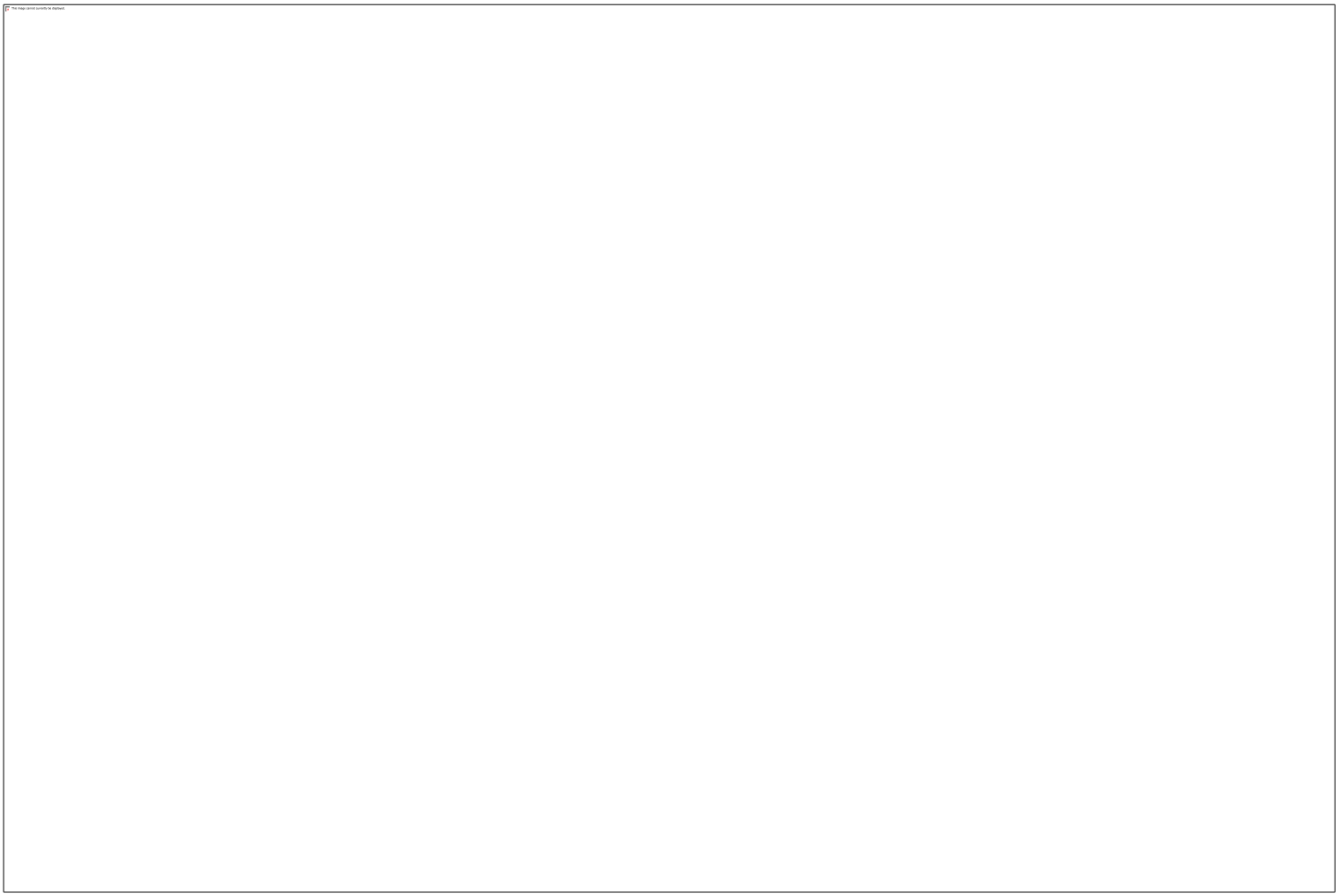
Mount Longonot

Volcanic landscape with exposed rock surfaces.



Mount Kenya

High-altitude rocky landscapes affected by frost action.



Chyulu Hills

Volcanic rock landscapes shaped by surface processes.

Tourism supports:

- Employment creation.
- Income generation.
- Development of infrastructure.
- Growth of local businesses.
- Conservation of natural heritage.

10.5 Mining and Quarrying

- Knowledge of weathering helps locate and assess mineral deposits.
- It helps determine the quality of building stones.
- It assists in planning safe mining operations.
- It helps identify weathered materials suitable for construction.
- It supports rehabilitation of abandoned quarries.

KEY GEOGRAPHICAL TERMS AND DEFINITIONS

Term	Meaning
Weathering	Breakdown or decomposition of rocks in their original position.
Erosion	Wearing away and transportation of materials.
Exfoliation	Peeling off of outer layers of rocks.
Frost wedging	Breaking of rocks due to freezing and expansion of water in cracks.
Block disintegration	Breaking of rocks into large angular blocks.
Granular disintegration	Separation of individual mineral grains from rocks.
Salt crystallisation	Breaking of rocks due to growth of salt crystals in pores and cracks.
Solution	Dissolving of soluble minerals in water.
Carbonation	Chemical reaction involving carbonic acid and minerals in rocks.
Oxidation	Reaction of oxygen with minerals, especially iron-bearing minerals.
Hydration	Absorption of water into the structure of minerals.
Hydrolysis	Chemical reaction between water and minerals, resulting in decomposition.
Biological weathering	Breakdown of rocks through the activities of living organisms.
Root wedging	Breaking of rocks by growing plant roots.
Parent rock	Original rock material from which soil develops.
Humus	Dark organic material formed from decomposed plant and animal remains.
Joint	A natural fracture in a rock along which there has been little or no displacement.
Carbonic acid	A weak acid formed when carbon dioxide dissolves in water.
Saprolite	Deeply weathered rock material that retains features of the original rock.
Weathering rate	The speed at which rocks break down or decompose.

REVISION QUESTIONS AND ASSESSMENT

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Instructions: Answer all the questions. Each question carries 1 mark. Choose the correct answer from the four alternatives provided.

1. Weathering is best described as the process through which rocks are:

A. Transported from one place to another.
B. Broken down at or near the Earth's surface.
C. Deposited in river valleys.
D. Changed into metamorphic rocks.

2. Which of the following distinguishes weathering from erosion?

A. Weathering involves transportation of materials.
B. Erosion occurs only in dry areas.
C. Weathering does not involve transportation of broken materials.
D. Erosion occurs only through chemical reactions.

3. Which of the following is an agent of physical weathering?

A. Carbon dioxide.
B. Temperature changes.
C. Organic acids.
D. Oxygen.

4. The peeling off of outer layers of rocks in curved sheets is known as:

A. Carbonation.
B. Hydration.
C. Exfoliation.
D. Oxidation.

5. Exfoliation is also referred to as onion-skin weathering because:

A. Rocks become covered with soil.
B. Outer rock layers peel off in sheets.
C. Rocks dissolve in water.
D. Rock surfaces become smooth through erosion.

6. Which of the following processes produces large angular rock blocks?

A. Block disintegration.
B. Carbonation.
C. Hydrolysis.
D. Oxidation.

7. Granular disintegration occurs mainly because:

A. Rocks dissolve in acidic water.
B. Different minerals expand and contract at different rates.
C. Plant roots grow into rocks.
D. Oxygen combines with iron minerals.

8. Frost wedging occurs when:

A. Salt crystals grow inside rocks.
B. Water freezes and expands inside rock cracks.

C. Oxygen reacts with iron minerals.
D. Rocks absorb carbon dioxide.

9. Salt crystallisation is most common in environments characterised by:

A. High evaporation rates.
B. Continuous heavy rainfall only.
C. Permanent freezing conditions.
D. Very low temperatures throughout the year.

10. The removal of overlying rocks, resulting in the expansion of underlying rocks, is known as:

A. Hydration.
B. Unloading.
C. Carbonation.
D. Solution.

11. Which of the following is an example of chemical weathering?

A. Exfoliation.
B. Frost wedging.
C. Carbonation.
D. Block disintegration.

12. Carbonation involves the reaction between:

A. Oxygen and iron.
B. Carbonic acid and calcium carbonate.
C. Water and sodium chloride.
D. Ice and granite.

13. Which gas combines with water to form carbonic acid?

A. Nitrogen.
B. Oxygen.
C. Carbon dioxide.
D. Hydrogen.

14. The reddish-brown colour that develops on iron-rich rocks is mainly associated with:

A. Hydration.
B. Oxidation.
C. Solution.
D. Exfoliation.

15. The absorption of water molecules into the structure of certain minerals is called:

A. Hydration.
B. Hydrolysis.
C. Carbonation.
D. Oxidation.

16. Hydrolysis is particularly important in the decomposition of which mineral?

A. Diamond.
B. Feldspar.

C. Gold.
D. Quartz only.

17. Which of the following is commonly produced through hydrolysis of feldspar?

A. Kaolinite clay.
B. Rock salt.
C. Pure gold.
D. Coal.

18. Which of the following is an example of biological weathering?

A. Oxidation of iron.
B. Dissolution of limestone.
C. Root wedging.
D. Frost action.

19. Lichens contribute to weathering mainly by:

A. Producing organic acids that react with rock minerals.
B. Increasing the weight of rocks.
C. Preventing water from entering rocks.
D. Transporting rocks downstream.

20. Which of the following animals contributes to weathering through burrowing activities?

A. Fish.
B. Termites.
C. Eagles.
D. Butterflies.

21. Which climatic condition favours chemical weathering?

A. Warm and moist conditions.
B. Extremely dry conditions only.
C. Permanent freezing conditions.
D. Complete absence of rainfall.

22. Which of the following rocks is particularly susceptible to carbonation?

A. Granite.
B. Limestone.
C. Quartzite.
D. Basalt.

23. Closely spaced joints in rocks increase the rate of weathering because they:

A. Reduce the surface area exposed to weathering.
B. Prevent water from entering rocks.
C. Provide pathways for water and other weathering agents.
D. Increase the chemical resistance of rocks.

24. Which of the following is a positive significance of weathering?

A. Weakening of building foundations.
B. Development of unstable slopes.

C. Formation of soil.
D. Destruction of historical monuments.

25. Weathering contributes to soil fertility by:

A. Removing all mineral nutrients.
B. Releasing mineral nutrients from rocks.
C. Preventing organic matter decomposition.
D. Increasing soil salinity in every environment.

26. Which of the following is a negative effect of weathering?

A. Formation of fertile soils.
B. Development of tourist attractions.
C. Weakening of buildings and roads.
D. Release of useful minerals.

27. Which of the following is a suitable instrument for examining small mineral grains during a field study?

A. Thermometer.
B. Hand lens.
C. Rain gauge.
D. Wind vane.

28. A learner observes a tree root growing through a crack in a rock. The process demonstrated is:

A. Carbonation.
B. Oxidation.
C. Root wedging.
D. Solution.

29. Which of the following factors does NOT directly determine the rate of weathering?

A. Climate.
B. Rock composition.
C. Rock structure.
D. Direction of political boundaries.

30. Which precaution should be observed during a field study of weathering?

A. Climbing unstable rock surfaces.
B. Collecting samples from dangerous cliffs.
C. Wearing appropriate footwear.
D. Working far away from the assigned group.

SECTION B: STRUCTURED QUESTIONS (50 MARKS)

50 MARKS

Instructions: Answer all questions. Show clearly explained points and relevant examples where necessary.

QUESTION 1: INTRODUCTION TO WEATHERING (8 MARKS)

a) Define the term weathering. (2 marks)

b) Differentiate between weathering and erosion. (2 marks)

c) Identify four major agents of weathering. (4 marks)

QUESTION 2: PHYSICAL WEATHERING (8 MARKS)

a) Define physical weathering. (2 marks)

b) Explain three processes of physical weathering. (6 marks)

QUESTION 3: CHEMICAL WEATHERING (8 MARKS)

a) Define chemical weathering. (2 marks)

b) Explain three processes of chemical weathering. (6 marks)

QUESTION 4: BIOLOGICAL WEATHERING (8 MARKS)

a) Define biological weathering. (2 marks)

b) Explain three ways through which living organisms contribute to weathering. (6 marks)

QUESTION 5: FACTORS INFLUENCING WEATHERING (9 MARKS)

a) Explain five factors influencing the rate of weathering. (5 marks)

b) Explain four ways in which weathering contributes positively to the physical and human environment. (4 marks)

QUESTION 6: FIELD STUDY AND ENVIRONMENTAL SIGNIFICANCE (9 MARKS)

a) Describe five activities you would undertake when conducting a field study on weathering in your school locality. (5 marks)

b) Explain four negative effects of weathering on the human and physical environment. (4 marks)

TEACHER'S MARKING SCHEME

SECTION A: MULTIPLE-CHOICE ANSWERS

Question	Answer	Question	Answer
1	B	16	B

2	C	17	A
3	B	18	C
4	C	19	A
5	B	20	B
6	A	21	A
7	B	22	B
8	B	23	C
9	A	24	C
10	B	25	B
11	C	26	C
12	B	27	B
13	C	28	C
14	B	29	D
15	A	30	C

SECTION B: MARKING SCHEME

QUESTION 1: INTRODUCTION TO WEATHERING (8 MARKS)

a) Weathering is the process through which rocks are broken down, disintegrated or decomposed at or near the Earth's surface without being transported from their original position. (2 marks)

b)

- Weathering involves the breakdown of rocks in their original position. (1 mark)
- Erosion involves the wearing away, removal and transportation of materials from one place to another. (1 mark)

c) Any four:

1. Temperature changes.
2. Water.
3. Ice and frost.
4. Wind.
5. Oxygen.
6. Carbon dioxide.
7. Acids.
8. Living organisms.
9. Pressure changes.

(1 mark each)

QUESTION 2: PHYSICAL WEATHERING (8 MARKS)

a) Physical weathering is the breakdown of rocks into smaller fragments without changing their chemical composition. (2 marks)

b) Any three processes, explained:

1. Exfoliation

- Repeated heating causes the outer rock layers to expand.
- Cooling causes contraction.

- Repeated expansion and contraction produce stress.
- Outer layers eventually peel off in curved sheets.

2. Frost wedging

- Water enters cracks in rocks.
- Water freezes and expands.
- Expanding ice exerts pressure on the rock.
- Repeated freezing and thawing widens the cracks until pieces break away.

3. Block disintegration

- Rocks contain natural joints and cracks.
- Weathering agents widen the joints.
- The rocks separate along the joints.
- Large angular blocks are formed.

4. Granular disintegration

- Different minerals expand and contract at different rates.
- Stress develops between the mineral grains.
- Bonds holding the grains together weaken.
- Individual grains become detached.

5. Salt crystallisation

- Salty water enters rock pores.
- Water evaporates.
- Salt crystals grow and exert pressure.
- Rock surfaces gradually break down.

6. Pressure release

- Overlying rocks are removed.
- Pressure on underlying rocks decreases.
- Rocks expand and develop sheet joints.
- Outer layers may separate.

Award 2 marks for each of three well-explained processes.

QUESTION 3: CHEMICAL WEATHERING (8 MARKS)

a) Chemical weathering is the decomposition of rocks through chemical reactions that alter the chemical composition of the original minerals. (2 marks)

b) Any three processes, explained:

1. Carbonation

- Carbon dioxide dissolves in rainwater.
- Carbonic acid is formed.
- The acid reacts with calcium carbonate in limestone.
- Soluble calcium bicarbonate is produced and removed by water.

2. Oxidation

- Oxygen reacts with iron-bearing minerals.
- Water facilitates the reaction.
- Iron oxides are formed.
- The rock may develop reddish-brown stains and weaken.

3. Hydration

- Minerals absorb water molecules.
- Their chemical structure changes.
- The minerals expand.
- The rock gradually weakens.

4. Hydrolysis

- Water reacts with feldspar minerals.
- The minerals decompose.
- Clay minerals such as kaolinite are formed.
- Soluble substances are removed.

5. Solution

- Water comes into contact with soluble minerals.
- The minerals dissolve.
- Dissolved substances are carried away.
- The rock gradually weakens.

Award 2 marks for each of three well-explained processes.

QUESTION 4: BIOLOGICAL WEATHERING (8 MARKS)

a) Biological weathering is the breakdown or decomposition of rocks through the activities of living organisms. (2 marks)

b) Any three:

1. Plant roots

- Roots grow into cracks in rocks.
- They increase in thickness.
- They exert pressure on the crack walls.

- Rocks eventually split apart.

2. Burrowing animals

- Animals dig holes and tunnels.
- Their movements loosen soil and weathered materials.
- They expose buried rocks to air and water.
- This encourages further weathering.

3. Lichens

- Lichens grow on exposed rocks.
- They produce weak organic acids.
- The acids react with rock minerals.
- The minerals gradually decompose.

4. Mosses

- Mosses grow on damp rock surfaces.
- They retain moisture.
- They trap dust and organic matter.
- They encourage further weathering.

5. Human activities

- Mining and quarrying break rocks.
- Construction exposes fresh rock surfaces.
- These surfaces become vulnerable to weathering.

Award 2 marks for each of three well-explained ways.

QUESTION 5: FACTORS INFLUENCING WEATHERING (9 MARKS)

a) Any five factors:

1. **Climate:** Temperature and rainfall influence the rate of physical and chemical weathering.
2. **Rock composition:** Rocks containing soluble minerals weather more easily through solution.
3. **Rock structure:** Rocks with many joints and cracks allow water and other agents to penetrate easily.
4. **Vegetation:** Plant roots widen cracks, while organic acids contribute to chemical weathering.
5. **Relief:** Steep slopes expose rocks and facilitate the removal of weathered materials.
6. **Time:** Rocks exposed for longer periods generally experience greater weathering.
7. **Human activities:** Mining and quarrying expose fresh rock surfaces.
8. **Drainage:** Water movement and retention influence chemical reactions.

(1 mark each)

b) Any four:

1. **Soil formation:** Weathering produces mineral particles that contribute to soil development.

2. **Formation of fertile soils:** Chemical weathering releases nutrients such as potassium, calcium and magnesium.
3. **Tourism:** Weathering creates attractive landscapes such as caves and rock formations.
4. **Building materials:** Weathering produces sand, clay, gravel and other construction materials.
5. **Mineral deposits:** Weathering may concentrate economically important minerals.
6. **Water infiltration:** Cracks and joints allow water to enter underground formations.
7. **Habitat development:** Weathering produces soil and spaces that support living organisms.

(1 mark each)

QUESTION 6: FIELD STUDY AND ENVIRONMENTAL SIGNIFICANCE (9 MARKS)

a) Any five:

1. Select a suitable study area within the school locality.
2. Identify exposed rocks and weathered surfaces.
3. Observe cracks, joints and peeling rock layers.
4. Identify plants growing on rocks.
5. Examine rock colour and texture.
6. Identify evidence of chemical weathering.
7. Record observations in a notebook.
8. Take photographs of important features.
9. Discuss findings with other learners.
10. Prepare a field study report.

(1 mark each)

b) Any four:

1. **Damage to buildings:** Weathering weakens building stones and may cause walls to crack.
2. **Damage to roads:** Weathered materials and deteriorating construction materials may contribute to road damage.
3. **Rockfalls:** Weathering weakens rocks on steep slopes, causing fragments to fall.
4. **Landslides:** Weathered materials may become unstable and move downslope.
5. **Destruction of monuments:** Weathering damages historical buildings and stone structures.
6. **Soil instability:** Excessive breakdown of rocks may contribute to loose and unstable materials.

(1 mark each)

STRAND 2.0: NATURAL SYSTEMS AND PROCESSES

SUB-STRAND 2.5: MASS WASTING

1.0 INTRODUCTION TO MASS WASTING

1.1 Meaning of mass wasting

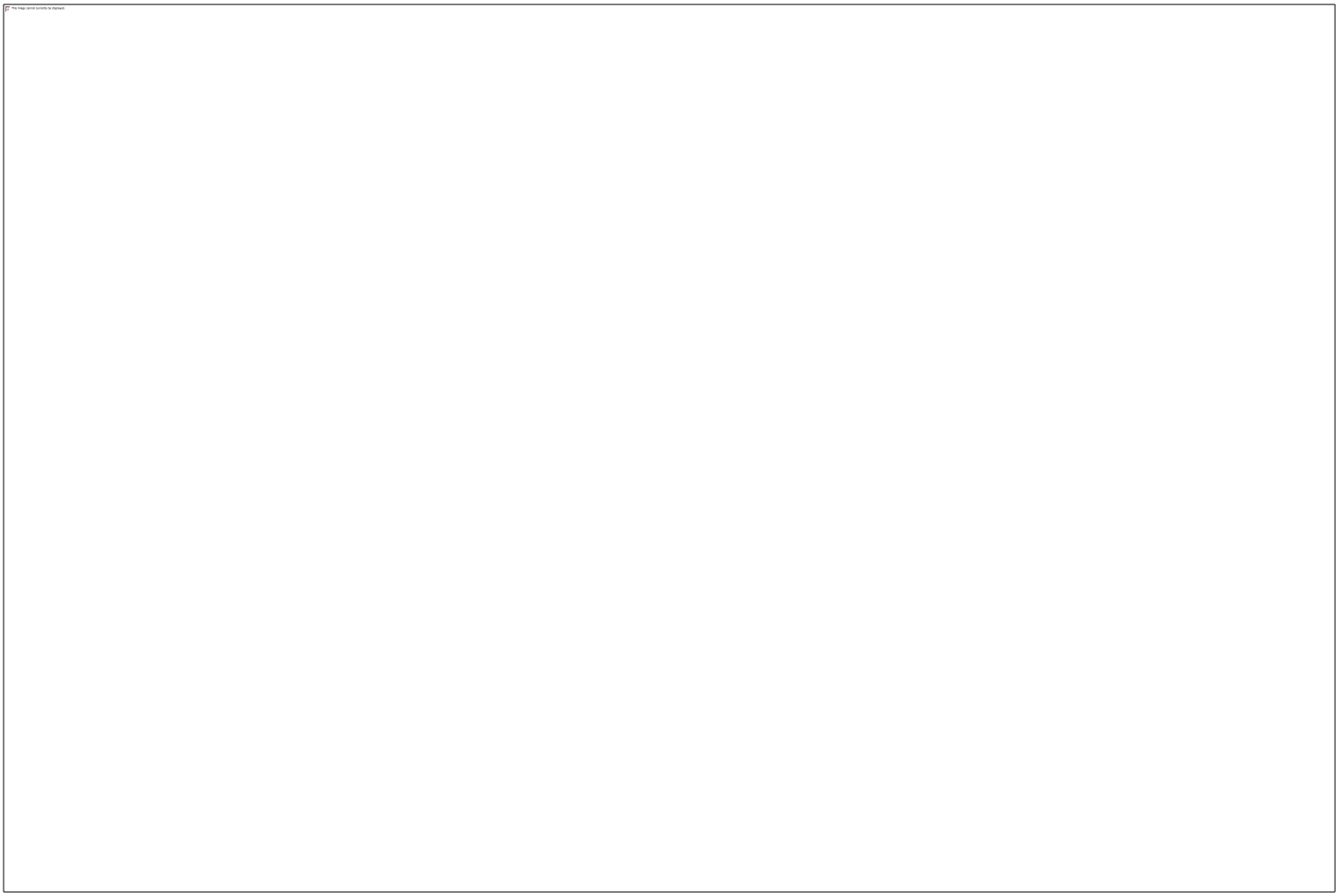
Mass wasting refers to the downward movement of weathered rock materials, soil, mud and debris along a slope under the influence of gravity.

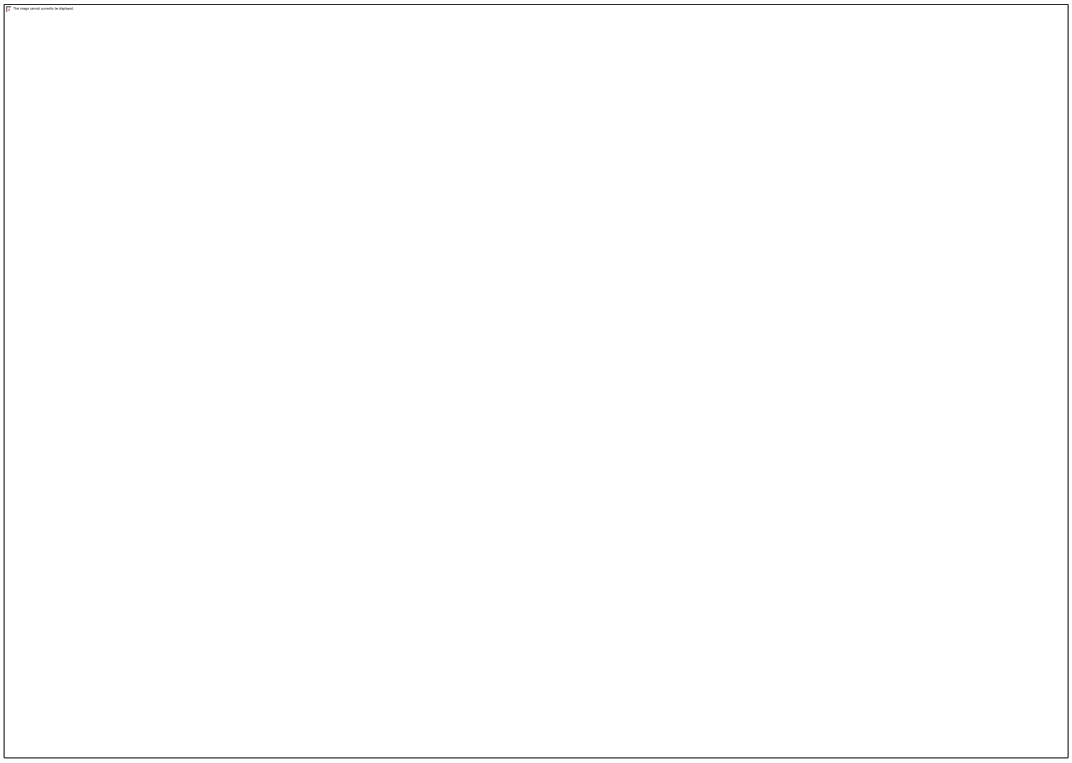
- It occurs when materials on a slope become unstable and move downhill.
- The movement may be slow or very rapid.
- It may involve individual rock fragments, large blocks of rock, soil, mud or a mixture of materials.
- It occurs on hillsides, mountains, escarpments, river valleys and other sloping surfaces.
- Water often increases the likelihood of mass wasting by adding weight to slope materials and reducing friction between particles.

Examples in Kenya:

- Landslides and mudflows on steep slopes in parts of the Aberdare Ranges.
- Slope failures in the Mount Kenya region.
- Soil and debris movement on steep cultivated hillsides in parts of the Central Highlands and Western Kenya.
- Rockfalls along steep road cuttings and mountainous areas.







1.2 Meaning of mass movement

Mass movement is the general movement of rock materials and soil downslope due to gravity.

- It is a natural process that changes the shape of the Earth's surface.
- It may occur with or without the presence of water.

- It includes the movement of loose materials as well as large masses of rock.
- It can take place gradually over many years or suddenly within seconds.

1.3 Difference between mass wasting and mass movement

The terms *mass wasting* and *mass movement* are often used interchangeably in Geography.

- **Mass movement** describes the actual downslope movement of earth materials under gravity.
- **Mass wasting** commonly refers to the downslope movement and the associated wearing away or removal of materials from a slope.

1.4 Characteristics of mass wasting

1. **Movement is downslope:** Materials move from higher to lower ground.
2. **Gravity is the main driving force:** Gravity pulls materials towards the Earth's centre.
3. **It occurs on slopes:** It is common on hills, mountains, escarpments and valley sides.
4. **Movement varies in speed:** Some movements are extremely slow, while others are sudden and destructive.
5. **Different materials are involved:** Rock, soil, mud, sand and debris may move.
6. **Water can accelerate movement:** Heavy rainfall and water saturation may make slopes unstable.
7. **It changes landscapes:** It creates scars, deposits, irregular slopes and debris accumulations.
8. **It may cause disasters:** Rapid movements can destroy property, infrastructure and cause loss of life.

1.5 Difference between mass wasting and erosion

Mass wasting	**Erosion**
Mainly driven by gravity.	Mainly caused by agents such as running water, wind, waves and ice.
Involves movement of materials down a slope.	Involves detachment, removal and transportation of materials.
May occur without a transporting agent.	Usually involves a transporting agent.
Examples include landslides and rockfalls.	Examples include river erosion and wind erosion.

Important: Mass wasting can occur before or together with erosion. For example, a landslide may move soil downhill, after which a river carries some of the deposited material away.

2.0 TYPES OF MASS WASTING

Mass wasting can be classified according to the nature of movement, the speed of movement and the materials involved.

The major types include:

1. Falls.
2. Slides.

3. Flows.
4. Creep.
5. Solifluction.
6. Avalanches.

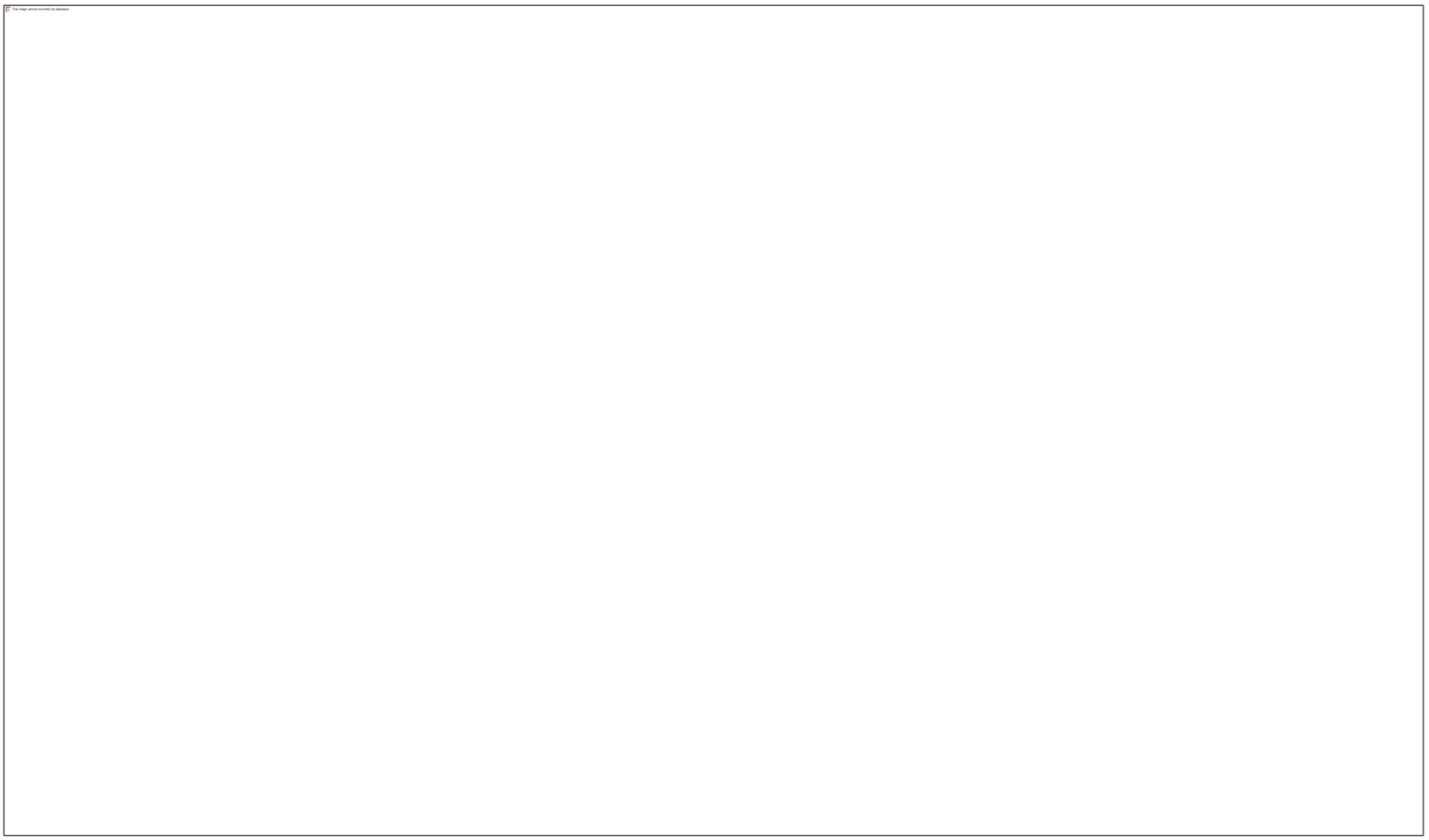
2.1 Falls

A fall is the sudden detachment and free downward movement of rock fragments or soil from a steep slope or cliff under gravity.

- Materials become detached from a steep rock face.
- They move through the air by falling, bouncing or rolling.
- Falls are common on cliffs, steep mountain slopes and road cuttings.
- They may be triggered by weathering, earthquakes, heavy rainfall and human activities.
- Large rockfalls can block roads, damage buildings and injure people.

Examples:

- Rock fragments falling from steep mountain slopes.
- Rocks breaking away from steep road cuttings in mountainous parts of Kenya.
- Rockfalls along steep escarpments.



Types of falls

a) Rockfall

- Involves the sudden detachment of rocks from a steep slope.

- The rocks fall, bounce or roll towards the foot of the slope.
- It is common where joints and cracks weaken the rock face.

b) Debris fall

- Involves the sudden falling of loose materials such as soil, gravel and rock fragments.
- It may occur where loose slope materials become unstable after heavy rainfall.

Conditions that encourage falls

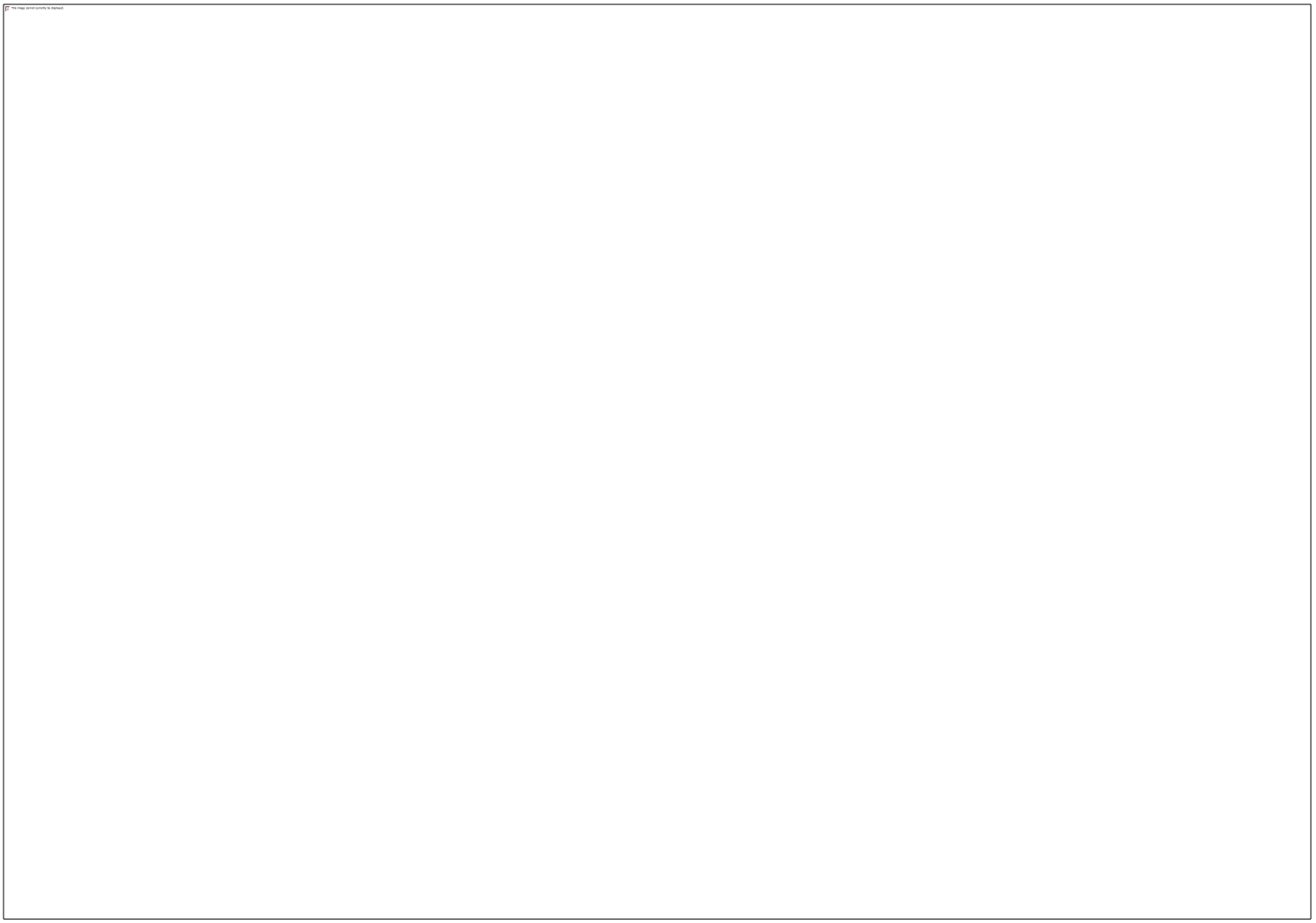
1. Very steep slopes.
2. Cracked and jointed rocks.
3. Intense weathering.
4. Heavy rainfall.
5. Earth tremors and earthquakes.
6. Excavation of slopes during road construction.
7. Removal of vegetation.

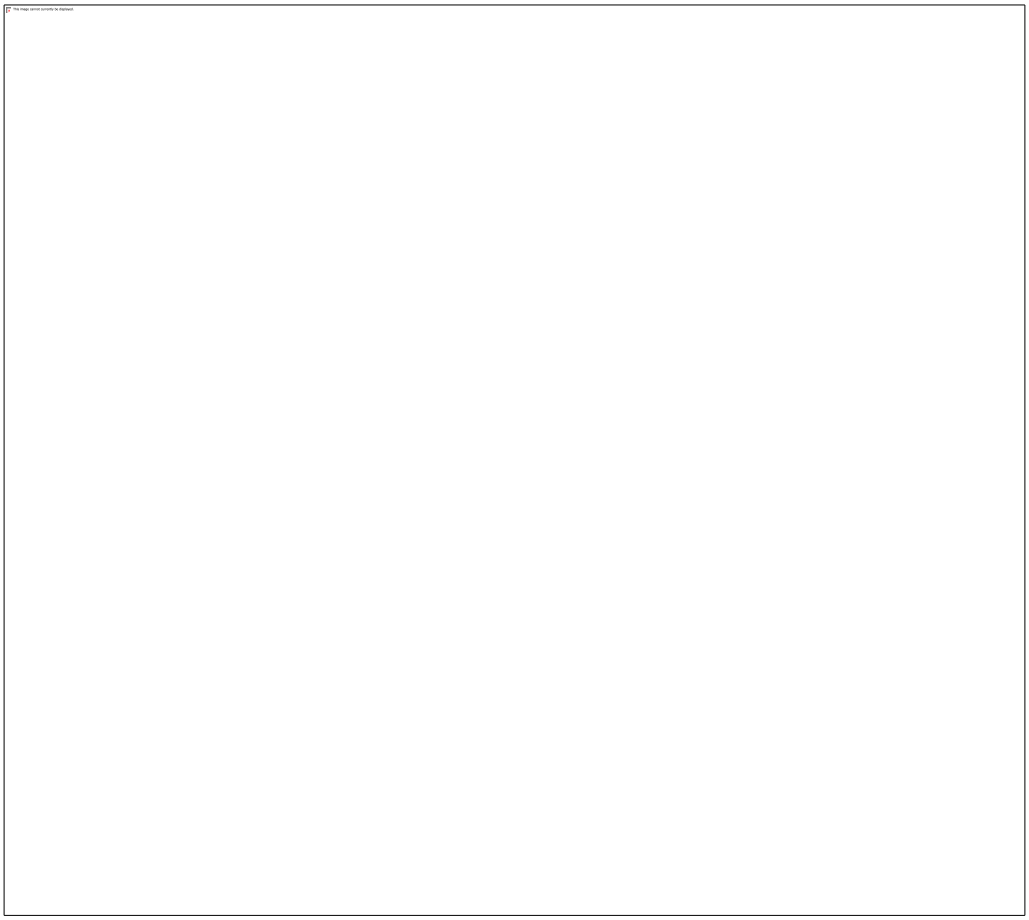
2.2 Slides

A slide is the downslope movement of a mass of rock, soil or debris along a recognisable failure surface.

- The moving materials remain relatively together as they move.
- The movement occurs along a surface of weakness.
- The failure surface may be curved or relatively flat.
- Slides may be rapid and destructive.
- Water saturation, earthquakes and slope excavation may trigger sliding.







Types of slides

a) Rotational slide (slumping)

A rotational slide occurs when a mass of soil or weathered rock moves downslope along a curved failure surface.

Characteristics:

1. The sliding surface is curved.
2. The moving material rotates backwards as it moves downwards.
3. It may produce a steep head scarp at the upper part of the slope.
4. The displaced materials may form a series of step-like features.
5. It is common on slopes made of thick, loose or waterlogged materials.

Example: A section of a water-saturated hillside may rotate and slide downwards after prolonged rainfall.

b) Translational slide

A translational slide occurs when rock or soil moves downslope along a relatively flat or planar surface.

Characteristics:

1. Movement takes place along a relatively straight failure surface.
2. The moving mass may remain fairly intact.
3. It commonly occurs along bedding planes, joints or other weaknesses.
4. It may be triggered by rainfall, earthquakes or slope cutting.
5. It can move rapidly where the slope is steep.

c) Rockslide

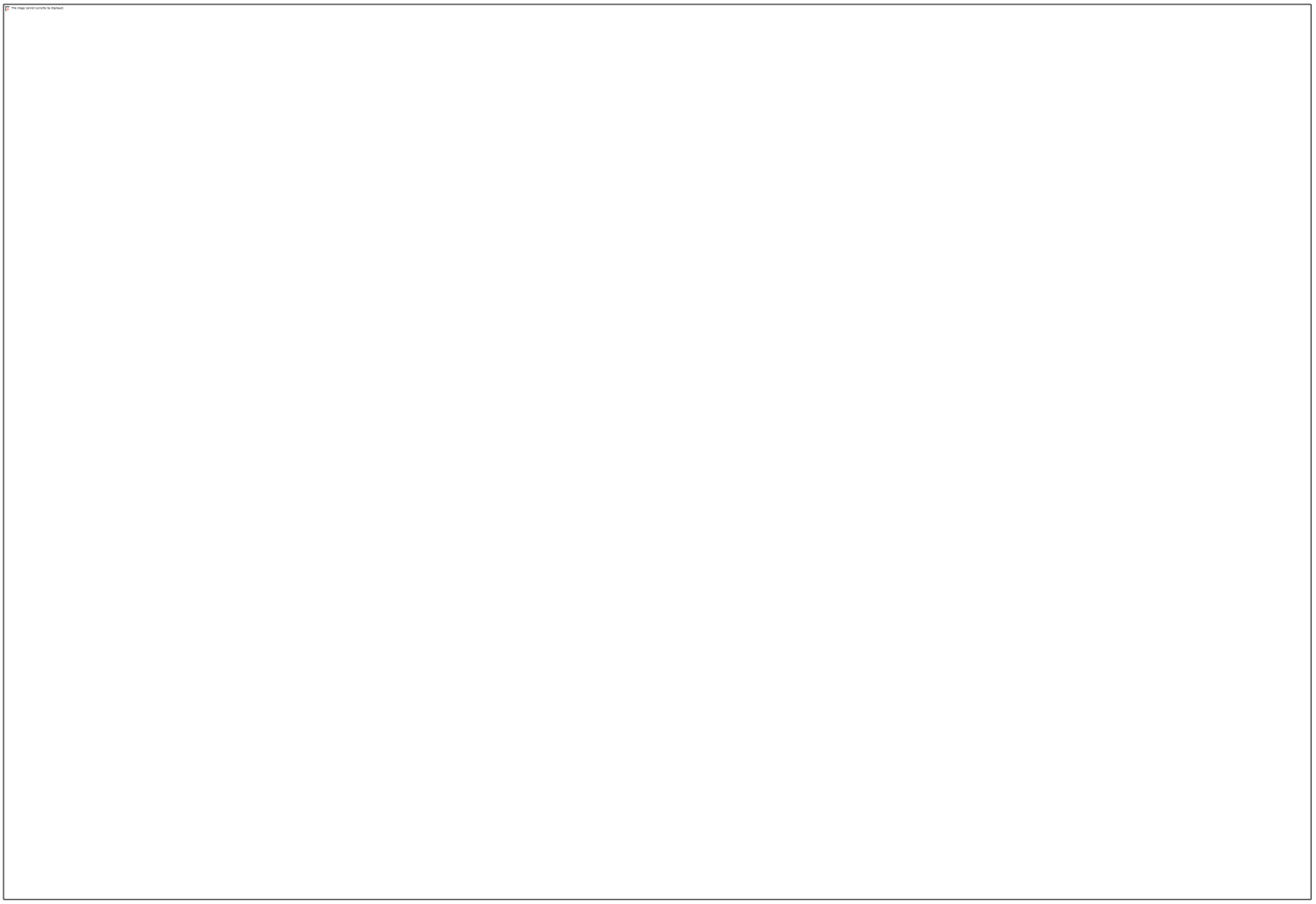
- Involves the sliding of a large mass of rock along a plane of weakness.
- It is common in mountainous and steep rocky areas.
- It may occur where rock layers are inclined towards a valley or slope.
- It can cause extensive destruction because of the large mass involved.

2.3 Flows

A flow is the downslope movement of water-saturated soil, mud, rock fragments or other loose materials behaving like a flowing fluid.

- The materials move in a manner similar to a liquid.
- Water plays an important role in many types of flows.
- Flows may move rapidly down valleys and drainage channels.
- They can travel long distances, burying land, roads, houses and farms.
- The speed and destructive power depend on the volume, slope gradient and amount of water.





Types of flows

a) Earthflow

An earthflow is the downslope movement of fine-grained, water-saturated soil or weathered earth materials.

Characteristics:

1. It usually involves clay-rich or fine-grained materials.
2. It may move slowly or moderately.
3. It commonly occurs on slopes after prolonged rainfall.
4. It may form a tongue-shaped deposit at the bottom of a slope.
5. It can damage crops, roads and buildings.

b) Mudflow

A mudflow is the rapid movement of a mixture of water and fine soil materials down a slope or through a valley.

Characteristics:

1. It contains a high proportion of water and fine sediments.
2. It is often triggered by intense or prolonged rainfall.
3. It can flow through river channels and drainage routes.
4. It may bury settlements, farms and roads.

5. It can carry trees, stones and other debris.

c) Debris flow

A debris flow is a rapid movement of a mixture of water, soil, rocks, gravel and other coarse materials.

Characteristics:

1. It contains materials of different sizes.
2. It usually moves rapidly.
3. It may follow river channels, gullies and steep valleys.
4. It can carry large boulders and tree trunks.
5. It is highly destructive due to its speed and the weight of the materials.

d) Debris avalanche

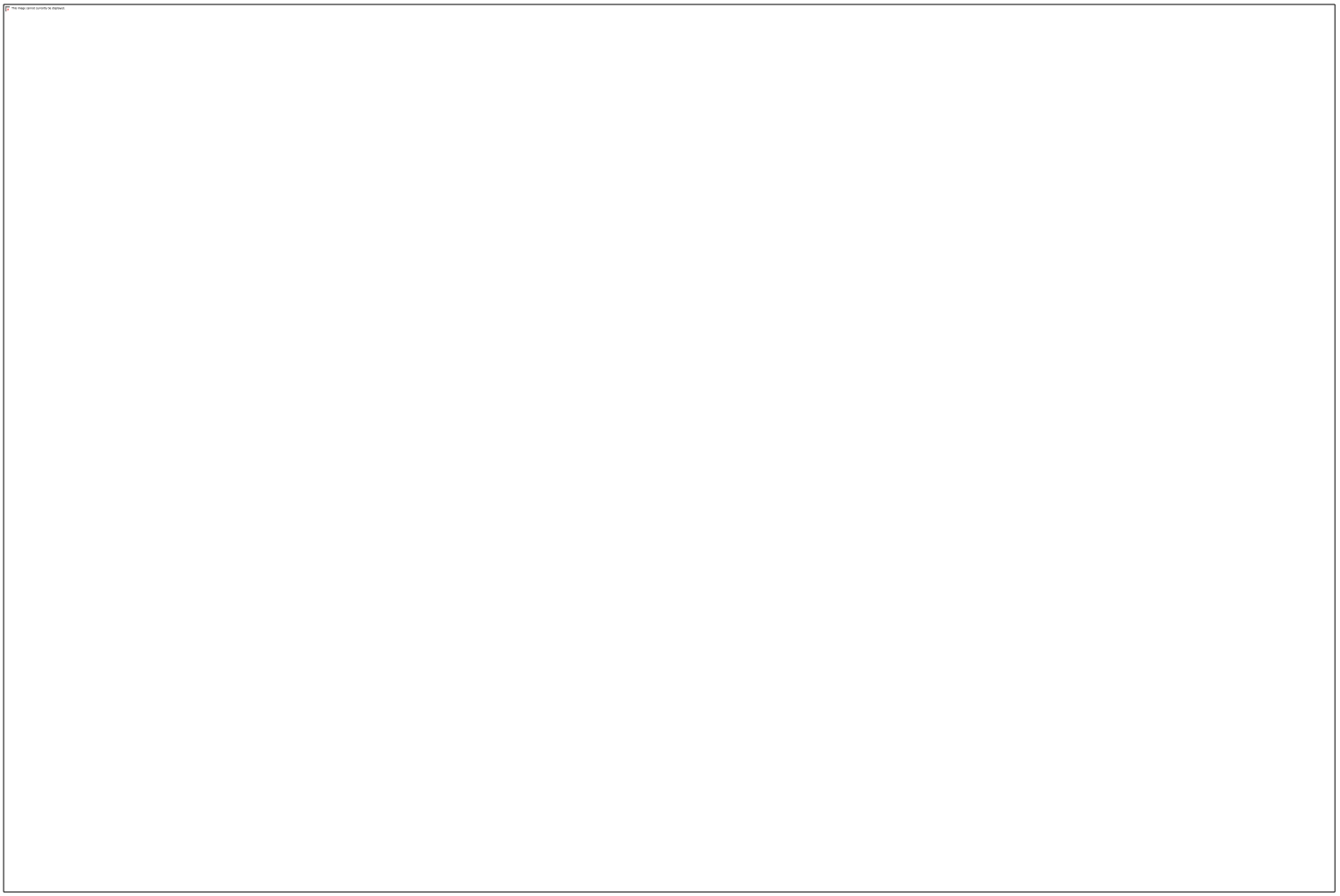
- This is the very rapid downslope movement of a large mass of loose rock and soil.
- It commonly occurs on steep slopes.
- It may be triggered by intense rainfall, earthquakes or volcanic activity.
- It can travel over considerable distances and destroy everything in its path.

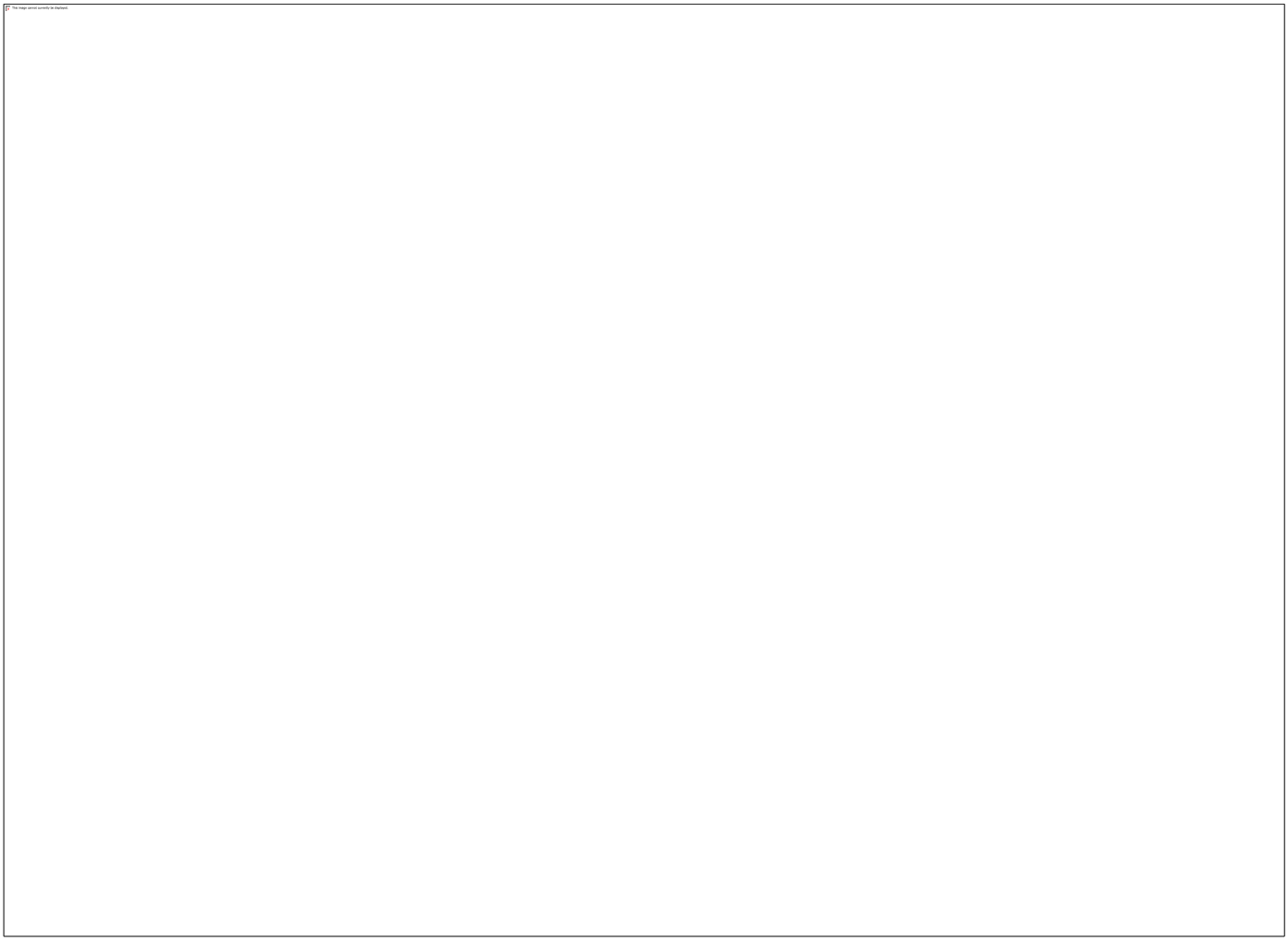
2.4 Creep

Creep is the extremely slow, gradual downslope movement of soil and weathered rock under the influence of gravity.

- It is one of the slowest forms of mass wasting.
- It may be difficult to notice over a short period.
- It becomes evident through changes in trees, fences, walls and other objects on slopes.
- It may be encouraged by repeated wetting and drying, freezing and thawing, and temperature changes.
- It commonly affects soil-covered hillsides.







Evidence of soil creep

1. Trees develop curved or bent trunks near the ground.
2. Fence posts lean downhill.
3. Electricity poles become tilted.
4. Retaining walls develop cracks or tilt.
5. Road surfaces become uneven.
6. Small steps called terracettes may develop on grass-covered slopes.
7. Buildings may develop cracks due to gradual ground movement.

Causes of soil creep

- Repeated wetting and drying of soil.
- Expansion and contraction of soil particles.
- Repeated freezing and thawing in cold environments.
- Gravity acting on loose materials.
- Disturbance of soil by animals.
- Removal of vegetation.

2.5 Solifluction

Solifluction is the slow downslope movement of waterlogged soil over an impermeable or frozen layer of ground.

- It is common in cold environments where the lower soil remains frozen or poorly drained.
- During warmer periods, the upper layer thaws and becomes saturated with water.
- The waterlogged upper layer slowly flows over the frozen or impermeable layer.
- It may produce lobes of soil on slopes.



Characteristics of solifluction

1. It involves water-saturated soil.
2. It is generally slow.
3. It occurs where drainage is restricted.
4. It is common in periglacial environments.
5. It produces lobes and irregular deposits on slopes.

2.6 Avalanches

An avalanche is the rapid downslope movement of a large mass of snow, ice, rock or a mixture of these materials under gravity.

- Snow avalanches are common in high mountainous regions with heavy snowfall.
- Rock avalanches involve the rapid movement of large quantities of rock debris.
- They may travel at very high speeds.
- They can bury roads, settlements and vegetation.
- They are particularly dangerous to people living or travelling in mountainous environments.



Note for learners: Snow avalanches are not common in Kenya's ordinary inhabited environments, but they are useful examples when studying mass wasting in high mountain regions around the world.

3.0 PROCESSES OF MASS WASTING

Mass wasting occurs when the forces resisting movement on a slope become weaker than the forces pulling materials downslope.

3.1 General processes involved in mass wasting

1. Weathering of rocks

- Rocks are broken down into smaller fragments through physical, chemical and biological weathering.
- Weathered materials may accumulate on slopes.
- Loose materials are more easily moved by gravity than solid, unweathered rock.

2. Water infiltration

- Rainwater enters the soil through pores, cracks and spaces between rock particles.
- The soil becomes saturated when it contains excessive water.
- Water adds weight to the slope materials.
- It may reduce friction and cohesion between particles.
- This makes the slope more likely to fail.

3. Weakening of slope materials

- Weathering weakens rocks and soil.
- Clay layers may become slippery when wet.
- Cracks and joints provide surfaces along which materials can move.
- Removal of vegetation reduces the binding effect of roots.

4. Development of slope instability

- A slope becomes unstable when the forces pulling materials downwards exceed the forces holding them in place.
- Steep slopes are particularly vulnerable.
- Water saturation, earthquakes and excavation may increase instability.

5. Detachment of materials

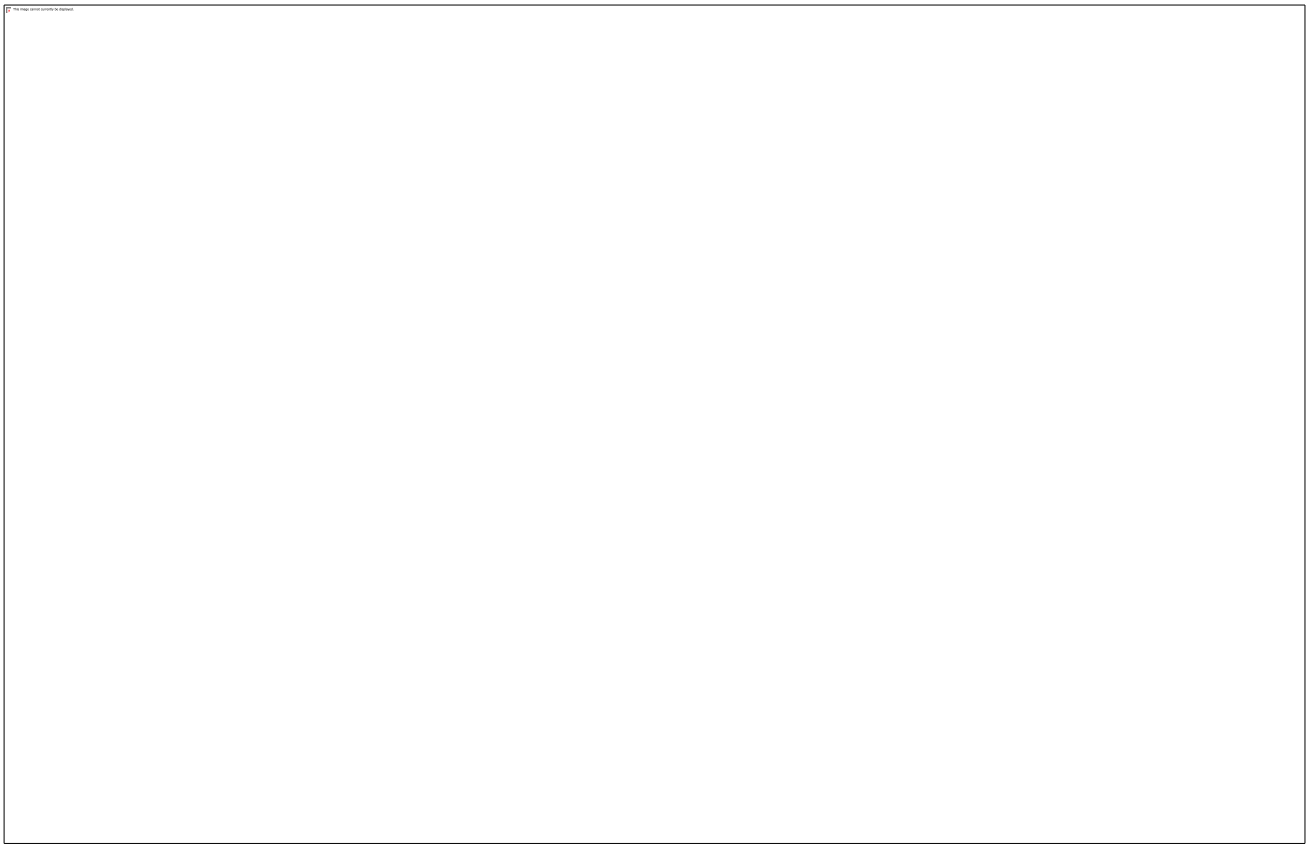
- Soil, rock or debris separates from the main slope.
- A crack or failure surface may develop.
- Materials begin to move under gravity.

6. Downslope movement

- The detached materials move through falling, sliding, flowing or creeping.
- The speed depends on the slope gradient, water content, material type and triggering event.

7. Deposition of materials

- Moving materials eventually lose energy and settle.
- Deposits may accumulate at the foot of slopes, in valleys or across drainage channels.
- The deposited materials may form debris fans, mounds or irregular land surfaces.



3.2 The role of gravity in mass wasting

Gravity is the main force responsible for downslope movement.

- It pulls soil and rock materials towards lower ground.
- Its influence is greater on steep slopes.
- It acts continuously, even when no visible movement is taking place.
- When slope materials become unstable, gravity causes them to move.

3.3 The role of water in mass wasting

Water influences mass wasting in several ways:

1. **Increases weight:** Water adds weight to soil and rock materials.
2. **Reduces friction:** Water may reduce friction between particles, making them slide more easily.
3. **Increases pore-water pressure:** Water in soil pores may reduce the effective strength holding particles together.
4. **Lubricates surfaces:** Water may help materials slide along joints and bedding planes.
5. **Causes erosion at the foot of slopes:** Running water may remove supporting materials, leaving slopes unstable.
6. **Promotes mudflows:** Large amounts of water mix with soil and debris to form flows.

3.4 The role of earthquakes

- Earthquakes cause vibrations within the Earth's crust.
- Vibrations may loosen soil and rock materials.
- Cracks may develop in slopes.

- Weak slopes may collapse or slide.
- Earthquakes can trigger landslides, rockfalls and debris avalanches.

3.5 The role of human activities

Human activities may accelerate mass wasting through:

- Cutting slopes to construct roads.
- Quarrying and mining.
- Deforestation.
- Overgrazing.
- Poor agricultural practices.
- Construction of buildings on unstable slopes.
- Blocking natural drainage channels.
- Poorly designed irrigation systems.

4.0 FACTORS INFLUENCING MASS WASTING

Mass wasting is influenced by natural and human factors. These factors determine whether a slope remains stable or becomes unstable.

4.1 Slope gradient

Slope gradient refers to the steepness of the land surface.

- Steep slopes encourage rapid downslope movement because gravity has a greater downslope effect.
- Materials on steep slopes are more likely to fall, slide or flow.
- Gentle slopes generally experience slower movement, although they can still undergo creep and other forms of mass wasting.
- Excavating the bottom of a steep slope may increase its instability.

Example: Steep mountain slopes in the Aberdare Ranges are more vulnerable to rapid movement of materials than gently sloping plains.

4.2 Amount and intensity of rainfall

- Heavy rainfall increases the amount of water entering the soil.
- Prolonged rainfall may saturate slope materials.
- Water increases the weight of soil and may reduce friction between particles.
- Intense rainfall may cause rapid runoff and undercut slopes.
- Areas receiving heavy or prolonged rainfall may experience increased landslide and mudflow risks, particularly where slopes are steep and vegetation has been removed.

4.3 Nature of rocks and soil

Different rocks and soils have different levels of strength and resistance.

- Loose, unconsolidated materials are easily moved.
- Clay-rich soils may become slippery when saturated.

- Highly weathered rocks are generally weaker than fresh, solid rocks.
- Rocks with many joints and cracks are more likely to break away.
- Alternating layers of permeable and impermeable rocks may encourage sliding.

4.4 Vegetation cover

- Plant roots bind soil particles together.
- Roots improve soil stability and reduce the likelihood of shallow slope failure.
- Vegetation reduces the direct impact of raindrops on the ground.
- Plant cover slows surface runoff.
- Deforestation and clearing of vegetation expose soil to erosion and instability.
- Removal of vegetation from steep slopes may increase the risk of landslides.

4.5 Geological structure

Geological structure refers to the arrangement and characteristics of rocks beneath the Earth's surface.

- Joints and cracks provide weak points in rocks.
- Faults may create zones of weakness.
- Bedding planes may provide surfaces along which rocks slide.
- Inclined rock layers dipping towards a valley may encourage slope failure.
- Strong and resistant rock layers may support slopes better than weak, weathered layers.

4.6 Earthquakes and earth tremors

- Vibrations loosen soil and rock materials.
- Cracks may form in slopes.
- Existing landslide-prone areas may become unstable.
- Strong earthquakes may trigger large-scale slope failures.

4.7 Human activities

Human activities can interfere with the natural stability of slopes.

Examples include:

1. **Deforestation:** Removes roots that hold soil together.
2. **Overgrazing:** Exposes soil and reduces vegetation cover.
3. **Road construction:** Cutting into slopes may remove support.
4. **Mining and quarrying:** Excavation may weaken surrounding land.
5. **Poor farming methods:** Cultivation along steep slopes may expose soil to erosion.
6. **Poor drainage:** Concentrated water may saturate slopes.
7. **Unplanned settlement:** Buildings may be constructed on unstable slopes.
8. **Excessive irrigation:** Overwatering may saturate soil and weaken slopes.

4.8 Slope drainage

- Well-drained slopes are generally less likely to become waterlogged.
- Poor drainage allows water to accumulate within soil and rock materials.
- Blocked drainage channels may direct water into unstable sections of slopes.
- Poorly managed roof water and road drainage may concentrate runoff and trigger slope failure.

4.9 Climate and temperature

- Climate influences the amount and distribution of rainfall.
- Freeze-thaw action in cold climates may widen cracks in rocks.
- Temperature changes may contribute to rock breakdown.
- Alternating wet and dry conditions may encourage soil movement.
- Climate also influences vegetation cover, which affects slope stability.

4.10 Undercutting of slopes

Undercutting occurs when the base or lower part of a slope is removed.

- Rivers may erode the foot of valley slopes.
- Waves may erode coastal cliffs.
- Road construction may cut into the base of hills.
- Quarrying may remove supporting materials.
- The unsupported upper section may collapse or slide.

4.11 Time

- Long periods of weathering weaken rocks and soil.
- Repeated wetting and drying may gradually destabilise slopes.
- Creep may occur over many years.
- A slope may remain stable for a long period before suddenly failing after heavy rainfall or an earthquake.

5.0 EFFECTS OF MASS WASTING ON THE ENVIRONMENT

Mass wasting has both positive and negative effects on the environment. Its effects depend on the type, volume, speed and location of movement.

5.1 Positive effects

1. Formation of new landforms

- Mass wasting changes the shape of the Earth's surface.
- It creates landslide scars, debris slopes, mounds and deposits at the foot of hills.
- It contributes to the development of irregular landscapes.

2. Soil formation

- Rock fragments and weathered materials are transported downslope.
- The materials may mix with organic matter.

- Over time, they contribute to the formation of new soil deposits.

3. Exposure of minerals and rocks

- Movement of soil and rock may expose mineral deposits.
- This may make some geological materials easier to identify and study.

4. Creation of habitats

- Deposited materials may create different surfaces and habitats.
- New vegetation may grow on suitable deposits.
- Some landforms may provide habitats for specialised plants and animals.

5. Supply of construction materials

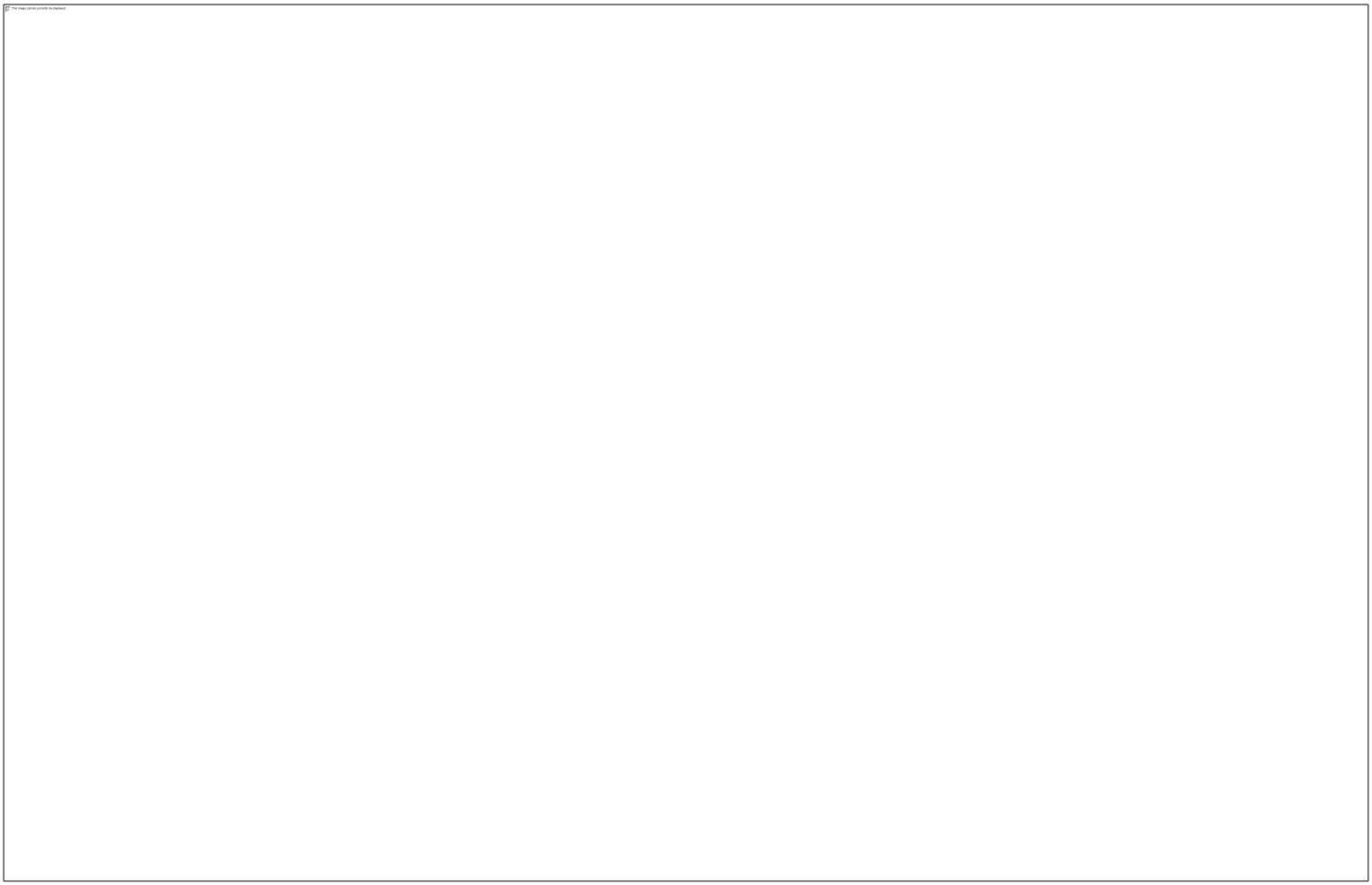
- Deposited rock fragments, gravel and sand may provide materials for construction.
- However, such materials should only be extracted after environmental and safety assessments.

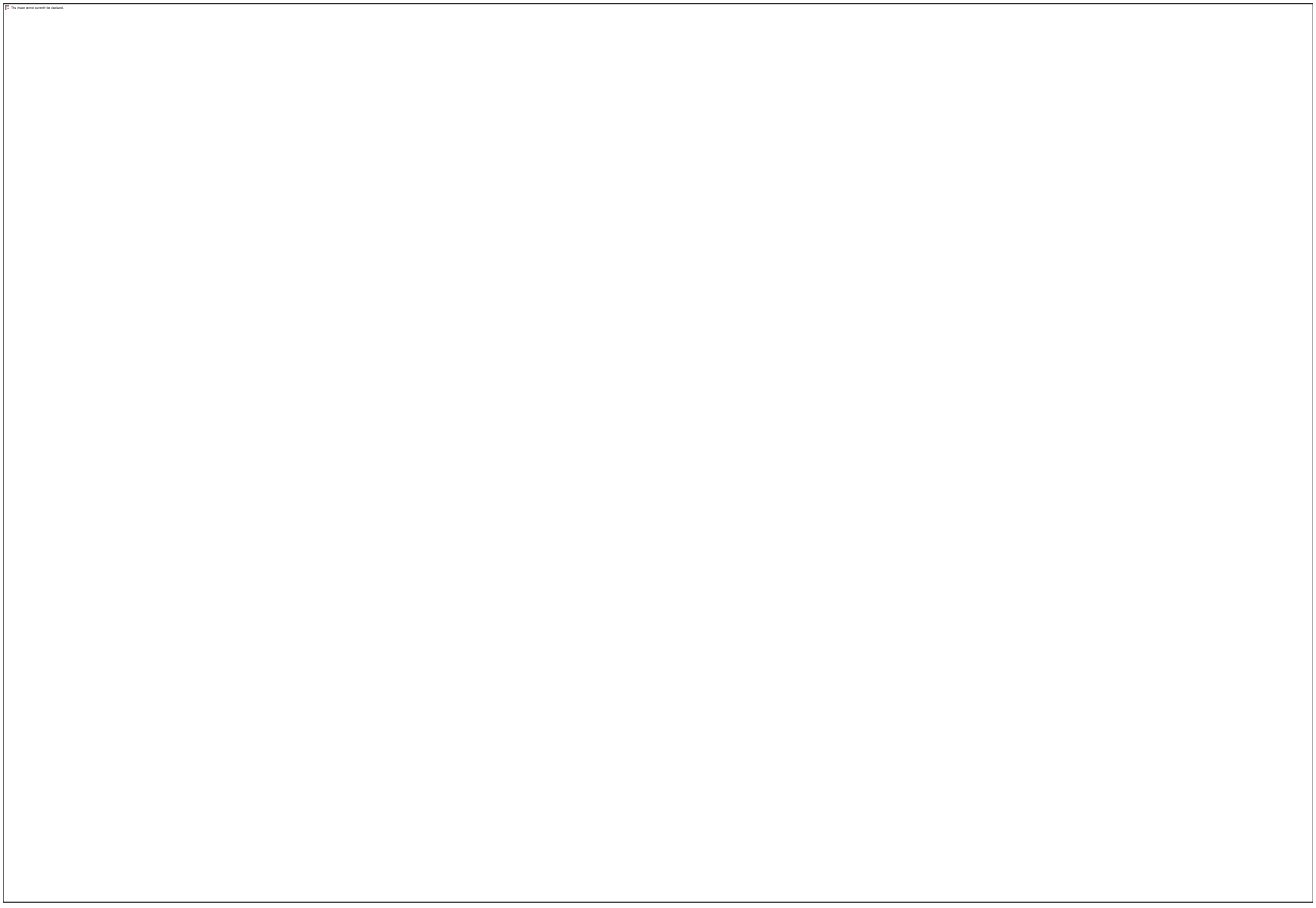
6. Scientific and educational value

- Mass wasting provides opportunities for studying slope processes.
- It helps learners and researchers understand how landscapes change.
- It can be studied during fieldwork and geographical investigations.

5.2 Negative effects







1. Loss of human life

- Rapid landslides and mudflows may bury people.
- Rockfalls may strike people travelling or working near steep slopes.
- Communities living in landslide-prone areas face serious danger.

2. Destruction of property

- Moving soil and rocks may destroy houses, schools and other buildings.
- Heavy debris may damage bridges and public facilities.
- Families may lose their homes and belongings.

3. Destruction of transport infrastructure

- Landslides may block roads and railway lines.
- Rockfalls may damage road surfaces and bridges.
- Transport services may be disrupted.
- Emergency and rescue teams may experience difficulties reaching affected communities.

4. Destruction of agricultural land

- Landslides may bury crops and fertile topsoil.
- Farms may become uneven and difficult to cultivate.
- Irrigation systems and farm structures may be destroyed.
- Farmers may lose their income and food supplies.

5. Displacement of people

- People may be forced to leave their homes.
- Families may move to temporary shelters or safer areas.
- Displacement may interrupt children's education and access to basic services.

6. Destruction of vegetation and wildlife habitats

- Moving debris may uproot trees and other vegetation.
- Forest habitats may be damaged.
- Wildlife may be killed, injured or displaced.
- The destruction of vegetation may expose more soil to erosion.

7. Blocking of rivers and drainage channels

- Landslide materials may enter river valleys.
- Debris may block natural drainage channels.
- Water may accumulate behind the deposited materials.
- A temporary landslide dam may form.
- If the blockage fails, sudden flooding may occur downstream.

8. Water pollution

- Soil, rocks and debris may enter rivers and streams.
- Sediment may make water muddy.
- The movement may introduce waste and other contaminants into water sources.
- Aquatic habitats may be affected.

9. Economic losses

- Governments and households spend money on rescue operations and rebuilding.
- Agricultural production may decline.
- Businesses may close temporarily.
- Transport and communication services may be interrupted.

10. Increased soil erosion

- Mass wasting removes vegetation and exposes bare soil.
- Rainwater may wash away the exposed materials.
- Gullies may develop on unstable slopes.
- Further land degradation may occur.

11. Psychological and social effects

- Survivors may experience fear, grief and emotional distress.
- Families may be separated.
- Community relationships may be disrupted.
- Children may lose access to their normal learning environment.

12. Increased flood risk

- Landslide debris may block rivers.
- Sudden failure of a natural blockage may release large volumes of water.
- Downstream communities may experience flash floods.

6.0 DISASTER PREPAREDNESS AND MANAGEMENT OF MASS WASTING

6.1 Meaning of a disaster

A disaster is a serious disruption of the normal functioning of a community or society, resulting in human, material, economic or environmental losses that exceed the community's ability to cope using its own resources.

Examples include landslides, floods, earthquakes, droughts and volcanic eruptions.

6.2 Meaning of disaster preparedness

Disaster preparedness refers to the actions taken before a disaster occurs to ensure that individuals, households and communities are ready to respond effectively.

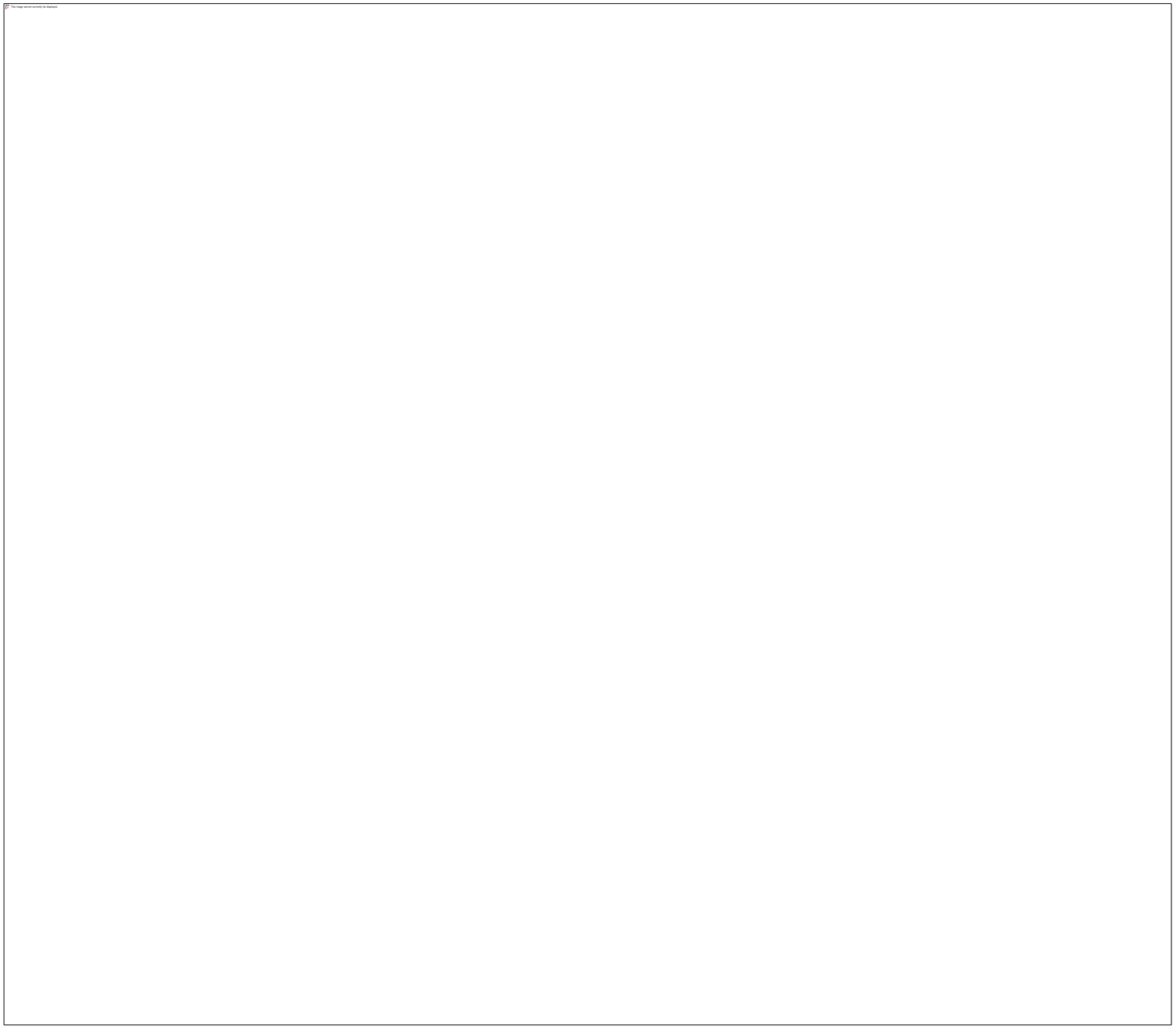
It involves planning, training, education, resource mobilisation, early warning systems and evacuation arrangements.

6.3 Meaning of disaster management

Disaster management refers to the organised process of preparing for, responding to and recovering from disasters in order to reduce their effects on people, property and the environment.

It involves four major stages:

1. Prevention and mitigation.
2. Preparedness.
3. Response.
4. Recovery.



6.4 Importance of disaster preparedness and management

1. **Saves human lives:** Early warnings and evacuation help people move away from dangerous areas.
2. **Reduces injuries:** Communities can avoid dangerous slopes and falling debris.
3. **Protects property:** Proper land-use planning reduces damage to houses and infrastructure.

4. **Reduces economic losses:** Prepared communities can respond quickly and reduce destruction.
5. **Promotes community awareness:** People learn how to identify warning signs and respond appropriately.
6. **Improves emergency response:** Rescue teams can act in an organised manner.
7. **Protects the environment:** Proper management reduces unnecessary disturbance of unstable slopes.
8. **Reduces displacement:** Safer settlement planning helps prevent people from living in high-risk areas.
9. **Promotes coordination:** Government agencies, schools, families and community organisations can work together.
10. **Supports faster recovery:** Preparedness plans make it easier to restore essential services after a disaster.

6.5 Strategies for preventing and reducing mass wasting

A. Proper land-use planning

- Avoid building houses on unstable slopes.
- Identify areas prone to landslides before establishing settlements.
- Restrict construction on steep and unstable ground.
- Conduct geological and environmental assessments before major developments.
- Establish safe distances from unstable cliffs and slopes.

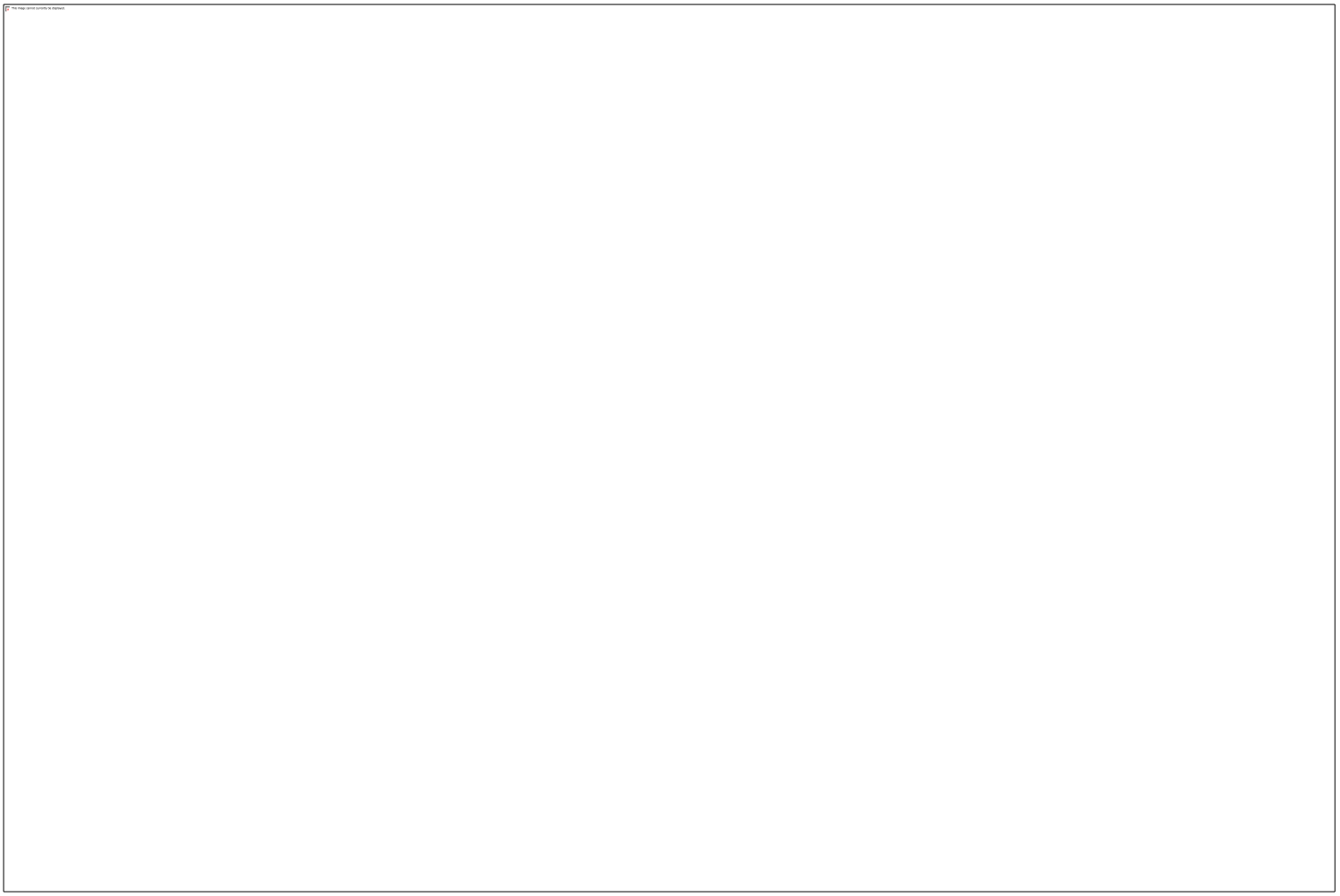
B. Afforestation and reforestation

- Plant trees on suitable slopes.
- Maintain natural vegetation cover.
- Protect forests from uncontrolled clearing.
- Encourage community tree-planting programmes.
- Use suitable grasses and shrubs to cover exposed soil.

How it helps: Plant roots bind soil particles together and reduce surface runoff.

C. Construction of retaining walls

- Retaining walls support soil on steep slopes.
- They help prevent loose materials from sliding.
- They should be properly designed to withstand the pressure of the soil.
- Suitable drainage should be provided behind the wall to prevent water pressure from building up.

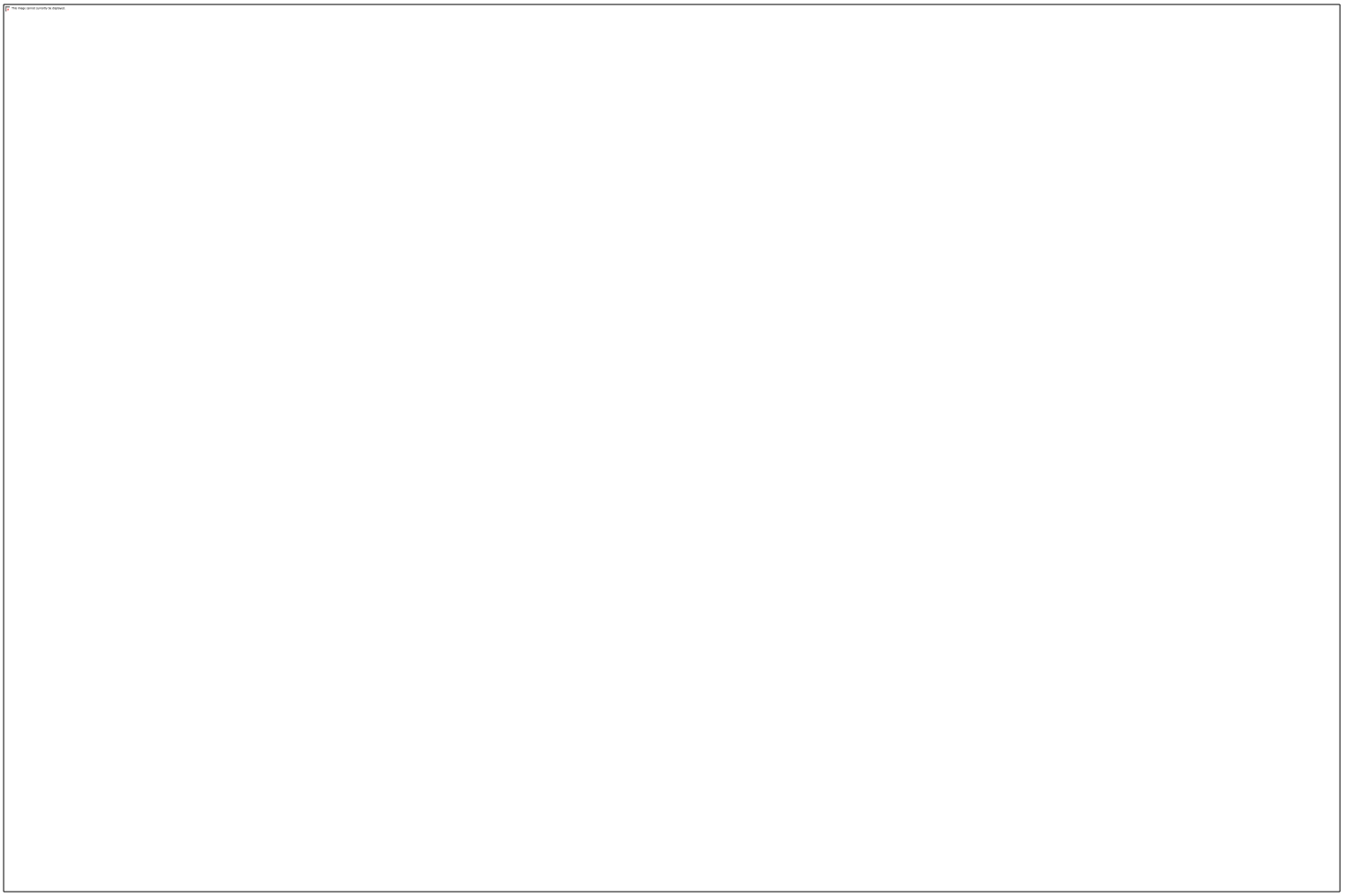


D. Proper drainage systems

- Construct drains to safely direct rainwater away from unstable slopes.
- Keep drainage channels free from blockages.
- Prevent uncontrolled discharge of roof water onto slopes.
- Maintain culverts and road drains.
- Avoid directing large volumes of water towards weak sections of a hillside.

E. Terracing

- Construct terraces on suitable steep agricultural slopes.
- Terraces reduce the length and steepness of the slope.
- They slow down surface runoff.
- They reduce soil loss and help improve slope management.
- Terraces should be properly maintained and drained.



F. Construction of gabions

Gabions are wire-mesh containers filled with stones and used to stabilise slopes and control erosion.

- They provide support to unstable sections of slopes.
- They reduce the movement of loose materials.
- They allow water to drain through them.
- They are useful in some road construction and riverbank protection projects.



G. Slope reinforcement

- Use suitable engineering structures to strengthen unstable slopes.
- Rock bolts may be used to secure loose rock masses.
- Soil nailing may help reinforce suitable soil slopes.
- Wire mesh may be installed to control falling rock fragments.
- Engineering methods should be selected after professional assessment.

H. Controlled excavation and mining

- Avoid uncontrolled cutting of slopes.
- Ensure road construction follows appropriate engineering standards.
- Avoid removing supporting materials from the foot of unstable slopes.
- Restore and stabilise disturbed land after mining or quarrying.
- Conduct environmental impact assessments for major projects.

I. Controlled grazing and farming

- Avoid overgrazing on steep slopes.
- Maintain ground cover.
- Use contour farming where suitable.
- Plant grass and cover crops.
- Avoid cultivation on highly unstable slopes.

6.6 Disaster preparedness strategies

1. Hazard mapping

- Identify areas prone to landslides, rockfalls and mudflows.
- Mark dangerous slopes and valleys.
- Use maps to guide settlement and infrastructure planning.
- Share hazard information with local communities.

2. Early warning systems

- Monitor rainfall and slope conditions in high-risk areas.
- Establish communication channels for warnings.
- Use radio, mobile phones, public announcements and community networks.
- Ensure warnings reach people with disabilities and those living in remote areas.

3. Community education

- Teach residents about causes and warning signs of mass wasting.
- Organise public awareness meetings.
- Display posters showing safe actions.
- Encourage reporting of cracks and unusual slope movement.

4. Evacuation planning

- Identify safe evacuation routes.
- Establish safe assembly points.
- Identify people who may need assistance.
- Conduct evacuation drills in schools and communities.
- Avoid routes that pass beneath unstable slopes.

5. Emergency supplies

Prepare emergency kits containing:

- Drinking water.
- First-aid supplies.
- A torch and spare batteries.
- A whistle.
- A battery-powered radio.
- Essential medicines.
- Important documents stored in waterproof packaging.
- Basic food supplies.
- A charged mobile phone and power bank where available.

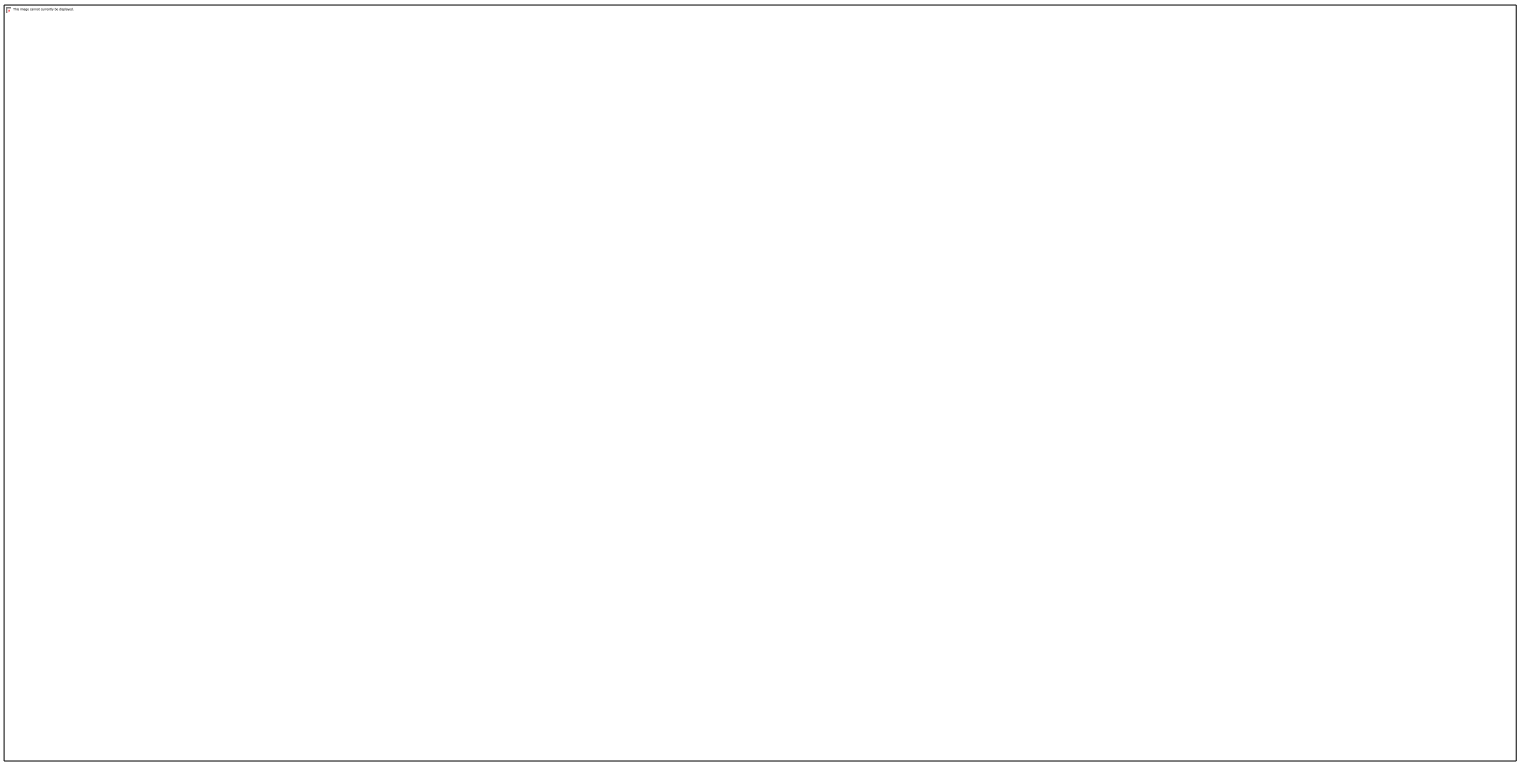
6. Establishment of emergency response teams

- Train community members in basic emergency response.
- Identify first-aid providers.
- Coordinate with relevant government disaster-management agencies.
- Establish communication arrangements with health facilities and rescue services.

7. Monitoring of warning signs

People should be alert to:

- New cracks on the ground.
- Cracks appearing in walls and foundations.
- Leaning trees, poles or fences.
- Bulging ground at the foot of a slope.
- Unusual water seepage.
- Sudden changes in stream flow.
- Small rockfalls or soil movement.
- Unusual sounds such as cracking or rumbling from a slope.



6.7 Strategies during a mass-wasting disaster

1. Move away from the path of the moving materials.
2. Evacuate to a safe area identified by emergency authorities.
3. Avoid crossing active landslide areas.
4. Keep away from river channels blocked by landslide debris.
5. Follow official instructions.
6. Alert neighbours and vulnerable people where it is safe to do so.
7. Contact emergency services.
8. Do not attempt to rescue trapped people without proper training and equipment.
9. Avoid returning to affected areas until authorities declare them safe.
10. Be alert to further slope movement and possible flooding.

6.8 Strategies after a mass-wasting disaster

1. Conduct search and rescue operations using trained personnel.
2. Provide first aid and emergency medical services.
3. Move affected people to safe temporary shelters.
4. Supply clean drinking water and food.
5. Assess damage to houses, roads, schools and other infrastructure.
6. Restore essential services such as water, electricity and communication.
7. Clear debris only after safety assessments.
8. Rehabilitate damaged slopes using suitable engineering and environmental measures.
9. Provide psychosocial support to survivors.

10. Rebuild houses and infrastructure in safer locations where necessary.
11. Review the disaster response plan and improve future preparedness.

6.9 Roles of different stakeholders in mass-wasting disaster management

Stakeholder	Responsibilities
National government	Develop disaster policies, coordinate response and provide emergency resources.
County governments	Support local disaster planning, public awareness and emergency response.
Meteorological services	Provide rainfall information and relevant weather warnings.
Geological and environmental experts	Assess slope stability and identify hazardous areas.
Schools	Educate learners, conduct drills and prepare school safety plans.
Community leaders	Mobilise residents and communicate warnings.
Health workers	Provide first aid, medical treatment and psychosocial support.
Non-governmental organisations	Support relief, shelter, education and recovery programmes.
Households	Maintain emergency supplies, follow warnings and avoid dangerous locations.
Media	Share verified information and public safety messages.

7.0 CASE STUDY: MASS WASTING IN THE KENYAN ENVIRONMENT

Kenya has varied relief, including mountains, highlands, escarpments, plateaus and valleys. Some areas have steep slopes and receive substantial rainfall, making them vulnerable to landslides, mudflows and other forms of mass wasting.

7.1 Areas that may be vulnerable

Examples of environments where mass-wasting hazards may occur include:

- Steep slopes in the Aberdare Ranges.
- Parts of the Mount Kenya region.
- Steep highland areas in Murang'a, Nyeri and other parts of Central Kenya.
- Sloping areas in Western Kenya and parts of the Rift Valley.
- Steep valley sides and road cuttings.
- Areas where settlements or farms occupy unstable slopes.





7.2 Factors that may increase mass-wasting risk in Kenya

1. Heavy or prolonged rainfall.
2. Steep slopes in mountainous and highland areas.

3. Deforestation and removal of natural vegetation.
4. Cultivation on steep slopes without adequate soil conservation.
5. Poorly constructed roads and drainage systems.
6. Settlement on unstable hillsides.
7. Quarrying and excavation.
8. Weathered and fractured rock materials.
9. Poor land-use planning.
10. Concentrated surface runoff.

7.3 Lessons communities can learn

- People should avoid settling on unstable slopes.
- Vegetation should be protected.
- Drainage systems should be maintained.
- Communities should learn to recognise early warning signs.
- Local authorities should identify and map high-risk areas.
- Schools should conduct safety education and evacuation drills.
- People should follow official warnings and evacuation instructions.

8.0 FIELD STUDY: INVESTIGATING MASS WASTING IN THE LOCAL ENVIRONMENT

A field study enables learners to observe evidence of mass wasting and understand how it affects the environment.

8.1 Meaning of a field study

A field study is an organised investigation carried out outside the classroom to collect first-hand geographical information about a particular environment or geographical phenomenon.

8.2 Objectives of the field study

By the end of the field study, learners should be able to:

1. Identify evidence of mass wasting.
2. Describe the types of mass wasting observed.
3. Examine factors influencing slope instability.
4. Identify effects of mass wasting on the environment.
5. Suggest measures for reducing mass-wasting hazards.
6. Develop skills in observation, recording, analysis and communication.

8.3 Equipment and materials

- Notebook and pen.
- Camera or mobile phone.
- Clipboard.
- Measuring tape.

- Topographical map.
- Compass.
- Appropriate protective clothing.
- First-aid kit.
- Field observation checklist.

8.4 Procedure

1. Select a safe site where evidence of mass wasting can be observed.
2. Obtain permission from relevant authorities or landowners.
3. Study the location using a map.
4. Observe the slope gradient and vegetation cover.
5. Identify cracks, scars, tilted trees and deposited materials.
6. Record the type of mass wasting observed.
7. Identify possible causes.
8. Examine effects on roads, buildings, farms and vegetation.
9. Take photographs from safe locations.
10. Suggest measures for reducing the risk.
11. Present the findings in class.

8.5 Sample field observation table

Observation	**Evidence recorded**
Slope gradient	Gentle, moderate or steep
Vegetation cover	Dense, sparse or bare
Ground condition	Dry, moist or waterlogged
Evidence of movement	Cracks, scars, fallen rocks or debris
Type of mass wasting	Creep, slide, flow or fall
Possible causes	Rainfall, slope cutting, deforestation or weak rocks
Effects	Damaged roads, farms, vegetation or buildings
Control measures	Drainage, vegetation, retaining walls or restricted settlement

8.6 Safety precautions during fieldwork

- Do not visit an active landslide site.
- Avoid standing below unstable cliffs or slopes.
- Do not walk across fresh cracks or unstable ground.
- Avoid river channels affected by landslide debris.
- Follow the teacher's instructions.
- Work in groups.
- Carry a first-aid kit.
- Do not collect samples from dangerous locations.
- Stop the investigation if rainfall or slope movement creates a risk.

REVISION EXERCISES AND ASSESSMENT

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Instructions: Answer all the questions. Choose the correct answer from the alternatives A, B, C and D. Each question carries 1 mark.

1. What is mass wasting?

A. Movement of materials by wind.
B. Downslope movement of earth materials under gravity.
C. Transportation of materials by ocean currents.
D. Deposition of sediments by rivers.

2. The main force responsible for mass wasting is:

A. Wind.
B. Solar energy.
C. Gravity.
D. Ocean currents.

3. Which of the following is the slowest type of mass wasting?

A. Rockfall.
B. Mudflow.
C. Debris avalanche.
D. Soil creep.

4. The sudden falling of rock fragments from a steep cliff is known as:

A. Rockfall.
B. Solifluction.
C. Soil creep.
D. Earthflow.

5. A rotational slide moves along:

A. A horizontal river channel.
B. A curved failure surface.
C. A vertical fault only.
D. A flat coastal surface.

6. Which type of mass wasting involves the movement of materials along a relatively flat failure surface?

A. Translational slide.
B. Soil creep.
C. Rockfall.
D. Solifluction.

7. A mixture of water, soil and fine sediments moving rapidly down a slope is called:

A. Rockslide.
B. Mudflow.
C. Soil creep.
D. Rockfall.

8. Which type of mass wasting is commonly associated with waterlogged soil moving over frozen or impermeable ground?

A. Rockfall.
B. Solifluction.
C. Debris avalanche.
D. Translational slide.

9. Which of the following is evidence of soil creep?

A. Fresh volcanic lava.
B. Straight tree trunks.
C. Tilted fence posts.
D. Rounded river stones.

10. Which of the following conditions is most likely to trigger a mudflow?

A. Prolonged drought.
B. Heavy rainfall.
C. Very low humidity.
D. Calm weather.

11. Which factor increases the likelihood of mass wasting on steep slopes?

A. Increased slope stability.
B. Dense vegetation cover.
C. Removal of vegetation.
D. Proper drainage.

12. The movement of a large mass of rock along a plane of weakness is known as:

A. Rockslide.
B. Soil creep.
C. Solifluction.
D. Earthflow.

13. Which of the following best explains why waterlogged soil is more likely to move downslope?

A. It always becomes lighter.
B. It increases soil weight and may reduce friction.
C. It prevents gravity from acting.
D. It makes all rocks stronger.

14. Which of the following geological features may provide a surface along which rocks slide?

A. Bedding plane.
B. Sand dune.
C. River delta.
D. Coral reef.

15. Which human activity may increase the risk of landslides?

A. Afforestation.
B. Controlled grazing.
C. Uncontrolled excavation of slopes.
D. Construction of suitable drainage systems.

16. The gradual removal of materials at the foot of a slope is known as:

A. Undercutting.
B. Deposition.

C. Condensation.
D. Evaporation.

17. Which type of mass wasting involves the rapid movement of a mixture of water, rocks and soil fragments?

A. Soil creep.
B. Debris flow.
C. Solifluction.
D. Rotational creep.

18. Which of the following is a characteristic feature of rotational slumping?

A. Movement along a curved failure surface.
B. Movement caused only by wind.
C. Movement of snow only.
D. Movement along a river bed.

19. Which of the following is a positive effect of mass wasting?

A. Destruction of houses.
B. Loss of human life.
C. Exposure of geological materials.
D. Displacement of people.

20. A landslide may cause flooding when it:

A. Increases evaporation.
B. Blocks a river channel.
C. Reduces rainfall.
D. Increases vegetation cover.

21. Which of the following is an important role of vegetation in slope stability?

A. Increasing soil saturation.
B. Removing all soil particles.
C. Binding soil particles with roots.
D. Increasing slope gradient.

22. Which of the following is the most suitable method of reducing soil movement on a cultivated hillside?

A. Removing all vegetation.
B. Cultivating directly downhill.
C. Constructing suitable terraces.
D. Blocking drainage channels.

23. Gabions are mainly used to:

A. Increase slope instability.
B. Support slopes and control erosion.
C. Increase waterlogging.
D. Encourage rockfalls.

24. Which of the following is an appropriate preparedness measure for landslide hazards?

A. Building houses below unstable cliffs.
B. Ignoring ground cracks.

C. Developing evacuation routes.
D. Blocking natural drainage channels.

25. Which of the following may indicate an approaching slope failure?

A. New cracks on the ground.
B. A clear blue sky.
C. Normal plant growth.
D. A decrease in slope gradient.

26. Which institution or service is important in providing weather information that may support early warning of rainfall-related hazards?

A. Meteorological services.
B. Sports clubs.
C. Retail shops.
D. Entertainment centres.

27. During an active landslide, the safest action is to:

A. Move towards the moving debris.
B. Stand below the unstable slope.
C. Move away from the path of the moving materials.
D. Cross the landslide area immediately.

28. Which of the following is a recovery activity after a mass-wasting disaster?

A. Ignoring damaged infrastructure.
B. Rebuilding in unsafe locations without assessment.
C. Providing temporary shelter and restoring essential services.
D. Encouraging settlement on unstable slopes.

29. Which of the following is a likely environmental effect of mass wasting?

A. Permanent prevention of soil erosion.
B. Increased sediment in rivers.
C. Elimination of all natural hazards.
D. Complete prevention of flooding.

30. Why is disaster preparedness and management important in communities exposed to mass wasting?

A. It increases the speed of landslides.
B. It encourages people to settle on unstable slopes.
C. It reduces loss of life and property.
D. It prevents all rainfall from reaching the ground.

SECTION B: STRUCTURED QUESTIONS

Instructions: Answer all the questions. The section carries 50 marks.

1. Introduction to mass wasting (8 marks)

a) Define the term mass wasting. (2 marks)

b) State four characteristics of mass wasting. (4 marks)

c) Give two examples of areas where mass-wasting hazards may occur in Kenya. (2 marks)

2. Types of mass wasting (8 marks)

a) Differentiate between a fall and a slide. (2 marks)

b) Describe four types of mass wasting. (4 marks)

c) State two characteristics of soil creep. (2 marks)

3. Processes and factors influencing mass wasting (8 marks)

a) Describe four processes involved in mass wasting. (4 marks)

b) Explain four factors influencing mass wasting on the Earth's surface. (4 marks)

4. Effects of mass wasting (8 marks)

a) Explain four negative effects of mass wasting on the environment. (4 marks)

b) Describe four positive effects of mass wasting. (4 marks)

5. Disaster preparedness and management (9 marks)

a) Define disaster preparedness. (2 marks)

b) Explain five strategies that communities can use to prepare for mass-wasting disasters. (5 marks)

c) State two actions that should be taken during an active landslide. (2 marks)

6. Application and geographical skills (9 marks)

A community is located on a steep hillside. The area has experienced prolonged rainfall. Residents have noticed cracks on the ground, leaning trees, blocked drainage channels and small movements of soil.

a) Identify three warning signs of possible mass wasting from the description. (3 marks)

b) Explain three factors that may cause mass wasting in the area. (3 marks)

c) Suggest three measures that the community and local authorities should take to reduce the risk of mass wasting. (3 marks)

TEACHER'S MARKING SCHEME

Section A: Multiple-choice answers

Question	Answer	Question	Answer
1	B	16	A

2	C	17	B
3	D	18	A
4	A	19	C
5	B	20	B
6	A	21	C
7	B	22	C
8	B	23	B
9	C	24	C
10	B	25	A
11	C	26	A
12	A	27	C
13	B	28	C
14	A	29	B
15	C	30	C

Total: 30 marks

Section B: Suggested marking scheme

1. Introduction to mass wasting (8 marks)

a) Define mass wasting. (2 marks)

- Mass wasting is the downslope movement of weathered rock materials, soil and debris under the influence of gravity. (2 marks)

b) State four characteristics of mass wasting. (4 marks)

Award 1 mark each for any four:

1. It involves the downslope movement of materials.
2. Gravity is the main driving force.
3. It occurs mainly on sloping surfaces.
4. It may be slow or rapid.
5. It involves soil, rocks, mud and debris.
6. It changes the shape of the Earth's surface.
7. Water may accelerate the movement.
8. It may cause environmental destruction.

c) Give two examples of areas where mass-wasting hazards may occur in Kenya. (2 marks)

Award 1 mark each for any two:

- Aberdare Ranges.
- Mount Kenya region.
- Steep highland areas of Murang'a.
- Nyeri highlands.
- Steep parts of Western Kenya.
- Steep valley sides and escarpments in the Rift Valley.

2. Types of mass wasting (8 marks)

a) Differentiate between a fall and a slide. (2 marks)

- A fall involves the sudden detachment and downward movement of materials through the air from a steep slope. (1 mark)
- A slide involves the downslope movement of a mass of material along a recognisable failure surface. (1 mark)

b) Describe four types of mass wasting. (4 marks)

Award 1 mark each for any four correctly described types:

1. **Rockfall:** Sudden falling of detached rock fragments from a steep slope.
2. **Rotational slide:** Movement of materials along a curved failure surface.
3. **Translational slide:** Movement of materials along a relatively flat failure surface.
4. **Mudflow:** Rapid movement of water mixed with fine soil materials.
5. **Debris flow:** Rapid movement of water, rocks, soil and coarse debris.
6. **Earthflow:** Downslope movement of water-saturated fine-grained soil.
7. **Soil creep:** Very slow movement of soil downhill under gravity.
8. **Solifluction:** Slow movement of waterlogged soil over frozen or impermeable ground.
9. **Avalanche:** Rapid downslope movement of snow, ice, rock or debris.

c) State two characteristics of soil creep. (2 marks)

Award 1 mark each for any two:

- It is very slow.
- It occurs gradually over a long period.
- It occurs under the influence of gravity.
- It causes fence posts to lean downhill.
- It causes trees to develop curved trunks.
- It may produce terracettes on slopes.

3. Processes and factors influencing mass wasting (8 marks)

a) Describe four processes involved in mass wasting. (4 marks)

Award 1 mark each for any four correctly described processes:

1. **Weathering:** Breaks rocks into loose materials that can move downslope.
2. **Water infiltration:** Rainwater enters soil and rock, increasing moisture content.
3. **Saturation:** Excessive water increases the weight of materials and may reduce slope strength.
4. **Slope weakening:** Weathering and water reduce the stability of soil and rocks.
5. **Detachment:** Materials separate from the main slope.
6. **Downslope movement:** Detached materials fall, slide, flow or creep under gravity.
7. **Deposition:** Moving materials settle when they lose energy.

b) Explain four factors influencing mass wasting. (4 marks)

Award 1 mark each for any four:

1. **Slope gradient:** Steep slopes encourage rapid downslope movement.
2. **Rainfall:** Heavy rainfall saturates soil and increases its weight.
3. **Vegetation:** Removal of vegetation reduces root binding and exposes soil.
4. **Rock structure:** Joints, faults and bedding planes provide surfaces of weakness.
5. **Soil type:** Loose and clay-rich materials may become unstable when saturated.
6. **Earthquakes:** Vibrations may loosen soil and rock materials.
7. **Human activities:** Excavation, quarrying and road construction may weaken slopes.
8. **Drainage:** Poor drainage allows water to accumulate within slope materials.
9. **Undercutting:** Removal of materials at the foot of a slope reduces support.

4. Effects of mass wasting (8 marks)

a) Explain four negative effects of mass wasting on the environment. (4 marks)

Award 1 mark each for any four:

1. **Loss of life:** People may be buried or struck by moving materials.
2. **Destruction of property:** Houses, schools and other buildings may be damaged.
3. **Damage to transport infrastructure:** Roads, bridges and railway lines may be destroyed or blocked.
4. **Loss of agricultural land:** Farms and crops may be buried by debris.
5. **Displacement:** Residents may be forced to leave their homes.
6. **Water pollution:** Sediments may enter rivers and streams.
7. **Habitat destruction:** Vegetation and wildlife habitats may be destroyed.
8. **Economic losses:** Money is spent on rescue, relief and reconstruction.
9. **Flooding:** Landslide debris may block rivers and cause sudden flooding.
10. **Soil erosion:** Exposed soil may be washed away by surface runoff.

b) Describe four positive effects of mass wasting. (4 marks)

Award 1 mark each for any four:

1. It contributes to the formation of new landforms.
2. It helps in the formation of new soil deposits.
3. It exposes mineral deposits and geological structures.
4. It provides sand, gravel and rock fragments that may be used as construction materials after assessment.
5. It creates new habitats on suitable deposits.
6. It provides opportunities for geographical research and field studies.
7. It contributes to the natural redistribution of weathered materials.

5. Disaster preparedness and management (9 marks)

a) Define disaster preparedness. (2 marks)

- Disaster preparedness refers to actions taken before a disaster occurs to ensure that individuals, households and communities are ready to respond effectively. (2 marks)

b) Explain five strategies that communities can use to prepare for mass-wasting disasters. (5 marks)

Award 1 mark each for any five:

1. **Hazard mapping:** Identifying and marking areas prone to landslides and rockfalls.
2. **Early warning systems:** Establishing systems for communicating information about dangerous conditions.
3. **Community education:** Teaching residents how to recognise warning signs and respond safely.
4. **Evacuation planning:** Identifying safe routes and assembly points.
5. **Emergency supplies:** Preparing first-aid kits, food, water, torches and radios.
6. **Emergency response teams:** Training community members to assist during emergencies.
7. **Land-use planning:** Preventing settlement on unstable slopes.
8. **Slope monitoring:** Observing cracks, leaning trees and unusual water seepage.
9. **Drainage maintenance:** Ensuring that drains and water channels are not blocked.

c) State two actions that should be taken during an active landslide. (2 marks)

Award 1 mark each for any two:

- Move away from the path of moving materials.
- Evacuate to a safe location.
- Alert others if it is safe to do so.
- Follow instructions from emergency authorities.
- Contact emergency services.
- Avoid crossing active landslide areas.
- Keep away from rivers that may be blocked by debris.

6. Application and geographical skills (9 marks)

a) Identify three warning signs of possible mass wasting from the description. (3 marks)

Award 1 mark each:

1. Cracks appearing on the ground.
2. Leaning trees.
3. Blocked drainage channels.
4. Small movements of soil.

Any three.

b) Explain three factors that may cause mass wasting in the area. (3 marks)

Award 1 mark each for any three:

1. **Prolonged rainfall:** Saturates the soil, increases its weight and may reduce friction between particles.

2. **Steep slope:** Increases the downslope effect of gravity.
3. **Blocked drainage:** Causes water to accumulate within slope materials.
4. **Weak soil or rock:** Easily becomes unstable when exposed to water.
5. **Loss of vegetation:** Reduces the binding effect of plant roots.

c) Suggest three measures that the community and local authorities should take to reduce the risk of mass wasting. (3 marks)

Award 1 mark each for any three:

1. Establish proper drainage systems.
2. Plant trees and suitable vegetation on stable sections of slopes.
3. Relocate residents from highly hazardous areas.
4. Construct suitable retaining walls and gabions following engineering assessment.
5. Establish early warning systems.
6. Educate residents about landslide warning signs.
7. Identify safe evacuation routes.
8. Restrict uncontrolled excavation and quarrying.
9. Carry out regular slope monitoring.
10. Prepare emergency response plans.

REVISION SUMMARY

Weathering

- Mechanical breakdown or chemical decay of rocks “in situ” (without movement)

Agents of Weathering

- Things that work to cause it:
    1. Weather elements:

- rainfall
- temperature
- frost
- gases e.g. CO_2,O_2

2. Plants
3. Animals
4. People

Factors That Influence Weathering

Climate

- Different areas with different climatic elements experience different types of weathering e.g. block disintegration are experienced in arid areas while frost action is experienced in temperate regions and mountainous regions of tropics.

Topography

- Weathering is faster on steep slopes than on gentle slopes because weathered material is washed away quickly exposing the rock once again to agents while on gentle slopes materials remain in one position shielding the rock from weathering agents.

Nature of rocks

- Dark coloured rocks absorb more heat than light coloured ones hence break faster due to excessive expansion and contraction.
- A rock with different minerals may disintegrate faster due to differential expansion and contraction of minerals.
- A well jointed rock will break faster because physical and chemical agents can penetrate faster e.g. by freezing and thawing.
- Fine textured rocks have a large surface area on which chemical processes can act e.g. Limestone.

Biological organisms

- Bacteria facilitate rotting of organic matter producing organic acids which reacts with some minerals causing the rock to break up.
- Plant roots and burrowing animals penetrate rocks resulting in cracks providing passage for agents such as water to act on rocks.
- People accelerate the rate of weathering by exposing rocks buried deep below by digging, blasting and drilling.

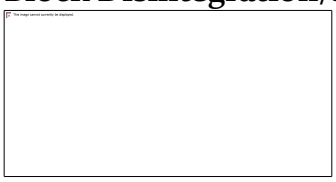
Types of Weathering

1. **Mechanical Weathering**

- Physical break up of rocks without change in their chemical composition.

Processes

a. **Block Disintegration/Separation**



- ✓ Breaking of rocks into blocks along the joints.
- ✓ It's effective in arid areas because of great diurnal temperature range.
- ✓ Day, well jointed rocks are subjected to intense heating causing minerals in it to expand.
- ✓ In the night the rock is cooled causing it to contract.
- ✓ The rock joints enlarge due to the alternating cooling and contraction.
- ✓ The process is repeated over a long time causing the rock to disintegrate into blocks along the joints e.g. Mundanda rock in Tsavo East.

b. **Exfoliation**



- ✓ Peeling off of layers of rocks.
- ✓ Also common in arid areas.
- ✓ Day, rock surface is heated more than inner layers because rocks are poor conductors of heat.
- ✓ The surface expands more than inner layers causing strain between the two layers.
- ✓ With time outer layer develops cracks and later peels off and pieces of rocks fall down under gravity e.g. along Mombassa-Nairobi road between Mtito Andei and Voi.

c. **Granular Disintegration**

- ✓ Disintegration of rocks into grains.
- ✓ Occurs in rocks with different minerals.



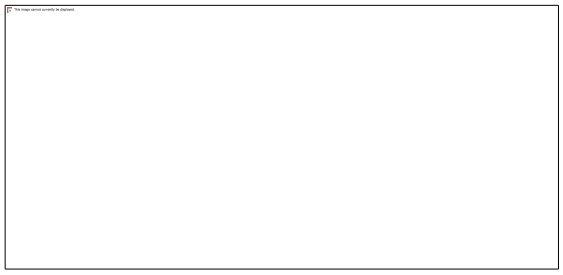
- ✓ When the rock is heated, different minerals expand differently.
- ✓ Internal stress results and with time the rock disintegrates into grains.

d. **Pressure Release/Sheeting/Unloading**

- ✓ Disintegration of rocks due to expansion when weight is removed from over it.
- ✓ Soil and other materials lying on top of a rock are removed by erosion and mass wasting (denudation).
- ✓ The exposed rock expands when the weight that was pressing it is removed.

- ✓ The outer layer curves and eventually shells are pulled out from the rock.
- ✓ The result is formation of a high rocky hills called granitic tors e.g. Maragoli and parts of Machakos.

e. **Frost Action**



- ✓ Breaking of rocks into angular blocks due to repeated freezing and thawing.
- ✓ Common in temperate regions or mountainous regions of tropics where temperature fall below zero.
- ✓ Water from melting ice collects into small cracks of rocks.
- ✓ It freezes and expands and exerts pressure on cracks widening them.
- ✓ Repeated freezing and thawing causes the rocks to break into angular blocks e.g. on Mt. Kenya, Kilimanjaro and Ruwenzori.

f. **Crystal Growth**

- ✓ Break up of rocks due to crystal growth.
- ✓ It occurs in arid areas.
- ✓ High rate of evaporation draws out moisture and dissolved minerals from the rock interior through capillary action.
- ✓ The moisture evaporates when it gets to the surface of the rock leaving behind crystals in the cracks and pores of rocks.
- ✓ The crystals continue to grow exerting pressure on the cracks or pores widening them and eventually causing the rock to break down e.g. at Hells Gate near Naivasha.

g. **Slaking/Rain Water Action**

- ✓ Breaking up of sedimentary rocks due to alternate wetting and drying.
- ✓ When it rains, the rock absorbs water and swells.
- ✓ When dry season comes, the rock loses water and the outer surface shrinks.
- ✓ The process is repeated and the minerals become loosely attached to another e.g. in Kenyan Coast at Tudor and Miritini areas.

2. **Chemical Weathering**

- Weathering involving changes in the chemical composition of minerals making up rocks

Processes

a. **Solution**

- ✓ Break up of rocks as a result of dissolving of minerals in water without chemical change in them.
- ✓ Rain water falls on rocks with soluble minerals.
- ✓ The minerals are dissolved and carried down in solution.
- ✓ The rock gets weakened and crumbles.

b. **Carbonation**

- ✓ Weathering caused by reaction of calcium carbonate in rocks with rain water containing a weak carbonic acid.
- ✓ Common in temperate regions.
- ✓ Rain water absorbs small quantities of carbon dioxide forming a weak carbonic acid. $H_2O+CO_2 \rightarrow H_2CO_3$
- ✓ The weak carbonic acid falls on limestone rocks reacting with calcite forming calcium bicarbonate.
  $CaCO_3+H_2CO_3 \rightarrow Ca(HCO_3)$
- ✓ Calcium bicarbonate is removed from the rock in solution.

c. **Hydrolysis**

- ✓ Weathering caused by reaction of hydrogen ions of water and ions of rock minerals.
- ✓ Igneous rocks are greatly affected.

d. **Oxidation**

- ✓ Weathering in which minerals in rocks combine with oxygen in the presence of moisture to form new minerals.
- ✓ Rocks containing iron are affected.
- ✓ Ferric oxide is formed on the rock surface which appears as a soft brown or red earth which can be scooped by hands.

e. **Hydration**

- ✓ Weathering in which hygroscopic minerals in rocks take up water causing them to swell and expand causing disintegration of rock due to internal stress.

3. **Biological Weathering**

- Weathering of rocks due to action of living organisms on them.

Processes

a. **Action of plants**

Mechanical

- ✓ The roots grow bigger into the cracks and joints of rocks widening them.
- ✓ With time the rock separate into blocks (wedging mechanism).
- ✓ The widened joints and cracks also provide passages for moisture and air to penetrate deeper into cracks facilitating hydrolysis and solution to act at deeper levels.

- ✓ Burrowing animals dig and break up small bits of rock from the main rock mass and bring them to the surface.
- ✓ By digging they also provide passages for other elements like gases and moisture to reach rocks that are deep.
- ✓ Large herds of animals such as cattle, zebra etc. pound the rocks with their hooves as they move resulting in resulting in mechanical breakdown of rocks.
- ✓ People break up rocks by using explosives in mining by exploding bombs on the ground and during building of houses and construction of roads.

Chemical

- ✓ Plants rot on rock in the presence of moisture and produce organic acid
- ✓ It reacts with some minerals within the rock causing decay.
- ✓ Animals excrete on rocks and release chemical substances which react with some minerals in rocks causing them to break up.
- ✓ Chemical substances released from the industries to rivers cause the water to act on rocks over which it flows.
- ✓ Gases such as CO_2 emitted from motor vehicles and industries are
- ✓ Absorbed by rain and acids such as carbonic or sulphurous which react with minerals causing rock to decay.

Significance of Weathering

Positive

1. Leads to soil formation which is important for agriculture.
2. Produces other natural resources such as clay used in pottery, brick making, etc.
3. Weathered rocks form beautiful scenery for tourist attraction e.g. Hells Gate and crying stones of Kakamega.
4. Weakens rocks easing their exploitation by quarrying and mining

Negative

- May weaken the earth's crust resulting in unstable foundations of buildings and roads and eventually lead to their collapse.

Mass Wasting

- Movement of weathered material down slope under the influence of gravity

Factors Influencing Mass Wasting

a. **Degree of slope**
   - Movement of weathered material is faster on steep slopes than on gentle slopes due to the influence of gravity.

b. **Climate**

- Weathered material in areas receiving heavy rainfall move faster since wet materials have less cohesion.

c. **Nature of the material**

- Material saturated with water is more likely to move down slope as its heavy.
- Mass wasting is more likely to occur in areas where the weathered material is deep.
- Weathering is more likely where massive rocks lie on weak rocks such as clays, shale than where fine materials lie over weak rocks.

d. **Vegetation**

- Surfaces with vegetation experience less mass wasting because it binds weathered material together.

e. **Tectonic movements**

- Earth movements such as earthquakes, volcanic eruptions or faulting cause large and widespread mass wasting.

f. **Human activities**

- Explosives used in mining and quarrying shake the ground initiating downward movement of materials.
- Mining and quarrying also interferes with the stability of the surface by loosening it making it easy for the loosened materials to move down slope.

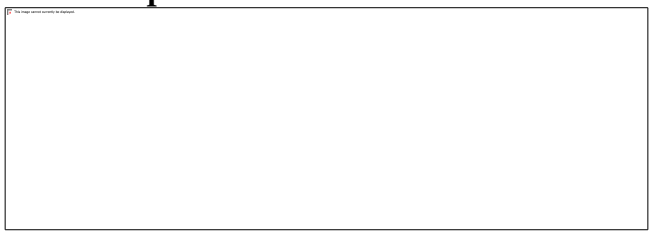
Types of Mass Wasting

1. **Slow Mass Wasting**

- Slow but steady movement of soil or loose rock debris down slope.

Processes

- **Soil Creep**



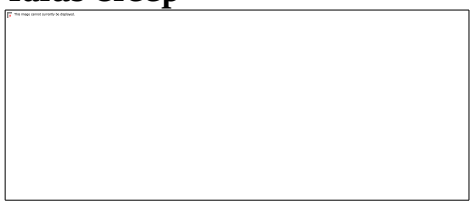
- Slow and steady movement of soil and other fine materials along a very gentle slope.

Causes

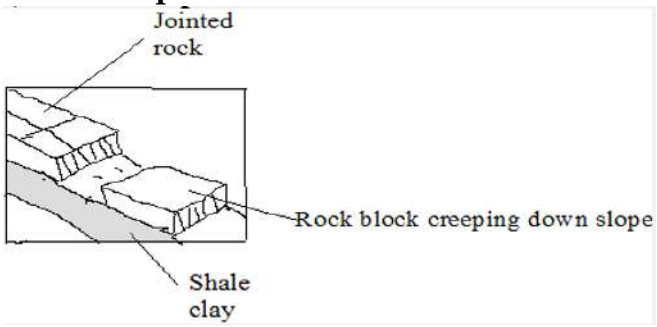
- Alternate heating and cooling causing expansion and contraction of particles causing them to change their positions.
- Alternate wetting and drying of soil whereby when it's wet its compact and when dry the particles are loosened and tend to move away from each other.
- Trampling and burrowing of animals.
- External forces e.g. shaking by earthquakes, explosives, heavy vehicles, etc.

- Ploughing down hill
- Freezing of soil water causing it to expand which lifts particles at right angles to the slope in a process called heaving.

- **Solifluction**
  - Movement of saturated soil, gravel and weathered rock down a moderate slope.
  - Common in mountainous and very cold climates
  - Thawing occurs during spring causing top soil to become saturated.
  - Saturated soil begins to creep over the subsoil which still remains frozen(permafrost).
- **Talus Creep**



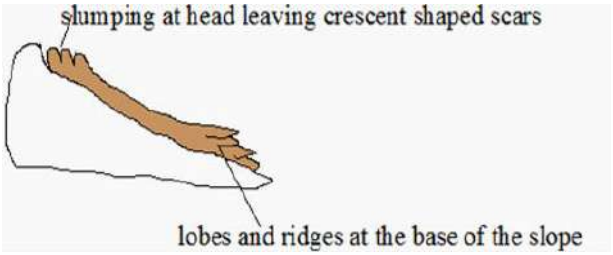
  - Slow and gentle movement of the mass of broken rock particles which accumulate at the base of cliffs (scree) downhill.
- **Rock Creep**



  - Slow movement of individual rocks which lie on clay at a very low speed down slope in the presence of moisture.

2. **Rapid Mass Wasting**
- Type of mass wasting involving large amounts of weathered material moving suddenly and fast down slope.

a. **Mud Flow**



  - Movement of oversaturated weathered material inform of liquid down slope.
  - It occurs mainly in dry areas after heavy rains.

b. **Earth Flow**

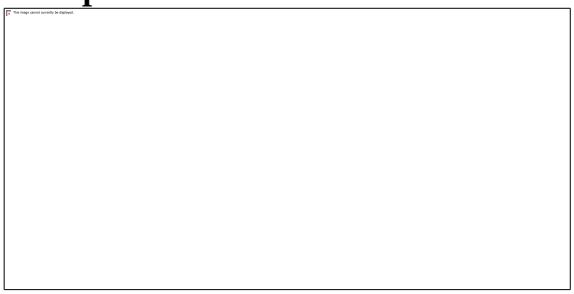


- Movement of saturated earth material on hill sides down slope.

c. **Land Slide**

- Sudden slipping of large quantities of loosened surface rock or soil down a slope.

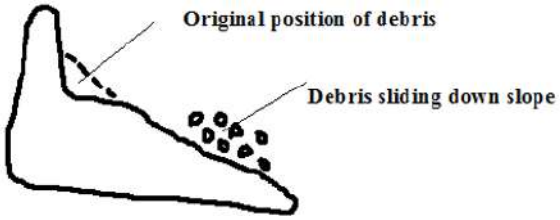
d. **Slump**



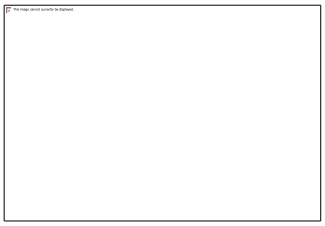
- Erosion occurs on the weak rocks at the base of a cliff undercutting the weak rock.
- The overlying rocks break off causing the overlying rocks to slide down hill rotating around a curved plane.

e. **Debris Slide**

- Sudden downhill movement of accumulated rock debris and other loose material downhill as a whole

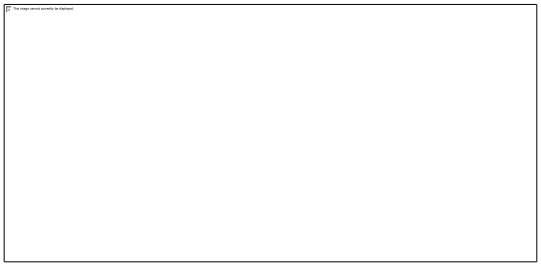


f. **Debris fall**



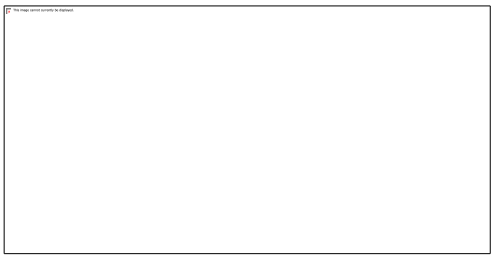
- Sudden free fall of debris from a vertical or hanging cliff to the base of the slope.

g. **Rock Slide**



- Sliding down of masses of rock a steep slope along a bending plane, joint of fault.

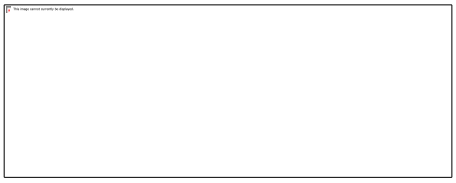
h. **Rock fall**



- Falling or rolling of individual rocks or boulders down a steep slope or a cliff.
- Most rapid of all mass wasting.

i. **Avalanche**

- Sudden slipping and falling of a large mass of snow, ice and loose rock materials down a mountain side.



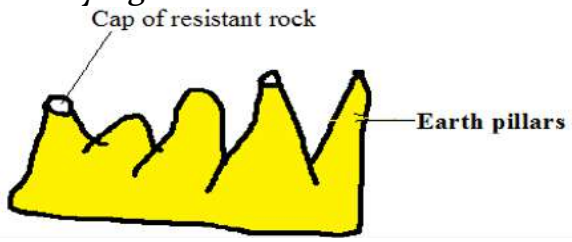
j. **Rain Wash**

- Type of mass wasting involving removal of weathered materials by rain water.
- When rains come, the first drops scatter soil particles that have been loosened by drying.
- The increasing downpour then washes large quantities of loosened soil downhill.

Types

- **Sheet wash**
  - Uniform removal of soil from a large area.
  - Rainfall with uniform drops fall on loosened soil on a land with uniform slope.
  - The water from the rainfall then flows down slope.
  - As it does so, it uniformly sweeps all the loose soil from the surface. Its common around L. Baringo and Marigat.

- **Gulleying**



- Removal of soil through wide and deep channels called gullies.
    - Rain falls on an even slope
    - The water irregularly runs down slope along specific channels called rills.
    - The channels are widened and deepened by the water to form gullies.
    - Neighbouring gullies are widened and the ridges between them are reduced to form earth pillars.
- **Splash erosion**
    - Removal of soil by rain drops scattering loose particles and carrying them down slope by runoff.

Effects of Mass Wasting On Physical and Human Environment

Positive

1. Make the soil to become fertile where soil from fertile areas is deposited.
2. Leads to formation of new land forms such as scars, depressions, lakes, rock pillars, etc.

Negative

1. Soil creep may destroy walls built across the slope when creeping soil exerts pressure on them.
2. Decrease soil fertility where fertile soil moves down slope.
3. Makes the ground prone to soil erosion especially where scars have formed.
4. Hinders transport and communication by blocking railway lines making maintenance to be costly.
5. Hinders mechanisation of agriculture e.g. gulleying does not allow movement of vehicles and machinery on farms.
6. Leads to destruction of property and loss of live by burying people in their houses and stones falling on escarpments along roads causing accidents.
7. May Cause Rivers to change their courses e.g. mud flow.

STRAND 2.0: NATURAL SYSTEMS AND PROCESSES

SUB-STRAND 2.6: SOILS

1.0 INTRODUCTION TO SOILS

1.1 Meaning and Definition of Soil

Soil is the uppermost loose layer of the Earth's crust, consisting of mineral particles, organic matter, water, air and living organisms. It develops through the breakdown of rocks and the decomposition of organic materials over a long period.

Soil forms the foundation of terrestrial ecosystems because it supports plant growth, provides habitats for organisms, stores water and nutrients, and supports numerous human activities.

Soil is a natural resource that varies from one geographical region to another depending on climate, parent rock, relief, organisms and the length of time over which it has developed.

Examples of soils in Kenya include:

Red volcanic soils found in parts of the Central Highlands, Rift Valley and Mount Kenya region.

Black cotton soils found in parts of Athi Plains, Mwea and other low-lying areas.

Sandy soils found in parts of coastal Kenya and arid regions.

Alluvial soils found along river valleys such as the Tana River basin.

Loamy soils found in several agricultural areas where mineral and organic materials are well balanced.

1.2 Importance of Studying Soils in Geography

The study of soils is important because it enables learners to:

Understand the relationship between rocks, climate, vegetation and soil development.

Explain how different soils are formed through natural processes.

Identify and classify different soil types found in the environment.

Understand the distribution of soils across the Earth's surface.

Determine the suitability of different soils for agricultural activities.

Explain the relationship between soil properties and vegetation distribution.

Understand the causes and effects of soil degradation.

Identify appropriate methods of soil management and conservation.

Appreciate soil as an important natural resource that requires sustainable utilisation.

Understand how human activities influence soil quality and productivity.

1.3 Specific Learning Outcomes

By the end of this sub-strand, the learner should be able to:

a) Explore the composition of soil on the Earth's surface.

b) Explain soil-forming processes on the Earth's surface.

c) Describe the main types of soils on the Earth's surface.

d) Analyse the properties and characteristics of soil in the environment.

e) Examine the significance of soil to humans.

f) Appreciate soil management and conservation in the community.

1.4 Suggested Learning Experiences

Learners should be guided to:

Think, pair and share on the composition of soil.

Watch videos showing soil-forming processes and make class presentations.

Use print and digital resources to research the main types of soils.

Watch video clips showing soil profiles and soil catena and take notes.

Draw and label soil profiles and soil catenas and display them in class.

Write essays explaining the significance of soil to humans.

Conduct field studies on soil management and conservation in the community.

Prepare and present reports on findings from soil conservation activities.

2.0 COMPOSITION OF SOIL ON THE EARTH'S SURFACE

2.1 Meaning of Soil Composition

Soil composition refers to the different substances and materials that combine to form soil.

Soil is made up of four major components:

Mineral matter.

Organic matter.

Soil water.

Soil air.

Living organisms are also important components of soil because they contribute to decomposition, nutrient cycling and soil formation.

2.2 Main Components of Soil



A. Mineral Matter (Approximately 45%)

Mineral matter consists of small particles formed through the weathering and breakdown of rocks.

It forms the largest component of most mineral soils.

Sources of mineral matter:

Weathering of parent rocks.

Deposition of sediments by rivers.

Wind deposition.

Glacial deposition.

Volcanic materials.

Breakdown of previously deposited mineral materials.

Main types of mineral particles

1. **Sand particles**

These are the largest mineral particles in ordinary soil.

They have relatively large spaces between them.

They allow water to drain through easily.

They provide good aeration.

They have a low capacity to retain water and nutrients.

Sandy soils are common in some coastal and semi-arid environments in Kenya.

2. **Silt particles**

These are smaller than sand particles but larger than clay particles.

They have a smooth or flour-like texture when dry.

They retain more water than sandy particles.

They are easily transported by running water and wind.

They contribute to soil fertility when adequately managed.

3. **Clay particles**

These are the smallest mineral particles in soil.

They have very fine textures.

They retain considerable amounts of water and nutrients.

They become sticky when wet.

They become hard and may crack when dry.

They have poor drainage when compacted.

Importance of mineral matter in soil

Provides essential nutrients such as calcium, potassium, phosphorus and magnesium.

Determines soil texture.

Influences soil drainage.

Provides a medium for plant root development.

Influences soil structure and stability.

Determines the water-holding capacity of soil.

B. Organic Matter (Approximately 5%)

Organic matter refers to materials derived from the remains of plants, animals and other living organisms at different stages of decomposition.

It includes decomposing leaves, dead roots, animal remains, microorganisms and humus.

Humus is the dark-coloured, relatively stable organic material produced through the decomposition of plant and animal remains.

Sources of organic matter

Fallen leaves.

Dead grasses and other vegetation.

Animal droppings.

Dead insects and other animals.

Decomposing roots.

Crop residues.

Compost manure.

Farmyard manure.

Importance of organic matter

Improves soil fertility by supplying nutrients.

Improves soil structure by binding soil particles together.

Increases water-holding capacity.

Improves soil aeration.

Provides food for soil organisms.

Reduces soil erosion by improving soil aggregation.

Improves the ability of sandy soils to retain water.

Improves the structure of heavy clay soils.

Supports nutrient cycling.

Gives many fertile soils their dark colour.

C. Soil Water (Approximately 25%)

Soil water refers to the water held within the spaces between soil particles.

It enters the soil through rainfall, irrigation, flooding and capillary movement.

Sources of soil water

Rainfall.

Irrigation.

Floodwater.

Underground water moving upwards through capillary action.

Water released during the decomposition of organic materials, although this is a minor source.

Types of soil water

1. **Gravitational water**

This is water that moves downwards through soil under the influence of gravity.

It occupies large soil pores after heavy rainfall or irrigation.

Most of it drains away into deeper soil layers.

Excessive gravitational water may cause waterlogging.

2. **Capillary water**

This is water held in small soil pores by capillary forces.

It moves in different directions, including upwards.

It is the main form of soil water available to most plants.

It dissolves mineral nutrients for absorption by plant roots.

3. **Hygroscopic water**

This is a very thin film of water held tightly around soil particles.

It is held by strong molecular forces.

It is generally unavailable to plants because roots cannot extract it easily.

Importance of soil water

Supports seed germination.

Dissolves nutrients for plant absorption.

Supports photosynthesis indirectly by supplying water to plants.

Maintains plant cell turgidity.

Supports soil microorganisms.

Regulates soil temperature.

Supports decomposition of organic matter.

Facilitates chemical reactions in the soil.

D. Soil Air (Approximately 25%)

Soil air refers to the mixture of gases occupying the spaces between soil particles that are not filled with water.

It is essential for the survival of plant roots and soil organisms.

Main gases found in soil air

Nitrogen.

Oxygen.

Carbon dioxide.

Water vapour.

Soil air generally contains less oxygen and more carbon dioxide than atmospheric air because plant roots and soil organisms use oxygen during respiration and release carbon dioxide.

Importance of soil air

Provides oxygen for root respiration.

Supports respiration by soil microorganisms.

Promotes decomposition of organic matter.

Supports the activity of beneficial soil bacteria.

Facilitates the development of healthy plant roots.

Influences soil temperature and chemical processes.

Factors influencing the amount of soil air

Soil texture.

Soil structure.

Soil moisture content.

Soil compaction.

Organic matter content.

Drainage conditions.

Biological activity.

Note: The commonly used soil composition percentages are approximate values for an ideal mineral soil. Actual proportions vary according to soil type, depth, season, moisture and environmental conditions.

3.0 SOIL-FORMING PROCESSES ON THE EARTH'S SURFACE

3.1 Meaning of Soil Formation

Soil formation, also known as *pedogenesis*, refers to the natural processes through which soil develops from parent rock and organic materials under the influence of climate, living organisms, relief and time.

Soil formation is a continuous process that may take hundreds or thousands of years.

The materials from which soil develops are known as **parent materials**. These may include weathered rocks, volcanic deposits and sediments transported by rivers, wind or glaciers.

3.2 Factors Influencing Soil Formation

There are five major soil-forming factors, commonly remembered using the CLORPT concept:

Climate.

Organisms.

Relief (topography).

Parent material.

Time.



A. Climate

Climate refers to the long-term atmospheric conditions of an area, particularly rainfall and temperature.

Climate is one of the most important factors influencing soil formation.

How climate influences soil formation:

1. **Rainfall**

Rainwater causes chemical weathering by dissolving minerals in rocks.

Heavy rainfall encourages leaching, which removes soluble minerals from upper soil layers.

Rainfall supports vegetation growth, which increases organic matter in soil.

In dry areas, limited rainfall slows down chemical weathering and decomposition.

2. **Temperature**

High temperatures accelerate chemical reactions involved in weathering.

Temperature changes cause repeated expansion and contraction of rocks.

High temperatures encourage decomposition of organic materials when moisture is available.

Low temperatures slow down biological and chemical processes.

3. **Humidity**

High humidity encourages the growth of vegetation and microorganisms.

It influences the rate of decomposition of organic matter.

It affects soil moisture conditions.

Examples:

Warm and wet areas of Kenya experience relatively rapid chemical weathering.

Arid areas such as parts of Turkana and Marsabit experience limited chemical weathering because of low rainfall.

B. Organisms (Living Things)

Organisms include plants, animals, bacteria, fungi and other microorganisms that contribute to soil development.

How organisms influence soil formation:

Plant roots penetrate rock cracks and widen them, encouraging physical weathering.

Dead leaves and plants decompose to form humus.

Earthworms burrow through the soil, improving aeration and mixing soil materials.

Termites construct tunnels and mounds, changing soil structure.

Bacteria decompose organic materials and release nutrients.

Fungi break down plant remains and contribute to nutrient cycling.

Burrowing animals mix soil materials and improve soil porosity.

Vegetation protects the soil surface against erosion.

Example: Grasslands in parts of the Kenyan Highlands contribute organic matter to the soil through the continuous decomposition of grass roots and leaves.

C. Relief (Topography)

Relief refers to the differences in elevation, slope and shape of the Earth's surface.

It influences soil formation through its effects on drainage, erosion, deposition and exposure to sunlight.

How relief influences soil formation:

Steep slopes experience rapid surface runoff, which removes topsoil.

Gentle slopes encourage infiltration and the accumulation of soil materials.

Valley bottoms receive transported sediments from higher ground.

Flat areas may experience poor drainage and waterlogging.

Slopes facing the sun may experience higher temperatures and faster evaporation.

Mountain slopes may have shallow soils due to continuous erosion.

Depressions may accumulate organic matter and fine sediments.

Example: River valleys in Kenya may contain deep alluvial soils because of repeated deposition of sediments during flooding.

D. Parent Material

Parent material refers to the original rock or unconsolidated material from which soil develops.

It determines many of the initial physical and chemical characteristics of soil.

How parent material influences soil formation:

It determines the mineral composition of soil.

It influences soil colour.

It affects soil texture.

It influences soil fertility.

It determines the rate of weathering.

It affects soil drainage and water-holding capacity.

It influences the soil's pH.

Examples:

Basalt may weather to form clay-rich, dark soils.

Granite may weather to produce sandy soils.

Volcanic ash can develop into fertile volcanic soils.

Limestone may contribute to calcium-rich soils.

Sedimentary deposits may develop into alluvial soils.

Kenyan examples: Volcanic materials around Mount Kenya and the Rift Valley have contributed to the formation of important agricultural soils.

E. Time

Time refers to the duration over which soil-forming processes have operated on parent material.

How time influences soil formation:

Young soils have undergone limited weathering.

Older soils generally show more developed soil horizons where conditions permit.

Long periods of weathering may lead to the accumulation of clay in lower soil horizons.

Prolonged leaching may remove soluble minerals from upper soil layers.

Organic matter gradually accumulates through decomposition.

Soil profiles become more differentiated as soil-forming processes continue.

Example: A recently deposited river sediment may have a poorly developed soil profile, while an older, stable landscape may have well-developed soil horizons.

3.3 Major Processes of Soil Formation

Soil formation involves several physical, chemical and biological processes.

A. Weathering

Weathering is the breakdown and decomposition of rocks at or near the Earth's surface without transportation of the resulting materials.

Weathering supplies mineral particles that contribute to soil formation.

Types of weathering

1. Physical or mechanical weathering

This is the breakdown of rocks into smaller fragments without changing their chemical composition.

Processes include:

Temperature changes: Rocks expand when heated and contract when cooled. Repeated changes cause cracks and eventual disintegration.

Exfoliation: Outer layers of rocks peel off due to pressure release and temperature changes.

Freeze-thaw action: Water enters rock cracks, freezes, expands and widens the cracks. This is important in cold mountain environments.

Pressure release: Rocks expand when overlying materials are removed, causing joints and fractures.

Salt crystallisation: Salts crystallise in rock cracks and exert pressure that breaks rocks apart.

2. Chemical weathering

This involves the decomposition of rocks through chemical reactions that change the mineral composition of the rocks.

Major processes include:

Oxidation: Oxygen combines with minerals, especially iron-bearing minerals, producing oxides. This may give soil a reddish or brownish colour.

Carbonation: Carbon dioxide dissolves in rainwater to form weak carbonic acid, which reacts with minerals such as limestone.

Hydration: Minerals absorb water, causing expansion and changes in their chemical structure.

Hydrolysis: Water reacts with minerals, leading to their decomposition and formation of new minerals such as clay.

Solution: Soluble minerals dissolve directly in water and are carried away.

3. Biological weathering

This is the breakdown of rocks through the activities of plants and animals.

Examples:

Tree roots penetrate cracks in rocks.

Burrowing animals expose and loosen rock materials.

Lichens produce substances that help decompose rock surfaces.

Microorganisms release organic acids that react with minerals.

B. Humification

Humification is the process through which decomposed plant and animal remains are transformed into humus.

Stages involved:

Plants and animals die or produce organic wastes.

Organic remains accumulate on the soil surface.

Bacteria and fungi begin decomposing the materials.

Complex organic compounds break down into simpler substances.

Some of the decomposed materials are transformed into relatively stable humus.

Humus mixes with mineral particles and improves soil fertility.

Importance of humification:

Improves soil fertility.

Increases water retention.

Improves soil structure.

Supplies nutrients.

Supports soil organisms.

C. Mineralisation

Mineralisation is the process through which microorganisms convert organic nutrients into inorganic forms that plants can absorb.

For example, decomposing organic matter may release nitrogen in the form of ammonium ions, which can subsequently be converted into nitrates.

Importance:

Makes nutrients available to plants.

Supports plant growth.

Maintains nutrient cycling.

Improves agricultural productivity.

D. Leaching

Leaching is the downward movement and removal of soluble minerals and nutrients from upper soil horizons by percolating water.

How leaching occurs:

Rainwater enters the soil.

Water dissolves soluble minerals and nutrients.

The dissolved materials move downwards through the soil.

Some nutrients are removed from upper horizons.

The transported materials may accumulate in lower horizons or move beyond the soil profile.

Effects of leaching:

May reduce soil fertility.

Can make upper soil horizons acidic.

May cause nutrient deficiencies.

Can result in the accumulation of certain minerals in lower horizons.

May contribute to the formation of strongly weathered tropical soils.

E. Illuviation

Illuviation is the accumulation of materials such as clay, iron, aluminium and humus in a lower soil horizon after their transportation from upper horizons.

It commonly occurs below a zone of eluviation.

F. Eluviation

Eluviation is the removal or washing out of clay, iron, aluminium or other materials from an upper soil horizon through downward-moving water.

Difference between leaching, eluviation and illuviation

Process	**Meaning**
Leaching	Removal of soluble substances by water.
Eluviation	Removal of suspended or dispersed materials from an upper horizon.
Illuviation	Accumulation of transported materials in a lower horizon.

G. Calcification

Calcification is the accumulation of calcium carbonate in the soil, commonly in areas with limited rainfall and high evaporation.

Characteristics:

Calcium carbonate accumulates in lower soil horizons.

It may form hard calcareous layers.

It commonly occurs in semi-arid and arid environments.

It may increase soil alkalinity.

H. Salinisation

Salinisation is the accumulation of soluble salts in soil.

It commonly occurs in arid and semi-arid environments where evaporation is high and drainage is poor.

Causes:

Excessive irrigation without adequate drainage.

High evaporation rates.

Use of saline irrigation water.

Shallow saline groundwater.

Poor soil drainage.

Effects:

Reduces plant water uptake.

Lowers agricultural productivity.

May cause poor seed germination.

Can lead to the abandonment of agricultural land.

I. Podzolisation

Podzolisation is a soil-forming process in which acidic water causes the removal of iron, aluminium and organic compounds from upper horizons and their accumulation in lower horizons.

It is commonly associated with cool, humid environments and acidic vegetation.

J. Laterisation

Laterisation is a soil-forming process associated with intense chemical weathering and leaching in warm, humid tropical environments.

It involves the removal of silica and soluble bases and the relative accumulation of iron and aluminium oxides.

Characteristics:

May produce red or reddish-brown soils.

Often results in strongly weathered soils.

May lead to reduced natural fertility.

Can result in the formation of iron-rich lateritic layers.

K. Salinisation and Alkalisation

Alkalisation refers to the accumulation of exchangeable sodium in soil, which can cause poor soil structure and reduced permeability.

It is different from salinisation, although both may occur in dry environments.

3.4 Summary of Soil-Forming Processes

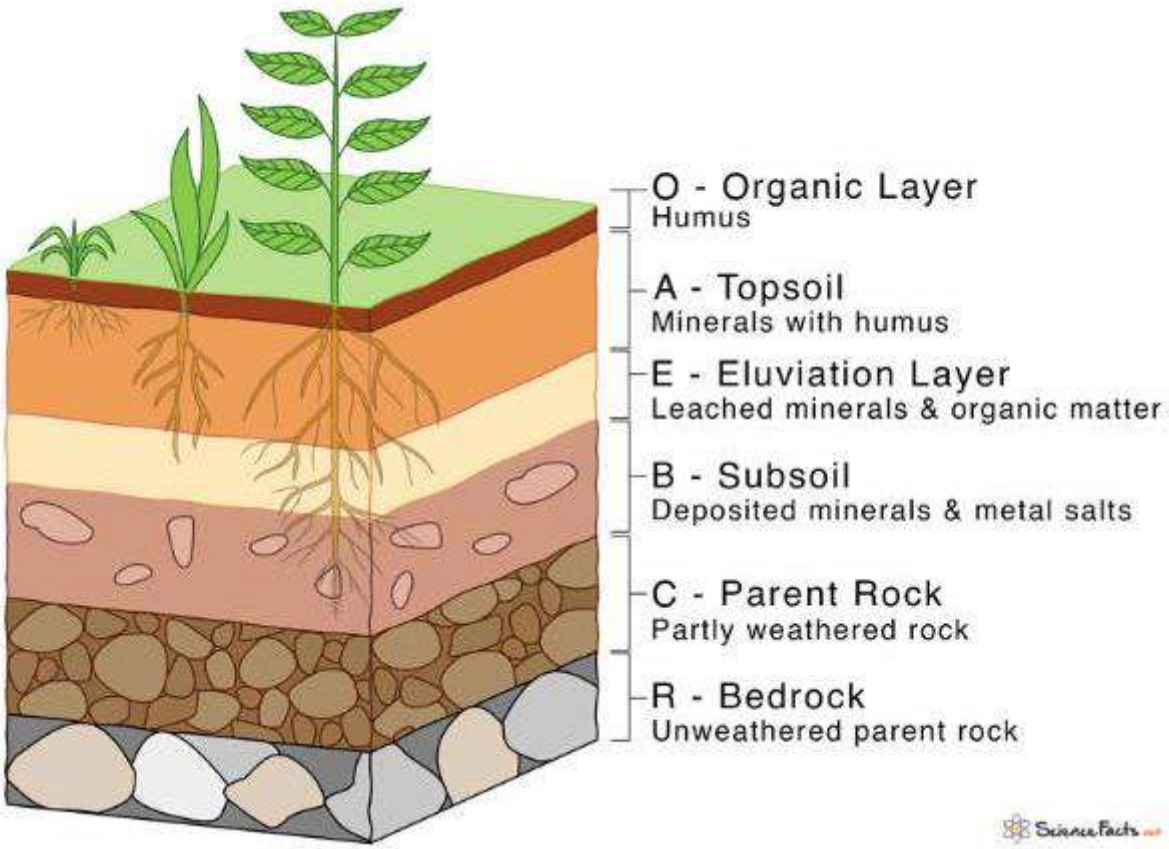
Process	Main activity
Weathering	Breakdown of rocks.
Humification	Formation of humus.
Mineralisation	Release of inorganic nutrients from organic matter.
Leaching	Removal of soluble materials.
Eluviation	Removal of materials from upper horizons.
Illuviation	Accumulation of materials in lower horizons.
Calcification	Accumulation of calcium carbonate.
Salinisation	Accumulation of soluble salts.
Podzolisation	Removal and accumulation of iron, aluminium and organic compounds in acidic environments.
Laterisation	Intense tropical weathering and concentration of iron and aluminium oxides.

4.0 SOIL PROFILE AND SOIL CATENA

4.1 Meaning of Soil Profile

A soil profile is a vertical section of the soil from the ground surface down to the underlying parent material or bedrock, showing the different layers known as soil horizons.

Each horizon has distinct characteristics, including colour, texture, structure, organic matter content and mineral composition.



4.2 Main Soil Horizons

A. O Horizon – Organic Layer

This is the uppermost organic layer found in soils where sufficient plant remains accumulate.

Characteristics:

Contains decomposing leaves, twigs and animal remains.

Has high organic matter content.

Often appears dark brown or black.

Supports many decomposers.

May be thick in forests and thin or absent in cultivated soils.

Importance:

Supplies organic matter.

Protects the mineral soil beneath.

Supports nutrient cycling.

Provides habitats for soil organisms.

B. A Horizon – Topsoil

This is the uppermost mineral soil horizon, usually containing a mixture of mineral particles and humus.

Characteristics:

Contains considerable organic matter.

Supports most plant roots.

Contains numerous soil organisms.

Usually has a relatively dark colour.

Is generally important for crop production.

Is susceptible to erosion when left bare.

Importance:

Provides nutrients for crops.

Supports seed germination.

Holds water for plants.

Provides a medium for root development.

Kenyan example: The fertile topsoil of well-managed agricultural land in the Kenyan Highlands supports the production of maize, potatoes, vegetables and tea.

C. E Horizon – Zone of Eluviation

This horizon is found in some well-developed soils.

Characteristics:

Experiences the removal of clay, iron, aluminium and other materials.

May have a pale or whitish appearance.

Often contains less organic matter than the A horizon.

May have a relatively coarse texture due to the removal of fine particles.

It is not present in every soil profile.

D. B Horizon – Subsoil

This is the zone where materials transported from upper horizons may accumulate.

Characteristics:

Contains less organic matter than the topsoil.

May accumulate clay, iron and aluminium compounds.

Is often denser than the A horizon.

May have a reddish, brownish or yellowish colour.

Usually has fewer living organisms than the topsoil.

May contain mineral materials important for deep-rooted plants.

Importance:

Stores water and nutrients.

Supports deep-rooted vegetation.

Provides anchorage for plant roots.

Influences soil drainage.

E. C Horizon – Parent Material

This horizon consists of partly weathered rock materials from which the soil develops.

Characteristics:

Contains large rock fragments.

Has little organic matter.

Shows limited biological activity.

Is less weathered than the horizons above it.

May contain partly decomposed parent rock.

F. R Horizon – Bedrock

This is the relatively solid underlying rock beneath the soil profile.

Characteristics:

Consists of consolidated rock.

Has undergone limited weathering at depth.

May provide the original parent material for soil formation.

May be fractured and allow water infiltration.

Examples: Granite, basalt, limestone and sandstone.

Important distinction: Not every soil has all six horizons. The development and thickness of horizons depend on environmental conditions and the history of soil formation.

4.3 Differences Between Soil Horizons

Horizon	Main characteristics
O	Organic litter and decomposing remains.
A	Humus-rich topsoil and many roots.
E	Zone of eluviation and removal of materials.
B	Zone of accumulation of transported materials.
C	Partly weathered parent material.
R	Solid underlying bedrock.

4.4 Factors Influencing the Development of Soil Horizons

Climate: Rainfall and temperature influence weathering, decomposition and leaching.

Vegetation: Plant remains contribute organic matter to the upper horizons.

Parent material: Determines the minerals and texture of developing soil.

Relief: Influences erosion, drainage and deposition.

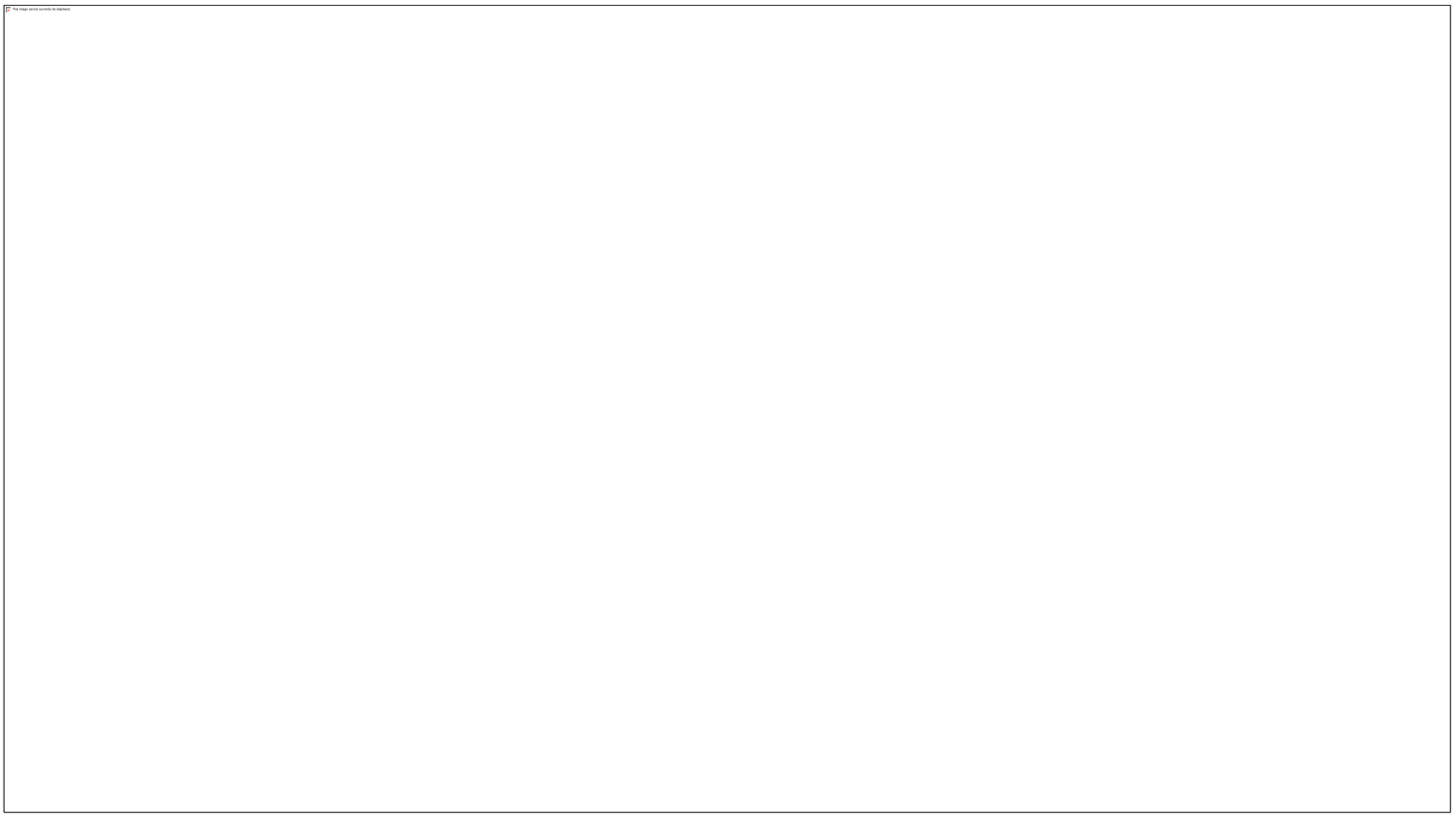
Time: Determines the extent of horizon development.

Organisms: Mix soil materials and facilitate decomposition.

4.5 Meaning of Soil Catena

A soil catena is a sequence of different soil types occurring along a slope from the upper slope to the valley bottom, developed mainly due to variations in drainage, erosion, deposition and soil moisture.

Although the soils may develop from similar parent materials and experience similar climatic conditions, they differ because of their positions along the slope.



4.6 Main Positions of a Soil Catena

A. Summit (Crest)

This is the highest part of a slope.

Characteristics:

Often experiences relatively limited deposition.

May have well-drained soils.

Soil depth varies according to weathering and erosion.

Surface runoff may be limited on a flat summit but increase on sloping margins.

May support grassland, woodland or cultivated vegetation.

B. Shoulder

This is the transitional area between the summit and backslope.

Characteristics:

May experience considerable surface runoff.

Often experiences soil erosion.

May have shallow soils.

Fine soil particles may be removed.

Soil fertility may be reduced where erosion is severe.

C. Backslope (Middle Slope)

This is the steep or moderately sloping section of the hillside.

Characteristics:

Experiences relatively rapid runoff.

Is susceptible to sheet and rill erosion.

Often has relatively shallow soils.

May have limited accumulation of fine sediments.

Vegetation cover is important in protecting the soil.

D. Footslope

This is the lower part of the slope where the gradient decreases.

Characteristics:

Receives sediments transported from upper slopes.

May have deeper soils.

Often has relatively high soil moisture.

May support productive agricultural activities.

Can experience temporary waterlogging.

E. Valley Bottom (Toeslope)

This is the lowest section of the slope.

Characteristics:

Receives water and sediments from higher areas.

May have deep, fine-textured soils.

Often experiences higher moisture levels.

May have poor drainage.

May contain alluvial deposits.

Can be highly productive where drainage is suitable.

4.7 Factors Responsible for Soil Catena Formation

Slope gradient.

Position along the slope.

Surface runoff.

Soil drainage.

Soil erosion.

Deposition of sediments.

Groundwater conditions.

Vegetation cover.

Parent material.

Soil moisture variations.

4.8 Importance of Studying Soil Catena

Helps explain soil distribution along slopes.

Helps farmers identify suitable locations for different crops.

Helps in planning soil conservation activities.

Explains differences in soil depth and fertility.

Helps identify areas susceptible to waterlogging.

Helps in understanding soil erosion and sediment deposition.

Supports proper land-use planning.

5.0 MAIN TYPES OF SOILS ON THE EARTH'S SURFACE

5.1 Meaning of Soil Classification

Soil classification is the systematic grouping of soils according to their characteristics, properties, formation processes and composition.

Soils can be classified according to:

Texture.

Colour.

Mineral composition.

Organic matter content.

Drainage.

Soil-forming processes.

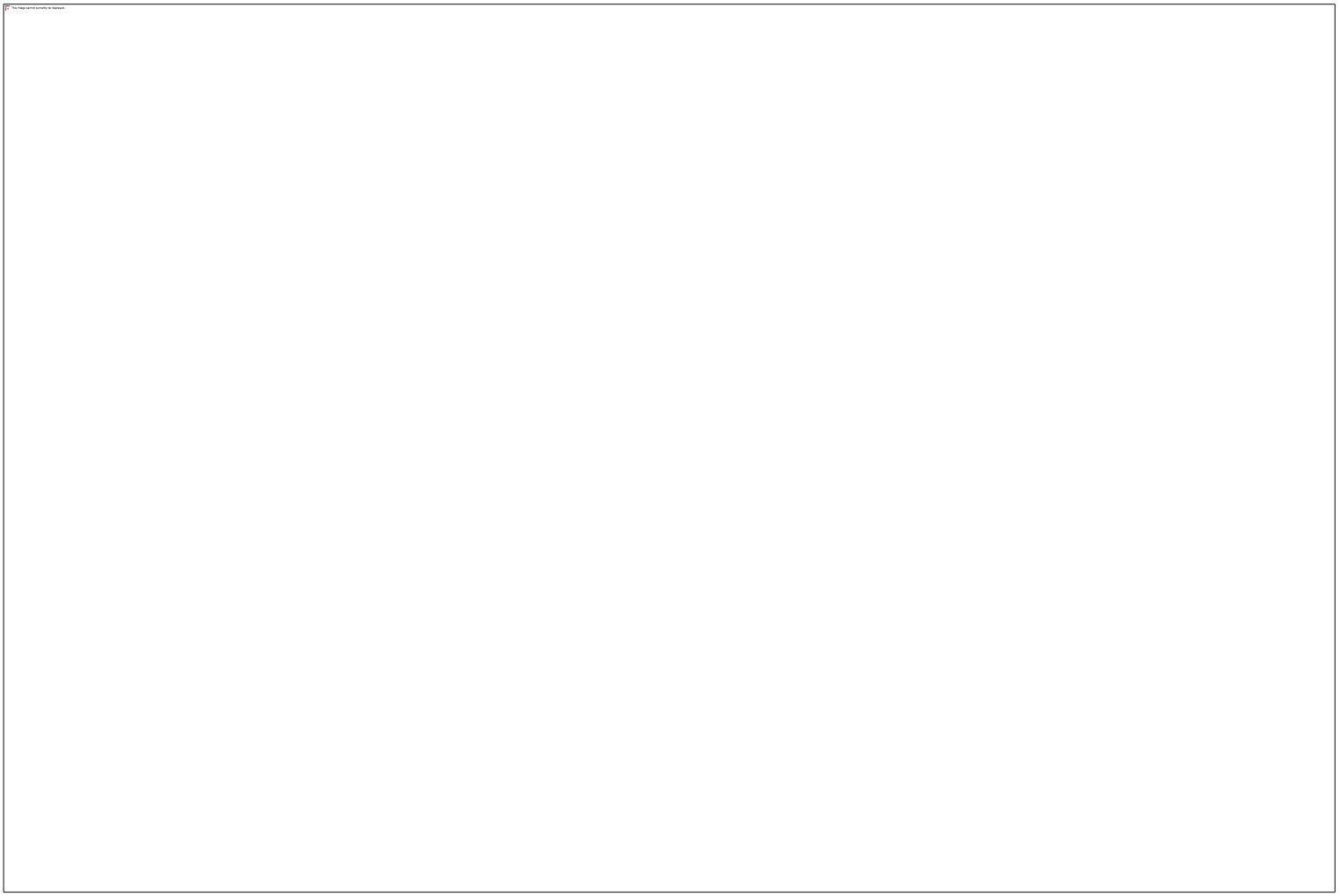
Soil profile development.

Chemical properties.

There is no single classification system used for every purpose. Geographers and soil scientists use systems such as the World Reference Base for Soil Resources (WRB) and USDA Soil Taxonomy.

5.2 Major Types of Soils

A. Sandy Soils



Sandy soil is soil containing a high proportion of sand-sized mineral particles.

Characteristics:

Has large mineral particles.

Has a coarse and gritty texture.

Has large pore spaces.

Allows water to drain quickly.

Has good aeration.

Has low water-holding capacity.

Usually has low nutrient-retention capacity.

Is easily eroded by wind when dry and exposed.

Warms up relatively quickly.

Is generally less fertile unless improved.

Suitable crops when properly managed:

Groundnuts.

Cassava.

Watermelon.

Sweet potatoes.

Coconut in suitable coastal conditions.

Areas of occurrence in Kenya: Sandy soils occur in parts of the coastal region and some semi-arid areas.

Management practices:

Add organic manure.

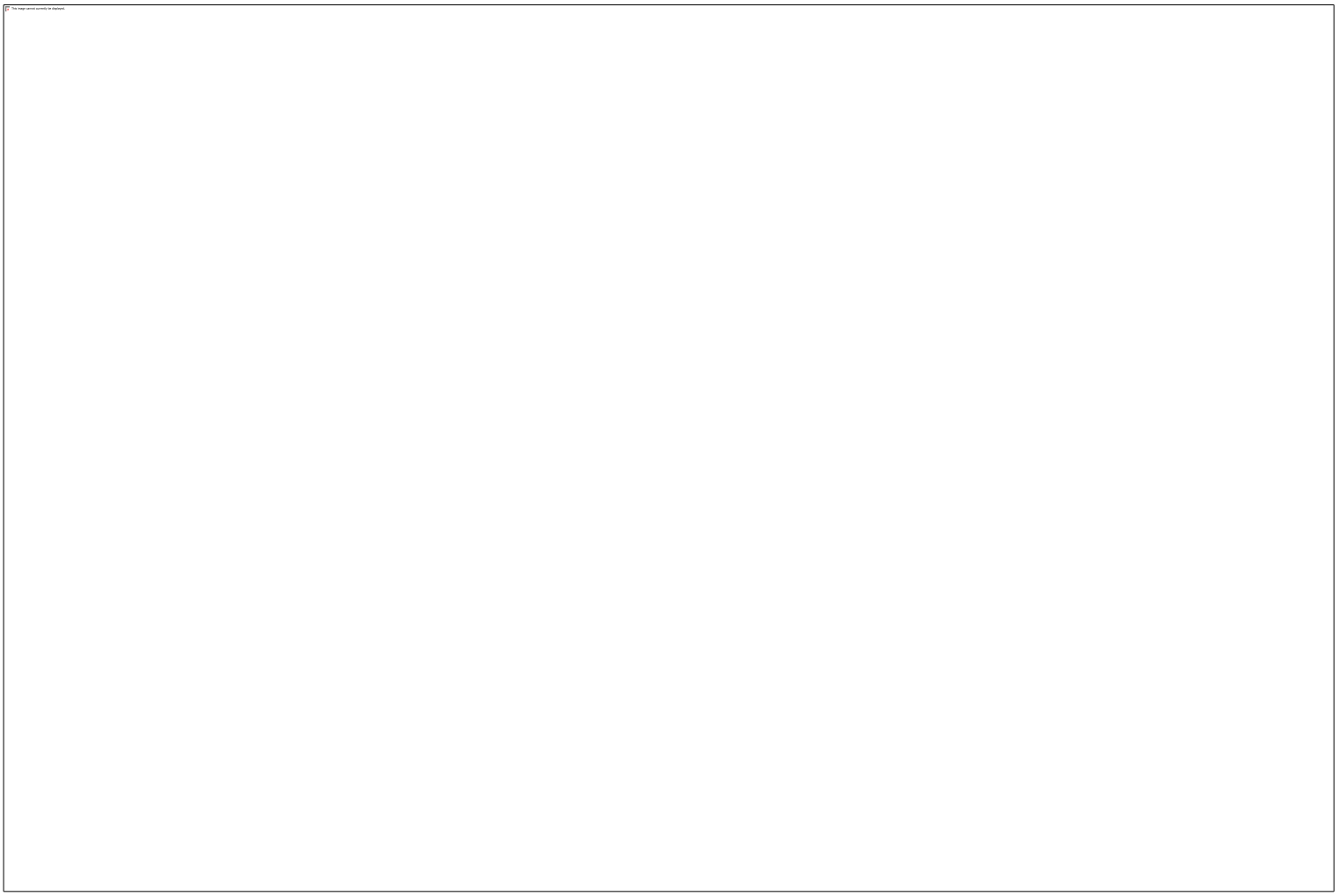
Apply mulch.

Use cover crops.

Irrigate appropriately.

Apply fertilisers according to soil tests.

B. Clay Soils



Clay soil contains a high proportion of very fine clay particles.

Characteristics:

Has a fine texture.

Is sticky when wet.

Becomes hard and may crack when dry.

Has small pore spaces.

Retains considerable water.

Drains slowly.

Has relatively high nutrient-retention capacity.

May become waterlogged.

Is difficult to cultivate when excessively wet or dry.

May become compacted under heavy machinery or livestock.

Suitable crops under appropriate management:

Rice in suitable irrigated areas.

Sugarcane.

Some varieties of maize.

Pasture grasses.

Management practices:

Improve drainage where necessary.

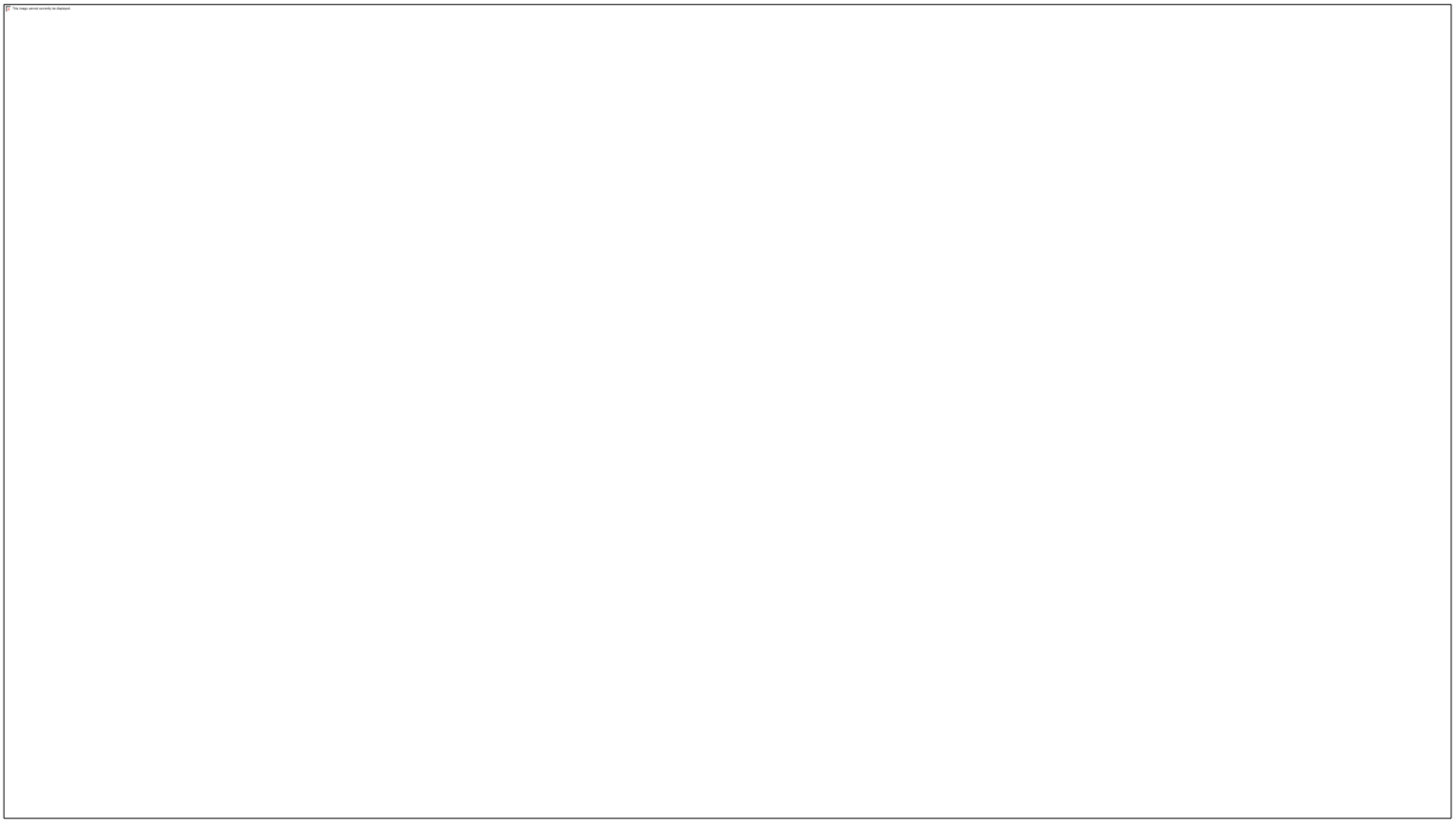
Add organic matter.

Avoid cultivating when excessively wet.

Avoid excessive machinery traffic.

Use raised beds where appropriate.

C. Loamy Soils



Loamy soil is soil containing a relatively balanced mixture of sand, silt and clay, often with useful quantities of organic matter.

It is generally regarded as favourable for agricultural production because it combines good drainage, aeration and water retention.

Characteristics:

Has a crumbly texture.

Contains sand, silt and clay.

Retains adequate moisture.

Allows excess water to drain.

Has good aeration.

Supports root development.

Can retain plant nutrients.

Is relatively easy to cultivate.

Supports many types of crops.

Often has good agricultural potential.

Suitable crops:

Maize.

Beans.

Potatoes.

Vegetables.

Fruits.

Wheat.

Management practices:

Maintain organic matter.

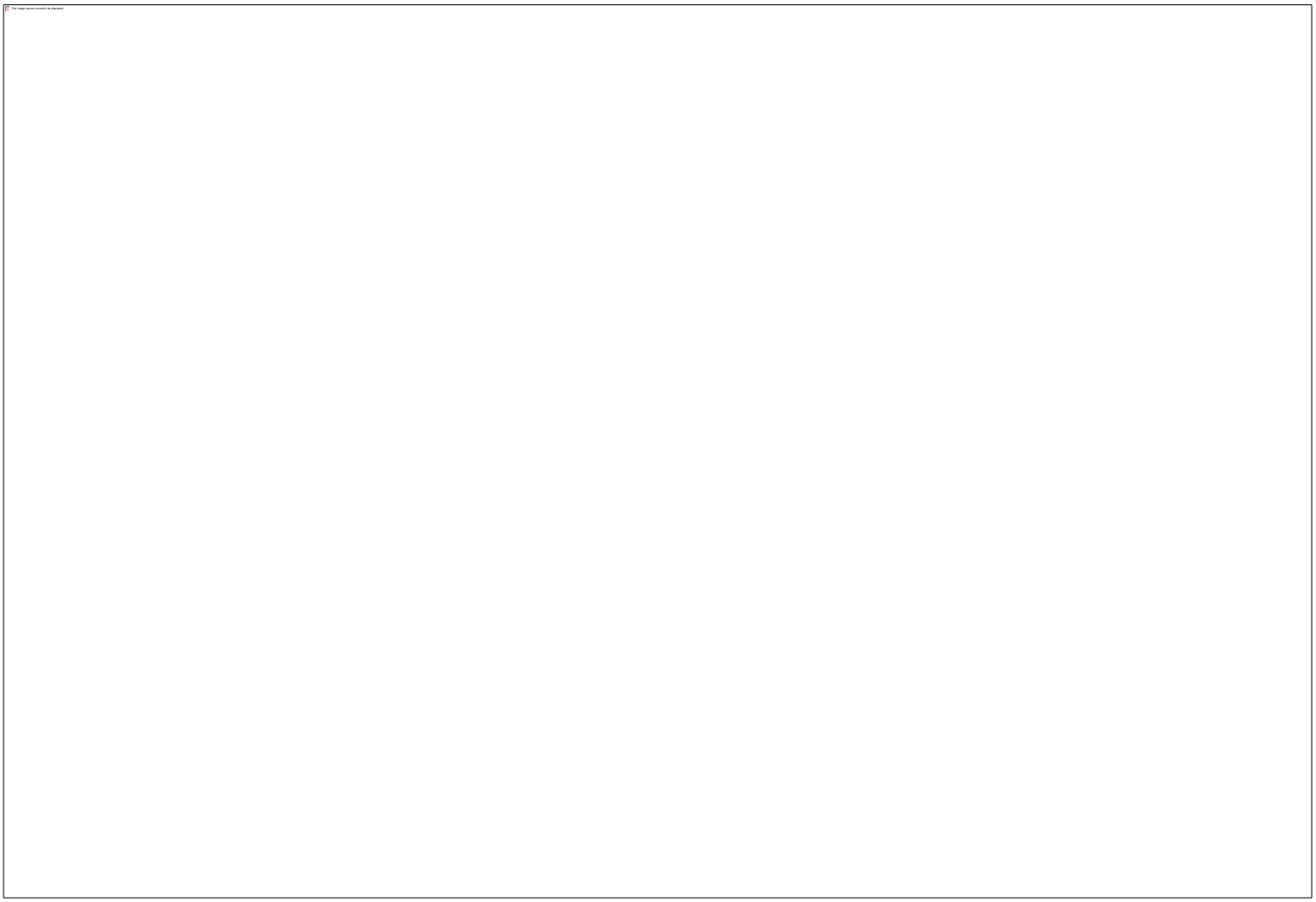
Practise crop rotation.

Control erosion.

Avoid overcultivation.

Use appropriate fertilisers.

D. Alluvial Soils



Alluvial soils are soils formed from sediments deposited by rivers and other running water.

Characteristics:

Commonly occur along river valleys and floodplains.

May contain sand, silt and clay in varying proportions.

Are often deep.

May be relatively fertile due to regular sediment deposition.

May have high moisture content.

Their texture varies depending on the deposited sediments.

May experience seasonal flooding.

Drainage varies according to location and texture.

Examples in Kenya:

Tana River floodplain.

Athi River valley.

Nzoia River floodplain.

Some areas along the Ewaso Ng'iro River.

Suitable crops:

Rice.

Sugarcane.

Maize.

Vegetables.

Bananas.

Challenges:

Flooding.

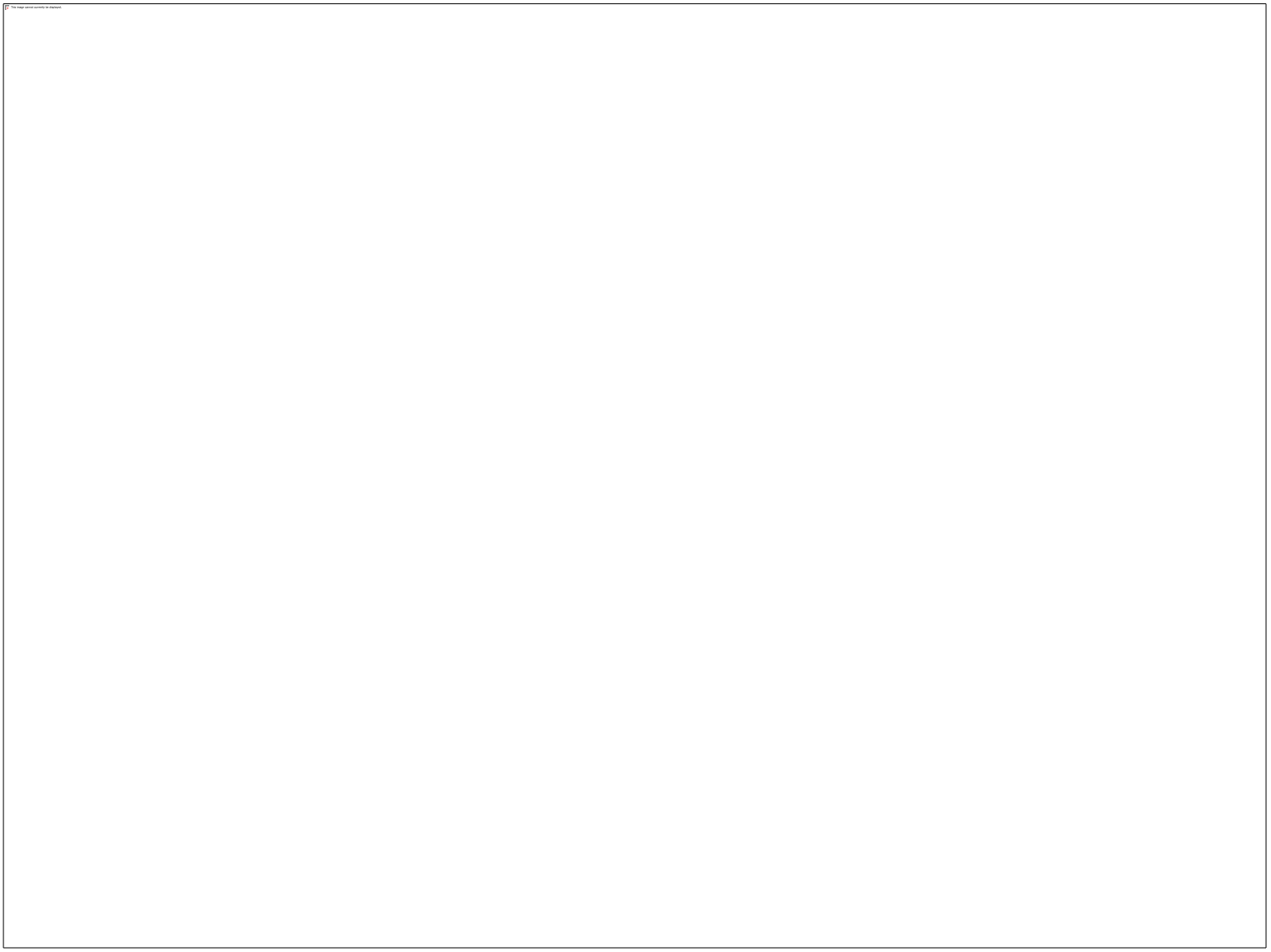
Waterlogging.

Sedimentation.

Soil erosion.

Pollution from agricultural and industrial activities.

E. Volcanic Soils



Volcanic soils develop from weathered volcanic materials such as volcanic ash, lava and other volcanic deposits.

Many volcanic soils are productive, although their properties vary considerably depending on the parent material and degree of weathering.

Characteristics:

Often have a dark brown, reddish or black colour.

May have good soil structure.

Often have good water-holding capacity.

May contain minerals derived from volcanic materials.

Can support intensive agriculture.

Some have high phosphorus fixation.

Their fertility varies according to weathering and management.

May be relatively deep.

Examples in Kenya:

Areas around Mount Kenya.

Parts of the Central Highlands.

Parts of the Rift Valley.

Areas surrounding volcanic landscapes such as Longonot and Menengai.

Suitable crops:

Tea.

Coffee.

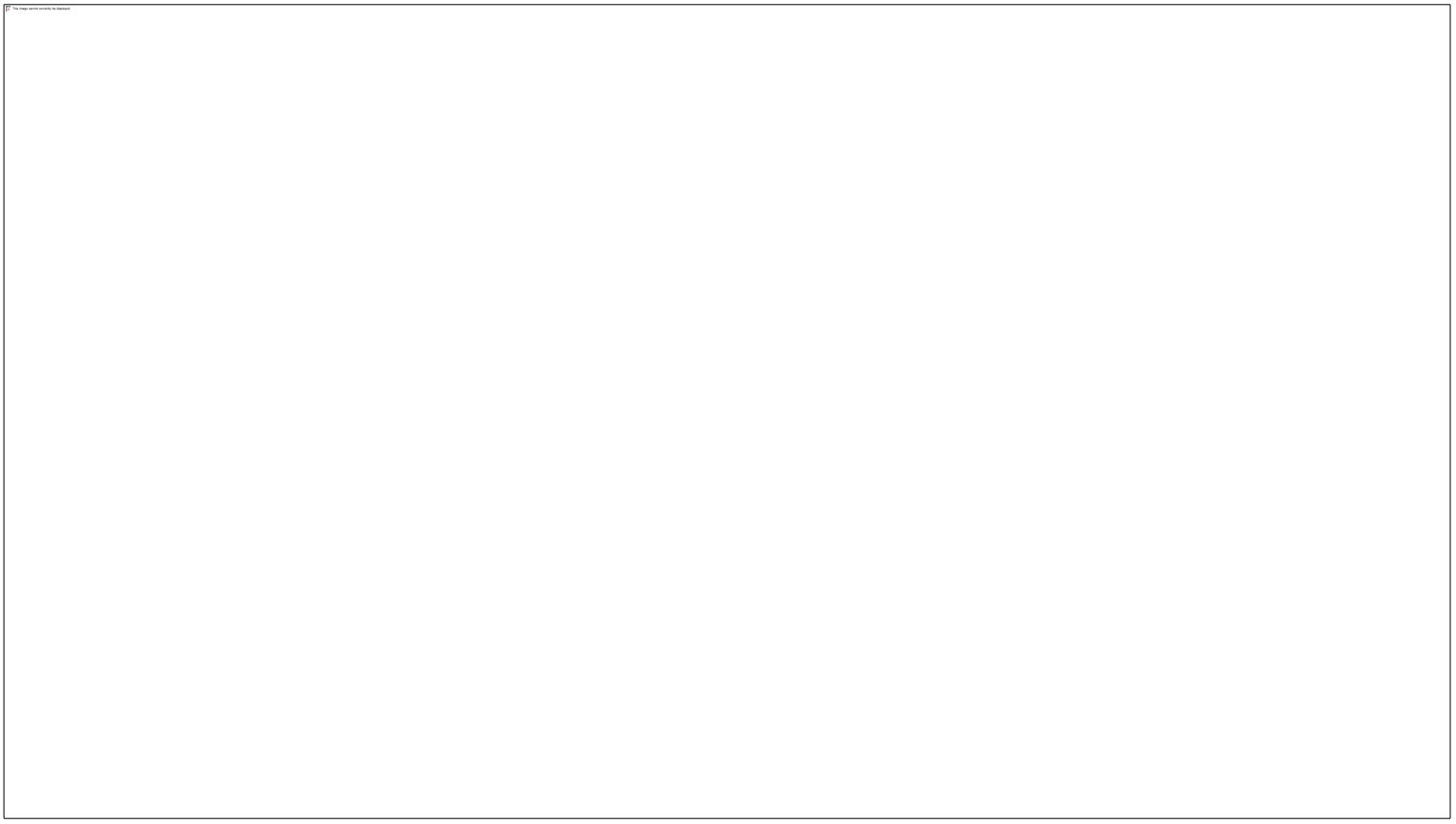
Potatoes.

Maize.

Vegetables.

Pyrethrum in suitable locations.

F. Black Cotton Soils (Vertisols)



Black cotton soils are dark, clay-rich soils that expand when wet and shrink when dry, often developing deep cracks during dry seasons.

In soil classification, many black cotton soils belong to the group known as Vertisols.

Characteristics:

Have a dark grey or black colour.

Contain a high proportion of expanding clay minerals.

Become sticky when wet.

Expand during wet seasons.

Shrink and develop deep cracks during dry seasons.

Have high water-holding capacity.

Often have poor drainage.

Are difficult to cultivate when wet.

May have high natural fertility.

Can damage buildings and roads due to swelling and shrinking.

Areas of occurrence in Kenya:

Athi-Kapiti Plains.

Parts of Mwea.

Some areas of the Kano Plains.

Other clay-rich low-lying areas.

Suitable crops under suitable conditions:

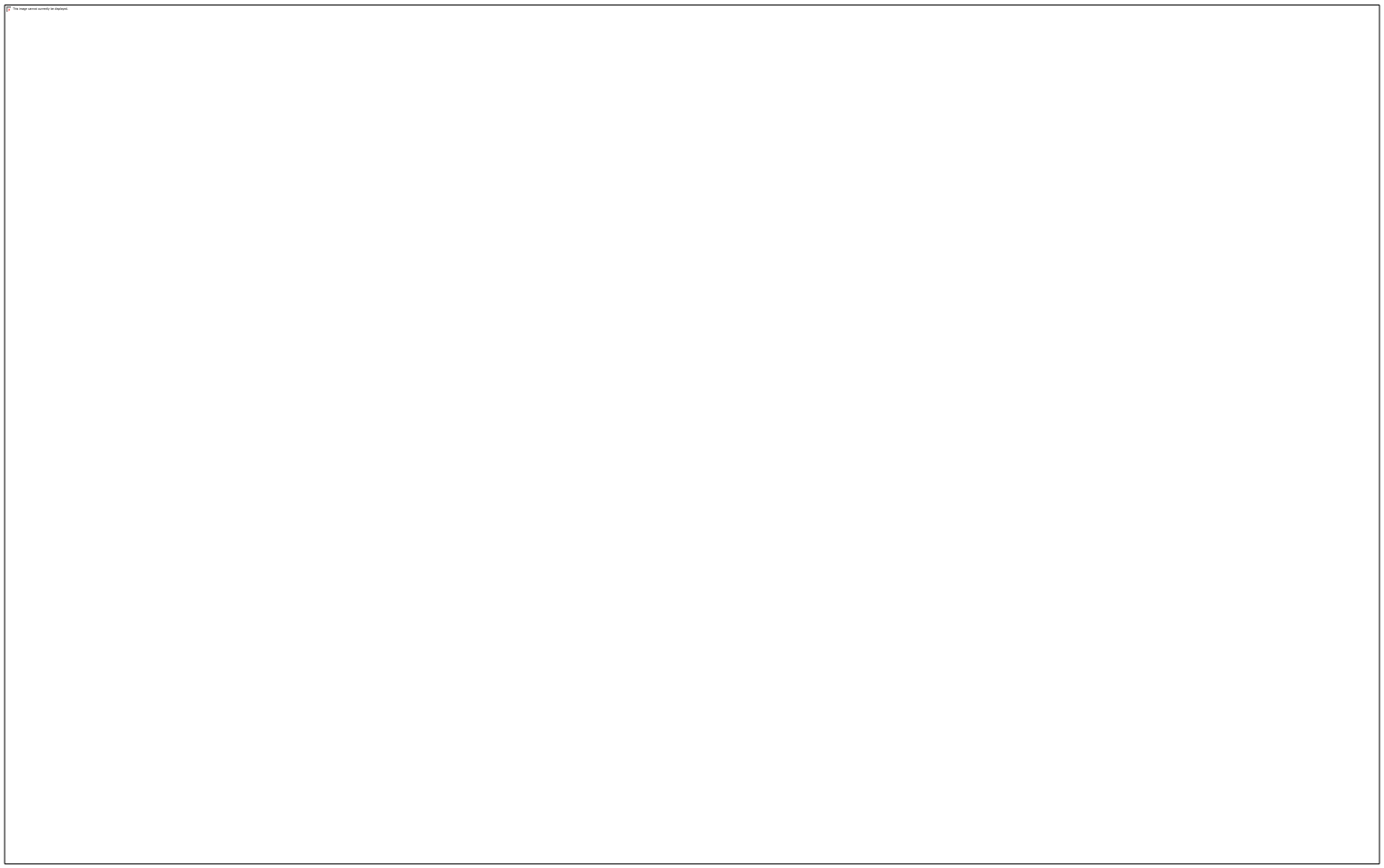
Rice.

Cotton.

Sorghum.

Some pasture crops.

G. Lateritic Soils



Lateritic soils develop in warm, humid tropical environments through intense chemical weathering and leaching.

Characteristics:

Usually red or reddish-brown.

Contain relatively high concentrations of iron and aluminium oxides.

May have low natural fertility after prolonged weathering.

May form hard crusts when exposed and hardened.

May have low organic matter in cultivated or degraded areas.

Are often strongly weathered.

May have poor nutrient-retention properties depending on their clay mineralogy.

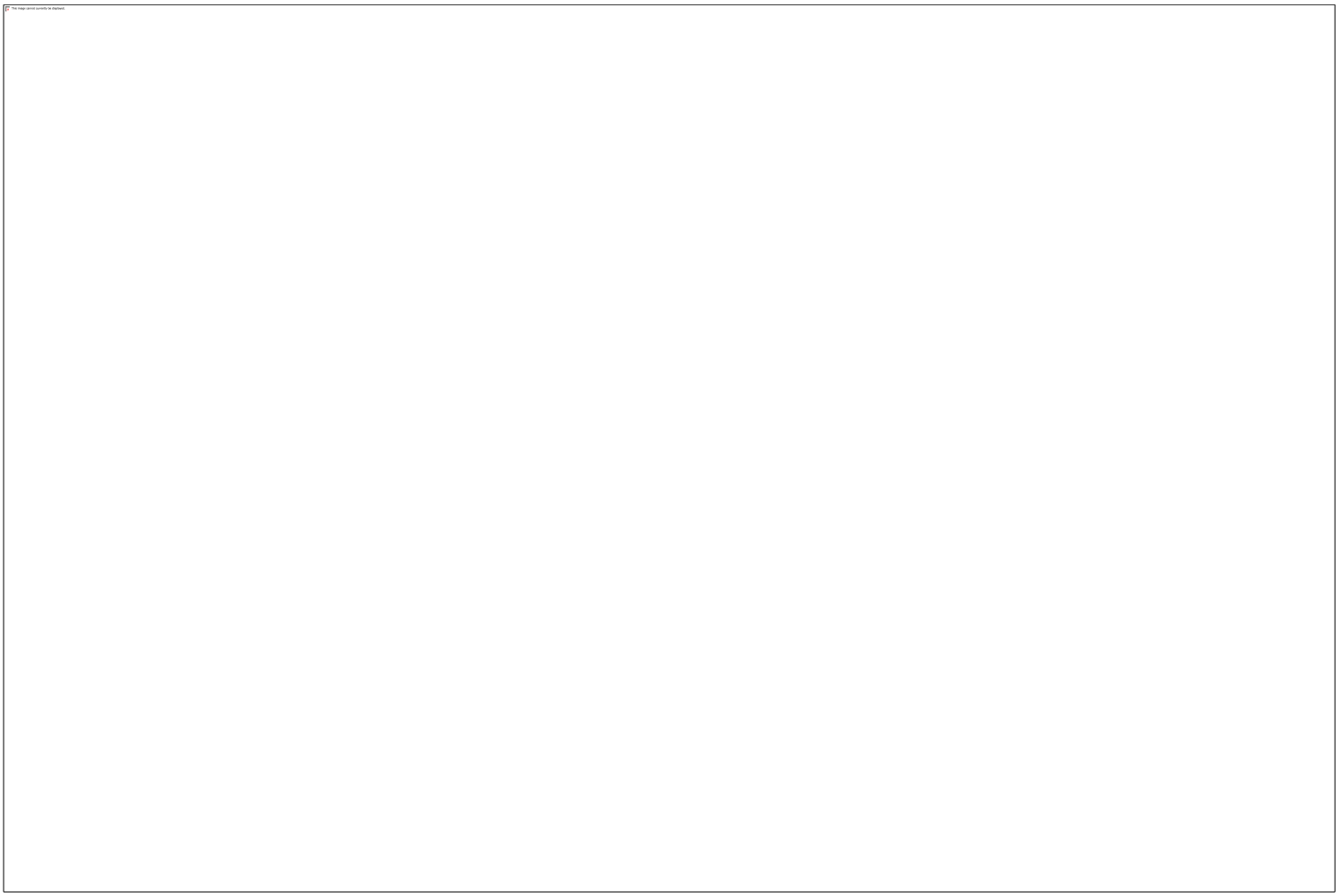
Agricultural suitability:

Can support crops when properly managed.

May require organic manure and suitable fertiliser application.

Requires protection against erosion.

H. Desert and Arid Soils



These are soils occurring in regions receiving very little rainfall and experiencing high evaporation rates.

Characteristics:

Often have low organic matter content.

May contain considerable sand or gravel.

May have limited biological activity.

Are commonly dry for long periods.

May accumulate soluble salts.

May have limited soil development.

Are susceptible to wind erosion.

May contain calcium carbonate accumulations.

Their agricultural productivity is often limited by moisture shortages.

Areas in Kenya:

Turkana.

Marsabit.

Garissa.

Wajir.

Mandera.

Parts of Isiolo.

Suitable activities:

Pastoralism.

Drought-resistant crop production.

Irrigated agriculture where water is available.

I. Peaty Soils



Peaty soils are soils containing very high amounts of partially decomposed organic matter, commonly developing in waterlogged environments.

Characteristics:

Have a dark brown or black colour.

Contain large amounts of organic matter.

Are often acidic.

Have high water-holding capacity.

May have poor drainage.

Develop where decomposition is slow due to waterlogging and limited oxygen.

May contain partially decomposed plant remains.

Uses:

May support specialised wetland vegetation.

Can be used for some agricultural purposes after appropriate drainage and management, although drainage may damage important wetland ecosystems.

Store large quantities of carbon.

J. Saline Soils



Saline soils are soils containing excessive concentrations of soluble salts that may interfere with normal plant growth.

Characteristics:

May have white salt deposits on the surface.

Commonly occur in arid and semi-arid environments.

May develop under excessive evaporation.

May have reduced agricultural productivity.

Can interfere with seed germination.

Can make water uptake difficult for plants.

Management:

Improve drainage.

Use suitable irrigation water.

Apply appropriate leaching where drainage permits.

Select salt-tolerant crops.

Manage irrigation carefully.

5.3 Summary of Main Soil Types

Soil type	Main characteristic	Agricultural potential

Sandy	Coarse and well drained	Often low without improvement
Clay	Fine and water-retentive	Good but difficult to manage
Loamy	Balanced texture	Generally high
Alluvial	River-deposited sediments	Often high
Volcanic	Derived from volcanic materials	Often high, but varies
Black cotton	Expanding clay and deep cracks	Good with proper management
Lateritic	Iron and aluminium-rich	Often limited without improvement
Desert	Dry and low in organic matter	Limited by water availability
Peaty	High organic matter	Specialised conditions
Saline	Excess soluble salts	Often limited

6.0 PROPERTIES AND CHARACTERISTICS OF SOIL

6.1 Meaning of Soil Properties

Soil properties are the physical, chemical and biological characteristics that determine how soil behaves and how suitable it is for supporting plants, animals and human activities.

They influence soil fertility, water movement, drainage, aeration, crop growth and land-use potential.

Soil properties are grouped into three main categories:

Physical properties.

Chemical properties.

Biological properties.

6.2 Physical Properties of Soil

A. Soil Texture

Soil texture refers to the relative proportions of sand, silt and clay particles in a soil.

It determines how soil feels and influences its water retention, drainage and aeration.

Main soil texture classes:

Sandy.

Silty.

Clayey.

Loamy.

Sandy loam.

Clay loam.

Silty clay.

Importance of soil texture:

Determines water-holding capacity.

Influences drainage.

Affects soil aeration.

Determines ease of cultivation.

Influences nutrient retention.

Affects root penetration.

Helps determine suitable crops.

Practical activity: Identifying soil texture by feel

Collect a small soil sample.

Remove stones and plant remains.

Add a little water.

Rub the soil between the fingers.

Observe whether it feels gritty, smooth or sticky.

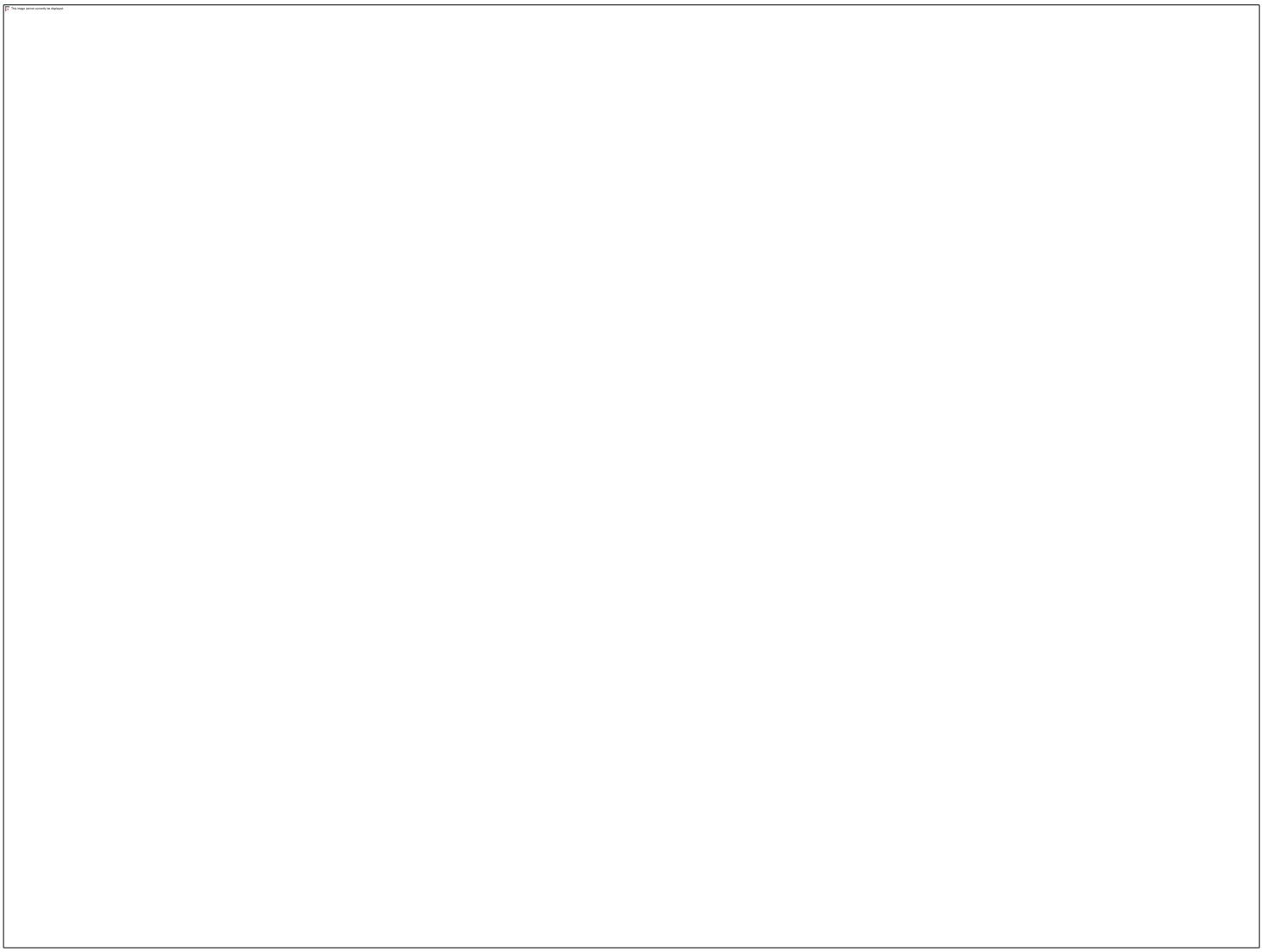
Try moulding it into a ball or ribbon.

Record the observations and identify the likely texture.

B. Soil Structure

Soil structure refers to the arrangement of individual soil particles into larger aggregates called peds.

Main types of soil structure



1. **Granular structure**

Soil particles form small rounded aggregates.

Commonly found in topsoil.

Allows good aeration and water movement.

Supports root development.

2. **Blocky structure**

Soil aggregates form roughly cube-like blocks.

Commonly found in subsoil.

May provide moderate drainage and aeration.

3. **Platy structure**

Soil aggregates form thin horizontal plates.

May restrict downward water movement.

Can restrict root penetration.

4. **Prismatic structure**

Aggregates form vertically elongated columns with flat tops.

Commonly found in some subsoils.

Influences water and root movement.

5. **Columnar structure**

Aggregates form vertical columns with rounded tops.

Commonly associated with soils affected by sodium.

May restrict water infiltration and root growth.

Importance of soil structure:

Influences soil aeration.

Controls water infiltration.

Determines ease of root penetration.

Reduces soil erosion when well developed.

Influences soil workability.

Affects microbial activity.

C. Soil Colour

Soil colour refers to the visible colour of soil, determined by its mineral composition, organic matter, moisture and drainage conditions.

Common soil colours and their meanings

Soil colour	Possible indication
Black	High organic matter or certain dark minerals
Dark brown	Organic matter accumulation
Red	Oxidised iron compounds and good aeration in many settings
Yellow	Hydrated iron oxides and weathering conditions
Grey	Poor drainage or prolonged waterlogging in many settings
White	Accumulation of salts, calcium carbonate or silica

Importance of soil colour:

Helps identify differences between soil horizons.

Provides clues about soil drainage.

May indicate organic matter content.

Helps in soil classification.

Gives information about soil-forming processes.

D. Soil Porosity

Porosity refers to the amount or proportion of empty spaces (pores) between soil particles.

These pores hold air and water.

Factors affecting soil porosity:

Soil texture.

Soil structure.

Organic matter.

Soil compaction.

Biological activity.

Importance:

Determines water storage.

Controls air movement.

Influences root development.

Affects drainage.

Supports soil organisms.

E. Soil Permeability

Soil permeability is the ability of soil to allow water and air to pass through it.

Characteristics:

Sandy soils generally have high permeability.

Clay soils generally have lower permeability.

Well-structured loamy soils often have favourable permeability.

Importance:

Determines the rate at which water moves through soil.

Influences drainage.

Affects irrigation efficiency.

Influences waterlogging.

Determines the movement of dissolved nutrients.

F. Soil Moisture Content

Soil moisture content refers to the amount of water held within the soil at a particular time.

Factors affecting soil moisture:

Rainfall.

Temperature.

Soil texture.

Soil structure.

Vegetation cover.

Slope gradient.

Evaporation.

Irrigation.

Drainage.

Importance:

Supports plant growth.

Influences soil organisms.

Affects soil temperature.

Supports nutrient absorption.

Influences soil erosion and runoff.

G. Soil Depth

Soil depth refers to the vertical distance from the soil surface to a restrictive layer, bedrock or another significant boundary.

Importance:

Determines the volume available for root growth.

Influences water storage.

Determines the types of crops that can be grown.

Influences soil productivity.

Affects land-use suitability.

H. Soil Consistency

Soil consistency refers to the degree of cohesion and resistance of soil to deformation or breakage under different moisture conditions.

Soil may be:

Loose.

Friable.

Firm.

Sticky.

Plastic.

Hard.

Importance:

Determines ease of cultivation.

Influences root penetration.

Affects soil compaction.

Helps assess soil workability.

6.3 Chemical Properties of Soil

A. Soil pH

Soil pH measures the acidity or alkalinity of soil.

It is measured using a pH scale ranging from 0 to 14, with 7 representing neutral conditions.



Classification of soil pH

pH range	Soil condition
Below 4.5	Very strongly acidic
4.5–5.5	Strongly acidic
5.6–6.5	Moderately to slightly acidic
6.6–7.3	Near neutral
7.4–8.4	Alkaline
Above 8.4	Strongly alkaline

These are broad teaching ranges; exact classification boundaries vary between soil-testing systems.

Importance of soil pH:

Influences the availability of plant nutrients.

Affects microbial activity.

Determines the suitability of soil for certain crops.

Influences the toxicity of some elements.

Affects the effectiveness of fertilisers.

Influences decomposition of organic matter.

Ways of correcting soil pH

Apply agricultural lime to suitable acidic soils based on soil-test recommendations.

Apply appropriate soil amendments to manage excessive alkalinity.

Improve drainage where waterlogging contributes to poor soil conditions.

Use suitable fertilisers.

Maintain organic matter.

Conduct regular soil testing.

B. Soil Fertility

Soil fertility refers to the ability of soil to supply essential nutrients to plants in adequate quantities and suitable proportions.

Major plant nutrients

Macronutrients

Nitrogen (N).

Phosphorus (P).

Potassium (K).

Calcium (Ca).

Magnesium (Mg).

Sulphur (S).

Micronutrients

Iron (Fe).

Zinc (Zn).

Copper (Cu).

Manganese (Mn).

Boron (B).

Molybdenum (Mo).

Chlorine (Cl).

Nickel (Ni).

Importance of soil fertility:

Supports healthy plant growth.

Increases crop yields.

Improves crop quality.

Supports livestock feed production.

Reduces the need for excessive fertiliser use when fertility is maintained.

Improves agricultural sustainability.

C. Cation Exchange Capacity (CEC)

Cation exchange capacity refers to the ability of soil to hold and exchange positively charged nutrient ions.

Examples of positively charged ions include:

Calcium (Ca^{2+}).

Magnesium (Mg^{2+}).

Potassium (K^{+}).

Ammonium (NH_4^{+}).

Importance:

Helps retain plant nutrients.

Reduces nutrient losses through leaching.

Supports soil fertility.

Influences fertiliser management.

Is generally higher in soils rich in clay and organic matter.

D. Soil Salinity

Soil salinity refers to the concentration of soluble salts in soil.

Excessive salinity makes it difficult for plants to absorb water.

Effects:

Reduces seed germination.

Causes poor plant growth.

Reduces agricultural productivity.

May lead to leaf scorching.

May cause plant wilting even when the soil contains water.

E. Soil Nutrient Content

This refers to the amount and availability of essential mineral nutrients in soil.

Nutrient availability is influenced by:

Soil pH.

Organic matter.

Soil texture.

Soil moisture.

Microbial activity.

Leaching.

Parent material.

6.4 Biological Properties of Soil

Biological properties refer to characteristics associated with living organisms and biological activities within the soil.

Major soil organisms

Earthworms.

Termites.

Ants.

Bacteria.

Fungi.

Nematodes.

Protozoa.

Soil insects.

Mites.

Other decomposers.

Importance of biological activities:

Decompose organic materials.

Release nutrients.

Improve soil structure.

Increase soil aeration.

Mix organic matter with mineral particles.

Support nitrogen cycling.

Help control certain soil pests and diseases.

6.5 Soil Fertility and Soil Productivity

These two terms are related but have different meanings.

Soil fertility	**Soil productivity**
Ability to supply essential nutrients to plants.	Ability of soil to produce crops or vegetation under given environmental and management conditions.
Mainly concerns nutrient availability.	Includes nutrients, water, climate, soil depth and management.
Is one component of productivity.	Is influenced by fertility and other factors.

A fertile soil may have low productivity if it lacks water or is poorly drained.

7.0 SIGNIFICANCE OF SOIL TO HUMAN ACTIVITIES

7.1 Meaning of Soil Significance

The significance of soil refers to the importance and benefits that soil provides to human beings, plants, animals and the natural environment.

Soil is one of the most important natural resources because it supports food production, construction, industrial development, water storage and ecological balance.

7.2 Importance of Soil to Human Beings



A. Agricultural Production

Soil provides the physical and chemical environment necessary for crop production.

Importance in agriculture:

Provides anchorage for plant roots.

Supplies mineral nutrients required for crop growth.

Stores water needed by plants.

Provides air for root respiration.

Supports the activities of beneficial soil organisms.

Provides a medium for seed germination.

Supports the production of food crops.

Supports the production of cash crops.

Examples in Kenya:

Maize production in Trans Nzoia and Uasin Gishu.

Tea production in Kericho, Nandi and Nyeri.

Coffee production in Kiambu and Kirinyaga.

Rice production in Mwea.

Sugarcane production in parts of western Kenya.

Horticultural production in parts of Nakuru, Naivasha and Mount Kenya region.

B. Livestock Production

Soil supports the growth of natural and planted pasture used to feed livestock.

Importance:

Supports the growth of grasses.

Provides nutrients for pasture plants.

Supports fodder production.

Provides grazing land for livestock.

Supports the growth of leguminous fodder crops.

Supports the production of hay and silage crops.

Kenyan examples: Pastoral communities in Kajiado, Narok, Turkana and Garissa depend on soil-supported vegetation for livestock production.

C. Construction and Building

Soil provides materials and foundations used in construction.

Uses:

Clay is used to manufacture bricks.

Clay is used in making roofing tiles.

Sand is used in making concrete and mortar.

Gravel is used in road construction.

Soil provides foundations for buildings.

Murram is used in road construction.

Lateritic materials may be used in road construction.

Soil is used in making earthen floors and walls.

Example: In many rural areas of Kenya, clay, sand, murram and other locally available soil materials are used in constructing houses, schools and roads.

D. Industrial Development

Soil provides raw materials for different manufacturing industries.

Examples:

Clay is used in pottery and ceramic industries.

Kaolin is used in the manufacture of ceramics and other industrial products.

Sand is used in glass manufacturing.

Certain clay minerals are used in cement and brick production.

Soil materials are used in the manufacture of tiles.

Some mineral-rich soil deposits provide materials for specialised industrial processes.

E. Water Storage and Supply

Soil plays an important role in the storage, movement and filtration of water.

Importance:

Allows rainfall to infiltrate into the ground.

Stores moisture for plant growth.

Recharges groundwater systems.

Filters some suspended materials and pollutants from water.

Regulates the movement of water into rivers and streams.

Reduces surface runoff when infiltration is high.

Supports springs and groundwater-dependent ecosystems.

F. Supports Natural Vegetation

Soil provides the conditions required for the growth and survival of natural vegetation.

Importance:

Supplies nutrients to plants.

Provides water for vegetation.

Anchors plant roots.

Provides air for root respiration.

Supports forest ecosystems.

Supports grasslands and savanna vegetation.

Supports wetland vegetation.

Influences the distribution of plant species.

G. Supports Wildlife and Biodiversity

Soil provides habitats for numerous organisms.

Examples:

Earthworms live in soil.

Termites construct underground nests.

Ants establish colonies in soil.

Burrowing mammals use soil for shelter.

Soil microorganisms support nutrient cycling.

Importance:

Maintains biodiversity.

Provides habitats for organisms.

Supports food chains and food webs.

Promotes decomposition.

Maintains ecological balance.

H. Supports Forestry

Soil supports the growth of trees used for timber, fuel, construction and environmental protection.

Importance:

Provides nutrients to trees.

Stores water for tree growth.

Supports root development.

Provides anchorage.

Supports commercial tree plantations.

Supports natural forests.

Helps maintain forest ecosystems.

I. Supports Transportation Infrastructure

Soil materials are important in the construction and maintenance of transport networks.

Uses:

Murram is used in constructing rural roads.

Gravel is used in road surfacing.

Compacted soil is used in road foundations.

Clay and other soil materials may be used in engineering applications.

Soil supports railway embankments and airport infrastructure.

J. Soil as a Source of Income and Employment

Soil supports economic activities that create employment and income.

Examples:

Farming creates employment for agricultural workers.

Brick making provides income to artisans.

Pottery provides employment to craft producers.

Horticulture creates employment in production, packaging and transport.

Forestry supports employment in timber production.

Construction industries depend on soil materials.

Irrigated agriculture supports commercial enterprises.

K. Soil in Environmental Regulation

Soil contributes to environmental stability.

Importance:

Stores carbon in organic matter.

Reduces flooding by absorbing rainfall.

Filters some pollutants.

Supports nutrient cycling.

Helps regulate the water cycle.

Supports vegetation that absorbs carbon dioxide.

Reduces dust when protected by vegetation.

Helps maintain ecosystem balance.

L. Soil as a Cultural and Historical Resource

Soil is important in understanding human history and cultural practices.

Examples:

Clay is used in traditional pottery.

Soil is used in traditional house construction.

Archaeological remains are preserved in soil.

Certain soils are used in traditional cultural activities.

Soil deposits provide evidence of past environmental conditions.

7.3 Summary: Importance of Soil

Sector	Importance of soil
Agriculture	Supports crop production.
Livestock	Supports pasture and fodder growth.
Construction	Provides building materials and foundations.
Industry	Supplies clay, sand and other raw materials.
Water resources	Stores and filters water and recharges groundwater.
Forestry	Supports tree growth.
Wildlife	Provides habitats for organisms.
Transport	Provides materials for road construction.
Economy	Creates employment and income.
Environment	Supports nutrient cycling and carbon storage.
Culture	Supports traditional crafts and preserves archaeological remains.

8.0 SOIL DEGRADATION AND ITS CAUSES

8.1 Meaning of Soil Degradation

Soil degradation refers to the deterioration of soil quality and productive capacity due to natural processes or human activities.

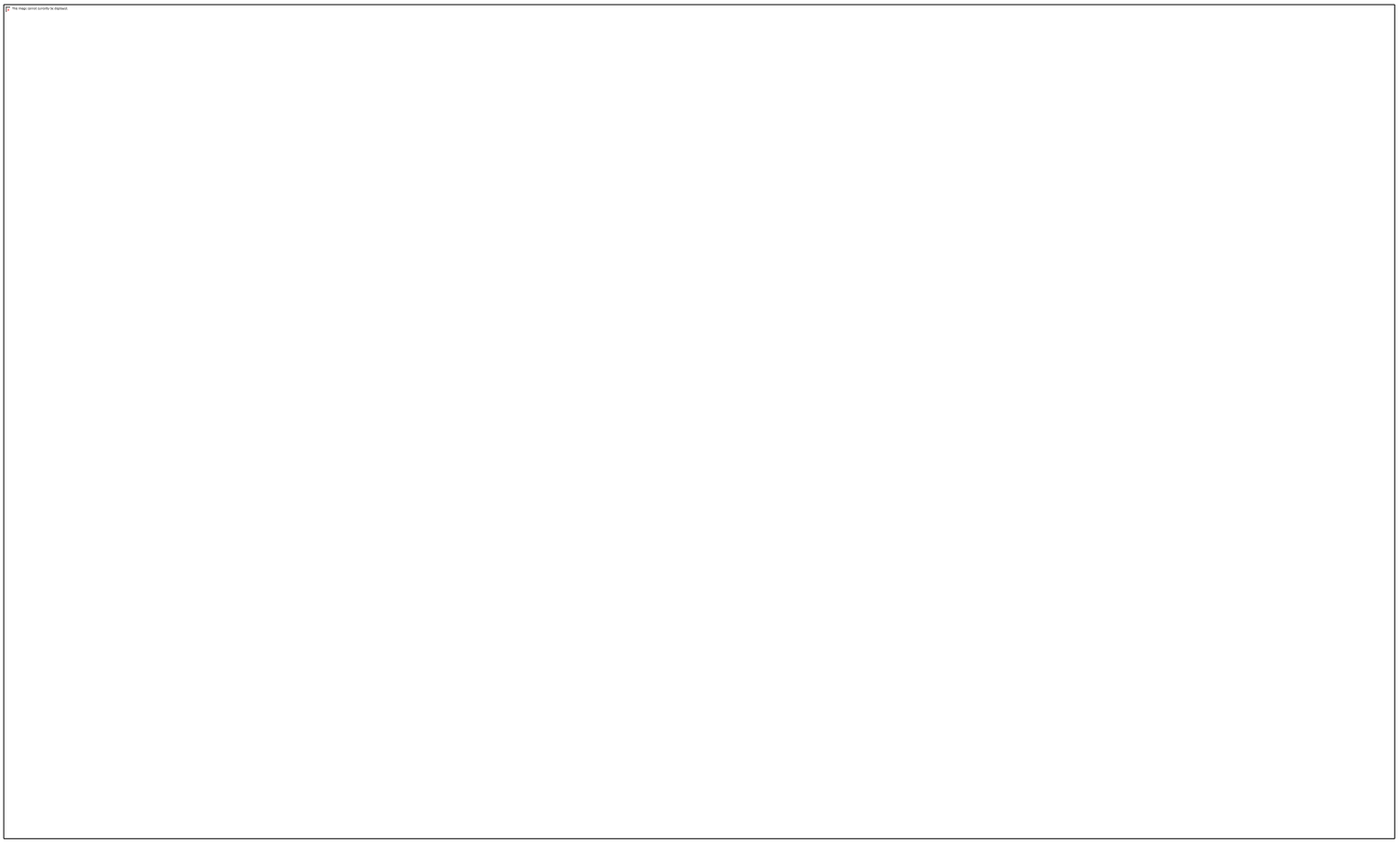
It reduces the ability of soil to support vegetation, agricultural production and ecological functions.

Soil degradation is a major environmental challenge in Kenya, particularly in areas affected by deforestation, overgrazing, inappropriate farming and prolonged drought.

8.2 Main Forms of Soil Degradation

A. Soil Erosion

Soil erosion is the detachment and removal of topsoil by agents such as water, wind and gravity.



Types of soil erosion

1. **Splash erosion**

Occurs when raindrops strike bare soil.

Soil particles are detached and scattered.

It is the initial stage of water erosion.

2. **Sheet erosion**

Involves the uniform removal of a thin layer of topsoil over a wide area.

It may be difficult to notice initially.

It reduces soil fertility.

3. **Rill erosion**

Occurs when running water forms small channels on the soil surface.

The channels can often be removed through normal cultivation.

4. **Gully erosion**

Occurs when running water cuts deep and wide channels into the soil.

It removes large quantities of soil.

It may make land unsuitable for cultivation.

5. **Wind erosion**

Occurs when strong winds detach and transport loose soil particles.

It is common in dry, bare and poorly protected environments.

6. **Mass movement**

Involves the downslope movement of soil under gravity.

Examples include landslides and soil slips.

B. Soil Exhaustion

Soil exhaustion refers to the depletion of essential nutrients from soil due to continuous crop production without adequate nutrient replacement.

Causes:

Continuous cultivation.

Monocropping.

Removal of crop residues.

Excessive harvesting.

Inadequate fertiliser application.

Soil erosion and leaching.

C. Soil Salinisation

This is the accumulation of excessive soluble salts in soil.

Causes:

Excessive irrigation.

Poor drainage.

High evaporation.

Use of saline water.

Shallow saline groundwater.

D. Soil Acidification

Soil acidification is the process through which soil becomes increasingly acidic.

Causes:

Excessive use of certain acid-forming fertilisers.

Heavy rainfall and leaching of basic cations.

Removal of harvested plant materials.

Acid deposition.

Natural soil-forming processes.

E. Soil Compaction

Soil compaction occurs when soil particles are pressed closely together, reducing the spaces between them.

Causes:

Heavy farm machinery.

Excessive livestock trampling.

Cultivation when soil is wet.

Repeated movement of vehicles.

Poor soil management.

Effects:

Reduces soil aeration.

Restricts root growth.

Reduces infiltration.

Increases surface runoff.

May increase erosion.

F. Desertification

Desertification refers to land degradation in arid, semi-arid and dry sub-humid areas resulting from climatic variations and human activities.

Causes:

Deforestation.

Overgrazing.

Unsustainable cultivation.

Prolonged drought.

Poor irrigation practices.

Excessive removal of vegetation.

Soil erosion.

Areas of concern in Kenya: Parts of Turkana, Marsabit, Garissa, Wajir and Kajiado.

G. Soil Contamination

Soil contamination refers to the introduction of harmful substances into soil, reducing its quality and potentially harming organisms.

Sources:

Industrial waste.

Excessive pesticides.

Improper disposal of plastics.

Oil spills.

Mining waste.

Untreated sewage.

Heavy metals.

Improper disposal of electronic waste.

Effects:

Reduces soil quality.

May contaminate groundwater.

Can harm soil organisms.

May introduce harmful substances into food chains.

Can reduce agricultural productivity.

8.3 Causes of Soil Degradation

The causes can be grouped into natural and human-induced factors.

A. Natural causes

Heavy rainfall.

Prolonged drought.

Strong winds.

Steep slopes.

Flooding.

Natural landslides.

Naturally occurring saline conditions.

Extreme temperature variations.

B. Human-induced causes

Deforestation.

Overgrazing.

Poor farming methods.

Overcultivation.

Bush burning.

Poor irrigation practices.

Mining and quarrying.

Uncontrolled urbanisation.

Improper waste disposal.

Excessive use of agrochemicals.

8.4 Effects of Soil Degradation

Decline in soil fertility.

Reduced agricultural production.

Increased food insecurity.

Loss of vegetation.

Increased flooding.

Siltation of rivers and dams.

Loss of soil biodiversity.

Increased desertification.

Loss of agricultural land.

Increased poverty among farming communities.

Reduced water infiltration.

Increased costs of agricultural production.

Displacement of communities in severely degraded areas.

Reduced resilience to climate change.

9.0 SOIL MANAGEMENT AND CONSERVATION

9.1 Meaning of Soil Management

Soil management refers to the proper use, improvement and maintenance of soil to ensure that it remains productive and supports human activities.

It involves practices aimed at maintaining soil fertility, structure, moisture and biological activity.

9.2 Meaning of Soil Conservation

Soil conservation refers to the protection of soil against erosion, degradation and loss of fertility through appropriate land-use and management practices.

Soil conservation aims at maintaining soil productivity for present and future generations.



9.3 Methods of Soil Management and Conservation

A. Afforestation

Afforestation is the establishment of forests by planting trees on land that was not previously under forest cover.

How it conserves soil:

Tree roots bind soil particles together.

Tree canopies reduce the impact of raindrops.

Fallen leaves provide organic matter.

Trees reduce the speed of surface runoff.

Tree cover reduces wind erosion.

Forests improve soil moisture conditions.

Kenyan example: Tree-planting programmes in degraded catchment areas around the Mau Forest complex.

B. Reforestation

Reforestation is the re-establishment of trees in areas where forests have previously been cleared or destroyed.

Importance:

Restores forest cover.

Reduces soil erosion.

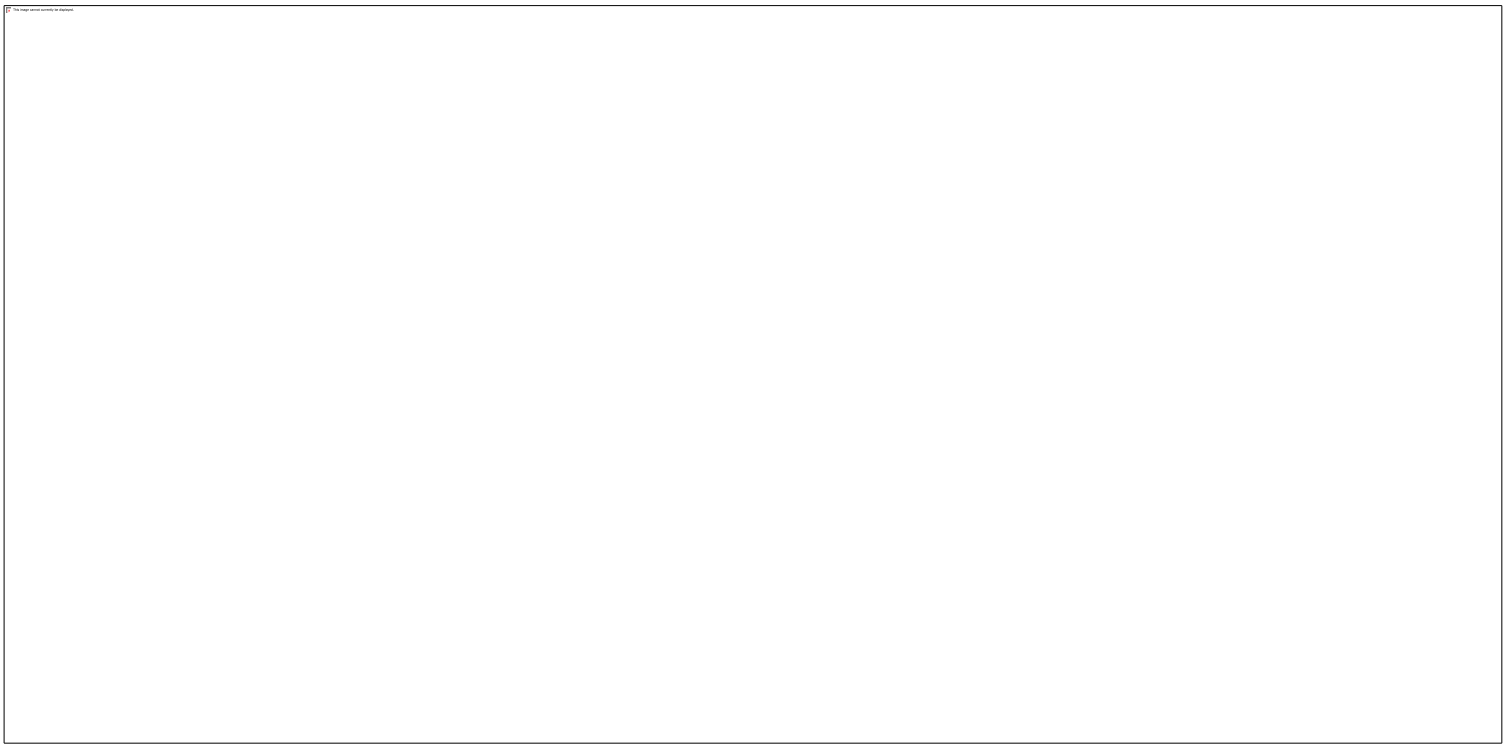
Improves soil organic matter.

Protects water catchment areas.

Restores biodiversity.

C. Contour Ploughing

Contour ploughing involves cultivating land along contour lines rather than up and down the slope.



How it conserves soil:

Reduces the speed of surface runoff.

Encourages water infiltration.

Reduces soil erosion.

Prevents the formation of rills.

Helps retain soil moisture.

D. Terracing

Terracing involves constructing a series of level or gently sloping platforms across steep slopes to reduce runoff and soil erosion.



Importance:

Reduces the speed of running water.

Prevents soil from being washed downslope.

Encourages water infiltration.

Provides relatively level land for cultivation.

Reduces gully formation.

Improves soil moisture retention.

Kenyan example: Terracing is practised in hilly agricultural areas around Murang'a, Nyeri and parts of the Rift Valley.

E. Strip Cropping

Strip cropping involves growing different crops in alternating strips across a slope or along the contour.

Importance:

Slows down surface runoff.

Reduces soil erosion.

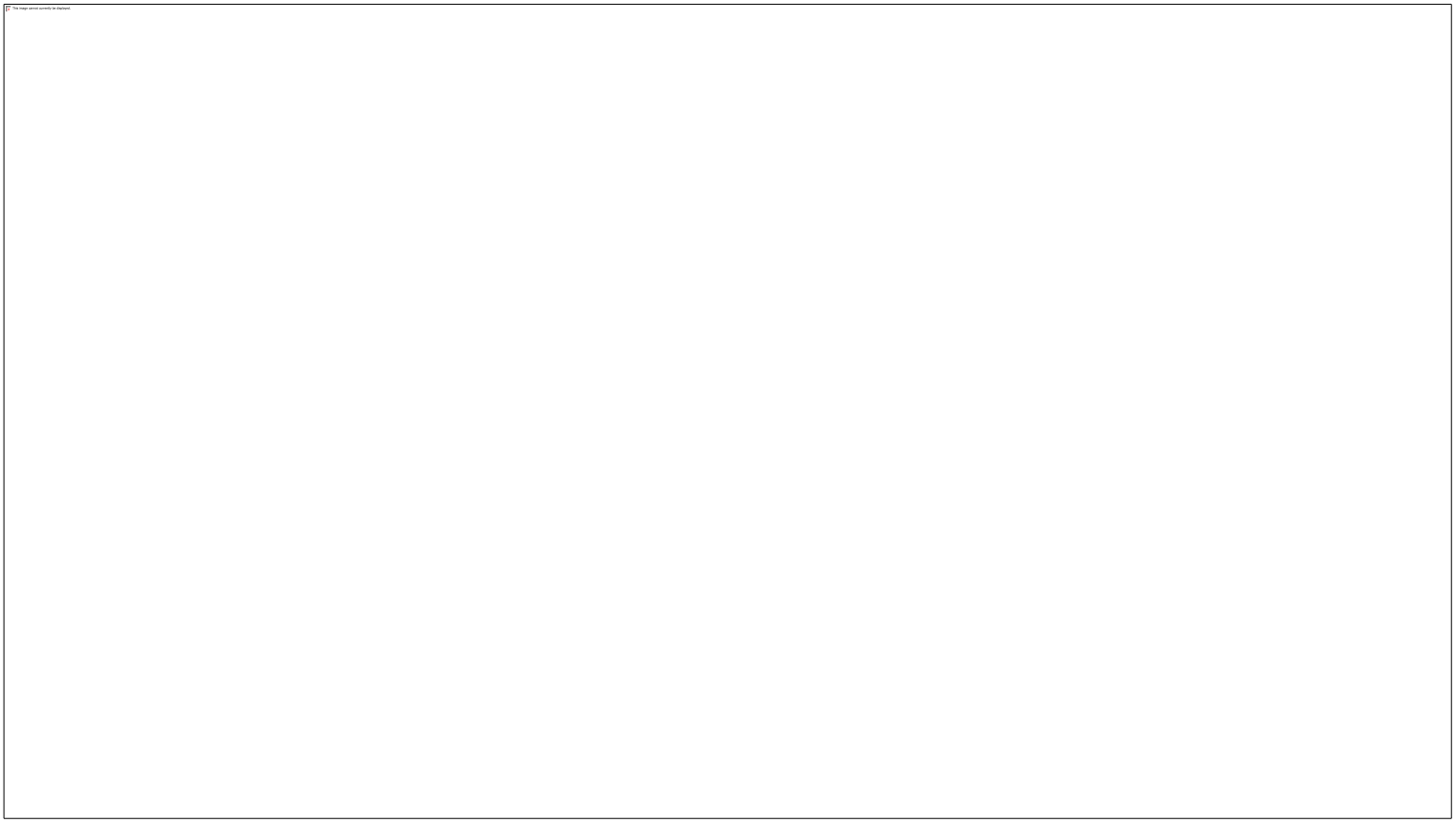
Traps soil particles.

Improves land utilisation.

May increase crop diversity.

F. Mulching

Mulching involves covering the soil surface with materials such as dry grass, crop residues, leaves or other suitable organic materials.



Importance:

Reduces evaporation.

Conserves soil moisture.

Reduces the impact of raindrops.

Suppresses weeds.

Adds organic matter when organic mulch decomposes.

Reduces surface runoff.

Regulates soil temperature.

G. Cover Cropping

Cover cropping involves growing crops mainly to protect and improve the soil rather than primarily for harvesting.

Examples:

Mucuna.

Cowpeas.

Dolichos.

Pigeon peas.

Suitable grasses.

Importance:

Protects soil from raindrop impact.

Reduces wind erosion.

Improves soil organic matter.

Reduces nutrient leaching.

Suppresses weeds.

Improves soil structure.

Some leguminous cover crops fix atmospheric nitrogen through symbiotic bacteria.

H. Crop Rotation

Crop rotation involves growing different crops on the same piece of land in a planned sequence over different seasons.

Example: Maize followed by beans, then potatoes or another suitable crop.

Importance:

Helps maintain soil fertility.

Reduces the build-up of certain pests and diseases.

Improves soil structure.

Promotes efficient nutrient use.

Reduces continuous nutrient depletion.

Leguminous crops can contribute nitrogen to the soil.

I. Intercropping

Intercropping involves growing two or more crops on the same piece of land at the same time.

Examples:

Maize and beans.

Sorghum and cowpeas.

Fruit trees and suitable legumes.

Importance:

Maintains soil cover.

Reduces soil erosion.

Improves land utilisation.

May improve nutrient cycling.

Reduces the risk of total crop failure.

Can improve soil fertility when suitable legumes are included.

J. Controlled Grazing

Controlled grazing involves managing livestock movement and grazing intensity to prevent excessive removal of vegetation.

Methods include:

Rotational grazing.

Paddocking.

Proper stocking rates.

Resting grazing fields.

Fodder production.

Importance:

Maintains vegetation cover.

Prevents overgrazing.

Reduces soil erosion.

Allows pasture regeneration.

Reduces soil compaction.

Maintains soil organic matter.

K. Construction of Check Dams

Check dams are small barriers constructed across drainage channels to slow down running water.

Importance:

Reduce water velocity.

Trap transported sediments.

Reduce gully erosion.

Encourage water infiltration.

Help stabilise drainage channels.

L. Grassed Waterways

Grassed waterways are natural or constructed drainage channels covered with grass to safely carry runoff.

Importance:

Reduce water velocity.

Prevent channel erosion.

Trap some sediments.

Protect agricultural fields.

Provide safe routes for excess water.

M. Proper Irrigation Management

Proper irrigation involves applying the correct quantity of water at suitable intervals and ensuring adequate drainage.

Importance:

Prevents waterlogging.

Reduces soil salinisation.

Maintains soil moisture.

Reduces wastage of water.

Supports sustainable crop production.

N. Application of Organic Manure

Organic manure includes decomposed plant and animal materials used to improve soil fertility.

Examples:

Farmyard manure.

Compost manure.

Green manure.

Well-decomposed animal manure.

Importance:

Adds nutrients.

Improves soil structure.

Increases water-holding capacity.

Supports beneficial soil organisms.

Reduces dependence on mineral fertilisers.

Improves soil aggregation.

O. Appropriate Fertiliser Application

Fertilisers supply essential plant nutrients to soil.

Examples:

Urea.

DAP.

NPK fertilisers.

CAN.

MOP.

Importance:

Replaces nutrients removed during harvesting.

Corrects nutrient deficiencies.

Improves crop growth.

Increases crop yields.

Helps maintain soil productivity when properly used.

Important: Fertiliser selection and application rates should be guided by crop requirements and soil testing.

P. Conservation Agriculture

Conservation agriculture is an approach to farming that seeks to minimise soil disturbance, maintain permanent soil cover and diversify crops.

Its three major principles are:

Minimum soil disturbance.

Permanent soil cover.

Crop diversification through rotations or associations.

Benefits:

Reduces soil erosion.

Conserves moisture.

Improves soil structure.

Increases soil organic matter over time.

Reduces fuel and labour requirements in suitable farming systems.

Supports sustainable agriculture.

Q. Windbreaks and Shelterbelts

Windbreaks are rows of trees or shrubs planted to reduce wind speed.

Importance:

Reduce wind erosion.

Trap moving soil particles.

Protect crops from strong winds.

Reduce evaporation.

Provide habitats for wildlife.

May provide timber, fruits and fuelwood.

R. Controlled Bush Clearing and Burning

Uncontrolled burning destroys vegetation cover and organic matter, exposing soil to erosion.

Proper land management should involve:

Avoiding unnecessary bush burning.

Retaining crop residues.

Using controlled vegetation clearance where necessary.

Protecting sensitive slopes and catchments.

9.4 Soil Conservation Practices Suitable for Different Environments in Kenya

Environment	Major soil challenges	Appropriate conservation measures

Highlands	Soil erosion on steep slopes	Terracing, contour farming, cover crops
Arid areas	Wind erosion and desertification	Afforestation, controlled grazing, windbreaks
Semi-arid areas	Drought and runoff	Mulching, water harvesting, zai pits
River valleys	Flooding and sediment deposition	Riparian vegetation, controlled cultivation
Irrigated areas	Salinity and waterlogging	Proper drainage and efficient irrigation
Grasslands	Overgrazing and compaction	Rotational grazing and reseeding
Urban areas	Soil sealing and contamination	Proper waste management and green spaces

9.5 Importance of Soil Management and Conservation

Maintains soil fertility.

Reduces soil erosion.

Improves agricultural productivity.

Supports food security.

Protects water catchment areas.

Prevents desertification.

Maintains biodiversity.

Reduces flooding and sedimentation.

Improves soil moisture retention.

Supports sustainable economic development.

Protects land for future generations.

Reduces the cost of restoring degraded land.

10.0 FIELD STUDY: SOIL MANAGEMENT AND CONSERVATION IN THE COMMUNITY

10.1 Meaning of a Field Study

A field study is an organised investigation conducted outside the classroom to collect first-hand information about geographical features and processes.

A soil conservation field study enables learners to examine soil conditions, identify erosion problems and investigate conservation practices within their community.

10.2 Objectives of the Field Study

By the end of the field study, learners should be able to:

Identify different soil types in the community.

Examine soil characteristics.

Identify causes of soil degradation.

Identify soil conservation practices.

Assess the effectiveness of conservation methods.

Recommend appropriate soil management measures.

Develop environmental responsibility.

10.3 Equipment and Materials Required

Notebook.

Pen and pencil.

Camera or smartphone.

Measuring tape.

Soil auger or suitable digging tool.

Sample containers.

Labels.

Spade.

Water.

Sample collection bags.

Field guide.

Protective gloves and appropriate footwear.

10.4 Procedure for Conducting a Soil Field Study

Identify a suitable study area.

Seek permission from the landowner or relevant authority.

Prepare a field study checklist.

Observe the soil surface and vegetation cover.

Identify the major soil types.

Collect small soil samples from appropriate locations.

Observe soil colour and texture.

Identify evidence of soil erosion.

Examine farming and grazing practices.

Identify existing soil conservation measures.

Interview farmers or community members where appropriate.

Record findings.

Take photographs where permission is granted.

Discuss the results.

Prepare and present a field report.

10.5 Sample Field Study Report

Title: A Field Study on Soil Management and Conservation in the Community.

Location: A selected agricultural area in the community.

Objectives:

To identify common soil types.

To examine soil degradation.

To investigate conservation methods.

To recommend sustainable soil management practices.

Findings:

Observation	**Findings**
Soil types	Sandy, clayey and loamy soils depending on location
Soil erosion	Sheet erosion and rill erosion in exposed fields
Vegetation cover	Reduced in some cultivated and grazed areas
Farming methods	Mixed cropping and continuous cultivation
Conservation methods	Terracing, mulching and tree planting
Main challenge	Removal of vegetation and uncontrolled runoff

Recommendations:

Encourage tree planting.

Promote terracing on steep slopes.

Encourage crop rotation.

Apply organic manure.

Avoid overgrazing.

Promote mulching.

Protect riverbanks.

Educate community members on sustainable land use.

10.6 Suggested Competency-Based Learning Activities

Activity	**Competency developed**

Collecting soil samples	Critical thinking and problem-solving
Drawing a soil profile	Creativity and imagination
Conducting a soil field study	Communication and collaboration
Researching soil types	Digital literacy and learning to learn
Preparing a conservation report	Self-efficacy and communication
Participating in tree planting	Citizenship and environmental responsibility
Comparing soil samples	Critical thinking and scientific investigation

11.0 EMERGING ISSUES IN SOIL MANAGEMENT

11.1 Climate Change and Soil

Climate change affects soil formation, moisture conditions and productivity.

Effects include:

Increased soil moisture stress due to prolonged droughts.

Increased erosion due to intense rainfall.

Changes in soil organic matter decomposition.

Increased risk of desertification.

Changes in soil biological activity.

Increased salinisation in some irrigated environments.

11.2 Technology in Soil Management

Modern technology helps farmers understand and manage soil resources.

Examples:

Soil testing laboratories.

GPS-based soil mapping.

Remote sensing.

Geographic Information Systems (GIS).

Soil moisture sensors.

Precision agriculture.

Digital soil databases.

Drone-based land monitoring.

Benefits:

Improves soil information.

Supports appropriate fertiliser application.

Helps identify degraded land.

Improves irrigation management.

Supports agricultural planning.

Reduces unnecessary input costs.

11.3 Sustainable Soil Management

Sustainable soil management involves using soil in ways that maintain its productivity and ecological functions without compromising the needs of future generations.

Principles:

Maintain soil cover.

Minimise unnecessary soil disturbance.

Maintain organic matter.

Prevent soil erosion.

Maintain balanced nutrient levels.

Manage irrigation carefully.

Protect soil biodiversity.

Avoid soil contamination.

Promote responsible land use.

Monitor soil conditions regularly.

REVISION EXERCISES

SUB-STRAND 2.6: SOILS

The following questions assess knowledge, understanding, application, analysis, critical thinking and problem-solving in line with Competency-Based Education.

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Instructions: Answer all questions. Choose the correct answer from the alternatives A, B, C and D. Each question carries 1 mark.

1. Which of the following best defines soil?

A. The solid rock found beneath the Earth's surface.

B. The uppermost layer of the Earth's crust containing mineral and organic materials.

C. The layer of gases surrounding the Earth.

D. The molten materials found beneath the Earth's crust.

2. Which one of the following is NOT a major component of soil?

A. Mineral matter.

B. Organic matter.

C. Soil water.

D. Magma.

3. Which soil particle has the smallest diameter?

A. Sand.

B. Gravel.

C. Silt.

D. Clay.

4. Which component of soil is mainly responsible for improving soil fertility through the decomposition of plant and animal remains?

A. Humus.

B. Sand.

C. Gravel.

D. Soil air.

5. The process through which rocks break down into smaller particles without transportation is known as:

A. Deposition.

B. Weathering.

C. Erosion.

D. Transportation.

6. Which of the following is a chemical weathering process?

A. Exfoliation.

B. Freeze-thaw action.

C. Oxidation.

D. Thermal expansion.

7. The process through which organic materials are transformed into humus is called:

A. Leaching.

B. Humification.

C. Illuviation.

D. Calcification.

8. Which soil-forming factor determines the original mineral composition of soil?

A. Climate.

B. Relief.

C. Parent material.

D. Time.

9. Which process involves the downward removal of soluble minerals from upper soil horizons?

A. Leaching.

B. Humification.

C. Calcification.

D. Weathering.

10. The accumulation of clay and iron materials in a lower soil horizon is known as:

A. Eluviation.

B. Illuviation.

C. Oxidation.

D. Salinisation.

11. Which soil horizon contains the greatest concentration of partly decomposed organic materials?

A. O horizon. B. B horizon.

C. C horizon. D. R horizon.

12. The E horizon of a soil profile is mainly associated with:

A. Accumulation of bedrock.

B. Removal of materials through eluviation.

C. Accumulation of fresh organic matter.

D. Solid parent rock.

13. Which soil horizon consists mainly of partly weathered parent material?

A. A horizon.

B. B horizon.

C. C horizon.

D. O horizon.

14. A sequence of different soil types occurring along a slope is known as:

A. Soil profile.

B. Soil catena.

C. Soil texture.

D. Soil structure.

15. Which part of a soil catena is most likely to receive sediments transported from higher slopes?

A. Summit.

B. Shoulder.

C. Backslope.

D. Footslope.

16. Which of the following soils is generally most suitable for a wide range of agricultural crops due to its balanced texture?

A. Sandy soil.

B. Loamy soil.

C. Saline soil.

D. Peaty soil.

17. Black cotton soils are scientifically associated with which soil group?

A. Podzols.

B. Vertisols.

C. Acrisols.

D. Arenosols.

18. Which of the following is a major characteristic of sandy soils?

A. High water retention.

B. Very small pore spaces.

C. Rapid drainage.

D. High clay content.

19. Which soil type develops from sediments deposited by rivers?

A. Alluvial soil.

B. Desert soil.

C. Lateritic soil.

D. Peaty soil.

20. The reddish colour of many tropical soils is mainly associated with:

A. Organic matter.

B. Iron oxides.

C. Sodium chloride.

D. Calcium carbonate.

21. Which of the following soil properties refers to the relative proportions of sand, silt and clay?

A. Soil structure.

B. Soil texture.

C. Soil permeability.

D. Soil porosity.

22. The arrangement of soil particles into aggregates is referred to as:

A. Soil texture.

B. Soil structure.

C. Soil depth.

D. Soil colour.

23. A soil with a pH of 5.0 is classified as:

A. Strongly acidic.

B. Neutral.

C. Alkaline.

D. Strongly alkaline.

24. Which of the following nutrients is classified as a macronutrient?

A. Zinc.

B. Copper.

C. Nitrogen.

D. Boron.

25. The ability of soil to hold and exchange positively charged nutrient ions is known as:

A. Soil porosity.

B. Cation exchange capacity.

C. Soil permeability.

D. Soil consistency.

26. Which of the following is a major environmental effect of soil erosion?

A. Increased soil depth.

B. Increased soil fertility.

C. Siltation of rivers and dams.

D. Increased organic matter.

27. A farmer cultivates land along contour lines to reduce the speed of surface runoff. This practice is known as:

A. Strip mining.

B. Contour ploughing.

C. Monocropping.

D. Overcultivation.

28. Which agricultural practice involves growing different crops on the same land in a planned sequence?

A. Monocropping.

B. Overgrazing.

C. Crop rotation.

D. Bush burning.

29. Which of the following is an appropriate method of reducing wind erosion in semi-arid areas?

A. Deforestation.

B. Overgrazing.

C. Establishment of windbreaks.

D. Continuous cultivation.

30. Which of the following best explains the importance of soil conservation?

A. To encourage the removal of vegetation.

B. To increase soil degradation.

C. To maintain soil productivity for present and future generations.

D. To increase the rate of soil erosion.

SECTION B: STRUCTURED QUESTIONS (50 MARKS)

Instructions: Answer all questions. Write your answers clearly and provide relevant examples where necessary.

1. Soil Composition and Formation (8 Marks)

a) Define the term soil. (2 marks)

b) State four major components of soil. (2 marks)

c) Explain four factors that influence soil formation. (4 marks)

2. Soil-Forming Processes (8 Marks)

a) Differentiate between physical weathering and chemical weathering. (2 marks)

b) Explain three chemical weathering processes involved in soil formation. (3 marks)

c) Describe three processes involved in the development and differentiation of soil horizons. (3 marks)

3. Soil Profile and Soil Catena (8 Marks)

a) Define the term soil profile. (2 marks)

b) Describe three characteristics of each of the following soil horizons:

i. A horizon. (2 marks)

ii. B horizon. (2 marks)

c) Explain two factors responsible for the development of soil catena. (2 marks)

4. Types and Properties of Soil (8 Marks)

a) Name four major types of soil found on the Earth's surface. (2 marks)

b) Explain three characteristics of black cotton soils. (3 marks)

c) Differentiate between soil texture and soil structure. (2 marks)

d) State one importance of soil pH in agricultural production. (1 mark)

5. Significance of Soil to Human Activities (10 Marks)

a) Explain five ways in which soil is important to human activities. (5 marks)

b) Discuss five negative effects of soil degradation on the environment and human activities. (5 marks)

6. Soil Management and Conservation (8 Marks)

A farming community in a hilly area of Kenya experiences severe soil erosion during rainy seasons. The farmers have reported declining crop yields due to the loss of fertile topsoil.

a) Identify two causes of soil erosion in the area. (2 marks)

b) Explain three methods that farmers can use to control soil erosion. (3 marks)

c) State three benefits of practising sustainable soil management in the community. (3 marks)

TEACHER'S REFERENCE: IMPORTANT GEOGRAPHICAL TERMS

Term	Meaning
Pedogenesis	The process of soil formation.
Parent material	Original material from which soil develops.
Humus	Relatively stable decomposed organic matter.
Weathering	Breakdown of rocks in situ.

Leaching	Removal of soluble substances by water.
Eluviation	Removal of materials from an upper soil horizon.
Illuviation	Accumulation of materials in a lower soil horizon.
Laterisation	Intense tropical weathering involving leaching and concentration of iron and aluminium oxides.
Podzolisation	Soil-forming process involving the movement of iron, aluminium and organic compounds in acidic environments.
Calcification	Accumulation of calcium carbonate in soil.
Salinisation	Accumulation of soluble salts in soil.
Soil profile	Vertical section showing soil horizons.
Soil catena	Sequence of different soils along a slope.
Soil texture	Relative proportions of sand, silt and clay.
Soil structure	Arrangement of soil particles into aggregates.
Soil porosity	Proportion of pore spaces in soil.
Soil permeability	Ability of soil to transmit water and air.
Soil fertility	Ability of soil to supply essential plant nutrients.
Soil degradation	Deterioration of soil quality and productive capacity.
Soil conservation	Protection of soil against erosion and degradation.

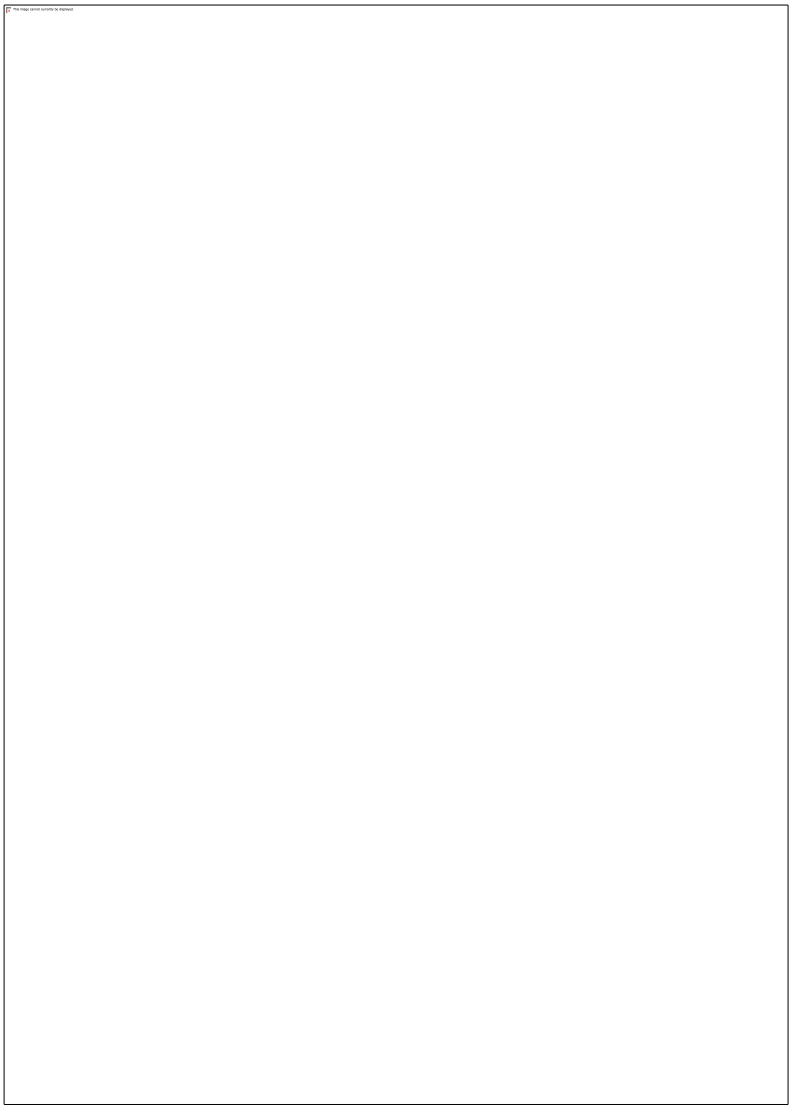
16.0 SUGGESTED TEACHING AND LEARNING RESOURCES

To make this topic practical and learner-centred, the teacher can use the following resources:



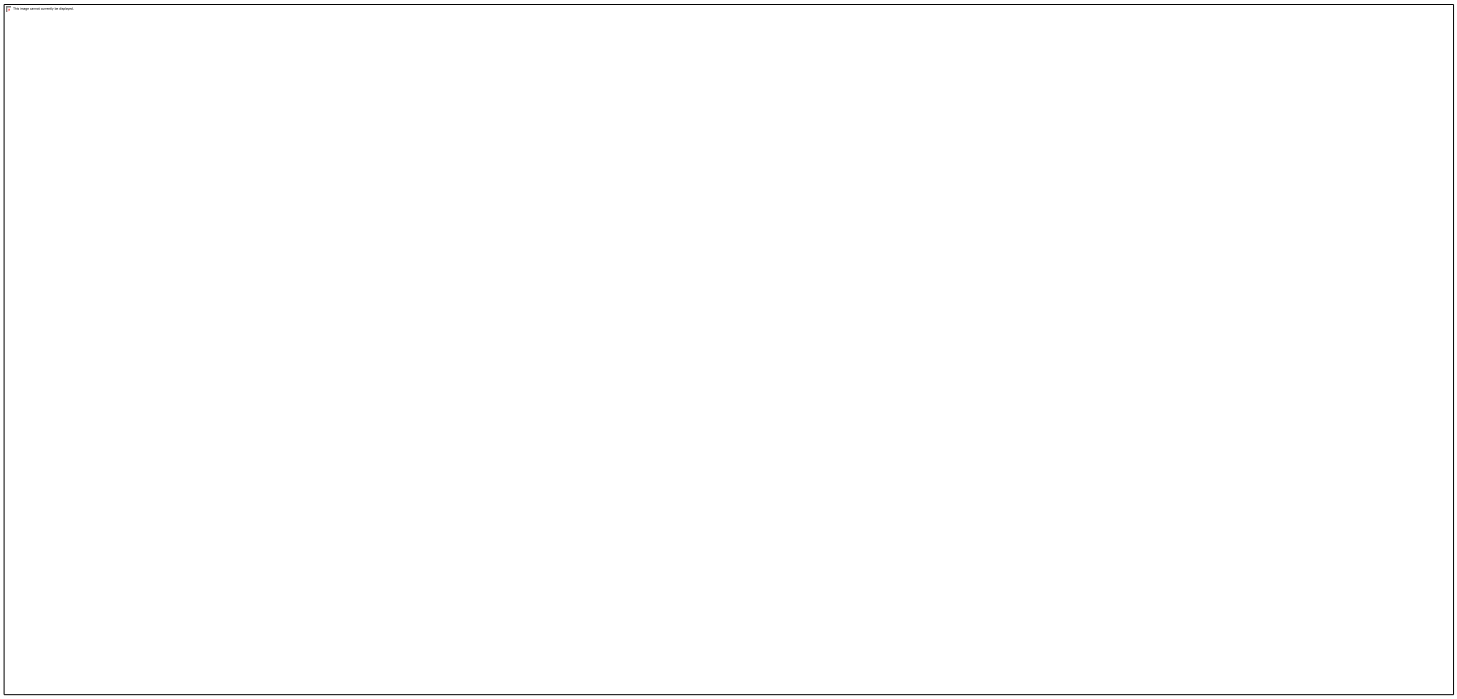
Soil samples

For investigating soil texture, colour and composition.



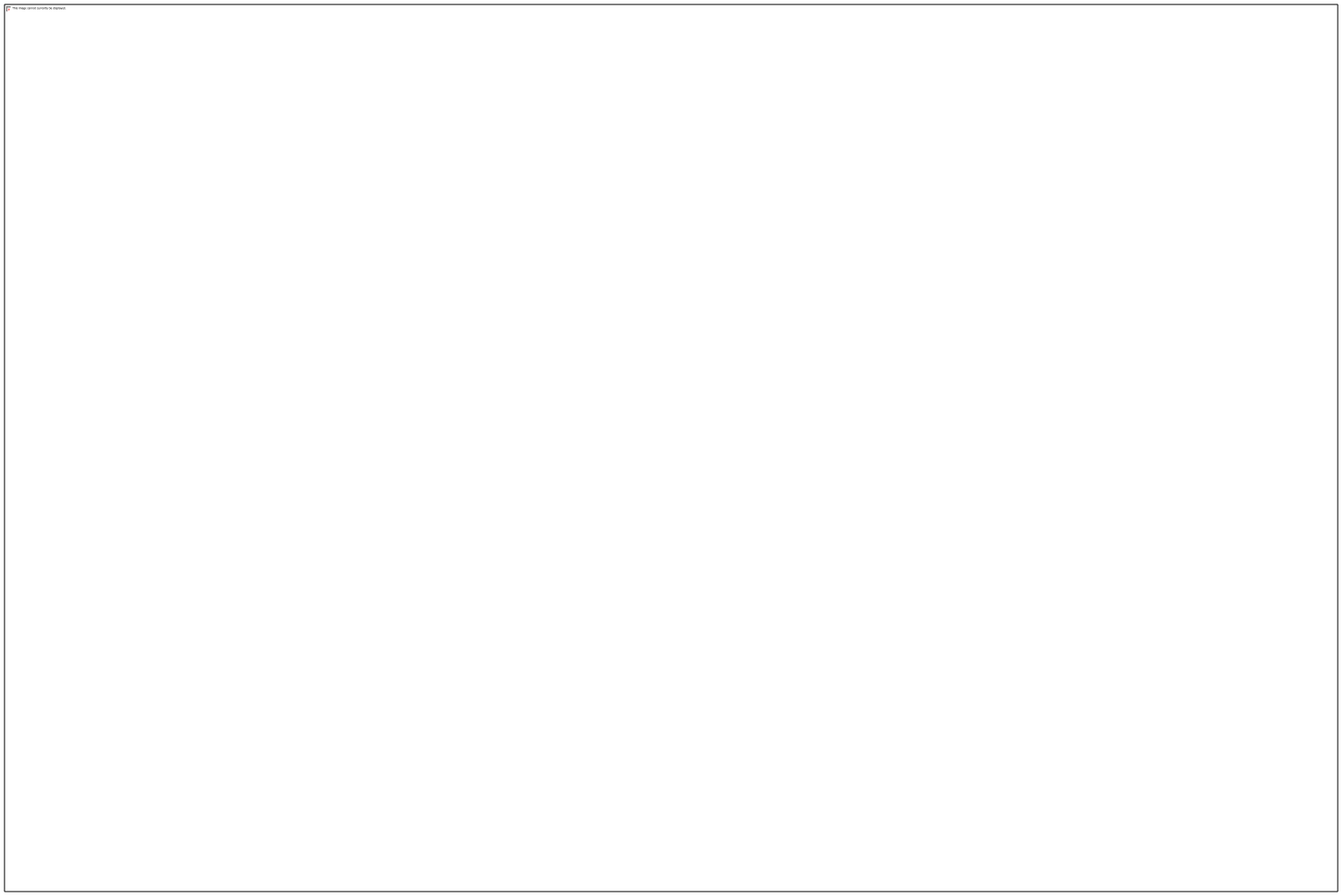
Soil profile charts

For identifying and drawing soil horizons.



Fieldwork equipment

For practical soil investigations.



Conservation demonstrations

For examining soil management practices.

17.0 EXPECTED LEARNING ACHIEVEMENT

By the end of the sub-strand, the Grade 11 learner should demonstrate the ability to:

Identify and explain the composition of soil.

Describe the factors and processes involved in soil formation.

Interpret soil profiles and soil catenas.

Classify and compare different types of soils.

Analyse physical, chemical and biological soil properties.

Explain the significance of soil to human activities.

Identify causes and consequences of soil degradation.

Demonstrate appropriate soil management and conservation practices.

Participate in community-based soil conservation initiatives.

Appreciate soil as a valuable resource requiring sustainable management.

STRAND 2.0: NATURAL SYSTEMS AND PROCESSES

SUB-STRAND 2.6: WATER CYCLE AND ACTION OF RIVERS

INTRODUCTION TO THE SUB-STRAND

Water is one of the most important natural resources on the Earth. It supports life, influences weather and climate, shapes the Earth's surface and provides numerous opportunities for human activities.

Water continuously moves between the atmosphere, land and oceans through a natural process known as the water cycle or hydrological cycle.

Rivers are important components of the water cycle. They transport water from higher ground towards lakes, seas and oceans. As they flow, rivers erode, transport and deposit materials, creating different landforms such as valleys, waterfalls, meanders, floodplains and deltas.

In Kenya, rivers support agriculture, hydroelectric power generation, domestic water supply, industries, tourism, fishing and livestock production.

Examples of important rivers in Kenya include:

River Tana.

River Athi-Galana-Sabaki.

River Nzoia.

River Mara.

River Ewaso Ng'iro.

River Yala.

River Sondu.

River Turkwel.

River Kerio.

River Nyando.

Understanding the water cycle and river processes enables learners to appreciate the importance of water resources and participate in their sustainable management.

2.0 THE WATER CYCLE

2.1 Meaning and Definition of the Water Cycle

The water cycle, also known as the hydrological cycle, refers to the continuous movement of water between the Earth's surface, underground and the atmosphere through processes such as evaporation, transpiration, condensation, precipitation, infiltration and surface runoff.

The cycle is driven mainly by energy from the sun and the force of gravity.

Water changes from one physical state to another as it moves through the different stages of the cycle.

The three physical states of water are:

Liquid: Water found in rivers, lakes, oceans, groundwater and rainfall.

Solid: Water found in ice, snow and glaciers.

Gas: Water vapour found in the atmosphere.

2.2 Main Components of the Water Cycle

The water cycle involves three major environmental components:

A. The Atmosphere

The atmosphere is the layer of gases surrounding the Earth.

Role in the water cycle:

Receives water vapour through evaporation and transpiration.

Provides conditions for condensation.

Holds water droplets and ice crystals in clouds.

Facilitates the movement of moisture through winds.

Releases water to the Earth's surface through precipitation.

B. The Hydrosphere

The hydrosphere refers to all water found on, below and above the Earth's surface.

It includes:

Oceans and seas.

Rivers and streams.

Lakes and ponds.

Groundwater.

Glaciers.

Ice caps.

Water vapour.

Role in the water cycle:

Provides water for evaporation.

Stores water temporarily or permanently.

Supplies water to rivers and streams.

Receives precipitation.

Supports aquatic ecosystems.

C. The Lithosphere

The lithosphere is the rigid outer part of the Earth, consisting of the crust and the uppermost mantle.

Role in the water cycle:

Receives rainfall and other forms of precipitation.

Allows water to infiltrate into the ground.

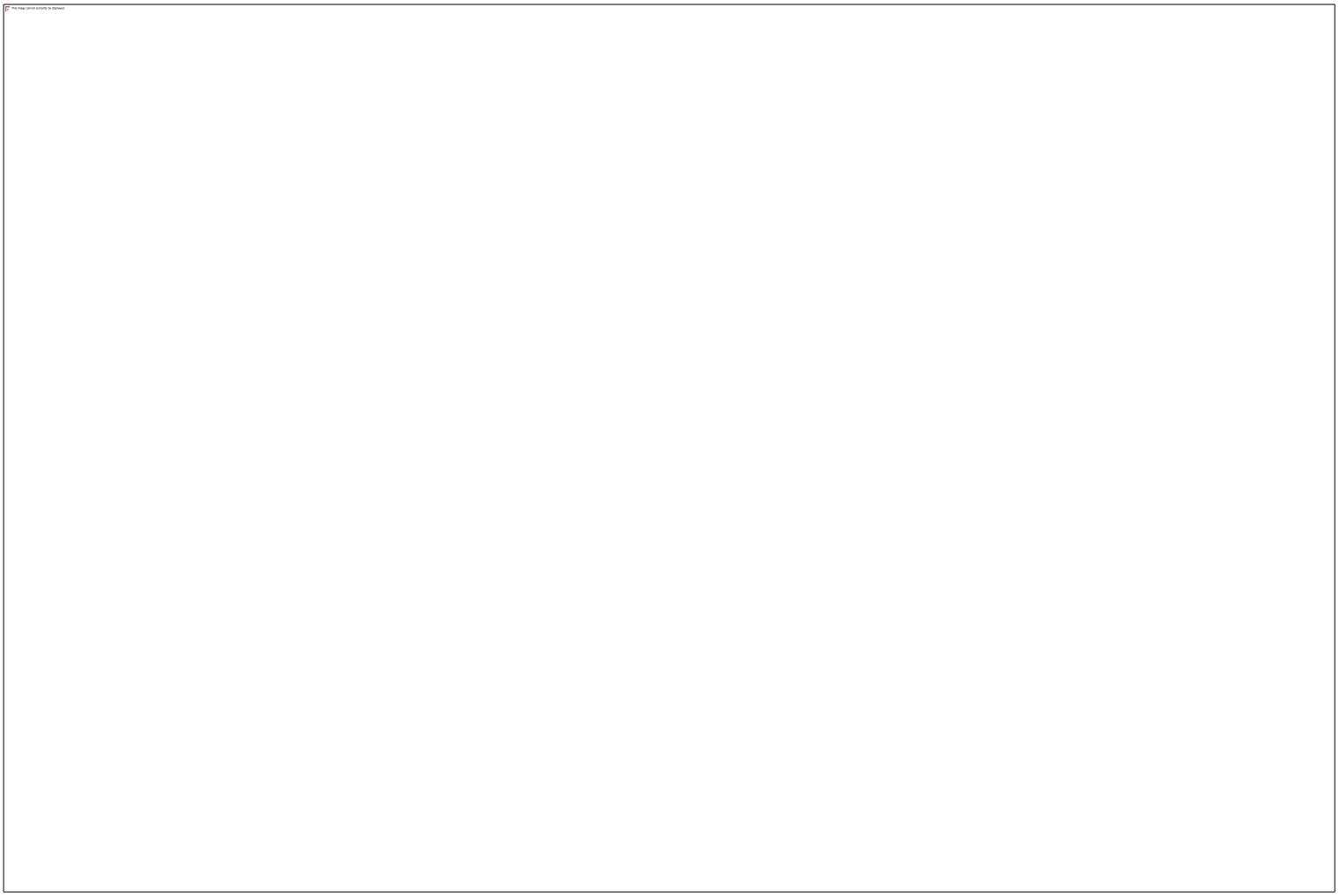
Stores groundwater in permeable rocks.

Supports surface runoff into rivers.

Provides underground pathways for water movement.

3.0 PROCESSES OF THE WATER CYCLE

The water cycle involves several interconnected processes that ensure the continuous movement of water in the environment.



3.1 Evaporation

Evaporation is the process through which liquid water changes into water vapour due to the absorption of heat energy.

It occurs mainly on the surfaces of oceans, seas, lakes, rivers, dams and other water bodies.

How evaporation takes place:

The sun supplies heat energy to water bodies.

Water molecules absorb the heat energy.

Some molecules gain sufficient energy to escape from the liquid surface.

The water molecules enter the atmosphere as water vapour.

The water vapour is carried away by atmospheric movements.

Main sources of evaporation:

Oceans and seas.

Lakes.

Rivers.

Dams and reservoirs.

Wet soil surfaces.

Wet vegetation surfaces.

Factors influencing the rate of evaporation:

Temperature: High temperatures increase the rate of evaporation because water molecules gain more energy.

Wind speed: Strong winds remove water vapour from above the water surface, allowing more evaporation to occur.

Humidity: Low atmospheric humidity encourages faster evaporation, while high humidity slows it down.

Surface area: Large exposed water surfaces generally experience greater total evaporation.

Atmospheric pressure: Lower atmospheric pressure generally favours evaporation.

Availability of water: Evaporation decreases when water becomes limited.

Solar radiation: Strong sunlight provides more energy for evaporation.

Examples in Kenya:

High evaporation rates occur in hot, dry environments such as Turkana and parts of Garissa.

Water evaporates from Lake Victoria, Lake Nakuru and Lake Naivasha.

Water stored in dams such as Masinga and Turkwel is lost through evaporation.

Importance of evaporation:

Transfers water from the Earth's surface into the atmosphere.

Contributes to cloud formation.

Helps regulate environmental temperatures.

Maintains the continuous water cycle.

Supports atmospheric moisture movement.

3.2 Transpiration

Transpiration is the process through which plants lose water vapour to the atmosphere, mainly through tiny openings known as stomata found on their leaves.

Plants absorb water from the soil through their roots. Some of this water is used in plant activities, while the excess is released into the atmosphere.

How transpiration occurs:

Plant roots absorb water from the soil.

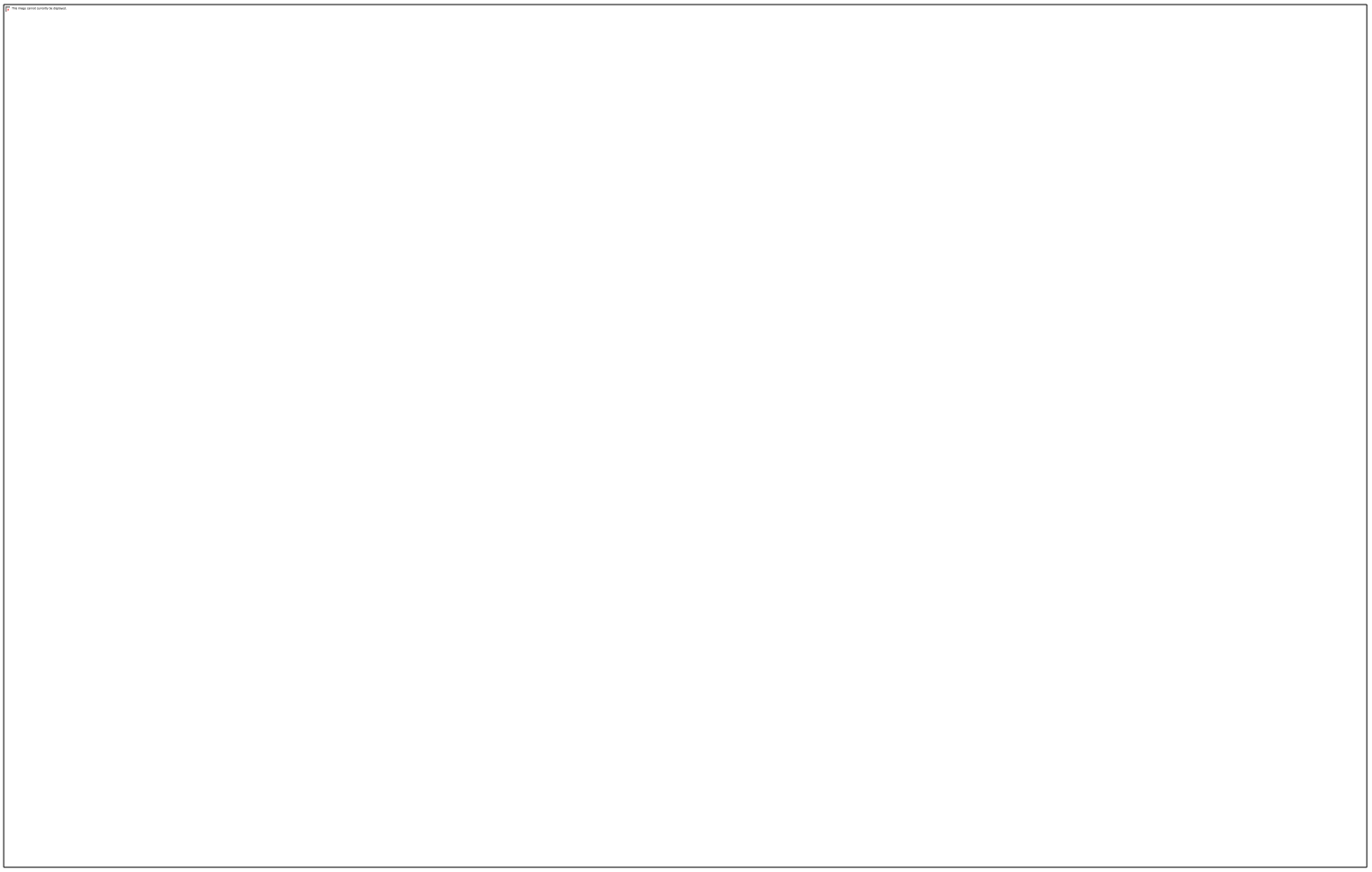
Water moves upwards through the xylem vessels.

Water reaches the leaves and other aerial plant parts.

Some water evaporates from moist internal leaf surfaces.

Water vapour escapes mainly through the stomata.

The vapour enters the atmosphere.



Factors influencing transpiration:

Temperature.

Wind speed.

Atmospheric humidity.

Light intensity.

Soil moisture availability.

Type of vegetation.

Number and distribution of stomata.

Leaf surface area.

Importance of transpiration:

Adds water vapour to the atmosphere.

Contributes to cloud formation and rainfall.

Helps regulate plant temperature.

Supports the movement of water and minerals through plants.

Contributes to environmental humidity.

Forms part of the water cycle.

Examples in Kenya:

Forests in the Mau Forest Complex release water vapour through transpiration.

Vegetation around Mount Kenya contributes to atmospheric moisture.

Trees in the Aberdare Ranges contribute to the local water cycle.

3.3 Condensation

Condensation is the process through which water vapour changes into tiny liquid water droplets or ice crystals when it loses heat energy.

It commonly occurs when moist air rises, expands and cools to its dew point.

How condensation occurs:

Evaporation and transpiration introduce water vapour into the atmosphere.

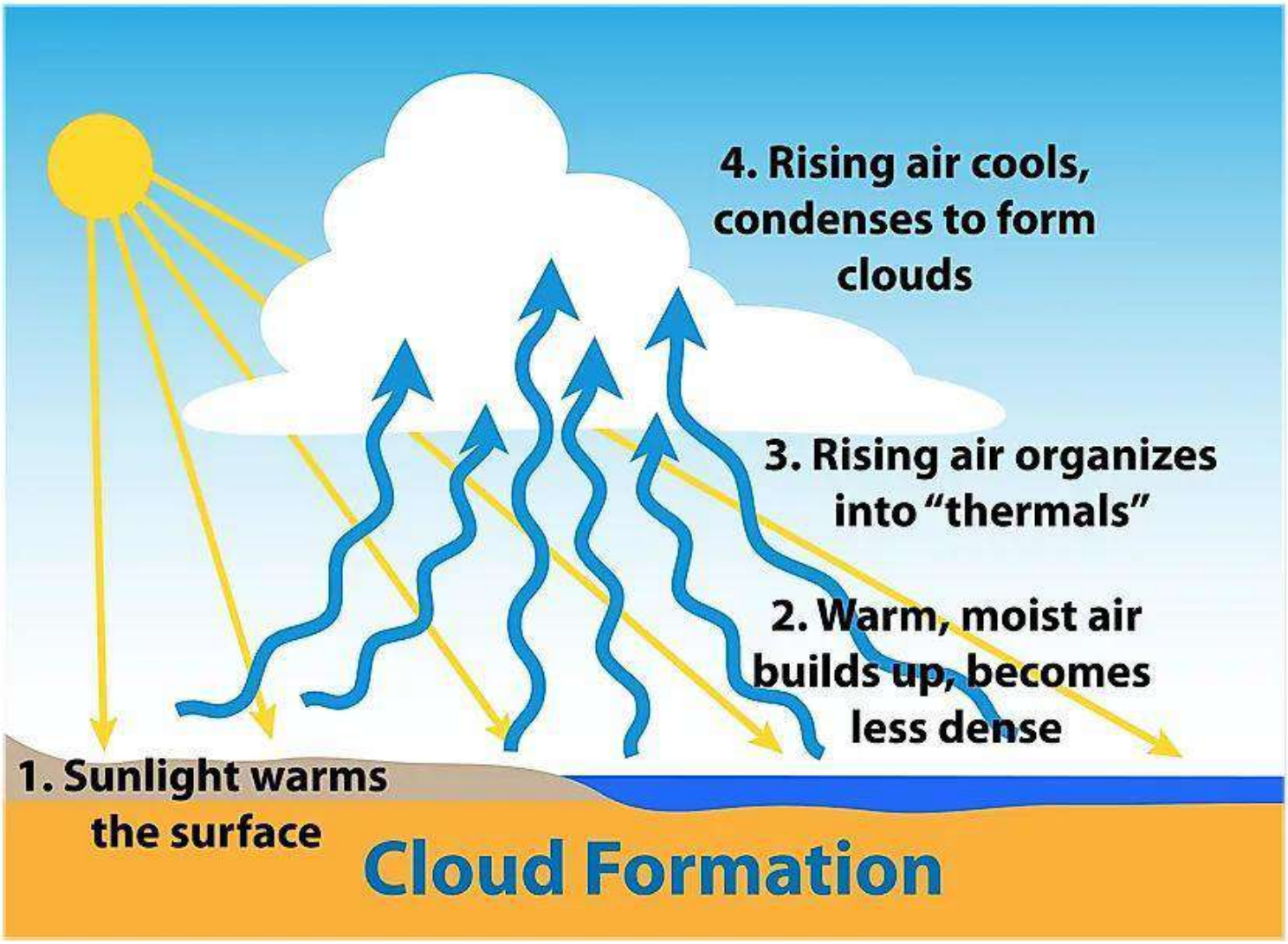
Moist air rises due to heating or other atmospheric processes.

Rising air expands and cools.

When air reaches its dew point, water vapour begins to condense.

Tiny water droplets or ice crystals form around microscopic particles known as condensation nuclei.

Large numbers of these droplets or crystals form clouds.



Factors influencing condensation:

Atmospheric temperature.

Relative humidity.

Availability of condensation nuclei.

Atmospheric pressure.

Cooling of moist air.

Atmospheric stability.

Importance of condensation:

Leads to cloud formation.

Prepares the atmosphere for precipitation.

Influences weather conditions.

Helps transfer water within the atmosphere.

Contributes to fog and dew formation.

3.4 Precipitation

Precipitation is the process through which water falls from the atmosphere to the Earth's surface in liquid or solid forms.

It occurs when water droplets or ice crystals in clouds become sufficiently large and heavy to fall under gravity.

Forms of precipitation:

Rain.

Snow.

Hail.

Sleet.



A. Rainfall

Rainfall occurs when water droplets in clouds become sufficiently heavy and fall to the ground as liquid water.

It is the most common form of precipitation in most parts of Kenya.

B. Snowfall

Snowfall occurs when ice crystals form in cold atmospheric conditions and fall to the ground as snowflakes.

Example: Snow occurs occasionally on the upper slopes of Mount Kenya and Mount Kilimanjaro.

C. Hail

Hail consists of balls or lumps of ice that form within strong thunderstorm clouds.

They grow through repeated movement within the cloud as supercooled water freezes onto them.

D. Sleet

Sleet consists of small ice particles or frozen precipitation. The precise meaning of the term varies between meteorological regions.

Factors influencing precipitation:

Availability of atmospheric moisture.

Temperature.

Air movement.

Atmospheric pressure.

Relief and altitude.

Wind direction.

Presence of condensation nuclei.

Importance of precipitation:

Supplies water to rivers and lakes.

Recharges groundwater.

Provides moisture for agriculture.

Supports natural vegetation.

Maintains aquatic ecosystems.

Supplies water for domestic and industrial use.

3.5 Infiltration

Infiltration is the process through which water enters the soil surface from the ground.

It occurs when rainfall or other surface water penetrates the spaces between soil particles.

How infiltration occurs:

Rainfall reaches the ground.

Water accumulates temporarily on the soil surface.

Water enters the soil through pores and cracks.

It moves into the upper soil layers.

Some water is stored in the soil for plant use.

Some water continues moving downwards to recharge groundwater.

Factors influencing infiltration:

Soil texture: Sandy soils generally allow faster infiltration than compact clay soils.

Soil structure: Well-aggregated soils have favourable pore spaces.

Vegetation cover: Vegetation protects soil and improves its structure.

Soil moisture: Already saturated soil has limited capacity to absorb additional water.

Slope gradient: Steep slopes may encourage runoff and reduce the opportunity for infiltration.

Soil compaction: Compacted soil has reduced pore spaces.

Rainfall intensity: Very intense rainfall may exceed the infiltration capacity of soil.

Importance of infiltration:

Recharges groundwater.

Reduces surface runoff.

Supports plant growth.

Maintains soil moisture.

Helps sustain springs and wells.

Reduces the risk of flooding.

3.6 Percolation

Percolation is the downward movement of water through the soil and permeable rock layers under the influence of gravity.

How it occurs:

Water infiltrates into the soil.

It moves through the soil pores.

It passes through different soil horizons.

It reaches deeper permeable rock layers.

Some of the water eventually contributes to groundwater storage.

Importance:

Recharges underground water reservoirs.

Supplies water to aquifers.

Maintains groundwater levels.

Supports springs and some river flows.

Contributes to the long-term storage of water.

3.7 Surface Runoff

Surface runoff is the movement of water over the Earth's surface towards rivers, lakes, reservoirs and oceans when rainfall exceeds infiltration or when the ground is already saturated.

How surface runoff occurs:

Rainfall reaches the ground.

Some water infiltrates into the soil.

When rainfall exceeds the infiltration capacity, excess water flows over the surface.

Water moves downslope under gravity.

Small streams combine to form larger streams and rivers.

Rivers transport water towards lakes, seas and oceans.

Factors influencing surface runoff:

Rainfall intensity.

Soil permeability.

Slope gradient.

Vegetation cover.

Soil moisture.

Land use.

Urbanisation.

Soil compaction.

Importance of surface runoff:

Supplies water to rivers.

Recharges lakes and reservoirs.

Supports river flow.

Provides water for irrigation.

Transports sediments and nutrients.

Negative effects of excessive runoff:

Flooding.

Soil erosion.

Destruction of crops.

Damage to roads and bridges.

Siltation of dams.

Loss of fertile topsoil.

3.8 Groundwater Flow

Groundwater flow is the movement of water through underground soil and permeable rock formations.

It occurs mainly through interconnected pores, joints, fractures and other openings in geological materials.

Importance:

Supplies water to wells and boreholes.

Maintains springs.

Supports river flow during dry seasons.

Sustains wetlands.

Provides water for domestic and agricultural activities.

3.9 Storage and Collection

Storage refers to the temporary or long-term accumulation of water in different parts of the environment.

Major water storage areas include:

Oceans and seas.

Lakes and reservoirs.

Rivers and streams.

Groundwater aquifers.

Glaciers and ice caps.

Soil moisture.

Atmospheric water vapour.

Living organisms.

Oceans are the largest reservoir of water on Earth.

Storage does not mean water stops moving. Water continuously enters and leaves these reservoirs through different hydrological processes.

4.0 SIGNIFICANCE OF THE WATER CYCLE IN THE ENVIRONMENT AND COMMUNITY

4.1 Meaning of Significance of the Water Cycle

The significance of the water cycle refers to the benefits and roles played by the continuous movement of water between the atmosphere, land and water bodies in supporting life and maintaining environmental balance.

The water cycle is essential because it ensures that water is continuously redistributed and renewed within the natural environment.

4.2 Importance of the Water Cycle

A. Maintains the Supply of Fresh Water

The water cycle replenishes rivers, lakes, dams and other water bodies through precipitation.

Rainfall supplies fresh water for domestic and agricultural use.

Infiltration and percolation replenish underground water reserves.

Groundwater provides water through wells, springs and boreholes.

The cycle maintains the availability of water in different parts of the environment.

Kenyan example: Rainfall replenishes the Tana River system, which supplies water to several communities and supports agricultural and hydroelectric activities.

B. Supports Agricultural Activities

Rainfall supplies water required for crop growth.

Soil moisture supports seed germination.

Water supports photosynthesis.

The water cycle maintains pasture growth for livestock.

Rainfall supports irrigation reservoirs and water storage facilities.

Soil moisture enables plants to absorb dissolved nutrients.

Example: Rainfall supports maize production in Trans Nzoia, tea production in Kericho and horticultural farming in Nakuru.

C. Regulates Environmental Temperature

Evaporation absorbs heat from the Earth's surface.

Condensation releases latent heat into the atmosphere.

Transpiration helps cool vegetation.

Evaporation from water bodies contributes to temperature regulation.

The movement of moisture influences local and regional climate.

D. Supports Natural Vegetation

Rainfall supplies water for plant growth.

Soil moisture supports root development.

Water supports nutrient absorption.

Transpiration contributes to atmospheric moisture.

The water cycle helps maintain forests and grasslands.

E. Recharges Groundwater

Rainwater infiltrates into the ground.

Water percolates through soil and permeable rocks.

Underground water reserves are replenished.

Groundwater supplies wells and boreholes.

Groundwater supports springs and wetlands.

F. Maintains River and Lake Systems

Rainfall supplies water to rivers.

Surface runoff feeds streams and lakes.

Groundwater contributes to river flow.

Precipitation replenishes lakes and reservoirs.

The cycle helps maintain aquatic habitats.

G. Supports Hydroelectric Power Generation

Rainfall replenishes reservoirs.

Stored water flows through turbines.

Turbines drive generators to produce electricity.

Continuous water replenishment helps sustain hydropower generation.

Kenyan examples:

Seven Forks hydroelectric power stations along River Tana.

Turkwel Hydroelectric Power Station.

Sondu-Miriu Hydroelectric Power Station.

H. Supports Wildlife and Biodiversity

Supplies water for wildlife.

Maintains wetlands.

Supports aquatic organisms.

Maintains habitats for birds and other animals.

Supports vegetation that provides food and shelter.

Maintains ecological balance.

Example: The Mara River supports aquatic organisms and wildlife in the Maasai Mara ecosystem.

I. Supports Industrial Activities

Supplies water for manufacturing.

Provides cooling water in some industries.

Supplies water for cleaning industrial equipment.

Supports food-processing industries.

Supplies water for construction activities.

J. Supports Human Health and Sanitation

Supplies water for drinking after appropriate treatment.

Provides water for washing and bathing.

Supports sanitation services.

Supplies water for cleaning homes and institutions.

Supports healthcare facilities.

K. Maintains the Natural Water Balance

Redistributes water between different parts of the Earth.

Maintains water exchange between oceans and the atmosphere.

Replenishes surface and underground water.

Supports ecosystem stability.

Helps maintain the availability of water for future use.

L. Supports Tourism and Recreation

Maintains rivers and lakes used for recreational activities.

Supports waterfalls and scenic landscapes.

Maintains wetlands and wildlife habitats.

Supports boating, sport fishing and nature tourism.

Provides attractive natural features for visitors.

4.3 Summary of the Significance of the Water Cycle

Area	Importance
Agriculture	Supplies water for crop and pasture growth.
Domestic use	Replenishes sources of household water.
Groundwater	Recharges aquifers.
Hydroelectricity	Replenishes reservoirs for power generation.
Industry	Supplies water for industrial processes.
Wildlife	Maintains habitats and biodiversity.
Climate	Influences atmospheric moisture and temperature.

Forestry	Supports tree growth.
Tourism	Maintains rivers, waterfalls and lakes.
Health	Supports sanitation and hygiene.

5.0 RIVERS AND THEIR CHARACTERISTICS

5.1 Meaning of a River

A river is a natural flowing body of water that moves through a channel from higher ground towards a lake, sea, ocean or another river.

Rivers are formed when water from rainfall, springs, melting snow and other sources accumulates and flows over the Earth's surface.

Rivers are important components of the hydrological cycle because they transport water from drainage basins towards larger water bodies.

5.2 Important Terms Used in River Geography

A. River Source

A river source is the point or area where a river begins.

Sources may include:

Springs.

Lakes.

Glaciers.

Mountain streams.

Wetlands.

Areas receiving substantial rainfall.

Example: River Tana has its headwaters in the Mount Kenya and Aberdare region.

B. River Mouth

A river mouth is the point where a river enters another water body such as a lake, sea or ocean.

Examples:

River Tana enters the Indian Ocean.

River Nzoia enters Lake Victoria.

River Athi-Galana-Sabaki enters the Indian Ocean.

C. Tributary

A tributary is a smaller river or stream that joins a larger river.

Example: River Thiba and River Nyamindi are tributaries within the Tana River drainage system.

D. Confluence

A confluence is the point where two or more rivers meet.

E. Distributary

A distributary is a branch of a river that flows away from the main channel, commonly in a delta.

F. River Channel

A river channel is the natural passage through which river water flows.

G. River Bed

A river bed is the bottom surface of the channel over which river water flows.

H. River Banks

River banks are the sides of a river channel that contain and guide the flow of water.

I. River Valley

A river valley is a relatively elongated depression or low-lying area through which a river flows.

J. Drainage Basin

A drainage basin is the area of land drained by a river and its tributaries.

K. Watershed (Drainage Divide)

A watershed is the elevated boundary separating two or more drainage basins.

L. River Discharge

River discharge refers to the volume of water flowing past a particular point in a river channel per unit time.

It is commonly measured in cubic metres per second (m^3/s).

M. River Regime

A river regime refers to the pattern of variation in the volume of water carried by a river over time, usually throughout the year.

N. River Load

River load refers to the materials transported by a river.

It includes:

Boulders.

Pebbles.

Gravel.

Sand.

Silt.

Clay.

Dissolved minerals.

O. River Gradient

River gradient refers to the steepness or rate of descent of a river channel over a given distance.

P. River Longitudinal Profile

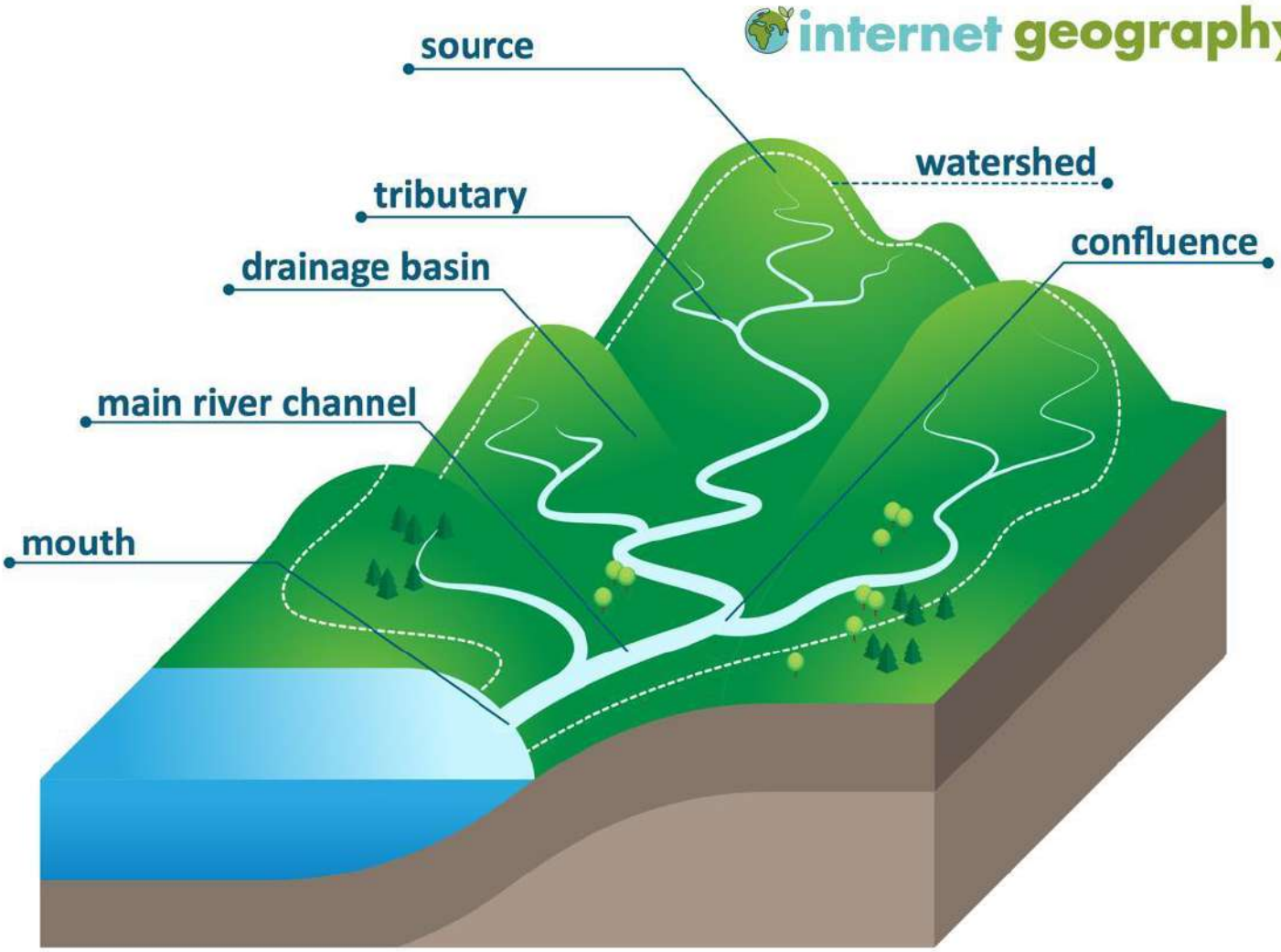
A longitudinal profile is a side-view representation showing changes in the gradient of a river channel from its source to its mouth.

6.0 THE DRAINAGE BASIN AND ITS CHARACTERISTICS

6.1 Meaning of a Drainage Basin

A drainage basin is an area of land drained by a main river and its tributaries.

It receives water through precipitation, which eventually flows towards a common outlet.



6.2 Main Components of a Drainage Basin

Watershed: The elevated boundary separating one drainage basin from another.

Source: The starting point of a river.

Main river: The principal river draining the basin.

Tributaries: Smaller rivers that join the main river.

Confluences: Points where tributaries join the main river.

River channel: The route followed by the flowing water.

Floodplain: A relatively flat area bordering a river that may be flooded during periods of high discharge.

River mouth: The point where the river enters a lake, sea or ocean.

6.3 The Hydrological Processes Within a Drainage Basin

A drainage basin receives and transfers water through several processes.

A. Precipitation

Water falls into the drainage basin as rainfall, snow or other forms of precipitation.

B. Interception

Interception is the process through which vegetation and other surfaces catch and temporarily retain precipitation before it reaches the ground.

Importance:

Reduces direct rainfall impact on soil.

Reduces immediate surface runoff.

Allows some water to evaporate.

Directs some water towards the ground through stemflow and throughfall.

C. Throughfall

Throughfall refers to precipitation that reaches the ground after passing through gaps in vegetation or falling from leaves and branches.

D. Stemflow

Stemflow is the movement of water down the stems and trunks of plants towards the ground.

E. Infiltration

Water enters the soil through the surface.

F. Percolation

Water moves downwards through soil and permeable rocks.

G. Groundwater Flow

Water moves underground towards rivers, lakes and other water bodies.

H. Surface Runoff

Water flows over the land surface into streams and rivers.

I. Channel Flow

Water moves through the river channel towards the river mouth.

6.4 Types of River Flow

A. Permanent Rivers

Permanent rivers are rivers that carry water throughout the year.

They are usually supplied by relatively reliable rainfall, groundwater, springs or a combination of sources.

Kenyan examples:

River Tana.

River Nzoia.

River Yala.

River Mara.

River Sondu.

B. Seasonal Rivers

Seasonal rivers carry water during certain seasons, particularly during or shortly after rainy periods.

They may reduce considerably in volume or dry up during prolonged dry seasons.

C. Ephemeral Rivers

Ephemeral rivers flow for short periods following rainfall events, especially in arid and semi-arid environments.

Kenyan examples: Some seasonal drainage channels in Turkana, Garissa and other dry regions.

6.5 Factors Influencing River Discharge

River discharge is influenced by natural and human factors.

Rainfall amount: High rainfall generally increases river discharge.

Rainfall intensity: Heavy rainfall may produce rapid runoff and sudden increases in discharge.

Rainfall duration: Prolonged rainfall may saturate the ground and increase runoff.

Drainage basin size: Large basins generally collect water from wider areas.

Vegetation cover: Dense vegetation may increase interception and infiltration.

Soil type: Permeable soils encourage infiltration, while less permeable soils may increase runoff.

Rock permeability: Permeable rocks allow more water to enter underground storage.

Slope gradient: Steep slopes may encourage rapid surface runoff.

Temperature: High temperatures increase evaporation and may reduce available water.

Human activities: Deforestation, urbanisation, dam construction and water abstraction influence river flow.

7.0 THE ACTION OF RIVERS

7.1 Meaning of River Action

River action refers to the processes through which flowing river water erodes, transports and deposits materials, thereby changing the shape and features of the Earth's surface.

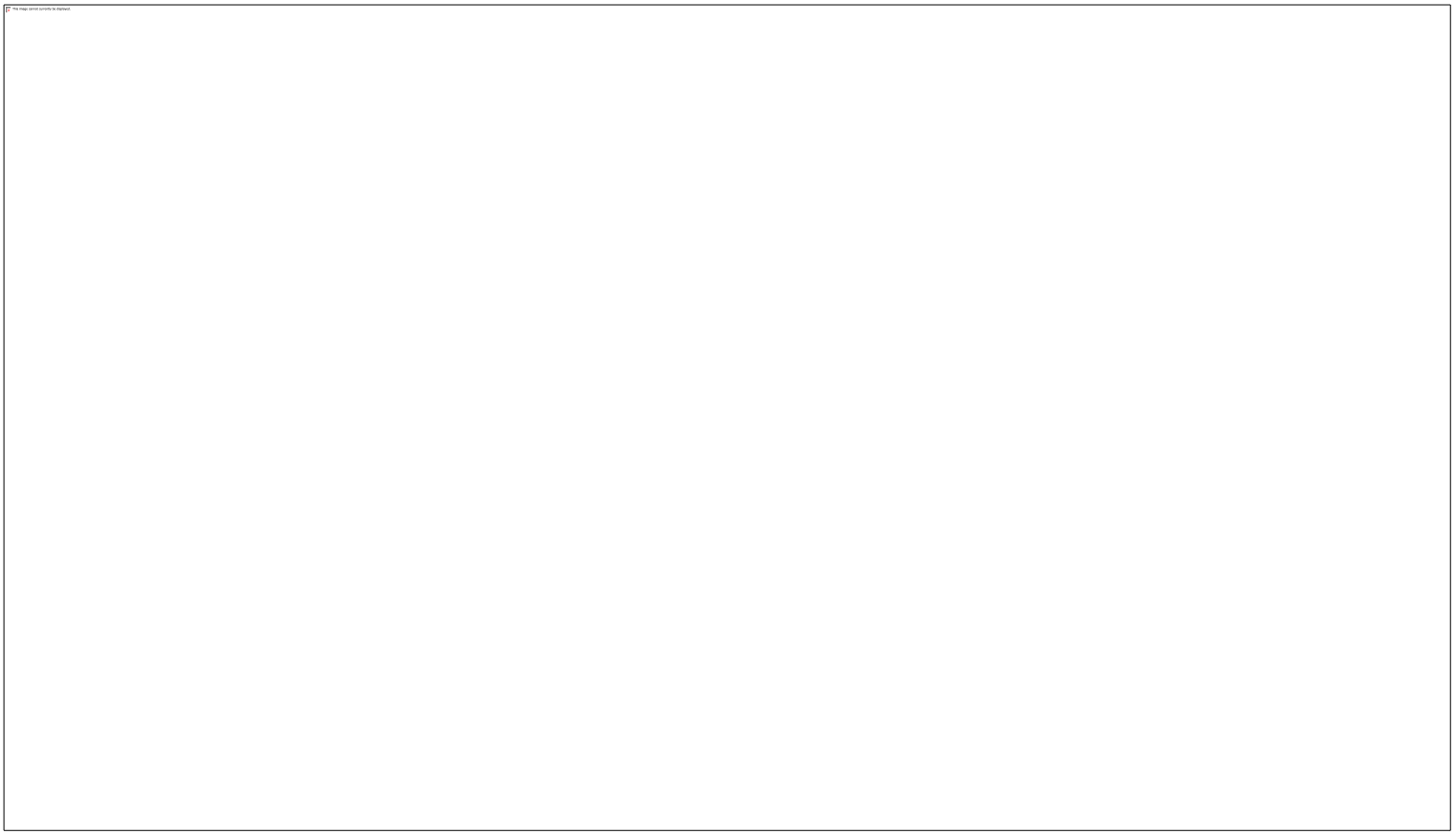
The three main river processes are:

Erosion.

Transportation.

Deposition.

These processes occur throughout the river course, although their relative importance varies from the upper course to the lower course.



7.2 RIVER EROSION

Meaning of River Erosion

River erosion is the wearing away and removal of rock materials from the river bed and banks by flowing water and the materials it carries.

River erosion is especially important in shaping river valleys and other landforms.

7.2.1 Processes of River Erosion

A. Hydraulic Action

Hydraulic action is the process through which the force of moving water dislodges and removes rock materials from the river bed and banks.

How hydraulic action occurs:

Fast-flowing water strikes the river bed and banks.

Water enters cracks and joints in rocks.

Air trapped in the cracks becomes compressed.

Pressure increases within the cracks.

Repeated pressure weakens the rocks.

Rock fragments become detached and are carried away by the river.

Effects:

Deepens the river channel.

Undercuts river banks.

Widens valleys.

Contributes to the formation of waterfalls and plunge pools.

B. Abrasion (Corrasion)

Abrasion is the process through which rock fragments carried by a river scrape, grind and wear away the river bed and banks.

How abrasion occurs:

A river carries sand, pebbles and other rock fragments.

The transported materials strike and rub against the river bed and banks.

The surfaces become worn away.

The channel may become deeper and wider.

Effects:

Produces smooth river channels.

Deepens valleys.

Contributes to the formation of potholes.

Helps create waterfalls and gorges.

C. Attrition

Attrition is the process through which rock fragments carried by a river collide with one another and become smaller, smoother and more rounded.

How attrition occurs:

A river transports rock fragments.

The fragments collide against one another.

Their edges break off.

The fragments gradually become smaller.

The materials become smoother and more rounded.

Effects:

Produces rounded pebbles.

Reduces the size of river load.

Produces finer sediments.

Makes transported materials smoother.

D. Solution (Corrosion)

Solution is the process through which soluble minerals in rocks dissolve in river water.

How it occurs:

River water comes into contact with soluble rocks and minerals.

Some minerals dissolve in the water.

Dissolved materials are carried downstream.

The rock surface gradually becomes worn away.

Examples of soluble materials:

Limestone.

Rock salt.

Gypsum.

Effects:

Enlarges river channels.

Removes soluble minerals.

Contributes to the formation of river valleys in soluble rock environments.

7.2.2 Factors Influencing River Erosion

Velocity of water: Fast-flowing rivers generally have greater erosive power.

Volume of water: Rivers carrying large volumes of water may have greater erosive capacity.

Gradient: Steep river gradients encourage faster flow.

Nature of rocks: Soft and fractured rocks are generally eroded more easily than resistant rocks.

River load: The quantity, size and hardness of transported materials influence abrasion.

Channel shape: Channel width and depth affect water movement.

Obstructions: Obstacles may increase turbulence and localised erosion.

Vegetation cover: Vegetation stabilises river banks and reduces erosion.

Rainfall: Heavy rainfall increases runoff and river discharge.

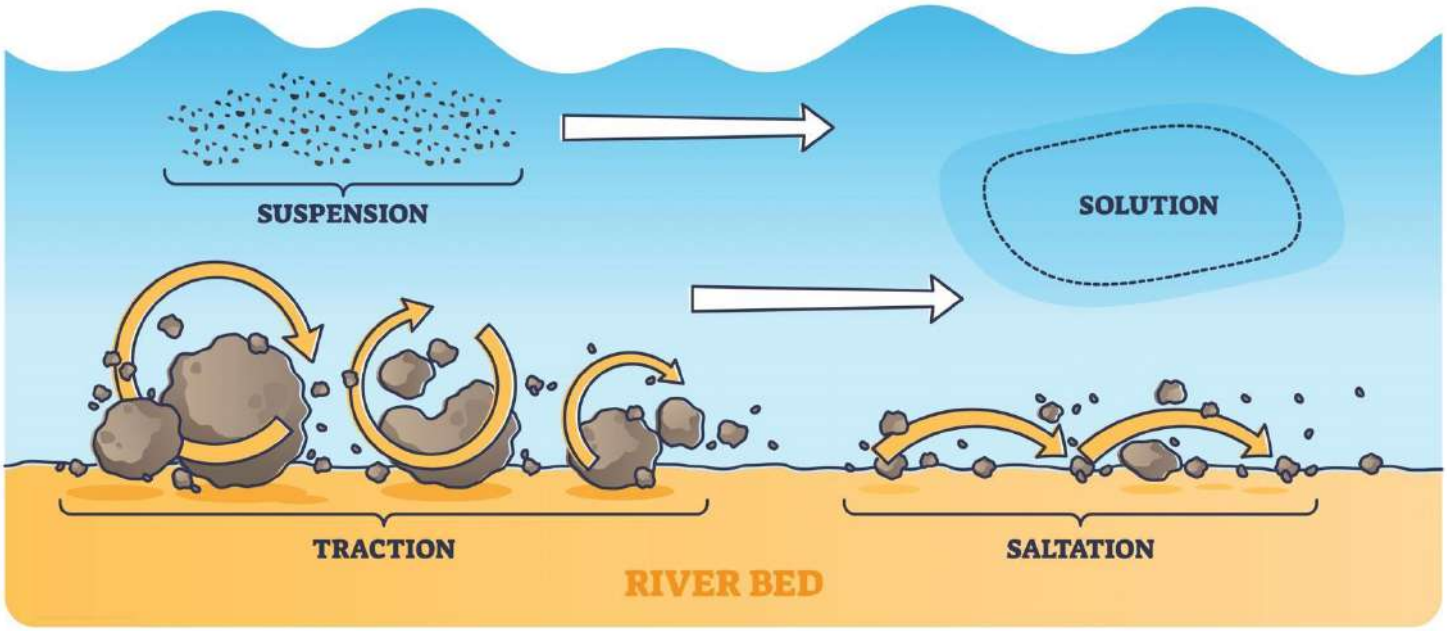
8.0 RIVER TRANSPORTATION

8.1 Meaning of River Transportation

River transportation is the movement of eroded materials from one location to another by flowing river water.

The materials transported by a river are collectively known as its load.

A river transports materials in four main ways.



8.2 Methods of River Transportation

A. Traction

Traction is the process through which large and heavy materials such as boulders and pebbles are rolled or dragged along the river bed by flowing water.

Characteristics:

Involves large and heavy particles.

Occurs mainly where water has sufficient energy.

Materials move along the river bed.

Transported particles may become rounded through attrition.

Example: Large stones may be rolled along the bed of a fast-flowing mountain river.

B. Saltation

Saltation is the transportation of relatively small particles through a series of short jumps or bounces along the river bed.

Characteristics:

Involves small pebbles and coarse sand.

Particles are lifted briefly by flowing water.

They fall back onto the river bed.

The process is repeated as the water flows.

C. Suspension

Suspension is the transportation of fine particles such as silt and clay within the flowing river water.

Characteristics:

Involves very fine particles.

Particles remain suspended in the water.

It commonly gives river water a muddy appearance.

Materials may be deposited when river velocity decreases.

Example: The brown or muddy appearance of some rivers during heavy rainfall results from suspended sediments.

D. Solution

Solution is the transportation of dissolved minerals and salts within river water.

Characteristics:

Soluble materials dissolve in water.

The dissolved materials move with the flowing water.

They are not normally visible to the naked eye.

They may be deposited through chemical processes under suitable conditions.

8.3 Factors Influencing River Transportation

River velocity.

River discharge.

Size of transported materials.

Shape of transported materials.

Density of materials.

Channel gradient.

Channel roughness.

Nature of the river bed.

Quantity of river load.

9.0 RIVER DEPOSITION

9.1 Meaning of River Deposition

River deposition is the process through which a river drops or lays down the materials it has been transporting when it loses some of its energy and carrying capacity.

Deposition commonly occurs where river velocity decreases.

Conditions encouraging river deposition:

Reduction in river velocity.

Reduction in channel gradient.

Increase in river load.

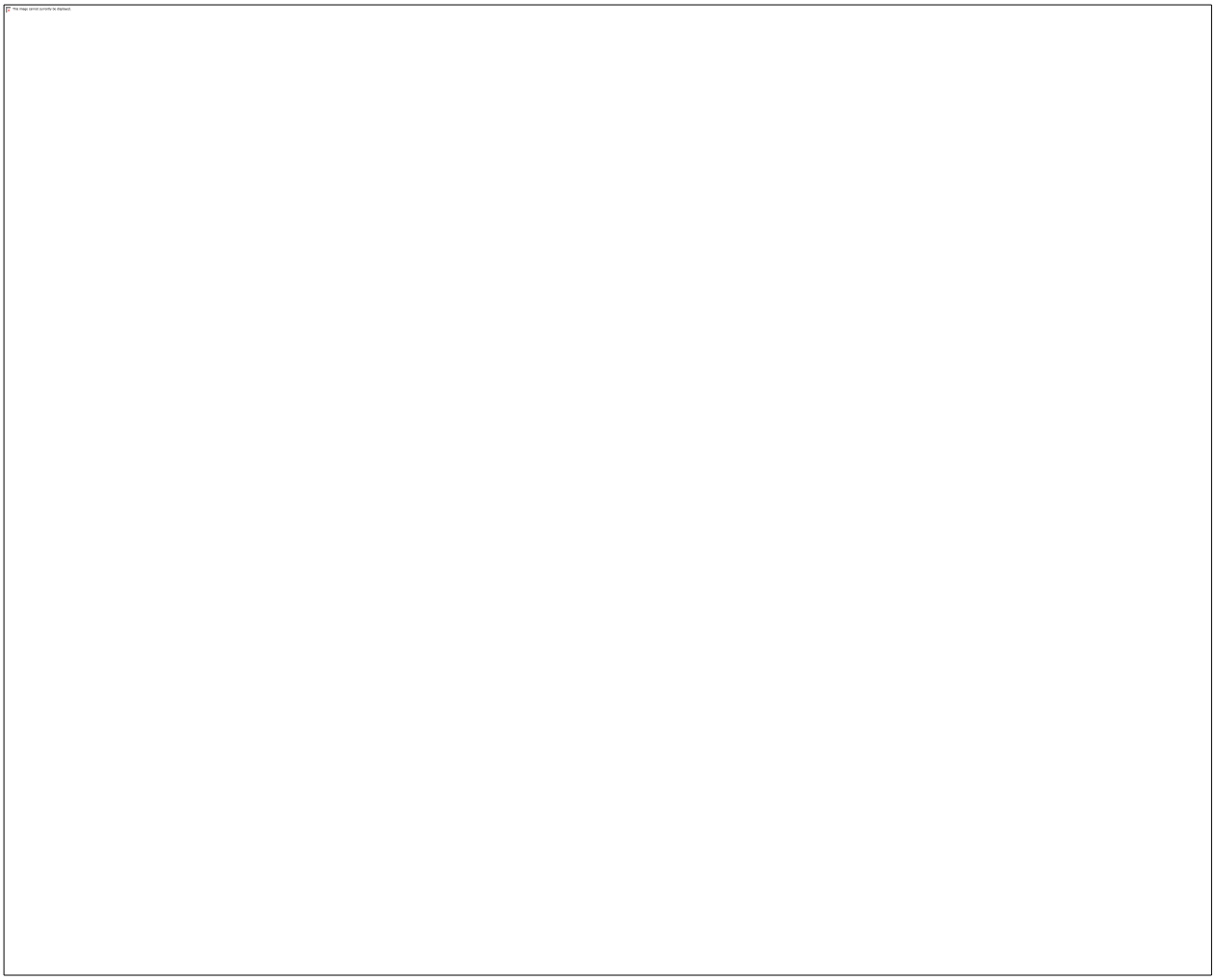
Entry of a river into a lake or sea.

Reduced river discharge.

Obstruction in the river channel.

Decrease in water turbulence.

Flooding onto a river floodplain.



9.2 Factors Influencing River Deposition

A. Reduction in River Velocity

When river velocity decreases, the river loses some of its capacity to transport materials.

B. Reduction in Gradient

A gentle gradient reduces the speed and energy of flowing water, encouraging deposition.

C. Increase in River Load

When the river carries more materials than it can transport, some materials are deposited.

D. Entry into a Lake or Sea

When a river enters a lake or sea, its velocity usually decreases, causing the deposition of sediments.

E. Obstruction in the Channel

Natural obstacles may reduce river velocity and encourage deposition.

F. Flooding

During flooding, water spreads over surrounding land and deposits fine sediments.

9.3 Sequence of Deposition

A river normally deposits its load according to the energy required to transport the particles.

Large and heavy particles are generally deposited first.

Medium-sized particles are deposited as energy decreases further.

Fine particles such as silt and clay may be transported over longer distances and deposited in calmer water.

However, the actual sequence depends on particle size, shape, density, water turbulence and channel conditions.

10.0 THE RIVER COURSE AND ITS ASSOCIATED FEATURES

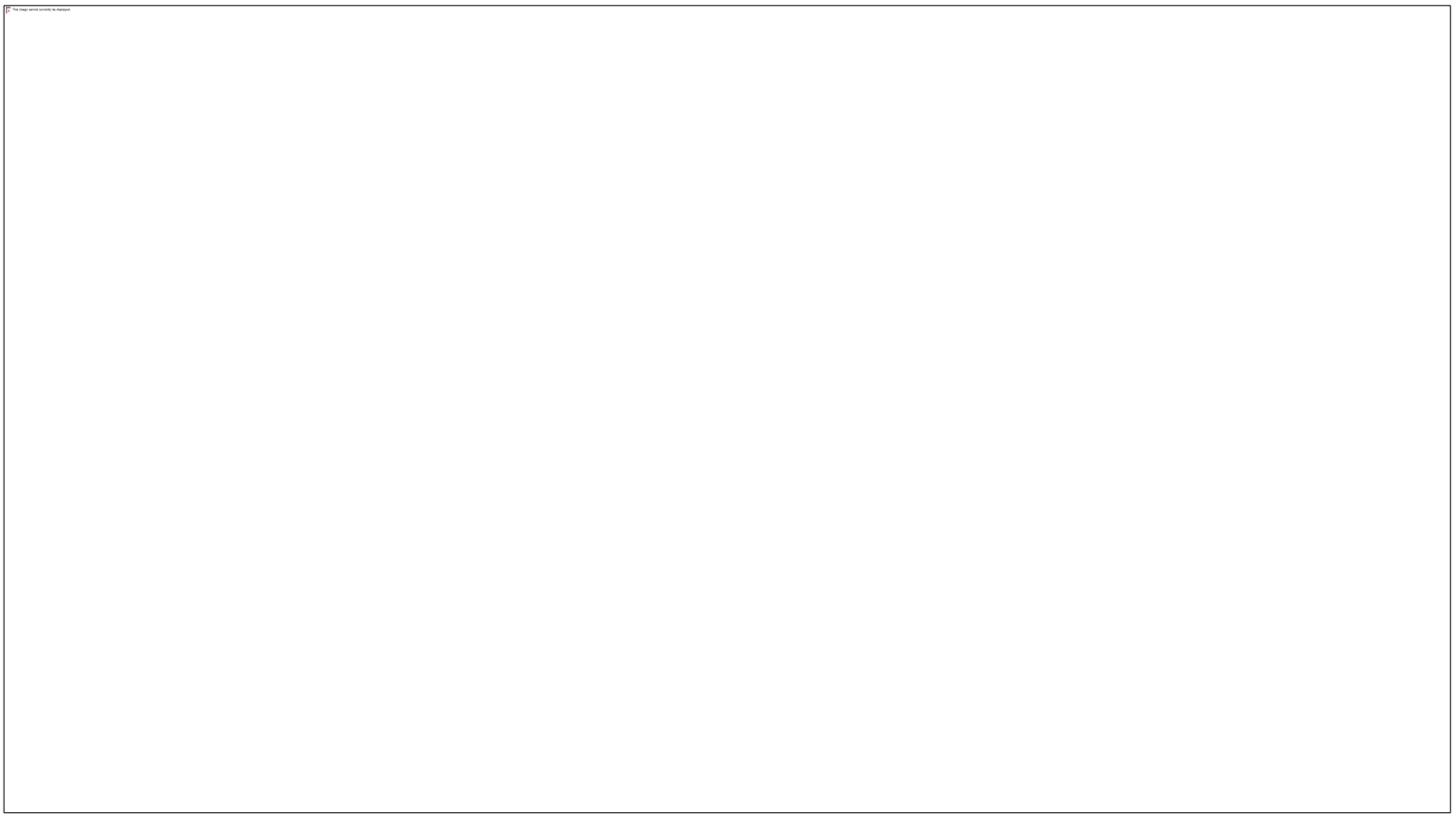
A river generally flows from its source towards its mouth through three broad sections:

Upper course.

Middle course.

Lower course.

Each section has different characteristics because the river's gradient, discharge, velocity, channel shape and load change downstream.



10.1 THE UPPER COURSE OF A RIVER

Meaning

The upper course is the section of a river close to its source, usually located in highland or mountainous areas.

It is characterised by steep gradients, relatively narrow channels and considerable vertical erosion.

Characteristics of the Upper Course

Located in highland or mountainous areas.

Has a steep gradient.

River channels are relatively narrow.

Water often flows rapidly down steep slopes.

Vertical erosion is dominant.

The river carries coarse materials.

The valley is generally narrow and deep.

Discharge is often relatively low compared with downstream sections.

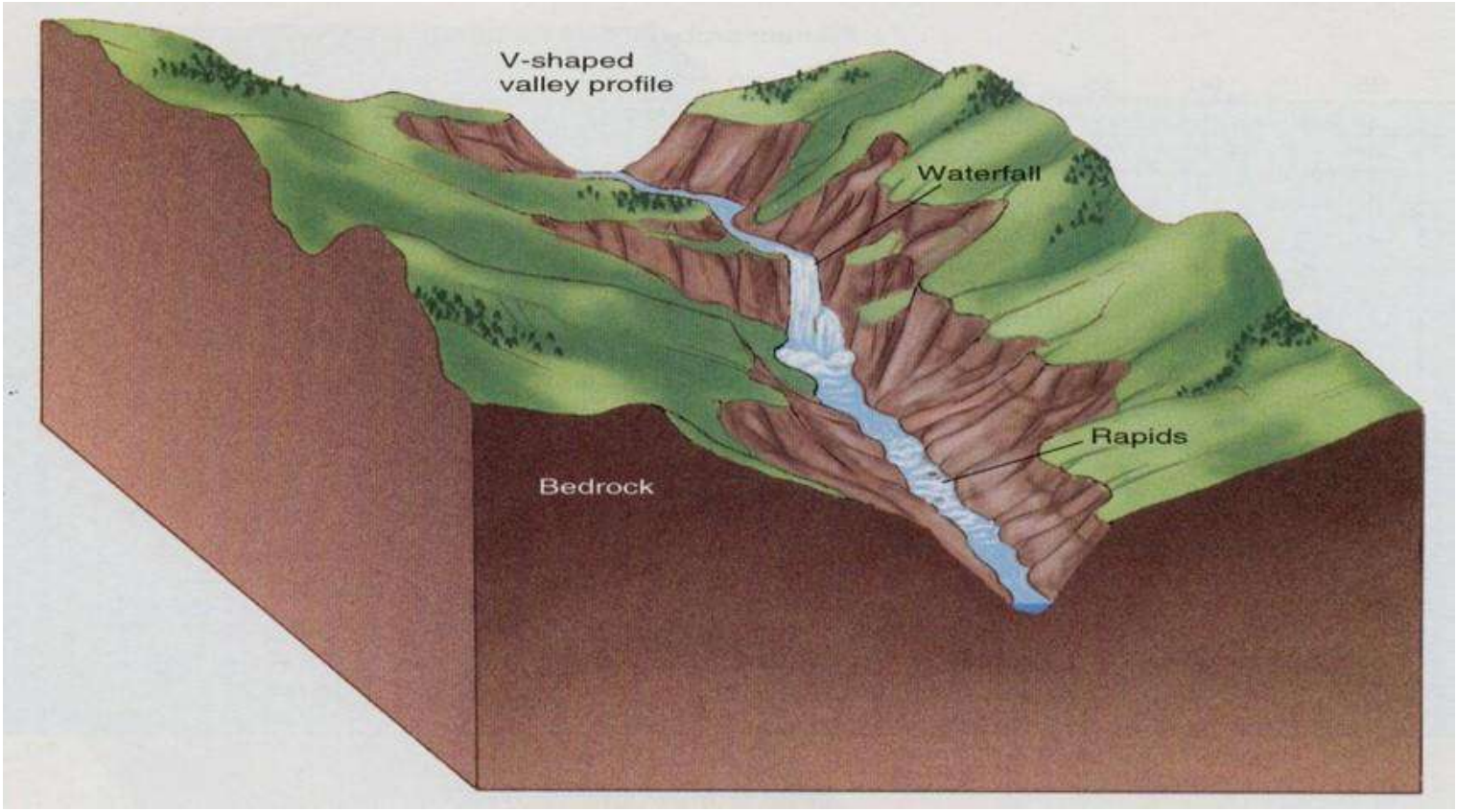
Water may flow through rocky channels.

Waterfalls and rapids may occur.

Major Features Formed in the Upper Course

A. V-Shaped Valleys

A V-shaped valley is a narrow, steep-sided valley with a cross-section resembling the letter V.



Formation of V-shaped valleys:

A river begins flowing down a steep gradient.

Vertical erosion deepens the river channel.

Hydraulic action and abrasion wear away the bed.

Weathering weakens the valley sides.

Weathered materials move downslope through mass movement.

The valley becomes deeper and develops steep sides.

Continued erosion produces a V-shaped valley.

Characteristics:

Narrow valley floor.

Steep valley sides.

Deep river channel.

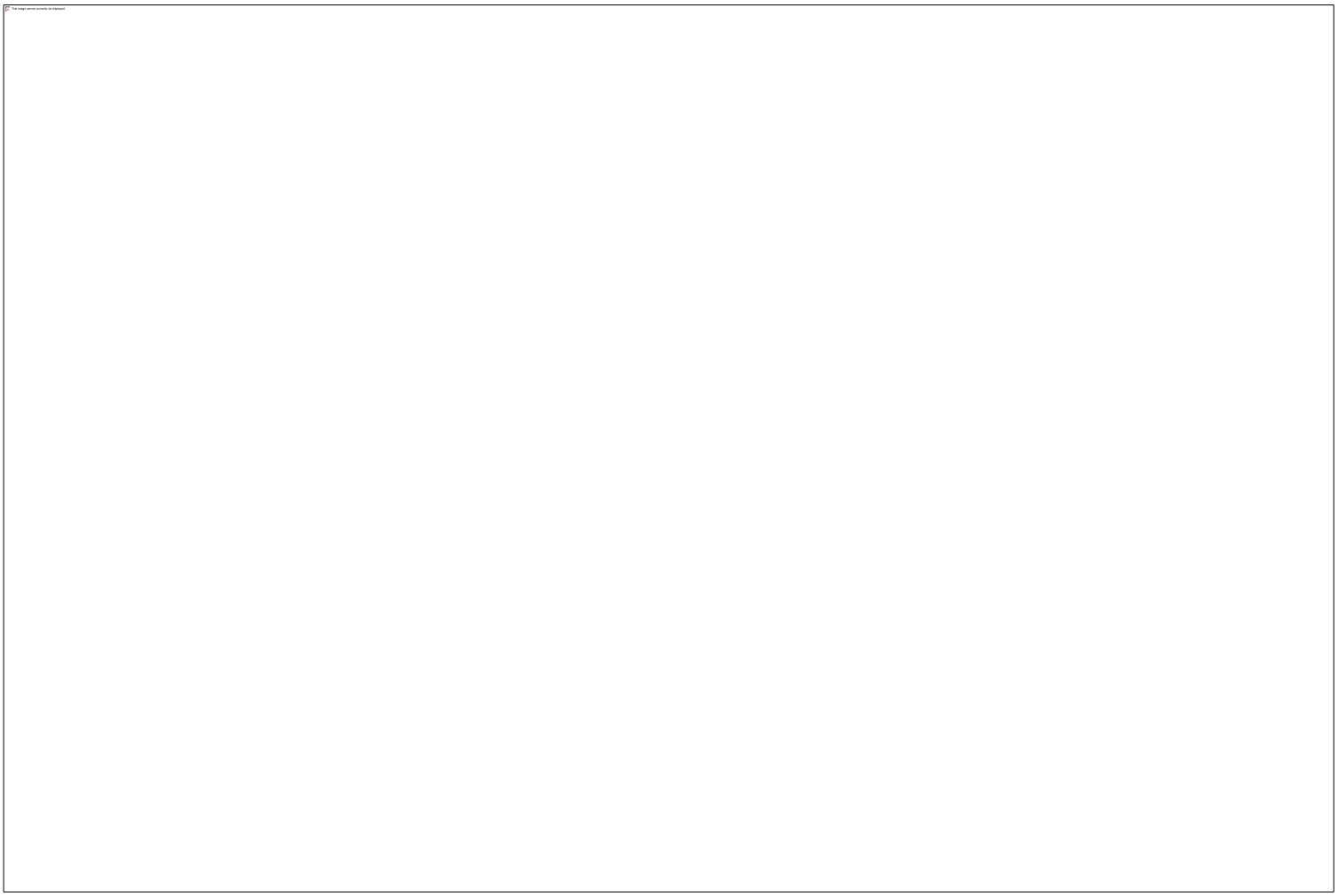
Dominance of vertical erosion.

Common in youthful river landscapes.

Examples: V-shaped valleys occur in mountainous and highland areas, including parts of the Mount Kenya and Aberdare regions.

B. Interlocking Spurs

Interlocking spurs are alternating projections of high land that extend into a river valley, causing a river to wind around them.



Formation:

A river flows down a steep-sided valley.

Resistant rock projections extend into the valley.

The river follows the path of least resistance.

It winds around the projecting areas.

The projecting ridges appear to interlock when viewed downstream.

Characteristics:

Found mainly in upper river courses.

Consist of alternating projecting ridges.

The river winds around the ridges.

Associated with narrow valleys.

C. Waterfalls

A waterfall is a sudden vertical or near-vertical drop in the course of a river.



Formation of waterfalls:

A river flows over alternating layers of hard and soft rocks.

The softer rock is eroded more rapidly than the harder rock.

A step develops in the river bed.

Water flows over the resistant rock layer.

The softer rock beneath is eroded.

An overhanging ledge of hard rock develops.

The overhang eventually collapses.

The waterfall retreats upstream.

A deep gorge may develop.

Characteristics:

Sudden drop in river bed level.

High-energy flowing water.

Plunge pool at the base.

May be associated with a gorge.

Often occurs where resistant and less resistant rocks alternate.

Examples in Kenya:

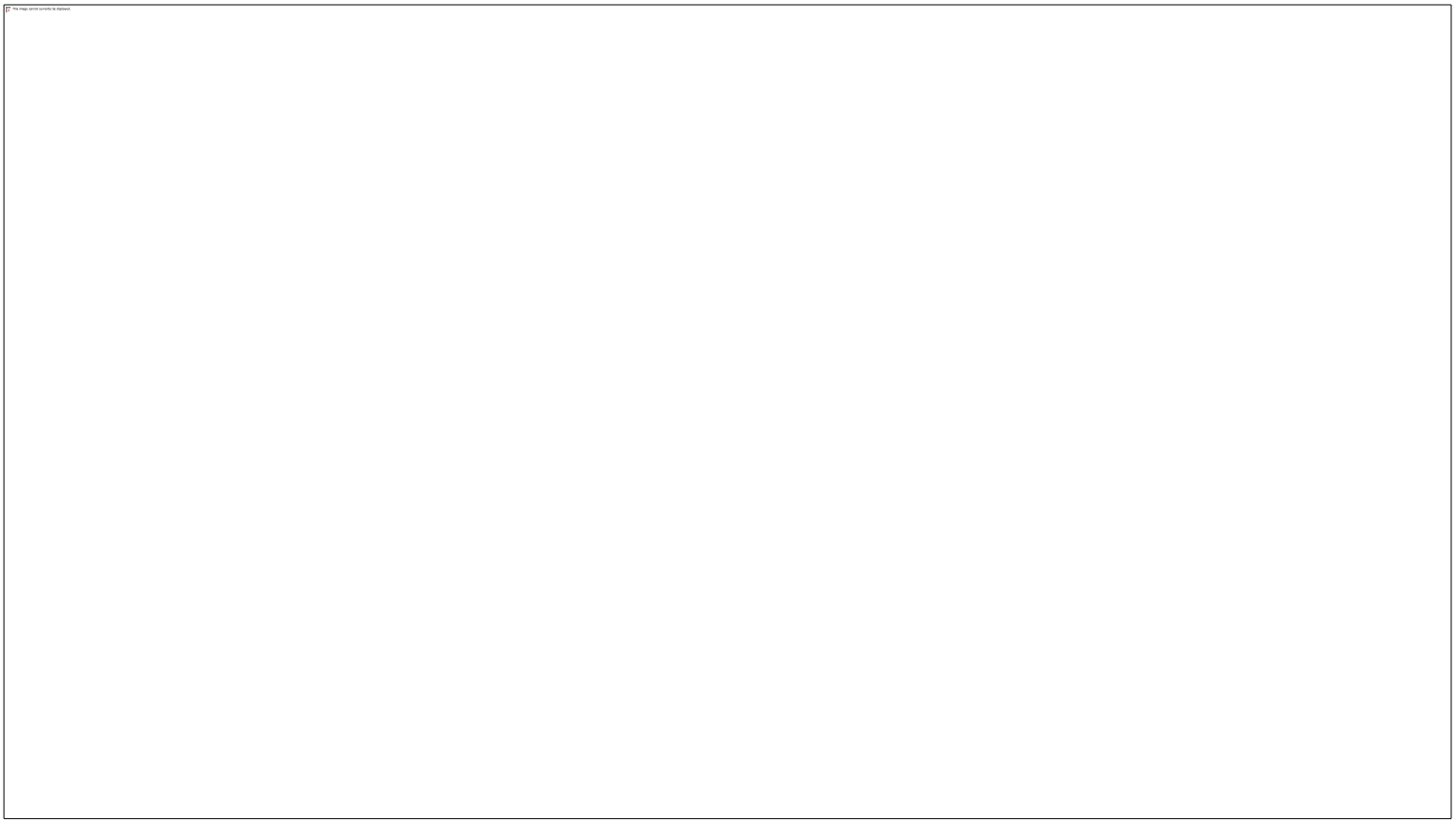
Thomson's Falls at Nyahururu on the Ewaso Ng'iro system.

Fourteen Falls along the Athi River.

Karuru Falls in the Aberdare region.

D. Rapids

Rapids are sections of a river where water flows turbulently and rapidly over an uneven or rocky river bed.



Formation:

A river flows over an uneven bed containing resistant rock outcrops.

The channel becomes irregular.

Water flows over and around the obstacles.

Turbulence and rapid movement develop.

The river forms a section of rough, fast-flowing water.

Characteristics:

Fast-flowing water.

Rocky and uneven river bed.

Turbulent movement.

Sudden changes in water depth.

Common in mountainous regions.

E. Potholes

Potholes are circular or cylindrical holes formed in the river bed through abrasion by rock fragments.



Formation:

Small depressions develop on the river bed.

Sand and pebbles become trapped in the depressions.

Turbulent water causes the trapped particles to rotate.

The rotating materials grind the bed through abrasion.

The depressions gradually become deeper and wider.

Circular potholes develop.

Characteristics:

Circular or cylindrical shape.

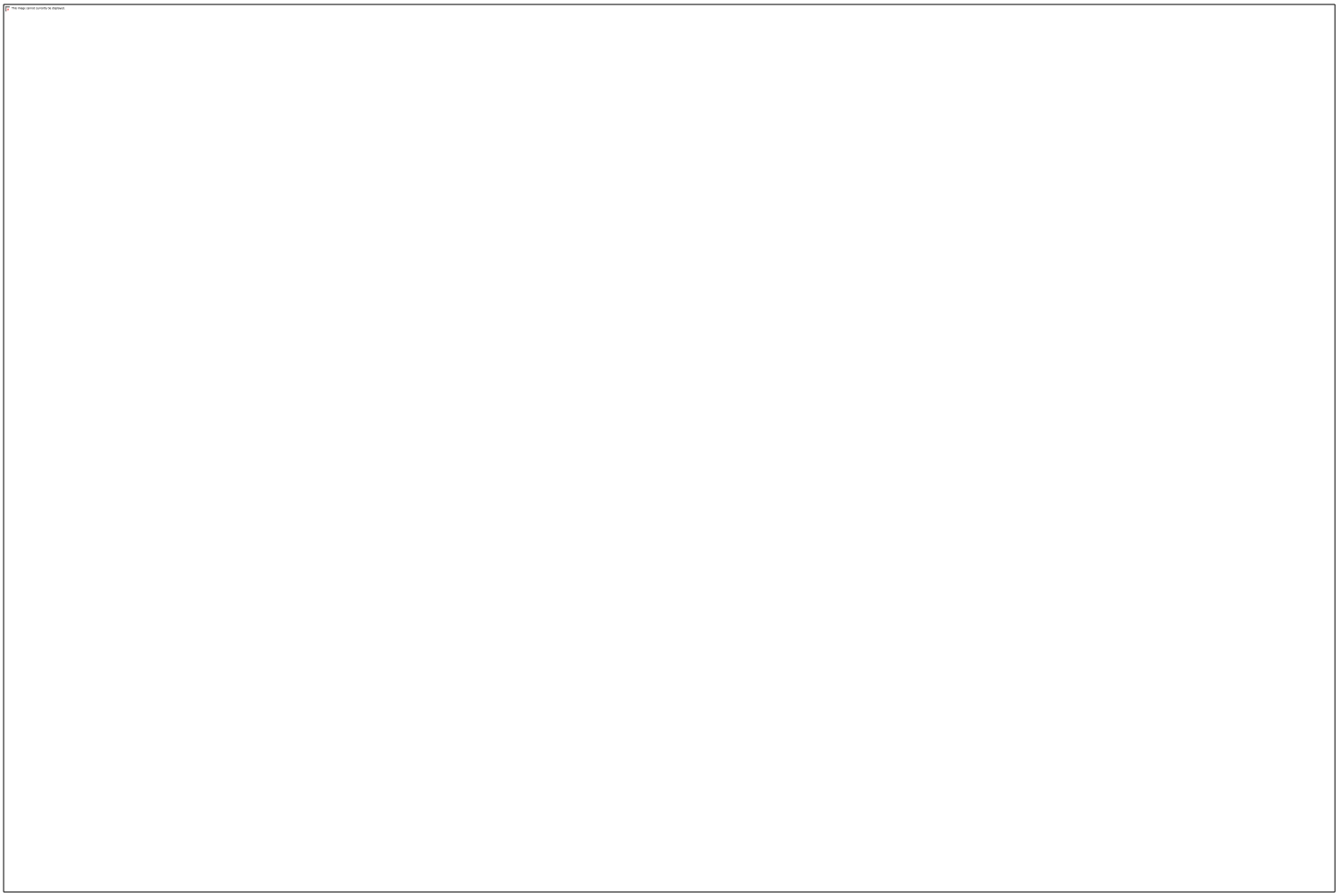
Smooth internal surfaces.

Found on rocky river beds.

May vary in depth and diameter.

F. Gorges

A gorge is a deep, narrow valley with very steep sides, often formed through prolonged river erosion or the retreat of a waterfall.



Formation:

A waterfall develops where a river crosses alternating rock layers.

The river erodes the softer rock at the base.

A plunge pool develops.

Undercutting causes the overhanging rock to collapse.

The waterfall retreats upstream.

Continued erosion produces a long, narrow gorge.

Characteristics:

Deep and narrow.

Steep or near-vertical sides.

Rocky surfaces.

Often associated with waterfalls.

Contains a river flowing along its floor.

G. Rapids and Waterfalls as Sources of Hydroelectric Power

Waterfalls and rapids may provide favourable conditions for hydroelectric power development where sufficient water volume, suitable height differences and engineering conditions exist.

10.2 THE MIDDLE COURSE OF A RIVER

Meaning

The middle course is the section between the upper and lower courses where the river gradient becomes gentler and the channel becomes wider and deeper.

Lateral erosion and transportation become increasingly important.

Characteristics of the Middle Course

Has a gentler gradient than the upper course.

River discharge generally increases.

Channel width increases.

Channel depth increases.

Lateral erosion becomes more significant.

Transportation of sediments is important.

Meanders commonly develop.

River valleys become wider.

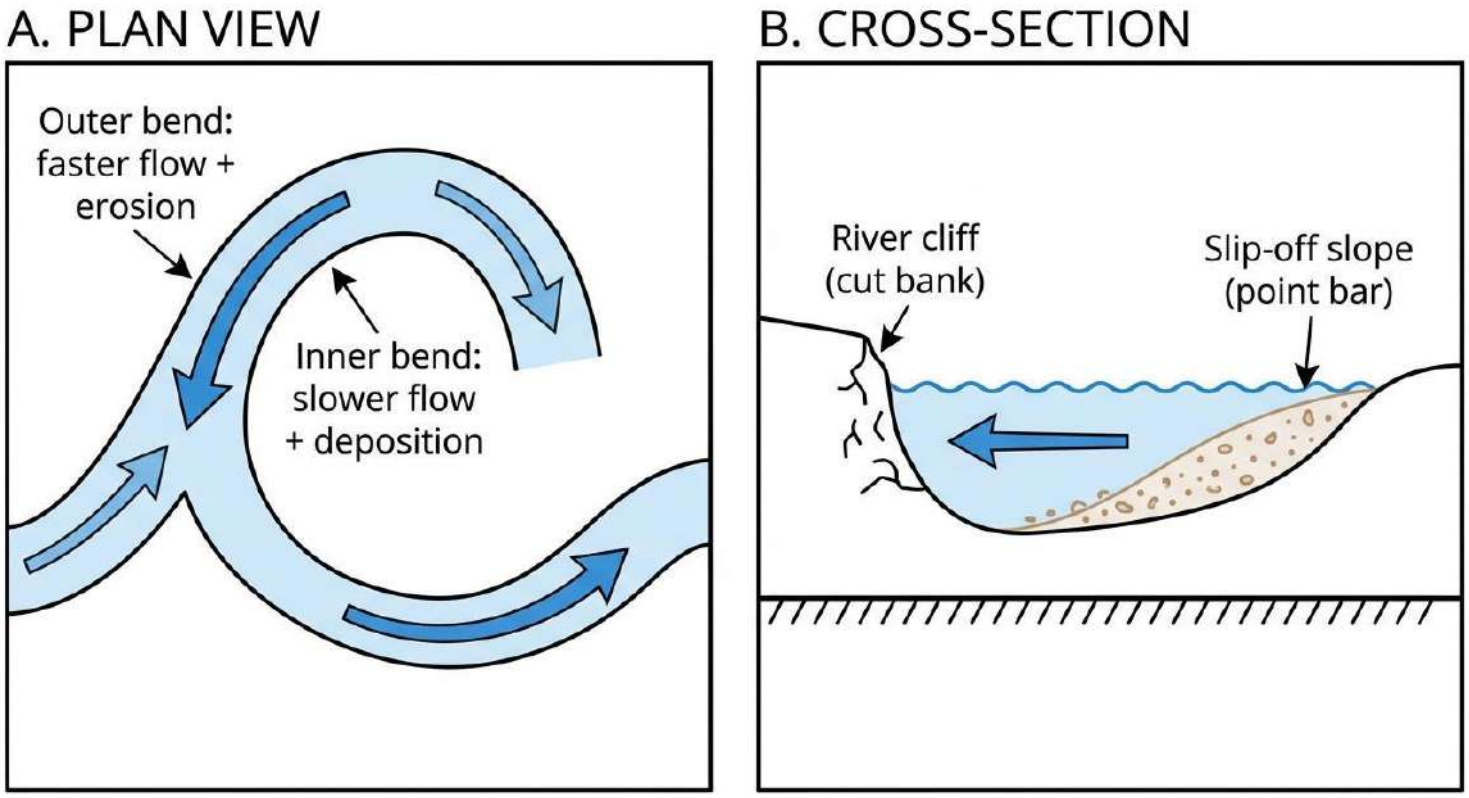
Floodplains may begin to develop.

Deposition occurs along selected sections of the channel.

Major Features Formed in the Middle Course

A. Meanders

Meanders are pronounced bends or curves that develop along a river channel.



Formation of meanders:

A river flows across a relatively gentle gradient.

Small irregularities develop along the channel.

Water flows faster along the outer bank of a bend.

Increased velocity causes greater erosion along the outer bank.

Water flows more slowly along the inner bank.

Deposition occurs along the inner bank.

The outer bank develops a river cliff or cut bank.

The inner bank develops a slip-off slope.

The bend becomes more pronounced.

Continuous erosion and deposition enlarge the meander.

Characteristics:

Curved river channels.

Outer banks experience greater erosion.

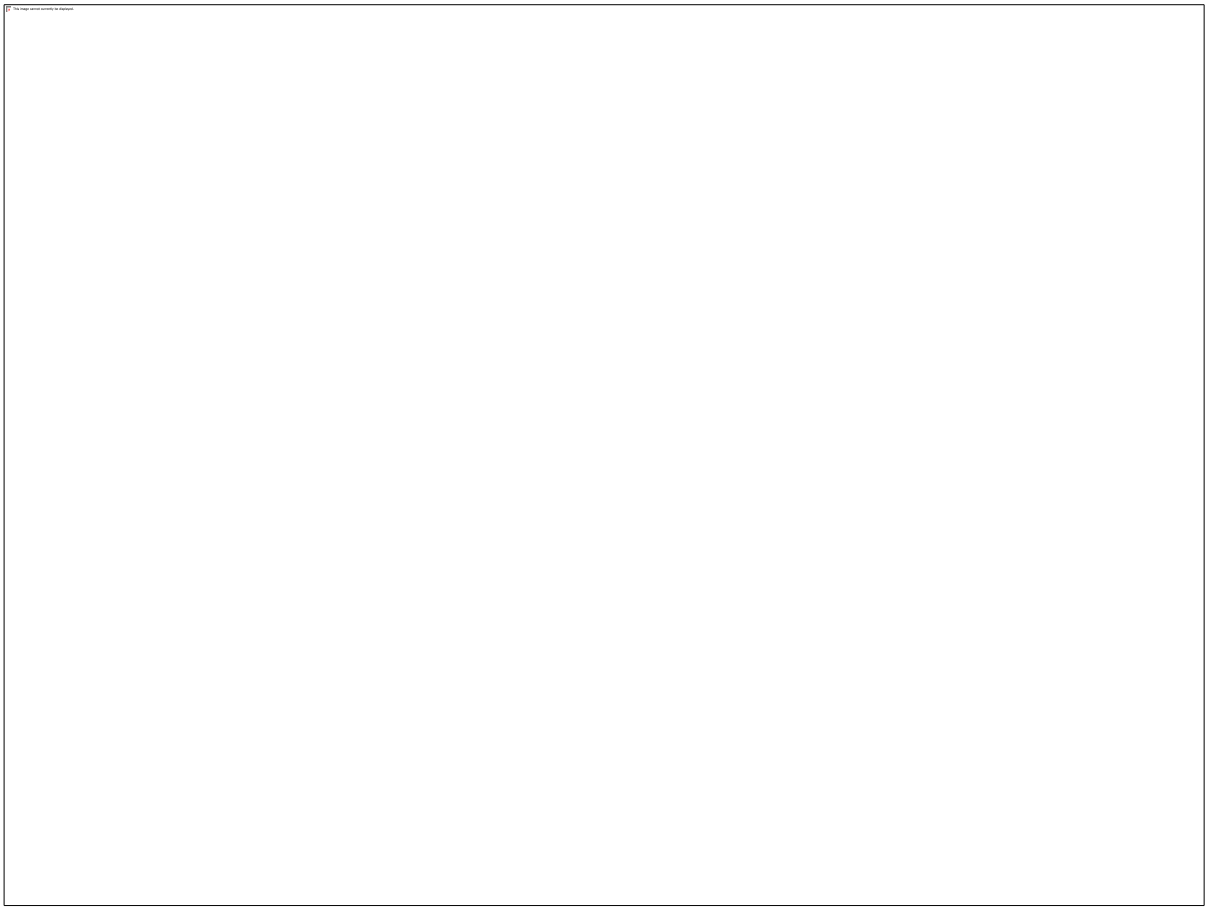
Inner banks experience deposition.

Channel width may vary along bends.

Common in middle and lower river courses.

B. River Cliffs (Cut Banks)

A river cliff is a steep bank formed along the outer side of a meander due to continuous lateral erosion.



Formation:

River water flows faster along the outer bend.

Hydraulic action and abrasion erode the outer bank.

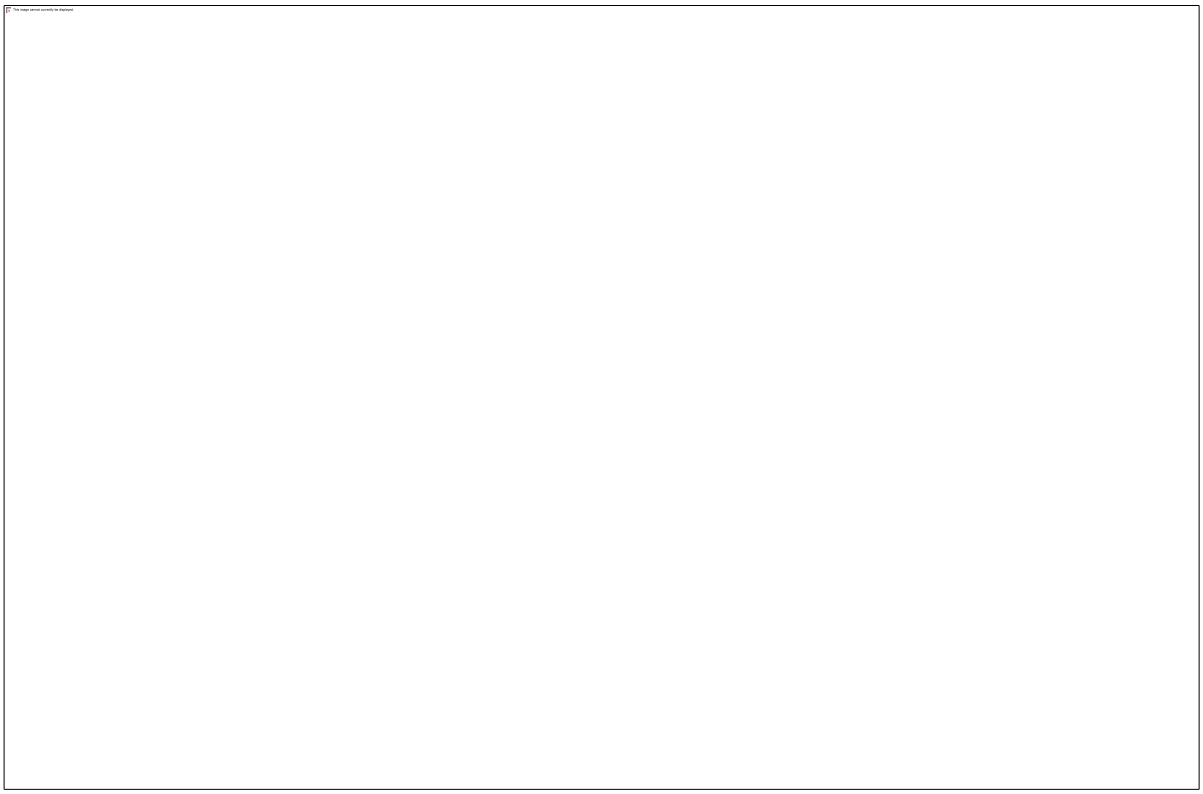
The bank becomes undercut.

Weakened materials collapse.

A steep river cliff develops.

C. Slip-Off Slopes (Point Bars)

A slip-off slope is a gently sloping depositional feature formed along the inner bank of a meander.



Formation:

Water flows more slowly along the inner bend.

The river loses some of its carrying capacity.

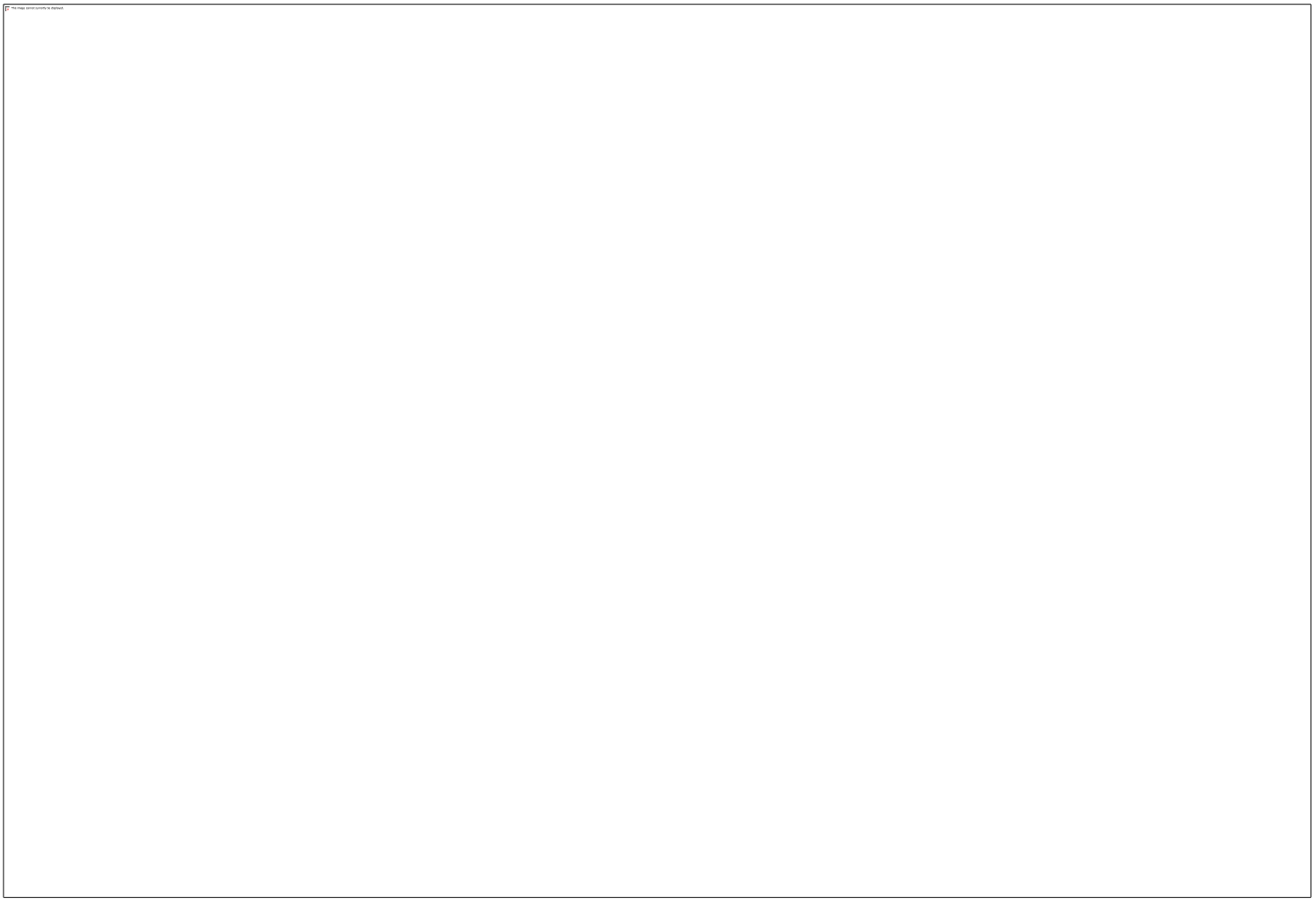
Sand and gravel are deposited.

Sediments accumulate along the inner bank.

A gently sloping depositional feature develops.

D. River Floodplains

A floodplain is a relatively flat area of land bordering a river channel that is formed mainly through repeated flooding and sediment deposition.



Formation:

A river carries fine sediments downstream.

During heavy rainfall, river discharge increases.

The river overflows its banks.

Water spreads over surrounding land.

Its velocity decreases outside the channel.

Fine sediments are deposited on the surrounding land.

Repeated flooding adds more sediments.

A broad, relatively flat floodplain develops.

Characteristics:

Flat or gently sloping land.

Located beside river channels.

May contain fertile alluvial soils.

Frequently experiences flooding.

Supports agriculture and settlement where conditions are suitable.

Kenyan examples:

Tana River floodplain.

Nzoia River floodplain.

Kano Plains associated with the Nyando drainage system.

E. River Terraces

River terraces are step-like flat surfaces found along the sides of a river valley, representing former floodplain levels.



Formation:

A river initially develops a floodplain.

Changes in climate, base level or land uplift may increase vertical erosion.

The river cuts down into its former floodplain.

The older floodplain remains at a higher level.

Further downcutting may produce additional step-like surfaces.

These surfaces are known as river terraces.

Characteristics:

Found along valley sides.

Have relatively flat surfaces.

May contain old alluvial deposits.

Represent former levels of the river valley.

F. River Islands

River islands are land areas surrounded by river water within a river channel.

Formation:

A river carries sediments.

Its velocity decreases in selected parts of the channel.

Sediments accumulate.

Deposits grow above the water level.

Vegetation may establish on the deposits.

River islands develop.

10.3 THE LOWER COURSE OF A RIVER

Meaning

The lower course is the section of a river near its mouth, where the river flows over a gentle gradient and approaches a lake, sea or ocean.

Deposition is generally dominant, although transportation and erosion continue.

Characteristics of the Lower Course

Has a very gentle gradient.

The river channel is generally wide.

The river carries a large volume of water.

The river valley is wide and shallow.

Deposition becomes increasingly important.

Fine sediments are commonly transported.

Extensive floodplains may occur.

Natural levees may develop.

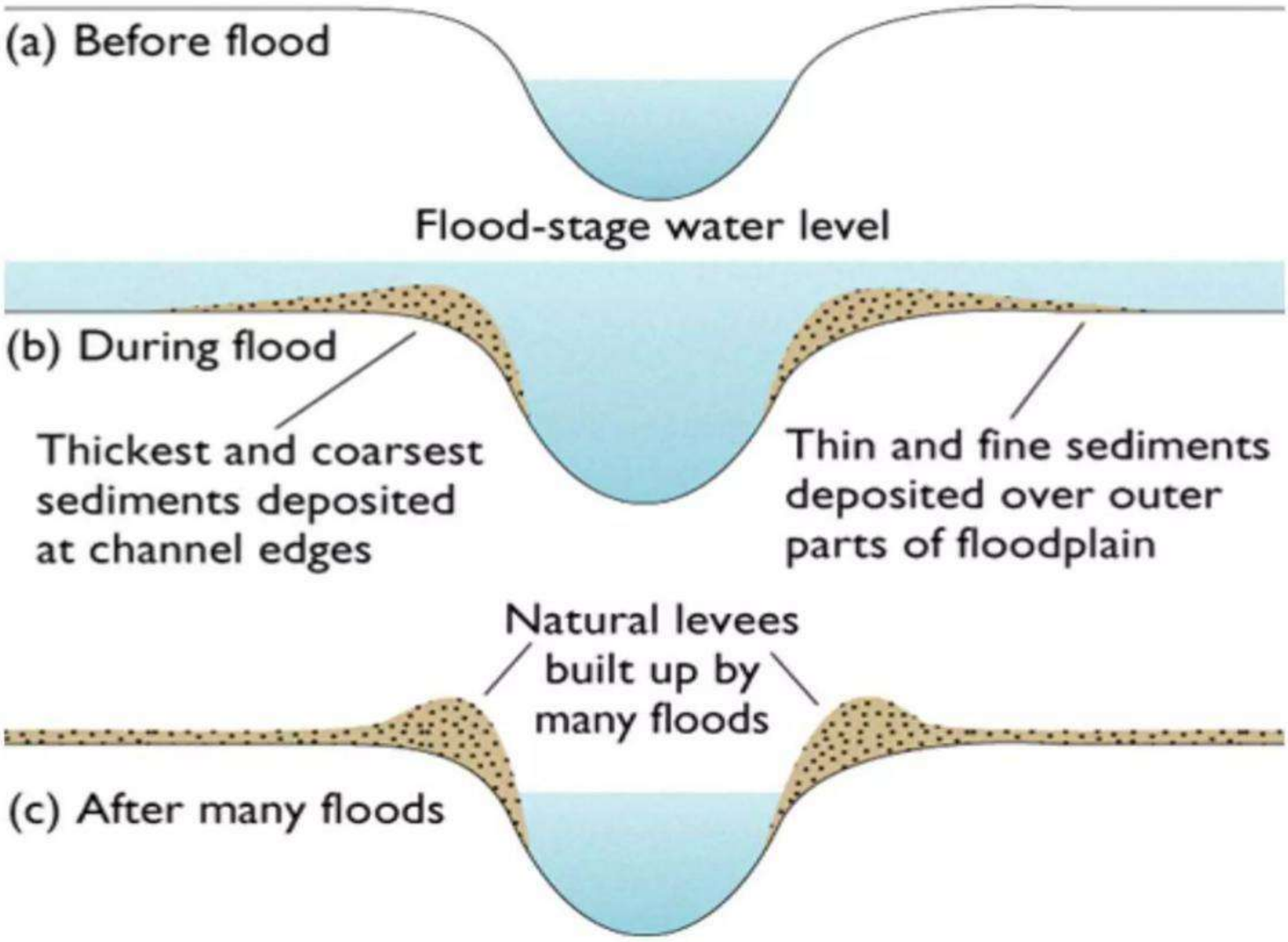
Deltas or estuaries may form at the river mouth.

The river may divide into distributaries in a delta.

Major Features Formed in the Lower Course

A. Natural Levees

Natural levees are raised embankments of sediment formed along the banks of a river through repeated flooding.



Formation:

A river experiences increased discharge during flooding.

Water overflows the river banks.

The water spreads onto the floodplain.

Its velocity decreases as it leaves the channel.

Coarser sediments are deposited close to the banks.

Fine sediments are transported farther across the floodplain.

Repeated flooding builds raised embankments along the channel.

These raised features are called natural levees.

Characteristics:

Raised features along river banks.

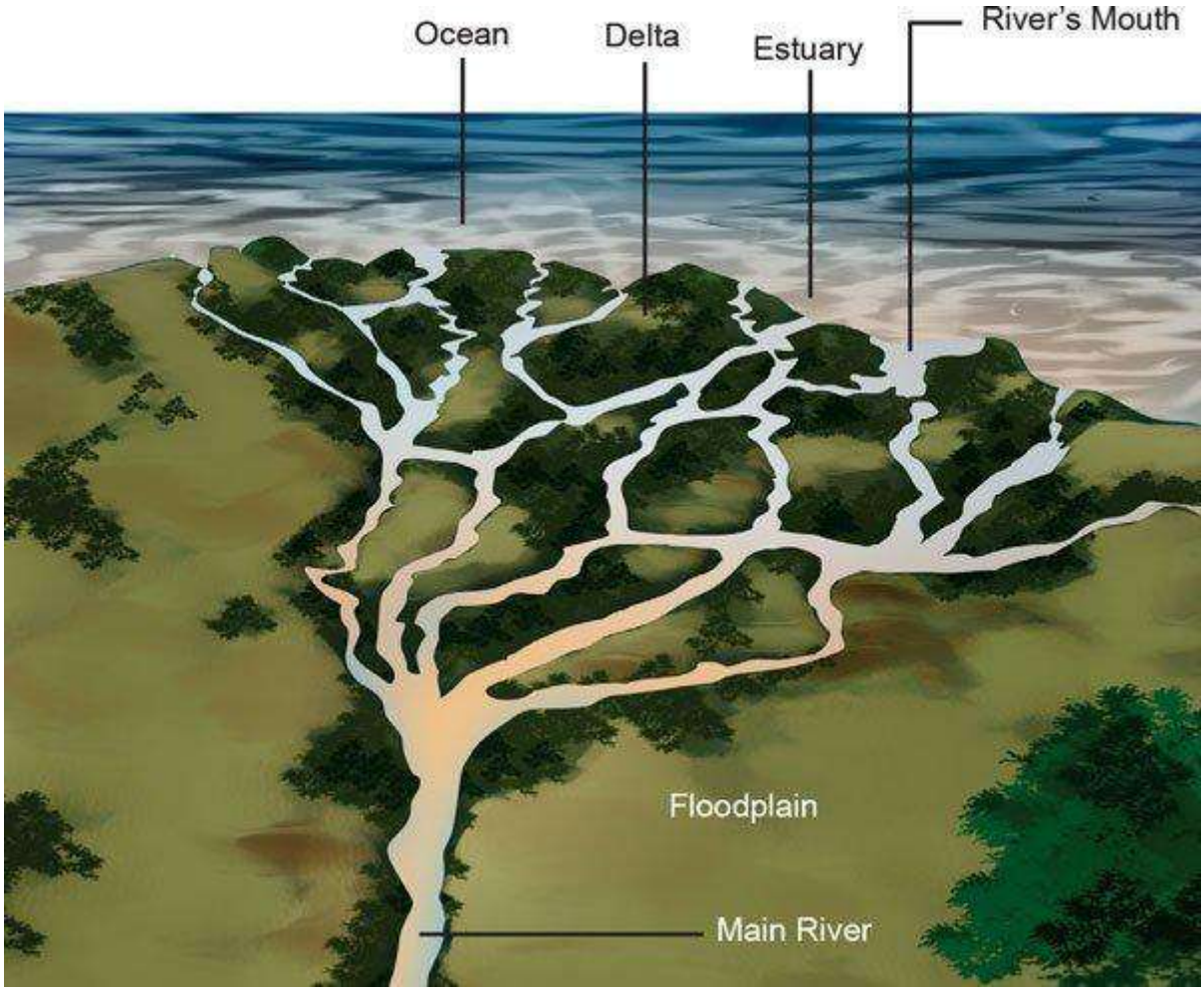
Formed through repeated deposition.

Usually higher than surrounding floodplain surfaces.

May influence settlement and drainage patterns.

B. Deltas

A delta is a depositional landform formed at the mouth of a river when sediments accumulate faster than they can be removed by waves, tides and currents.



Formation of a delta:

A river transports sediments towards its mouth.

The river enters a lake or sea.

Its velocity decreases.

The river loses some of its carrying capacity.

Sediments are deposited near the mouth.

Continued deposition builds up the river mouth.

The river may split into several distributaries.

A delta gradually develops.

Conditions favouring delta formation:

A river carries large quantities of sediments.

The river enters relatively calm water.

Wave action is weak.

Tidal currents are not strong enough to remove the deposited sediments.

The river has a relatively shallow mouth.

Sediment deposition exceeds sediment removal.

Characteristics:

Commonly fan-shaped or triangular.

Occurs at river mouths.

Contains deposited sediments.

May have several distributaries.

Often supports fertile agricultural land.

May contain wetlands and aquatic habitats.

Kenyan example: The Tana River Delta at the Indian Ocean coast.

C. Estuaries

An estuary is a partially enclosed coastal water body where freshwater from a river mixes with seawater.



Formation:

A river approaches the sea.

The river enters a coastal area influenced by tides.

Freshwater mixes with seawater.

Tidal movements influence the flow and distribution of sediments.

A tidal river mouth develops into an estuarine environment.

Characteristics:

Mixture of fresh and salt water.

Influenced by tides.

May contain mudflats and wetlands.

Supports specialised aquatic ecosystems.

May act as a breeding and feeding habitat for fish.

Importance:

Supports fisheries.

Provides habitats for aquatic organisms.

Supports tourism.

Acts as a natural filter for some sediments and nutrients.

Provides feeding grounds for birds.

D. Distributaries

Distributaries are channels that branch away from the main river and carry water towards different sections of a delta.

Formation:

Sediments accumulate near the river mouth.

The main channel becomes divided by deposited materials.

Water finds alternative channels.

Several branches develop.

The branches carry water towards different parts of the delta.

E. Braided Channels

A braided river channel consists of several shallow, interconnected channels separated by temporary or permanent sediment bars and islands.



Formation:

A river carries a large quantity of sediment.

Its ability to transport the load decreases.

Sediments are deposited within the channel.

Deposited materials form bars and islands.

Water divides into several channels around the deposits.

The channels rejoin and separate repeatedly.

Characteristics:

Multiple interconnected channels.

Sediment bars.

Shallow channels.

Frequently changing channel positions.

Common in rivers with abundant sediment supply.

11.0 COMPARISON OF THE THREE RIVER COURSES

Feature	Upper course	Middle course	Lower course
Gradient	Steep	Moderate	Gentle
Valley	Narrow and deep	Wider	Very wide
Dominant erosion	Vertical	Both vertical and lateral, with increasing lateral erosion	Generally less dominant
Deposition	Limited	Increasing	Extensive
River channel	Narrow and shallow in many cases	Wider and deeper	Widest and generally deepest
River load	Coarse materials	Mixed materials	More fine materials commonly carried
Discharge	Generally lower	Increases downstream	Generally greatest
Main landforms	V-shaped valleys, waterfalls, rapids, gorges	Meanders, river cliffs, slip-off slopes, floodplains	Levees, deltas, estuaries, distributaries

Important geographical principle: The three-course model is a general description. Actual rivers may not display all the listed features, and the relative importance of erosion, transportation and deposition depends on local conditions.

12.0 DRAINAGE PATTERNS OF RIVERS

12.1 Meaning of a Drainage Pattern

A drainage pattern refers to the arrangement or layout of river channels and their tributaries within a drainage basin when viewed from above.

Drainage patterns are influenced by:

Geological structure.

Rock type.

Slope and relief.

Faulting and folding.

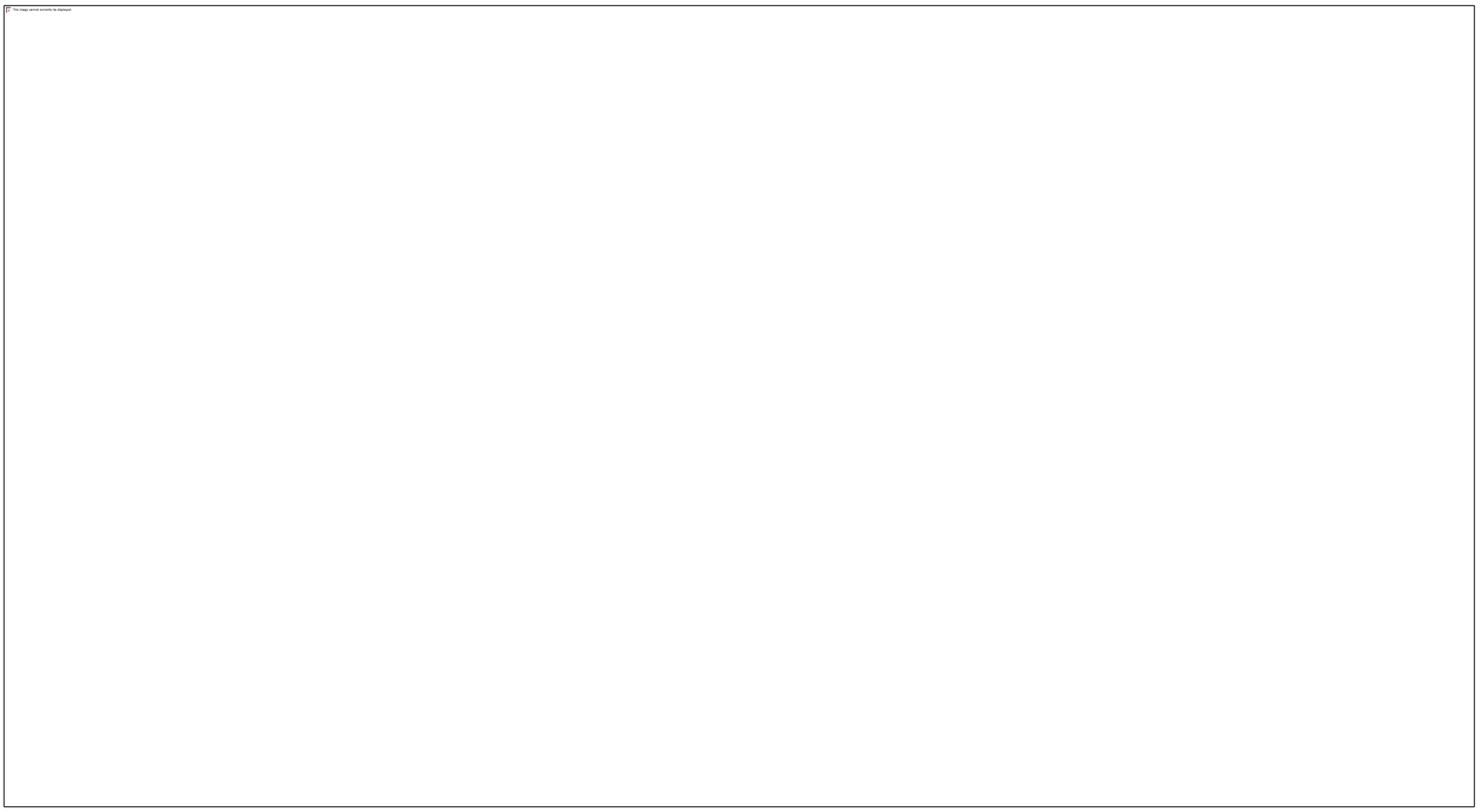
Volcanic activity.

Resistance of rocks to erosion.

Existing landforms.

12.2 Main Types of Drainage Patterns

A. Dendritic Drainage Pattern



A dendritic drainage pattern is a branching river system resembling the branches of a tree.

Characteristics:

Has a tree-like appearance.

Tributaries join the main river at acute angles.

Develops mainly on relatively uniform rock structures.

Does not follow a strongly controlled geological pattern.

Is common where rocks have relatively similar resistance to erosion.

Formation:

Water flows down a relatively uniform slope.

Small streams develop.

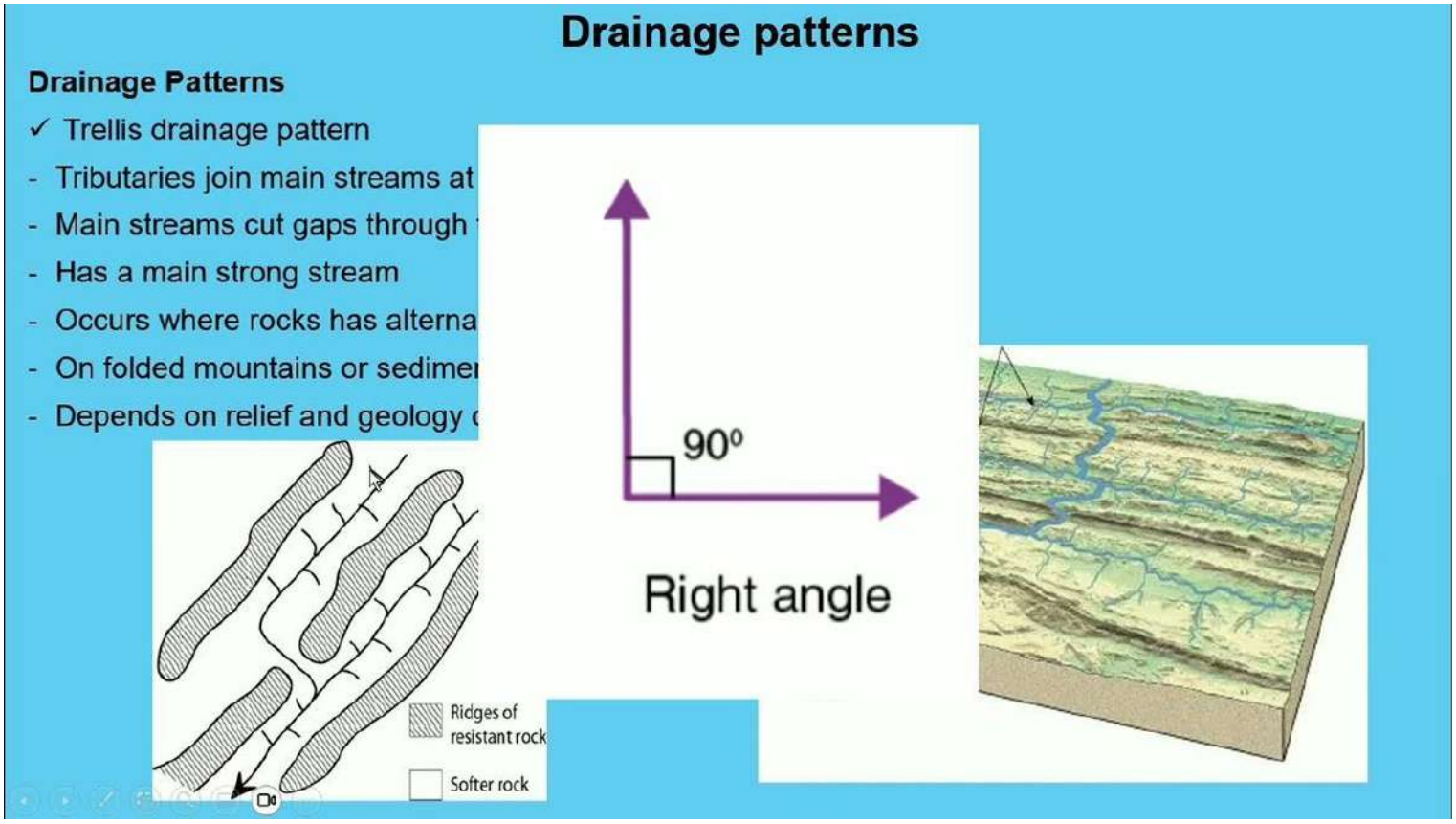
Smaller tributaries join larger streams.

A branching network develops.

The resulting arrangement resembles a tree.

Occurrence: Common in areas with relatively uniform underlying geology.

B. Trellis Drainage Pattern



A trellis drainage pattern consists of parallel main streams with short tributaries joining them at nearly right angles.

Characteristics:

Main rivers flow in parallel valleys.

Tributaries join the main streams at approximately right angles.

Common in areas with alternating hard and soft rock layers.

Often develops in folded landscapes.

Shows strong structural control.

Formation:

The landscape develops alternating resistant and less resistant rock layers.

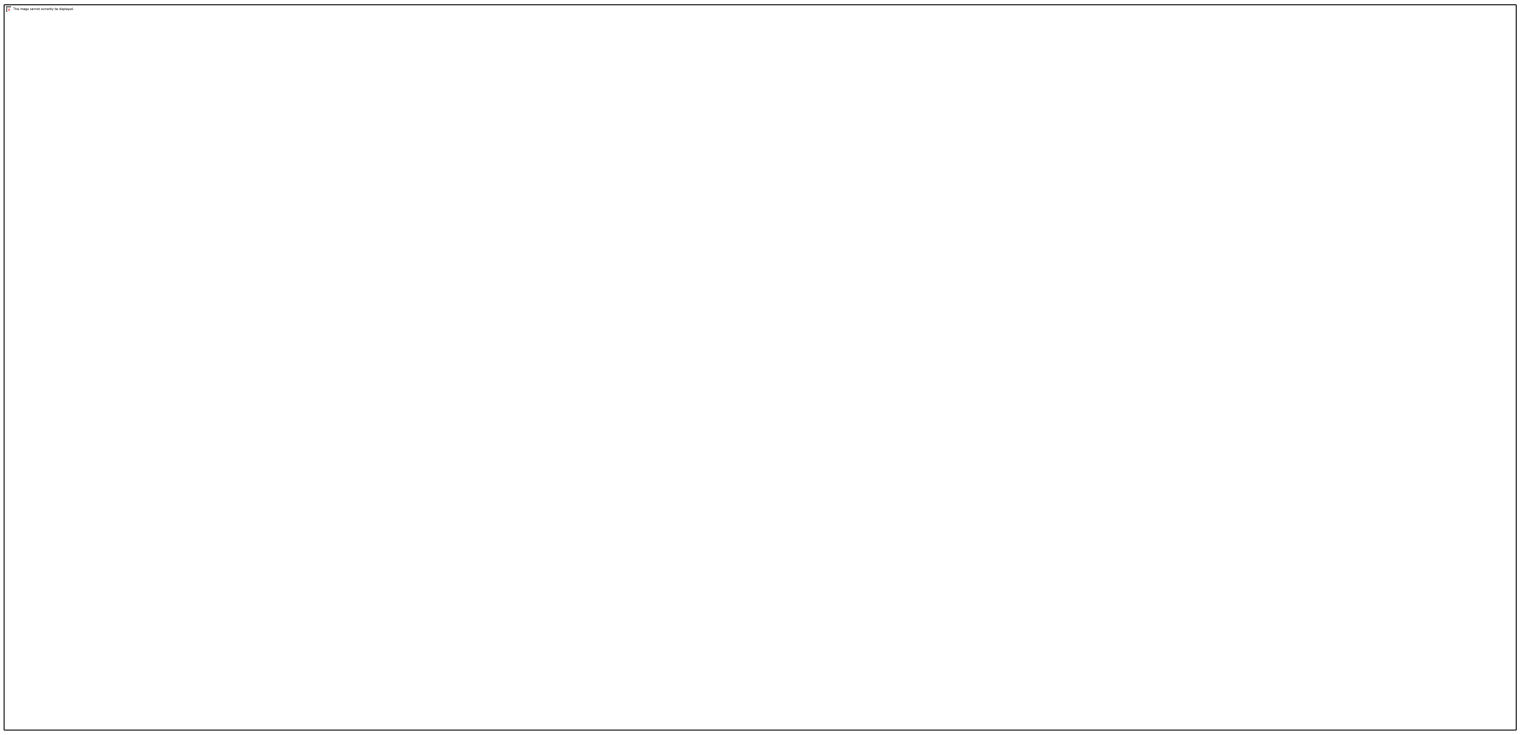
Valleys form along weaker rock layers.

Main streams follow these valleys.

Tributaries flow down slopes towards the main valleys.

Tributaries join the main streams at nearly right angles.

C. Radial Drainage Pattern



A radial drainage pattern is a drainage arrangement in which rivers flow outwards from a central elevated area.

Characteristics:

Rivers flow away from a central highland.

Streams radiate in different directions.

Common around volcanic mountains and domes.

The pattern resembles the spokes of a wheel.

Usually develops on elevated and isolated landforms.

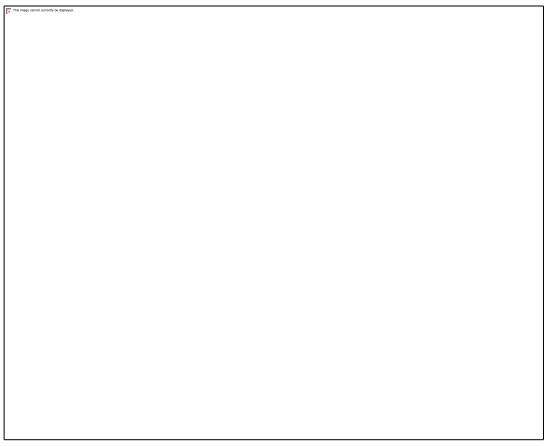
Examples in Kenya:

Drainage from Mount Kenya.

Drainage from Mount Elgon.

Drainage from other volcanic highlands.

D. Centripetal Drainage Pattern



A centripetal drainage pattern is a drainage arrangement in which rivers flow towards a central depression, basin or inland lake.

Characteristics:

Rivers flow towards a common central area.

Common in enclosed basins.

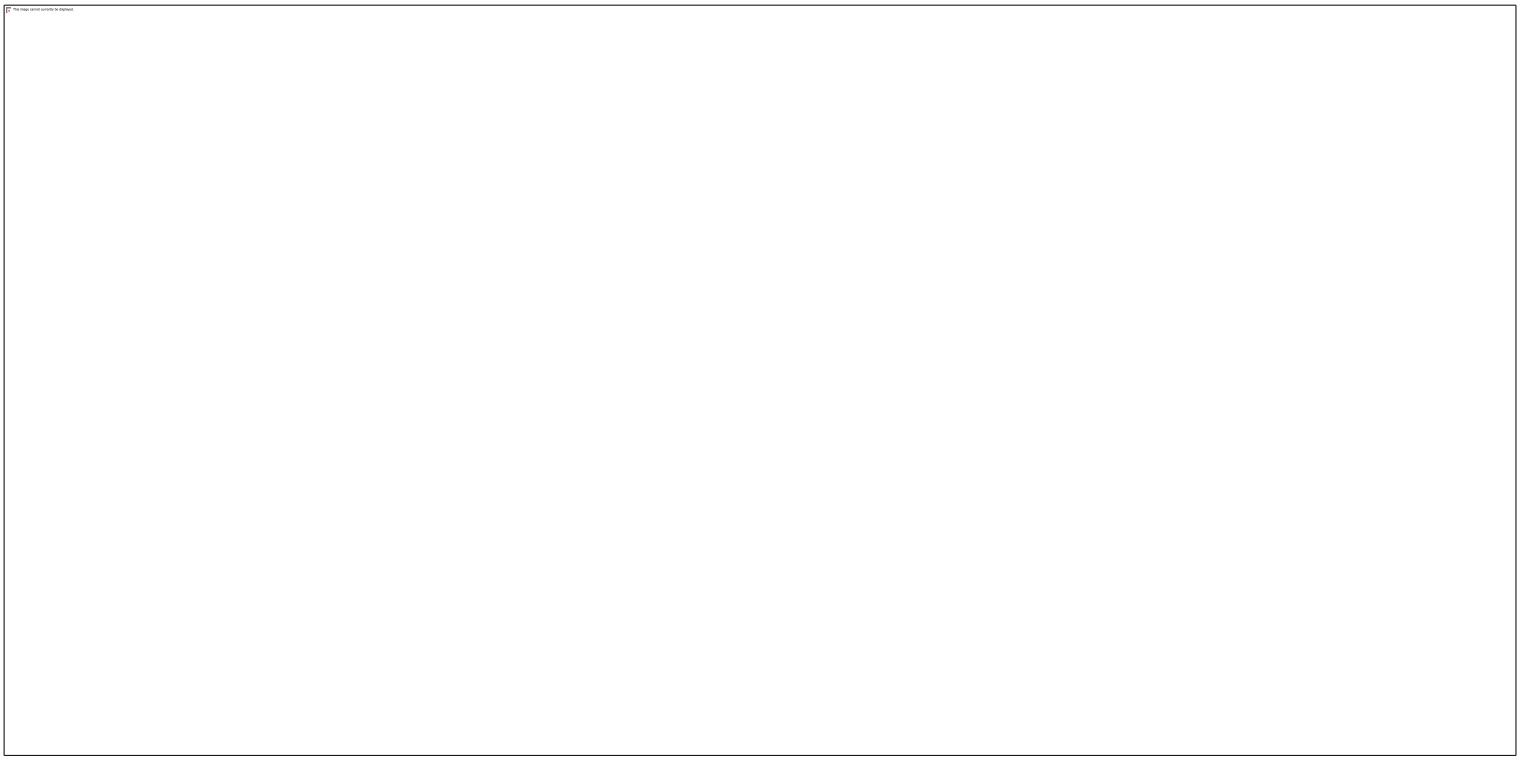
Often develops in depressions.

May occur in areas with no external drainage outlet.

Water may accumulate in lakes or swamps.

Example: Rivers draining into enclosed inland basins in parts of arid and semi-arid environments.

E. Rectangular Drainage Pattern



A rectangular drainage pattern is a river arrangement characterised by channels making frequent right-angle bends due to underlying joints and faults.

Characteristics:

River channels have sharp bends.

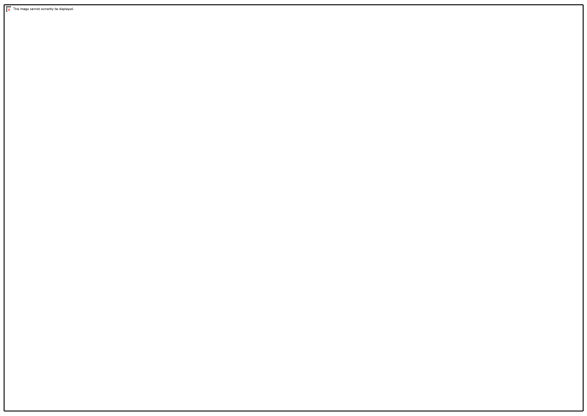
Tributaries join at nearly right angles.

Develops in areas with jointed or faulted rocks.

Geological structures influence channel direction.

The drainage network has a rectangular appearance.

F. Parallel Drainage Pattern



A parallel drainage pattern consists of rivers and streams flowing in approximately the same direction.

Characteristics:

Main streams flow parallel to one another.

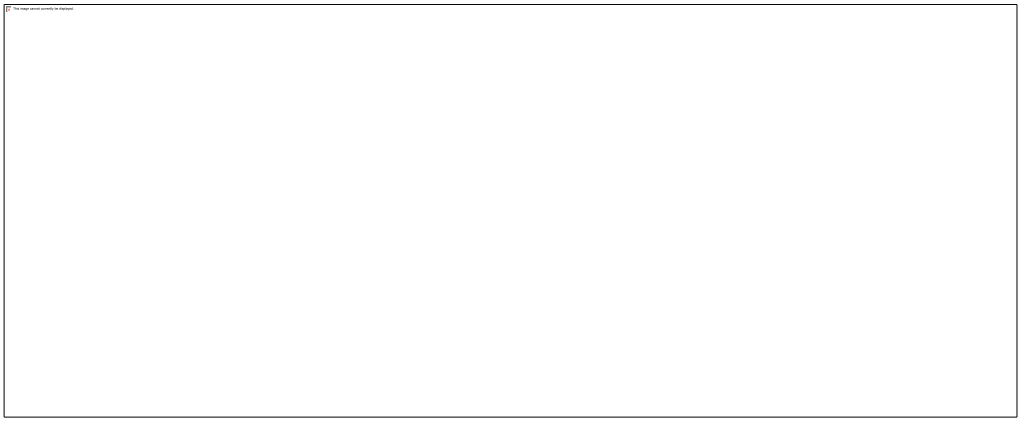
Develops on steep or uniformly sloping surfaces.

May occur in elongated landscapes.

Streams may have few tributaries.

Is influenced by slope direction.

G. Annular Drainage Pattern



An annular drainage pattern consists of river channels arranged in a series of roughly concentric rings around a central geological structure.

Characteristics:

Rivers follow circular or ring-like routes.

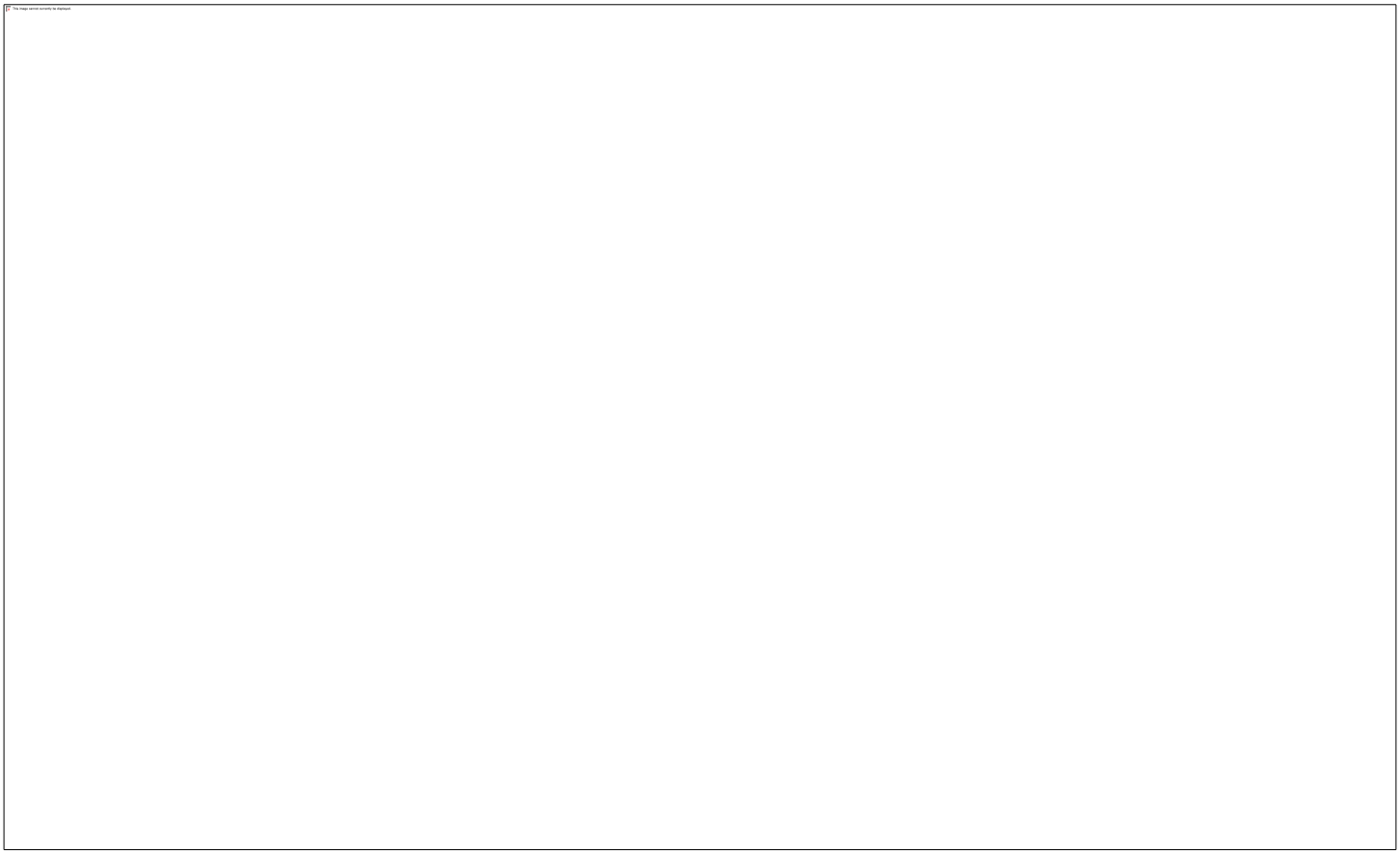
Common around domes and basins.

Influenced by alternating layers of resistant and less resistant rocks.

Tributaries may join at approximately right angles.

The pattern resembles concentric circles.

H. Deranged Drainage Pattern



A deranged drainage pattern is an irregular drainage arrangement characterised by poorly organised channels, numerous lakes, swamps and disconnected streams.

Characteristics:

Has no well-organised drainage network.

Contains numerous irregular lakes and wetlands.

Streams may be disconnected.

Common in recently glaciated landscapes.

May develop in areas with irregular relief.

12.3 Summary of Drainage Patterns

Drainage pattern	Main identifying feature	Main controlling factor
Dendritic	Tree-like branching	Uniform rock resistance
Trellis	Parallel streams with right-angle tributaries	Folded or alternating rock structures
Radial	Streams flow outwards	Central highland
Centripetal	Streams flow inwards	Central depression
Rectangular	Sharp right-angle bends	Joints and faults
Parallel	Streams flow in the same direction	Uniform or steep slope
Annular	Ring-like arrangement	Domes and basins
Deranged	Irregular lakes and streams	Disturbed or recently glaciated terrain

12.4 Importance of Studying Drainage Patterns

Helps understand the geological structure of an area.

Supports river basin planning.

Helps identify suitable locations for dams.

Supports flood management.

Helps in the identification of water resources.

Assists in agricultural planning.

Supports environmental management.

Helps interpret topographical maps.

Supports settlement planning.

Helps understand the relationship between relief and river development.

13.0 SIGNIFICANCE OF RIVERS TO HUMAN ACTIVITIES

13.1 Meaning of the Significance of Rivers

The significance of rivers refers to the various benefits and contributions that rivers provide to human beings, economic activities and the natural environment.

Rivers are important natural resources because they support livelihoods, economic development, environmental sustainability and social well-being.



13.2 Importance of Rivers

A. Domestic Water Supply

Rivers are important sources of water for domestic activities.

Uses:

Drinking water after appropriate treatment.

Cooking.

Washing clothes.

Cleaning homes.

Bathing.

Watering home gardens.

Sanitation and hygiene.

Kenyan examples:

River Tana supplies water to several communities.

River Nzoia supports water supply in parts of western Kenya.

River Athi is an important water resource for settlements in its drainage basin.

B. Agricultural Production

Rivers provide water for crop production and other agricultural activities.

Importance:

Supply water for irrigation.

Support horticultural farming.

Provide water for livestock.

Support rice cultivation.

Support the production of vegetables and fruits.

Provide water for agricultural processing.

Support fish farming in suitable locations.

Examples in Kenya:

River Tana supports irrigation schemes in its basin.

River Nyando supports irrigation and agricultural activities in the Kano Plains.

River Ewaso Ng'iro supports agriculture and livestock production in parts of northern Kenya.

C. Generation of Hydroelectric Power

Rivers provide flowing water used to generate hydroelectric power.

How hydroelectric power is generated:

Water is stored in a reservoir or diverted through an intake.

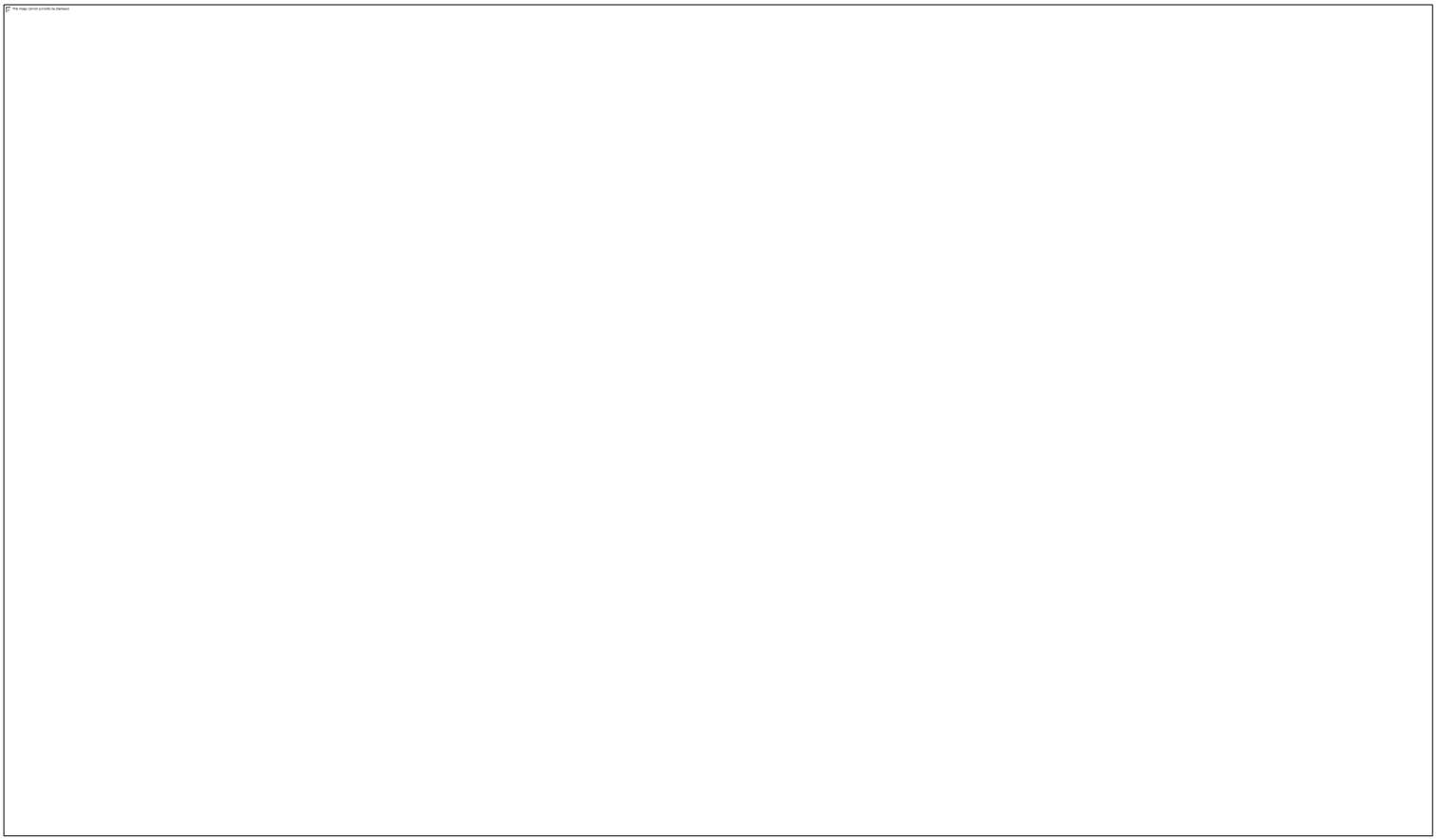
Water flows through a penstock or water-conveying system.

Flowing water turns turbine blades.

Turbines rotate generators.

Generators convert mechanical energy into electrical energy.

Electricity is transmitted to consumers.



Examples in Kenya:

Masinga Hydroelectric Power Station.

Kamburu Hydroelectric Power Station.

Gitaru Hydroelectric Power Station.

Kindaruma Hydroelectric Power Station.

Kiambere Hydroelectric Power Station.

Turkwel Hydroelectric Power Station.

Sondu-Miriu Hydroelectric Power Station.

D. Fishing and Aquaculture

Rivers support fishing activities and provide suitable environments for aquatic organisms.

Importance:

Provide habitats for freshwater fish.

Supply fish for human consumption.

Create employment for fishing communities.

Generate income through fish sales.

Support fish processing and marketing.

Support tourism through recreational fishing.

E. Industrial Development

Rivers supply water required by manufacturing and processing industries.

Uses:

Cooling industrial machinery.

Washing raw materials.

Processing food products.

Manufacturing beverages.

Supporting textile production.

Cleaning industrial equipment.

Supporting construction industries.

Note: Industrial wastewater must be properly treated before being released into rivers.

F. Transportation

Rivers provide transport routes in areas where they are navigable.

Importance:

Transport people.

Transport agricultural produce.

Transport building materials.

Support tourism boats.

Facilitate trade between settlements.

Some sections of rivers in Kenya are suitable for limited local boat transport, although many are not navigable because of waterfalls, rapids, shallow channels and seasonal fluctuations.

G. Tourism and Recreation

Rivers attract tourists because of their scenic beauty and recreational opportunities.

Tourism activities include:

White-water rafting.

Boat riding.

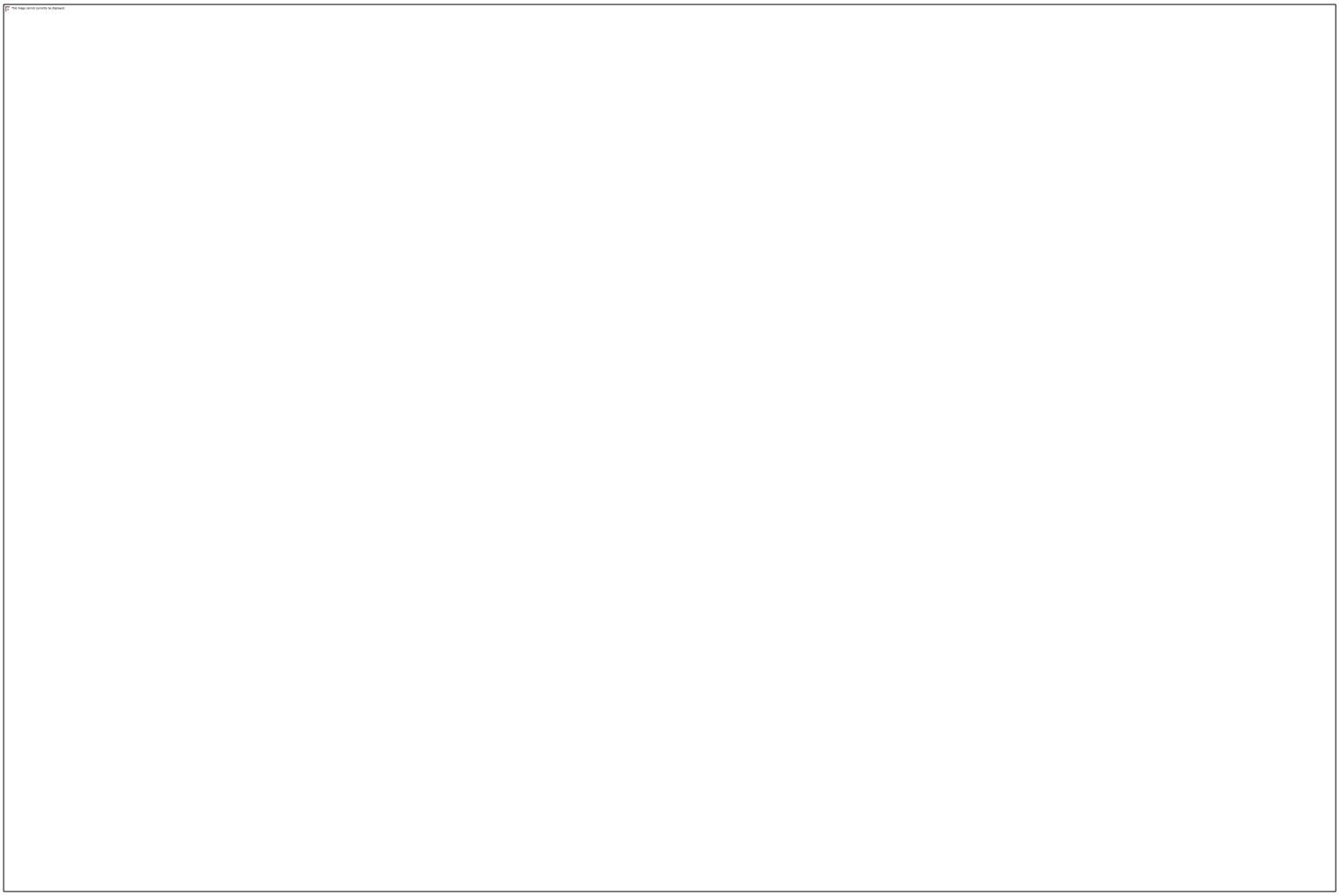
Sport fishing.

Bird watching.

Nature photography.

Sightseeing.

Swimming in safe designated areas.



Examples in Kenya:

Rapids along the Tana River.

Thomson's Falls at Nyahururu.

Fourteen Falls along the Athi River.

Mara River in the Maasai Mara ecosystem.

H. Support for Livestock Production

Provide drinking water for livestock.

Support the growth of pasture.

Supply water for dairy farming.

Support livestock washing and hygiene.

Support fodder irrigation.

Sustain pastoral livelihoods.

I. Support for Wildlife

Provide drinking water for wild animals.

Support aquatic habitats.

Maintain wetlands.

Support vegetation growth.

Provide breeding habitats for fish.

Sustain wildlife migration routes.

Example: River Mara is an important water source for wildlife in the Maasai Mara and Serengeti ecosystems.

J. Source of Building Materials

Rivers deposit sand, gravel and other sediments that may be used in construction.

Uses:

Sand is used in concrete production.

Gravel is used in road construction.

River stones are used in building.

Some fine sediments are used in making bricks.

Extraction must be regulated to prevent riverbank collapse, channel instability and habitat destruction.

K. Supports Settlement Development

Provides reliable water sources.

Supports agricultural activities.

Encourages the development of trading centres.

Supports livestock keeping.

Provides opportunities for employment.

Supports industries and services.

L. Fertile Agricultural Land

Rivers deposit fertile alluvial sediments.

Floodplains may support crop production.

River valleys may provide suitable irrigation conditions.

Sediments replenish some soil nutrients.

Water availability supports intensive agriculture.

M. Research and Education

Rivers provide sites for geographical field studies.

Support hydrological research.

Help learners study erosion and deposition.

Provide opportunities to investigate aquatic ecosystems.

Support climate and environmental studies.

Help researchers monitor water quality.

N. Cultural and Historical Importance

Rivers have influenced the location of human settlements.

Some rivers are associated with cultural traditions.

Rivers have historically provided water for communities.

They may form geographical boundaries.

They have influenced trade and human migration.

13.3 Summary of the Importance of Rivers

Sector	Contribution
Domestic	Water for household use
Agriculture	Irrigation and livestock watering
Energy	Hydroelectricity
Fishing	Fish production and employment
Industry	Water for processing
Transport	Movement of people and goods where navigable
Tourism	Recreation and sightseeing
Wildlife	Habitats and drinking water
Construction	Sand, gravel and stones
Settlement	Support for human habitation
Education	Research and fieldwork
Environment	Wetland and ecosystem maintenance

14.0 ENVIRONMENTAL ISSUES RELATED TO RIVERS IN THE CONTEMPORARY WORLD

14.1 Meaning of Environmental Issues Related to Rivers

Environmental issues related to rivers refer to the challenges and problems that affect the quality, quantity, flow and ecological condition of river systems as a result of natural processes and human activities.

Rivers across the world face increasing pressure from population growth, urbanisation, industrialisation, agricultural expansion, climate change and unsustainable resource exploitation.

In Kenya, river pollution, catchment degradation, flooding, water scarcity, sand harvesting and encroachment on riparian land are important environmental concerns.

14.2 Major Environmental Issues Affecting Rivers

A. River Pollution

River pollution is the contamination of river water by harmful substances that reduce its quality and make it unsafe for human use and aquatic life.



Sources of river pollution:

Industrial waste: Factories may release untreated or inadequately treated effluent into rivers.

Domestic sewage: Untreated sewage introduces harmful microorganisms and organic waste.

Agricultural chemicals: Fertilisers and pesticides may be washed into rivers.

Solid waste: Plastics, polythene bags and other refuse contaminate river channels.

Oil spills: Oil and petroleum products may enter rivers through accidental spills.

Mining activities: Mining waste may introduce heavy metals and suspended sediments.

Soil erosion: Eroded soil increases sediment loads in rivers.

Hospital waste: Improper disposal of medical waste may contaminate water.

Detergents: Chemicals from washing activities may affect aquatic organisms.

Urban runoff: Stormwater carries pollutants from roads and built-up areas into rivers.

Effects of river pollution:

Causes death of aquatic organisms.

Makes water unsafe for domestic consumption.

Spreads waterborne diseases.

Reduces the availability of clean water.

Causes unpleasant smells and colour changes.

Reduces biodiversity.

Affects fishing activities.

Increases water treatment costs.

May contaminate agricultural produce.

Disrupts aquatic food chains.

Possible solutions:

Treat sewage before discharge.

Enforce environmental laws.

Control industrial effluent.

Establish proper waste disposal systems.

Reduce excessive use of agricultural chemicals.

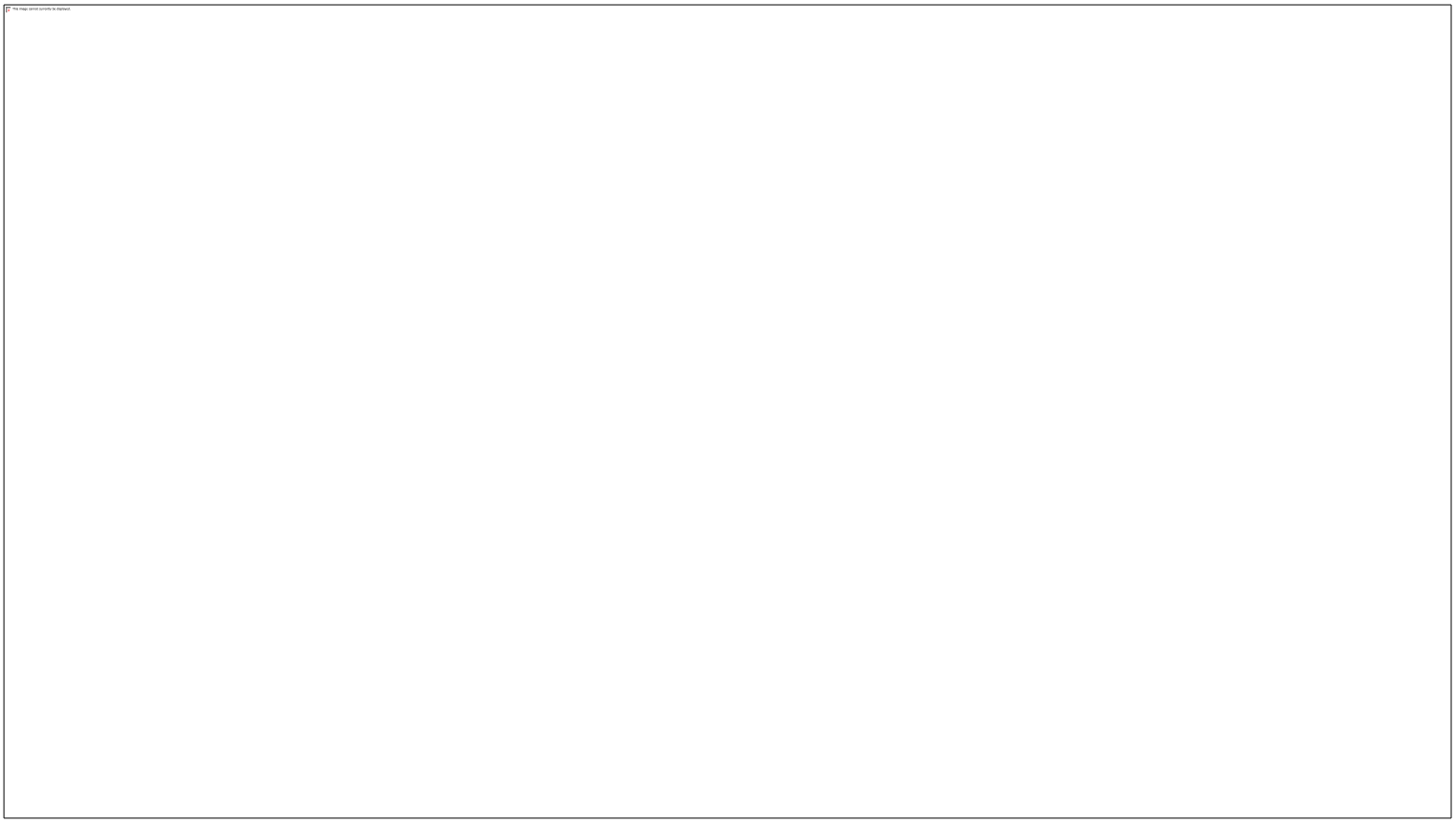
Protect riparian vegetation.

Conduct regular water quality monitoring.

Educate communities about river conservation.

B. Flooding

Flooding occurs when water exceeds the capacity of a river channel and spreads over normally dry surrounding land.



Causes of river flooding:

Prolonged heavy rainfall.

Intense rainfall within a short period.

Deforestation in river catchments.

Encroachment on river channels.

Siltation of river beds.

Poor drainage systems.

Blockage of drainage channels.

Dam releases and structural failures.

Settlement on floodplains.

Climate-related changes in rainfall patterns.

Effects of flooding:

Destruction of homes.

Loss of human life.

Displacement of communities.

Destruction of crops.

Death of livestock.

Damage to roads and bridges.

Contamination of drinking water.

Spread of waterborne diseases.

Loss of property.

Interruption of economic activities.

Soil erosion.

Destruction of wildlife habitats.

Management and control of floods:

Construct suitable flood-control dams and reservoirs.

Improve drainage systems.

Protect and restore forests in catchment areas.

Avoid settlement in high-risk floodplains.

Establish flood forecasting and early-warning systems.

Construct and maintain protective levees where appropriate.

Desilt selected drainage channels where environmentally justified.

Promote riverbank vegetation.

Develop emergency evacuation plans.

Educate communities on flood preparedness.

Kenyan examples: Flooding along River Tana, River Nzoia and River Nyando has affected communities, farmland and infrastructure in different periods.

C. Siltation

Siltation is the accumulation of transported sediments in river channels, lakes, reservoirs and dams.



Causes:

Soil erosion in catchment areas.

Deforestation.

Overgrazing.

Poor farming practices.

Mining and quarrying.

Riverbank cultivation.

Construction activities.

Heavy rainfall and runoff.

Effects:

Reduces the depth of river channels.

Reduces reservoir storage capacity.

Increases the risk of flooding.

Destroys aquatic habitats.

Interferes with water supply systems.

Increases water treatment costs.

Reduces the lifespan of dams.

Affects navigation in navigable rivers.

Solutions:

Afforestation.

Terracing.

Contour ploughing.

Riparian protection.

Controlled grazing.

Appropriate soil conservation.

Regulation of mining activities.

Sediment management in reservoirs.

D. Water Scarcity

Water scarcity occurs when the available quantity of water is insufficient to meet the needs of a population or ecosystem.

Causes:

Prolonged drought.

Reduced rainfall.

High evaporation.

Excessive abstraction of river water.

Population growth.

Deforestation.

Climate change.

Poor water management.

Pollution of existing water sources.

Destruction of catchment areas.

Effects:

Reduced agricultural production.

Increased livestock deaths.

Food insecurity.

Conflicts over water resources.

Reduced industrial production.

Poor sanitation.

Increased poverty.

Migration of communities.

Reduced hydroelectric power generation.

Deterioration of aquatic ecosystems.

Solutions:

Construct water storage facilities.

Promote rainwater harvesting.

Protect water catchments.

Encourage efficient irrigation.

Recycle and reuse treated wastewater.

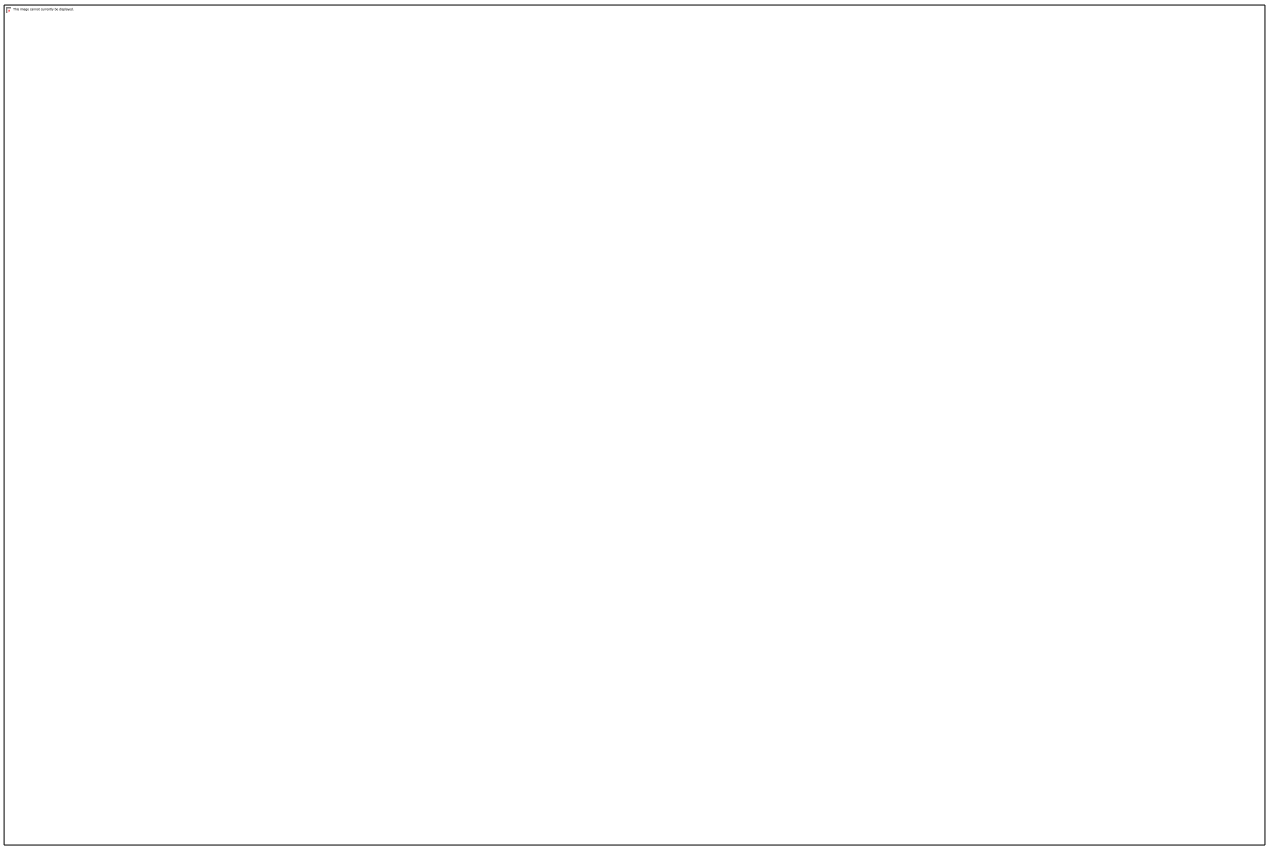
Regulate water abstraction.

Reduce water wastage.

Promote community water conservation.

E. Deforestation in River Catchments

Deforestation is the removal of trees and forest vegetation without adequate replacement.



Causes:

Agricultural expansion.

Settlement expansion.

Charcoal production.

Illegal logging.

Infrastructure development.

Overexploitation of forest resources.

Effects on rivers:

Increases surface runoff.

Increases soil erosion.

Raises sediment loads.

Reduces infiltration.

May reduce groundwater recharge.

Increases the risk of flooding.

Destroys riverbank habitats.

May affect the reliability of river flow.

Solutions:

Reforestation.

Afforestation.

Community forest management.

Protection of water towers.

Enforcement of forestry laws.

Sustainable harvesting of forest resources.

F. Encroachment on Riparian Land

Riparian land refers to land bordering rivers, streams and other water bodies.

Encroachment occurs when people occupy or undertake unauthorised activities within protected or sensitive riverbank areas.

Activities causing encroachment:

Building houses.

Cultivation close to river channels.

Illegal dumping.

Sand harvesting.

Livestock grazing.

Construction of commercial premises.

Removal of riverbank vegetation.

Effects:

Riverbank erosion.

Pollution.

Loss of vegetation.

Increased sedimentation.

Destruction of wildlife habitats.

Increased flood vulnerability.

Restricted access for river management.

Solutions:

Enforce riparian protection regulations.

Restore indigenous vegetation.

Control development near riverbanks.

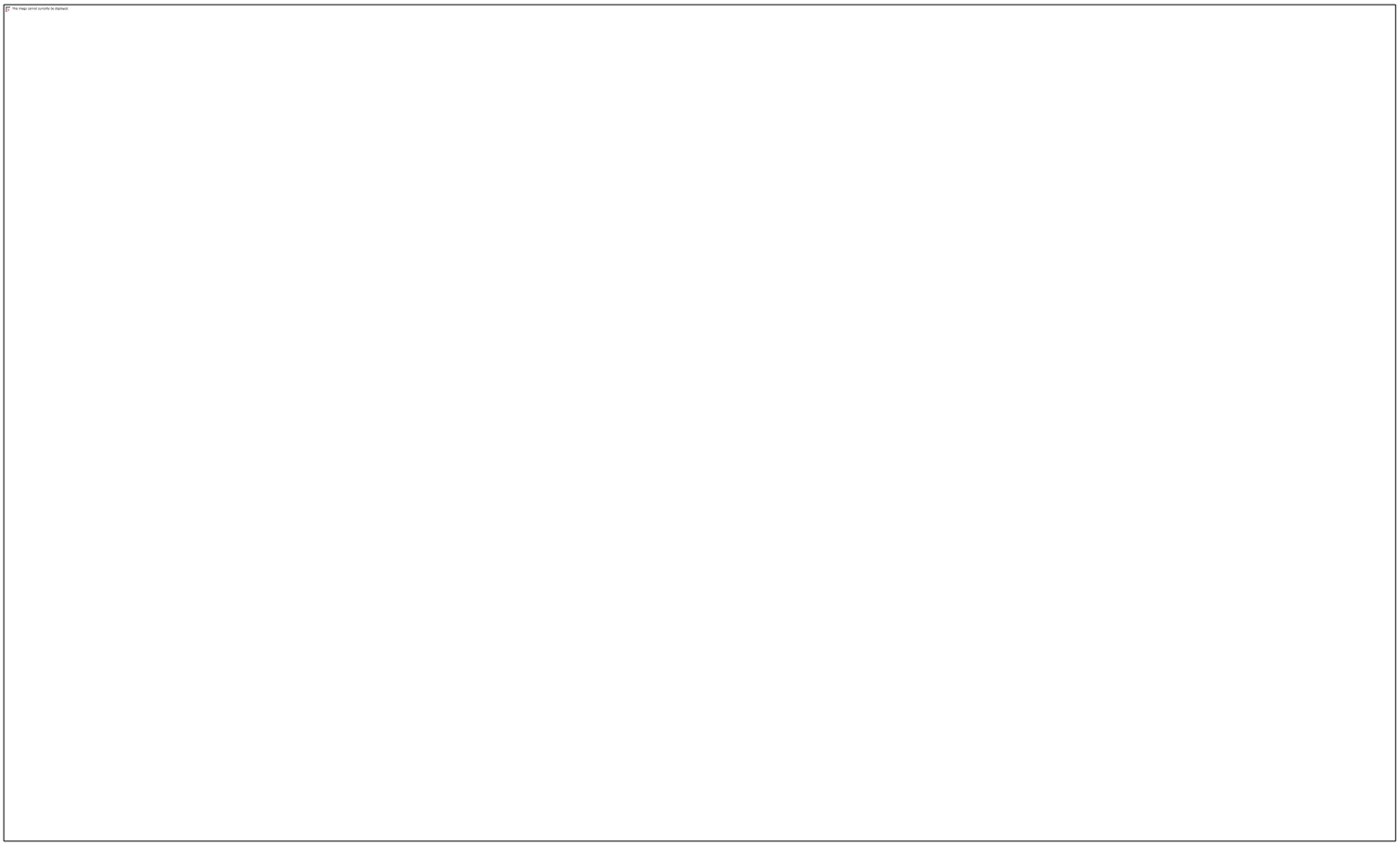
Conduct public awareness campaigns.

Promote appropriate land-use planning.

Involve local communities in river restoration.

G. Sand Harvesting

Sand harvesting refers to the extraction of sand from river channels and riverbanks for construction and other purposes.



Causes:

High demand for construction sand.

Rapid urbanisation.

Infrastructure development.

Unregulated extraction.

Limited alternative construction materials.

Negative effects:

Deepens river channels.

Causes riverbank collapse.

Increases erosion.

Destroys aquatic habitats.

Changes natural river flow.

May lower nearby groundwater levels.

Damages bridges and other infrastructure.

Increases water turbidity.

Possible solutions:

Regulate sand harvesting.

Enforce environmental legislation.

Identify suitable extraction sites.

Encourage the use of alternative construction materials.

Restore damaged riverbanks.

Involve communities in monitoring.

Conduct environmental impact assessments.

H. Climate Change and Rivers

Climate change refers to long-term changes in temperature, rainfall patterns and other climatic conditions.

Effects on rivers:

Changes in river discharge.

Increased frequency of floods in some regions.

Increased drought-related reduction in river flow.

Changes in seasonal river regimes.

Increased evaporation.

Changes in aquatic habitats.

Increased sediment movement following intense rainfall.

Pressure on water supplies.

Changes in the distribution of aquatic species.

Increased competition for water resources.

Possible solutions:

Protect catchment forests.

Promote climate-resilient agriculture.

Improve water storage.

Strengthen early-warning systems.

Restore wetlands.

Promote efficient water use.

Encourage integrated water resource management.

I. Invasive Species in River Ecosystems

Invasive species are organisms introduced into environments where they are not naturally found and which may spread and cause ecological or economic harm.

Examples of concerns:

Water hyacinth in parts of Lake Victoria and connected waterways.

Invasive aquatic plants in water channels.

Non-native organisms that compete with indigenous species.

Effects:

Block waterways.

Interfere with fishing.

Reduce oxygen levels in water under some conditions.

Interfere with water intake systems.

Affect aquatic biodiversity.

Increase the cost of water management.

Solutions:

Regular monitoring.

Appropriate mechanical removal.

Biological control where scientifically justified.

Prevention of further introductions.

Community participation.

Protection of indigenous aquatic ecosystems.

J. Human-Wildlife and Community Conflicts Around Rivers

Competition for water may occur where people, livestock and wildlife depend on the same river resources.

Causes:

Drought.

Population growth.

Reduced water availability.

Expansion of settlements.

Restricted access to water points.

Destruction of natural water sources.

Solutions:

Develop community water points.

Construct livestock watering facilities.

Protect wildlife corridors.

Improve water storage.

Promote dialogue among water users.

Establish fair water-sharing arrangements.

14.3 Summary of Contemporary River Issues

Environmental issue	Main cause	Appropriate solution
Pollution	Sewage and industrial waste	Wastewater treatment
Flooding	Heavy rainfall and poor drainage	Flood management and early warning
Siltation	Soil erosion	Catchment conservation
Water scarcity	Drought and over-abstraction	Water harvesting and efficient use
Deforestation	Tree removal	Reforestation

Riparian encroachment	Unplanned development	Riparian protection
Sand harvesting	Unregulated extraction	Sustainable extraction controls
Climate change	Changing climatic conditions	Climate adaptation
Invasive species	Introduction and spread of harmful species	Monitoring and control
Water conflicts	Competition for limited water	Equitable water management

15.0 MANAGEMENT AND CONSERVATION OF RIVERS

15.1 Meaning of River Management

River management refers to the planning, development, protection and regulation of river resources to ensure that they are used sustainably.

15.2 Meaning of River Conservation

River conservation refers to the protection and restoration of rivers and their surrounding ecosystems to maintain water quality, natural flow, biodiversity and other ecological functions.

15.3 Methods of River Management and Conservation

A. Protection of Water Catchment Areas

Prevent unnecessary clearing of forests.

Protect indigenous vegetation.

Control settlement in sensitive catchment areas.

Encourage afforestation.

Monitor activities that threaten water sources.

Promote community participation.

B. Protection of Riparian Vegetation

Maintain natural vegetation along riverbanks.

Plant suitable indigenous trees and grasses.

Avoid unnecessary cultivation near riverbanks.

Prevent uncontrolled grazing.

Control illegal construction.

Restore degraded riverbank areas.

C. Pollution Control

Treat sewage before discharge.

Treat industrial wastewater.

Enforce pollution-control regulations.

Prevent dumping of solid waste.

Promote proper sanitation.

Reduce agricultural chemical runoff.

Monitor river water quality.

D. Sustainable Water Abstraction

Regulate the amount of water removed from rivers.

Encourage efficient irrigation.

Prevent illegal abstraction.

Promote rainwater harvesting.

Reuse treated wastewater where appropriate.

Ensure adequate environmental flows.

E. Flood Management

Develop flood forecasting systems.

Construct suitable flood-control infrastructure.

Protect wetlands.

Improve urban drainage.

Avoid settlement in high-risk flood zones.

Educate communities on disaster preparedness.

F. Sustainable Sand Harvesting

Regulate extraction activities.

Identify environmentally suitable extraction areas.

Avoid excessive riverbed excavation.

Monitor river channel changes.

Restore damaged sites.

Promote alternative construction materials.

G. Wetland Protection

Protect wetlands connected to river systems.

Prevent illegal drainage.

Control pollution.

Restore degraded wetlands.

Promote sustainable use.

Protect wetland biodiversity.

H. Public Awareness and Education

Conduct environmental education programmes.

Organise river clean-up activities.

Encourage school environmental clubs.

Promote community conservation campaigns.

Educate farmers on sustainable land use.

Encourage responsible disposal of waste.

I. Enforcement of Environmental Laws

In Kenya, river management is supported by environmental and water-resource institutions.

Relevant institutions include:

Water Resources Authority (WRA).

National Environment Management Authority (NEMA).

Kenya Forest Service (KFS).

Kenya Wildlife Service (KWS).

County governments.

Water Resources Users Associations (WRUAs).

Their responsibilities include regulating water use, protecting catchments, enforcing environmental requirements, monitoring pollution and supporting conservation initiatives.

J. Integrated Water Resources Management

Integrated Water Resources Management (IWRM) is an approach that promotes coordinated management of water, land and related resources to maximise social and economic benefits without compromising the sustainability of ecosystems.

Principles:

Equitable access to water.

Sustainable water utilisation.

Stakeholder participation.

Protection of ecosystems.

Integrated planning.

Pollution prevention.

Efficient water use.

Conflict resolution.

15.4 Importance of River Conservation

Maintains clean water supplies.

Protects aquatic biodiversity.

Reduces flooding and erosion.

Supports agricultural production.

Maintains ecological balance.

Protects water catchment areas.

Supports hydroelectric power generation.

Maintains fisheries.

Promotes tourism.

Supports sustainable economic development.

Reduces conflicts over water.

Protects water resources for future generations.

16.0 FIELD STUDY ON RIVERS IN THE LOCALITY

16.1 Meaning of a River Field Study

A river field study is a geographical investigation conducted in or around a river environment to collect first-hand information about river characteristics, processes, uses and environmental challenges.

It enables learners to connect classroom knowledge with real geographical conditions.

16.2 Objectives of a River Field Study

By the end of the field study, learners should be able to:

Identify the physical characteristics of a local river.

Describe the direction of river flow.

Identify river erosion and deposition features.

Observe riverbank vegetation.

Identify human activities taking place around the river.

Examine sources of river pollution.

Investigate the significance of the river to the community.

Suggest appropriate conservation measures.

16.3 Equipment and Materials Required

Notebook.

Pen and pencil.

Camera or smartphone.

Measuring tape.

Compass.

Topographical map.

GPS device where available.

Sample containers.

Protective footwear.

Field observation checklist.

Appropriate safety equipment.

16.4 Procedure for Conducting the Field Study

Select a suitable river in the locality.

Seek permission from relevant authorities or landowners.

Identify the objectives of the study.

Prepare observation questions.

Observe the river's source and direction of flow where accessible.

Examine the river channel and banks.

Identify evidence of erosion.

Identify deposited materials.

Observe the vegetation around the river.

Identify human activities along the river.

Investigate possible pollution sources.

Interview selected community members.

Take photographs where permitted.

Record observations.

Discuss the findings.

Prepare and present a field report.

Safety precautions:

Avoid entering deep or fast-flowing water.

Keep a safe distance from unstable riverbanks.

Do not collect samples from polluted water without appropriate supervision and protective equipment.

Avoid fieldwork during heavy rainfall or flood warnings.

Work under teacher supervision.

Follow local access and environmental regulations.

16.5 Sample River Field Study Report

Title: A Field Study on the Physical Characteristics, Uses and Environmental Challenges of a River in the Locality.

Study area: A selected river within the local community.

Objectives:

To identify the characteristics of the river.

To examine the processes operating along the river.

To identify human activities.

To investigate environmental challenges.

To recommend conservation measures.

Sample observations:

Aspect investigated	Possible observations
River channel	Width, depth and shape
Water appearance	Clear, muddy or polluted
River banks	Stable, vegetated or eroded

River load	Sand, gravel, stones and silt
Vegetation	Grasses, shrubs and trees
Human activities	Irrigation, livestock watering and fishing
Pollution	Plastics, sewage and agricultural runoff
River features	Meanders, bars, rapids or waterfalls

Recommendations:

Protect riverbank vegetation.

Avoid dumping waste.

Control sand harvesting.

Promote catchment conservation.

Encourage sustainable water abstraction.

Educate community members.

Organise river clean-up campaigns.

Monitor water quality.

16.6 Suggested Community Project

Project title: Keep Our Rivers Clean and Healthy.

Learners can work in groups to:

Identify a local river.

Investigate its importance to the community.

Identify environmental challenges.

Prepare posters on river conservation.

Organise a supervised river clean-up activity.

Plant suitable indigenous vegetation in approved areas.

Interview local water users.

Present findings to the school and community.

Expected outcomes:

Increased environmental awareness.

Improved understanding of river systems.

Greater community participation.

Development of responsible water-use practices.

Improved environmental citizenship.

17.0 RELATIONSHIP BETWEEN THE WATER CYCLE AND RIVER ACTION

The water cycle and river action are closely connected.

Evaporation transfers water into the atmosphere.

Condensation leads to cloud formation.

Precipitation supplies water to the Earth's surface.

Infiltration replenishes soil moisture.

Percolation replenishes groundwater.

Surface runoff supplies water to rivers.

Groundwater flow helps maintain river discharge.

Rivers transport water towards lakes, seas and oceans.

Rivers erode, transport and deposit sediments.

Water bodies provide additional sources of evaporation.

This relationship demonstrates that rivers are an important part of the continuous movement of water through the environment.

18.0 IMPORTANT GEOGRAPHICAL TERMS

Term	Definition
Hydrological cycle	Continuous movement of water between the Earth and atmosphere.
Evaporation	Conversion of liquid water into water vapour.
Transpiration	Loss of water vapour from plants.
Condensation	Conversion of water vapour into liquid droplets or ice crystals.
Precipitation	Water falling from the atmosphere to the Earth.
Infiltration	Entry of water into the soil.
Percolation	Downward movement of water through soil and rocks.
Runoff	Movement of water over the Earth's surface.
Groundwater	Water stored beneath the Earth's surface.
River	Natural flowing body of water.
Tributary	Smaller river joining a larger river.
Confluence	Point where rivers meet.
Distributary	Branch flowing away from the main river.
Drainage basin	Area drained by a river and its tributaries.
Watershed	Boundary separating drainage basins.
River erosion	Wearing away of river beds and banks.
Hydraulic action	Erosion caused by the force of moving water.
Abrasion	Wearing away by rock fragments carried by water.
Attrition	Collision of transported particles causing them to become smaller and rounded.
Solution	Dissolving of soluble materials in river water.
Traction	Rolling or dragging of large particles along the river bed.
Saltation	Movement of particles by short jumps.
Suspension	Transportation of fine particles within water.
Deposition	Laying down of transported materials.
Meander	A pronounced bend in a river channel.
Floodplain	Flat land bordering a river that may be flooded.
Waterfall	Sudden vertical or near-vertical drop in a river.
Gorge	Deep, narrow valley with steep sides.
Delta	Depositional feature at a river mouth.
Estuary	Coastal water body where freshwater mixes with seawater.
River discharge	Volume of water flowing past a point per unit time.
Drainage pattern	Arrangement of rivers and tributaries in a drainage basin.
Siltation	Accumulation of sediments in water channels and reservoirs.

Riparian land	Land bordering a river or other water body.

REVISION EXERCISES

GRADE 11 GEOGRAPHY

SUB-STRAND: WATER CYCLE AND ACTION OF RIVERS

The following questions assess knowledge, understanding, application, analysis, critical thinking, creativity and problem-solving in accordance with the Competency-Based Education approach.

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Instructions: Answer all questions. Select the correct answer from the alternatives A, B, C and D. Each question carries 1 mark.

1. The continuous movement of water between the atmosphere, land and water bodies is known as:

A. Rock cycle.

B. Carbon cycle.

C. Hydrological cycle.

D. Nitrogen cycle.

2. Which of the following provides the main energy driving the water cycle?

A. The moon.

B. The sun.

C. The Earth's rotation.

D. Ocean currents.

3. The process through which liquid water changes into water vapour is called:

A. Condensation.

B. Precipitation.

C. Evaporation.

D. Infiltration.

4. The loss of water vapour from plant leaves into the atmosphere is known as:

A. Transpiration.

B. Percolation.

C. Condensation.

D. Precipitation.

5. Which process leads to the formation of clouds?

A. Evaporation.

B. Condensation.

C. Infiltration.

D. Surface runoff.

6. Water entering the soil through its surface is known as:

A. Percolation.

B. Infiltration.

C. Evaporation.

D. Transportation.

7. Which of the following represents the downward movement of water through soil and permeable rocks?

A. Transpiration.

B. Condensation.

C. Percolation.

D. Interception.

8. Which of the following is a form of precipitation?

A. Evaporation.

B. Transpiration.

C. Hail.

D. Infiltration.

9. The movement of water over the Earth's surface towards rivers and lakes is known as:

A. Surface runoff.

B. Condensation.

C. Transpiration.

D. Groundwater recharge.

10. Which of the following is the largest reservoir of water on Earth?

A. Rivers. B. Lakes.

C. Oceans. D. Glaciers.

11. A natural flowing body of water moving from higher ground towards a lake, sea or ocean is called:

A. A watershed.

B. A river.

C. A valley.

D. A drainage divide.

12. A smaller river that joins a larger river is known as:

A. Distributary.

B. Tributary.

C. Watershed.

D. River mouth.

13. The point where two rivers meet is called:

A. Source.

B. Mouth.

C. Confluence.

D. Watershed.

14. The area drained by a main river and its tributaries is known as:

A. River basin.

B. River cliff.

C. River channel.

D. Floodplain.

15. Which of the following processes involves the wearing away of a river bed by the force of moving water?

A. Deposition.

B. Hydraulic action.

C. Attrition.

D. Transportation.

16. The wearing away of river beds and banks by rock fragments carried by water is called:

A. Abrasion.

B. Solution.

C. Infiltration.

D. Humification.

17. The process through which transported rock fragments collide and become smaller and rounder is known as:

A. Hydraulic action.

B. Attrition.

C. Deposition.

D. Solution.

18. Which method of river transportation involves the rolling of large particles along the river bed?

A. Suspension.

B. Solution.

C. Traction.

D. Saltation.

19. The movement of small particles through repeated short jumps along the river bed is known as:

A. Traction.

B. Saltation.

C. Suspension.

D. Solution.

20. Which of the following is a method of transporting dissolved minerals in river water?

A. Traction.

B. Saltation.

C. Suspension.

D. Solution.

21. Which river process occurs when a river loses its energy and drops its load?

A. Erosion.

B. Transportation.

C. Deposition.

D. Weathering.

22. Which of the following features is commonly associated with the upper course of a river?

A. Delta.

B. Waterfall.

C. Natural levee.

D. Estuary.

23. A narrow valley with steep sides and a V-shaped cross-section is formed mainly through:

A. Vertical erosion.

B. River deposition.

C. Marine erosion.

D. Wind deposition.

24. A circular hole formed on a river bed through the grinding action of transported stones is known as:

A. Gorge.

B. Pothole.

C. Delta.

D. Levee.

25. Which feature develops along the outer bank of a meander due to lateral erosion?

A. Slip-off slope. B. River cliff.

C. Delta. D. Natural levee.

26. A raised embankment formed along a river bank through repeated flooding and deposition is called:

A. Waterfall.

B. Gorge.

C. Natural levee.

D. Pothole.

27. Which drainage pattern resembles the branches of a tree?

A. Radial.

B. Trellis.

C. Dendritic.

D. Centripetal.

28. Rivers flowing outwards from a central highland form which drainage pattern?

A. Centripetal.

B. Radial.

C. Rectangular.

D. Annular.

29. Which of the following is a major cause of river pollution?

A. Afforestation.

B. Proper sewage treatment.

C. Discharge of untreated industrial waste.

D. Protection of riparian vegetation.

30. Which of the following is the most appropriate method of conserving river ecosystems?

A. Uncontrolled sand harvesting.

B. Cultivation along riverbanks.

C. Disposal of untreated sewage.

D. Protection of catchment forests and riparian vegetation.

SECTION B: STRUCTURED QUESTIONS (50 MARKS)

Instructions: Answer ALL questions. Write your answers clearly and give relevant examples where necessary.

1. The Water Cycle (8 Marks)

a) Define the term hydrological cycle. (2 marks)

b) Explain three processes involved in the water cycle. (3 marks)

c) State three ways in which the water cycle is important to the community. (3 marks)

2. River Erosion and Transportation (8 Marks)

a) Define river erosion. (2 marks)

b) Explain three processes of river erosion. (3 marks)

c) Describe three methods through which rivers transport their load. (3 marks)

3. River Landforms (8 Marks)

a) Name four features associated with the upper course of a river. (2 marks)

b) Explain the formation of a waterfall. (3 marks)

c) Describe the formation of a river delta. (3 marks)

4. Drainage Patterns (8 Marks)

a) Define the term drainage pattern. (2 marks)

b) Describe three types of drainage patterns found on the Earth's surface. (3 marks)

c) State three factors influencing the development of drainage patterns. (3 marks)

5. Significance and Environmental Issues Related to Rivers (10 Marks)

a) Explain five ways in which rivers are important to human activities. (5 marks)

b) Discuss five environmental problems affecting rivers in Kenya and suggest appropriate solutions. (5 marks)

6. River Conservation and Field Study (8 Marks)

Your school has organised a geographical field study to investigate the condition of a river in the local community.

a) State two objectives of the field study. (2 marks)

b) Explain three environmental conservation measures that can be adopted to protect the river. (3 marks)

c) Identify three pieces of information that learners should collect during the field study. (3 marks)

20.0 ADDITIONAL COMPETENCY-BASED APPLICATION QUESTIONS

These activities can be used for group work, individual assignments, geographical investigations and classroom discussions.

Activity 1: Investigating the Water Cycle

Learners observe the water cycle in their community.

Identify three local sources of water.

Explain how evaporation takes place.

Describe the role of vegetation in the water cycle.

Explain how rainfall contributes to groundwater recharge.

Suggest four ways of protecting local water sources.

Activity 2: Interpreting River Landforms

A learner visits a mountainous area and observes a waterfall, rapids, potholes and a deep valley.

Identify the river course where these features are most likely to occur.

Explain how waterfalls develop.

Describe the formation of potholes.

Explain the importance of rapids and waterfalls to tourism.

Discuss how river erosion changes the Earth's surface.

Activity 3: Drainage Pattern Investigation

Using a topographical map or digital geographical map:

Identify the main river.

Locate its tributaries.

Identify the watershed.

Determine the drainage pattern.

Explain the influence of relief on the drainage pattern.

Activity 4: River Pollution Investigation

A river passing through an urban settlement has become polluted due to waste disposal and untreated sewage.

Identify four possible sources of pollution.

Explain four effects of pollution on the community.

Suggest five measures for controlling river pollution.

Explain the importance of community participation in river conservation.

Activity 5: Flood Risk Management

A community living along the River Tana experiences repeated flooding.

Explain four possible causes of flooding.

Discuss five effects of flooding on the community.

Suggest five methods of reducing flood risks.

Explain the importance of early-warning systems.

21.0 SUGGESTED TEACHING AND LEARNING RESOURCES

The following resources can be used to make the sub-strand practical, visual and learner-centred.



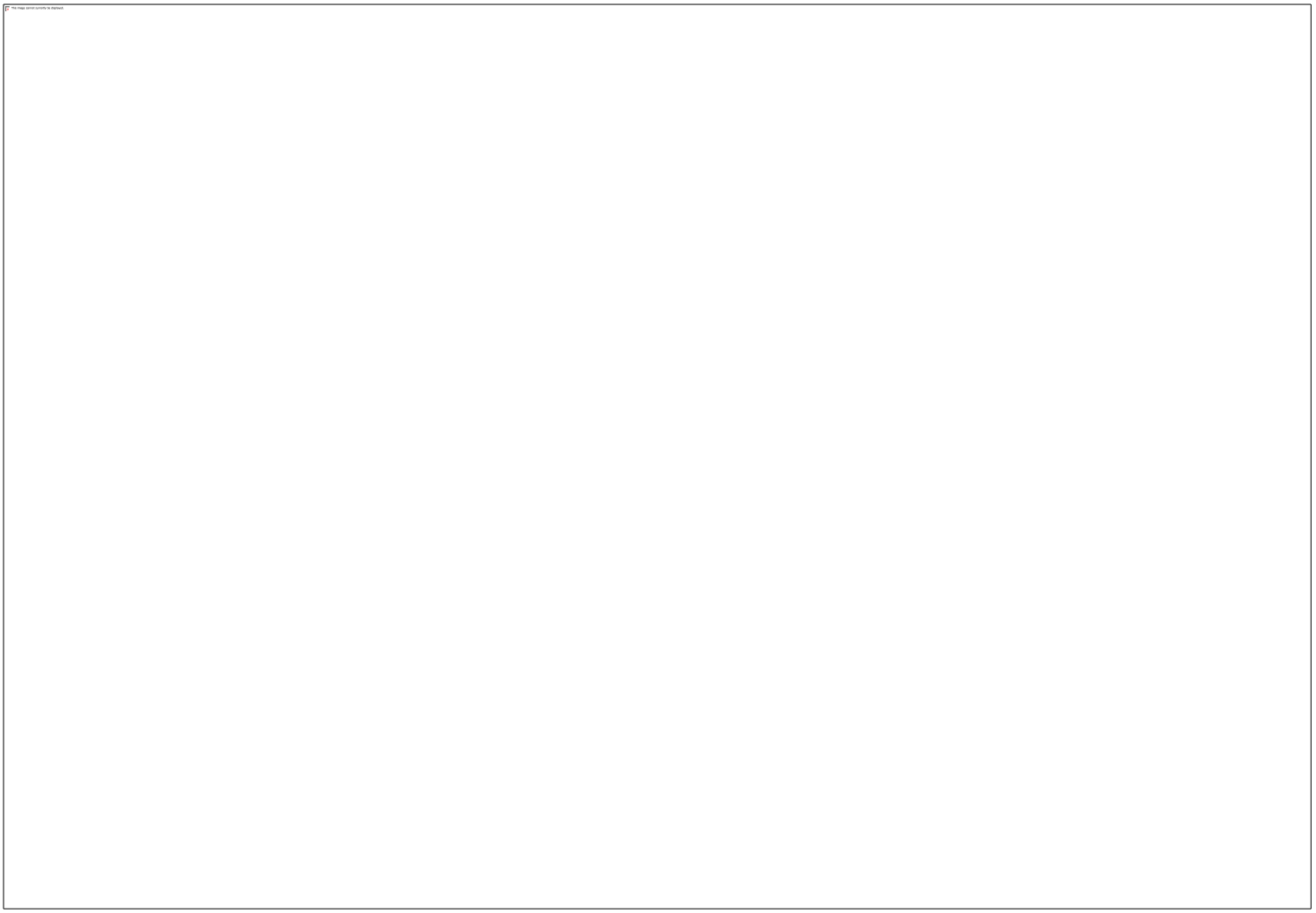
Water cycle models

Demonstrating evaporation, condensation and precipitation.



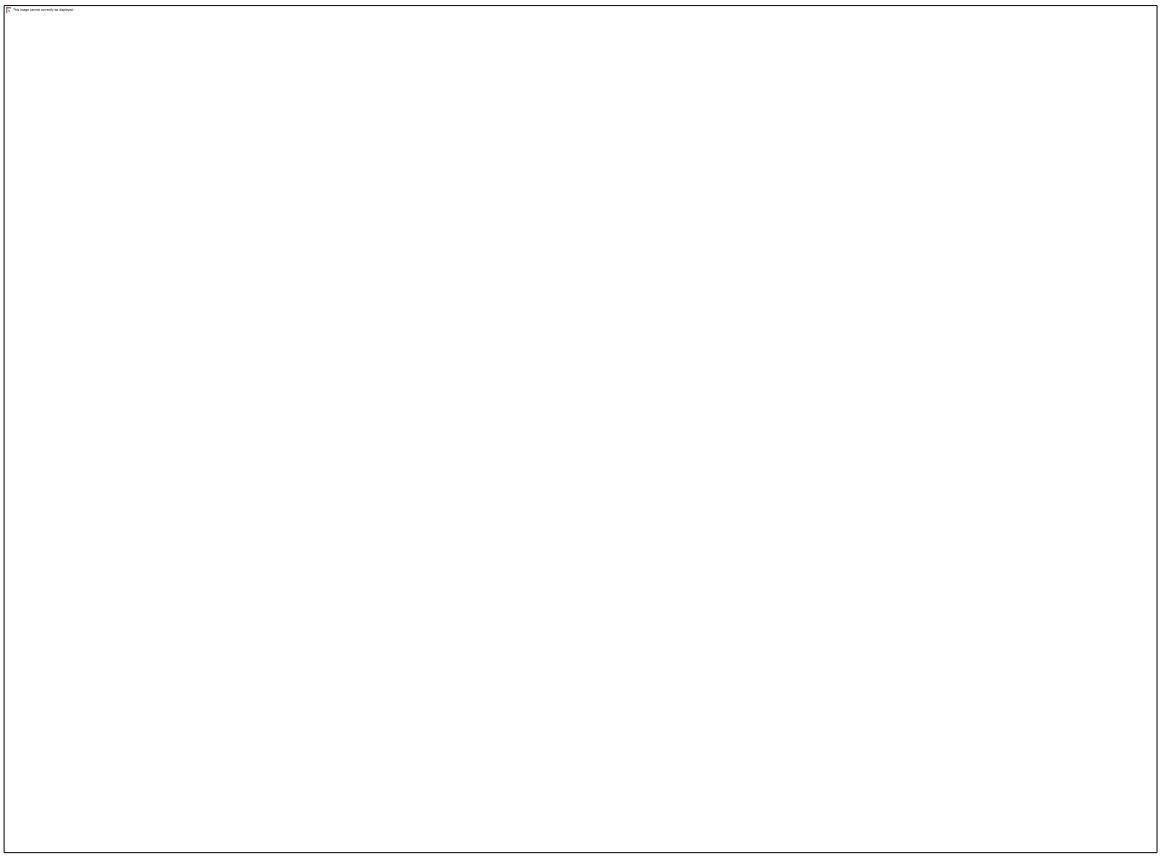
River landform charts

Identifying erosion, transportation and deposition features.



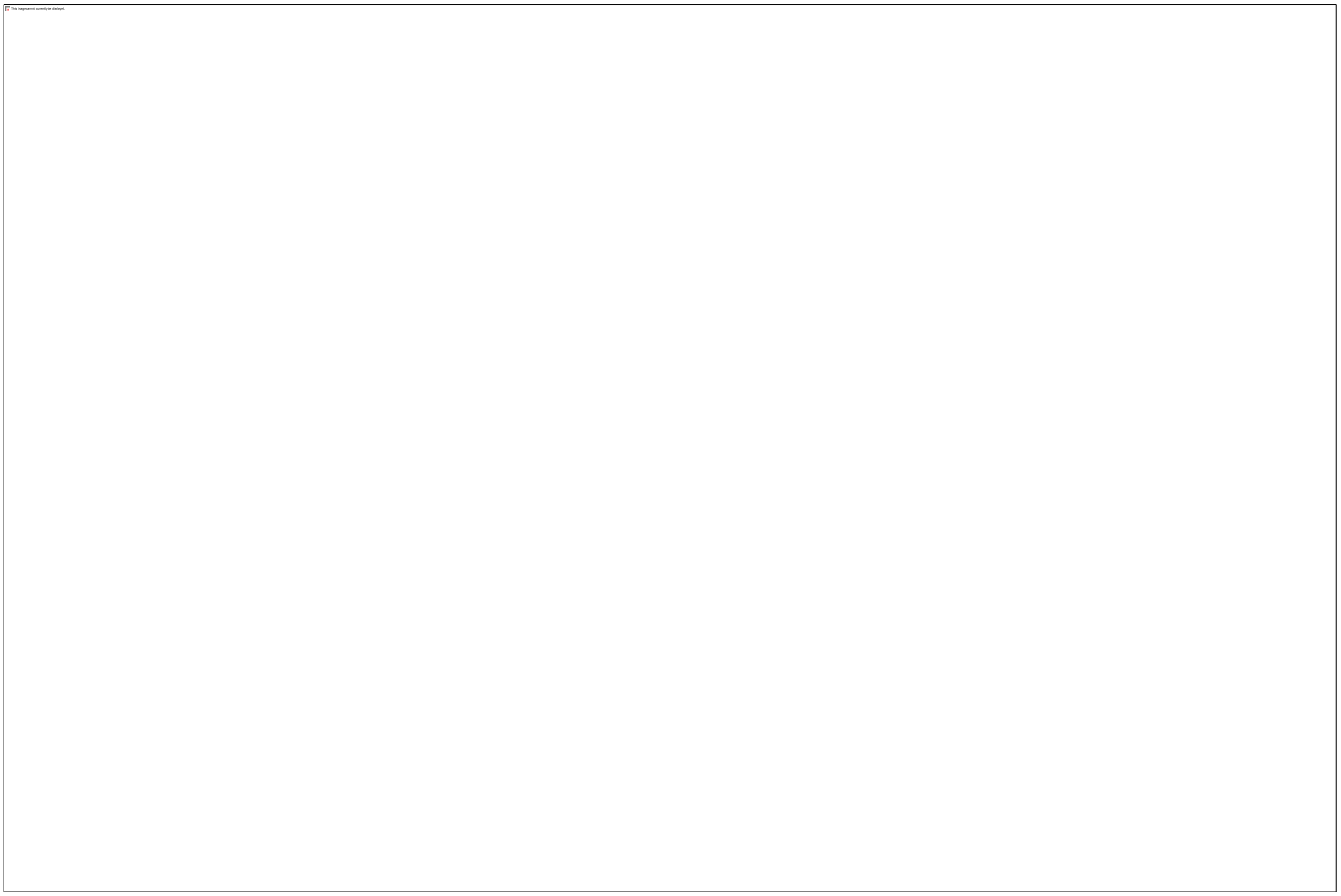
Drainage pattern diagrams

Drawing and interpreting different river arrangements.



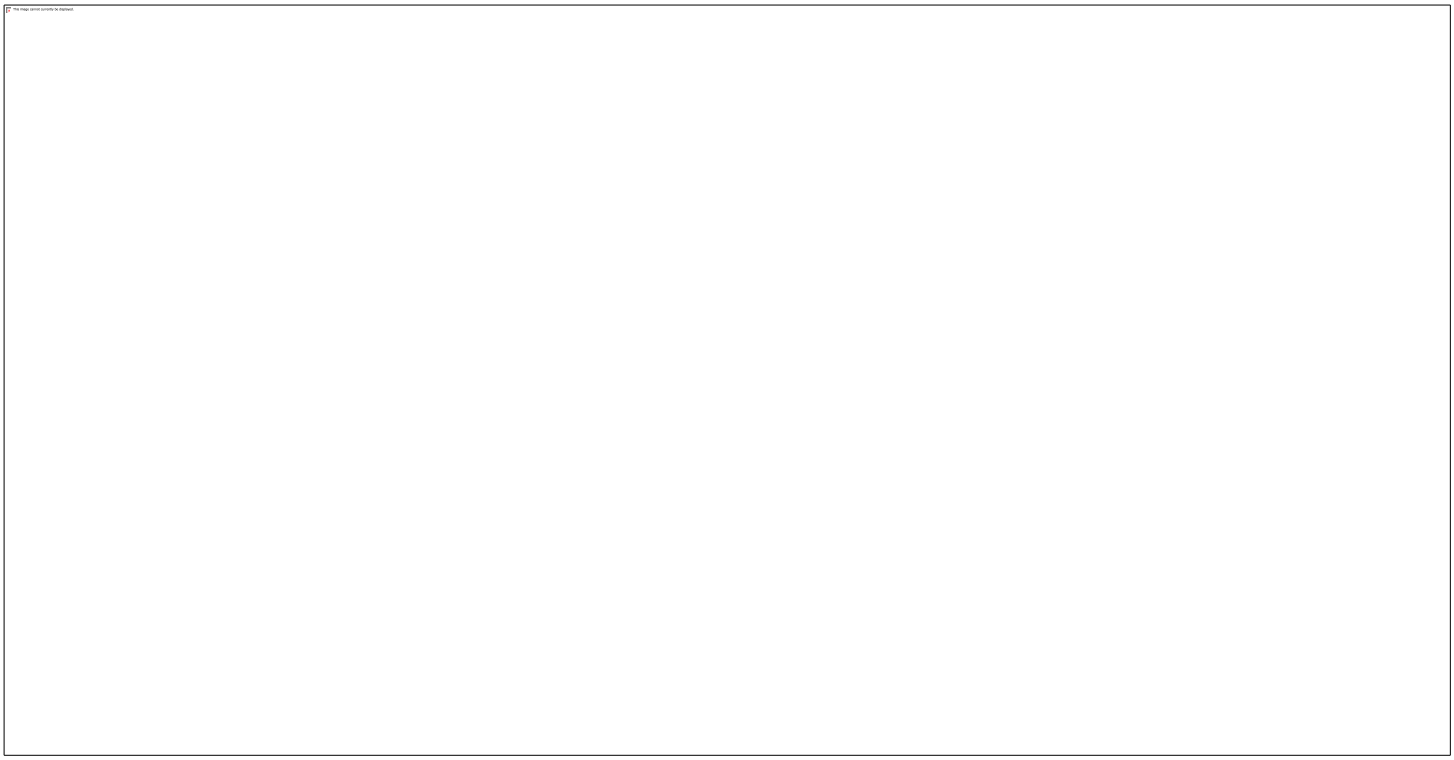
Fieldwork materials

Investigating local rivers and environmental conditions.



Kenyan river case studies

Understanding the economic significance of rivers.



River conservation projects

Promoting environmental responsibility and citizenship.

22.0 EXPECTED LEARNING ACHIEVEMENT

By the end of the sub-strand, the Grade 11 learner should be able to:

Define the water cycle and explain its importance.

Describe evaporation, transpiration, condensation and precipitation.

Explain infiltration, percolation, runoff and groundwater flow.

Analyse the significance of the water cycle to the community.

Explain river erosion, transportation and deposition.

Identify and explain landforms associated with different river courses.

Draw and interpret river drainage patterns.

Explain the economic and environmental importance of rivers.

Investigate contemporary environmental issues affecting rivers.

Recommend appropriate measures for sustainable river management.

Participate in community-based water conservation activities.

Demonstrate responsibility in protecting rivers and other water resources.

23.0 FINAL KEY LEARNING POINTS

The water cycle is a continuous natural process driven mainly by solar energy and gravity.

Evaporation and transpiration transfer water into the atmosphere.

Condensation leads to cloud formation, while precipitation returns water to the Earth's surface.

Infiltration and percolation replenish groundwater.

Surface runoff supplies water to rivers and lakes.

Rivers are natural channels that transport water from higher ground towards lower areas.

River action involves erosion, transportation and deposition.

Hydraulic action, abrasion, attrition and solution are the main processes of river erosion.

Traction, saltation, suspension and solution are the main methods of river transportation.

Waterfalls, gorges, potholes, meanders, floodplains, levees and deltas are examples of river landforms.

Drainage patterns are influenced by relief, geological structure and rock resistance.

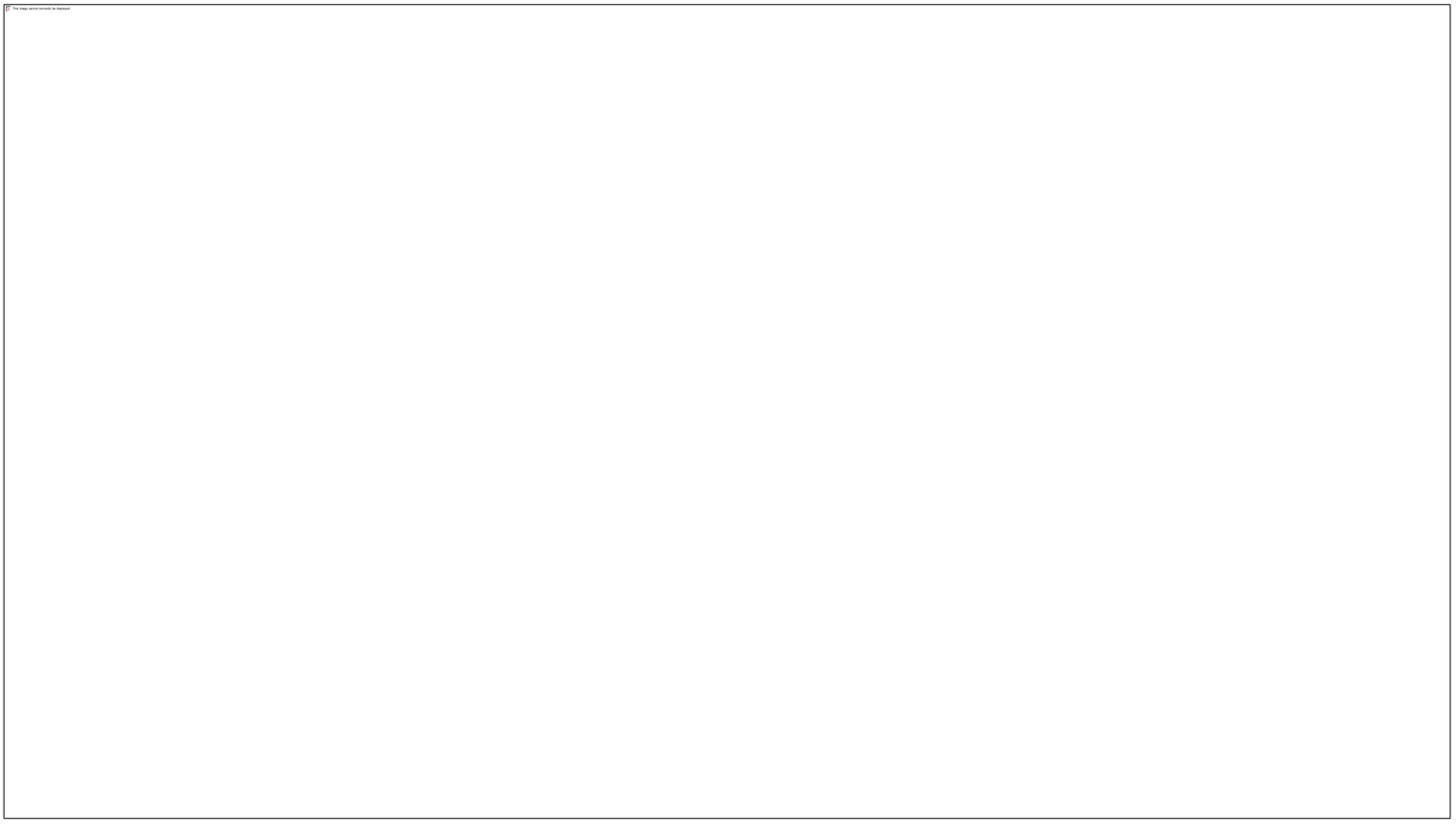
Rivers support agriculture, domestic water supply, industries, fishing, tourism and hydroelectric power generation.

River pollution, flooding, siltation, water scarcity and deforestation are major environmental challenges.

Sustainable river management requires cooperation between government institutions, communities, schools and other stakeholders.

STRAND 3.0: HUMAN AND ECONOMIC ACTIVITIES

SUB-STRAND 3.1: AGRICULTURE



COMPETENCY-BASED EDUCATION (CBE) • KENYAN CONTEXT • GRADE 11

1.0 Introduction to agriculture

Agriculture is one of the most important human economic activities. It involves the cultivation of crops and the rearing of animals for food, raw materials, income and other human needs.

Agriculture supports livelihoods, provides employment, promotes industrial development and contributes significantly to national economic growth.

In Kenya, agriculture is a major economic activity practised in different parts of the country depending on climate, soils, relief, water availability, capital and technology.

Examples include:

Wheat farming in Narok, Nakuru and Uasin Gishu counties.

Maize farming in Trans Nzoia, Uasin Gishu, Bungoma and Nakuru.

Coffee farming in Kiambu, Nyeri, Kirinyaga and Murang'a.

Tea farming in Kericho, Bomet, Nandi, Nyeri and Kiambu.

Dairy farming in Kiambu, Nyandarua, Nakuru and parts of Uasin Gishu.

Beef ranching in Laikipia, Kajiado, Narok and parts of the coastal region.

Agricultural practices differ from one country to another because of differences in physical and human factors.

1.1 Meaning of key agricultural terms

1. Agriculture

Agriculture refers to the practice of cultivating crops and rearing animals for food, income, industrial raw materials and other human requirements.

2. Agricultural system

An agricultural system refers to the organisation and interaction of inputs, processes and outputs involved in crop cultivation and livestock rearing.

3. Plantation agriculture

Plantation agriculture is a large-scale commercial farming system involving the cultivation of a single crop or a limited number of crops on extensive areas of land, mainly for sale and processing.

Examples:

Tea plantations in Kenya and Sri Lanka.

Coffee plantations in Brazil and Kenya.

Sugarcane plantations in Brazil.

Rubber plantations in Malaysia.

4. Commercial ranching

Commercial ranching is a large-scale livestock production system in which animals are reared on extensive areas of enclosed or managed land mainly for sale of meat, hides, skins and other livestock products.

Examples:

Beef ranching in Argentina.

Beef ranching in Kenya.

Commercial cattle ranching in Australia.

Beef ranching in the United States of America.

5. Large-scale farming

Large-scale farming refers to agricultural production carried out on extensive areas of land using substantial capital, labour, machinery, modern technology and organised management.

6. Subsistence farming

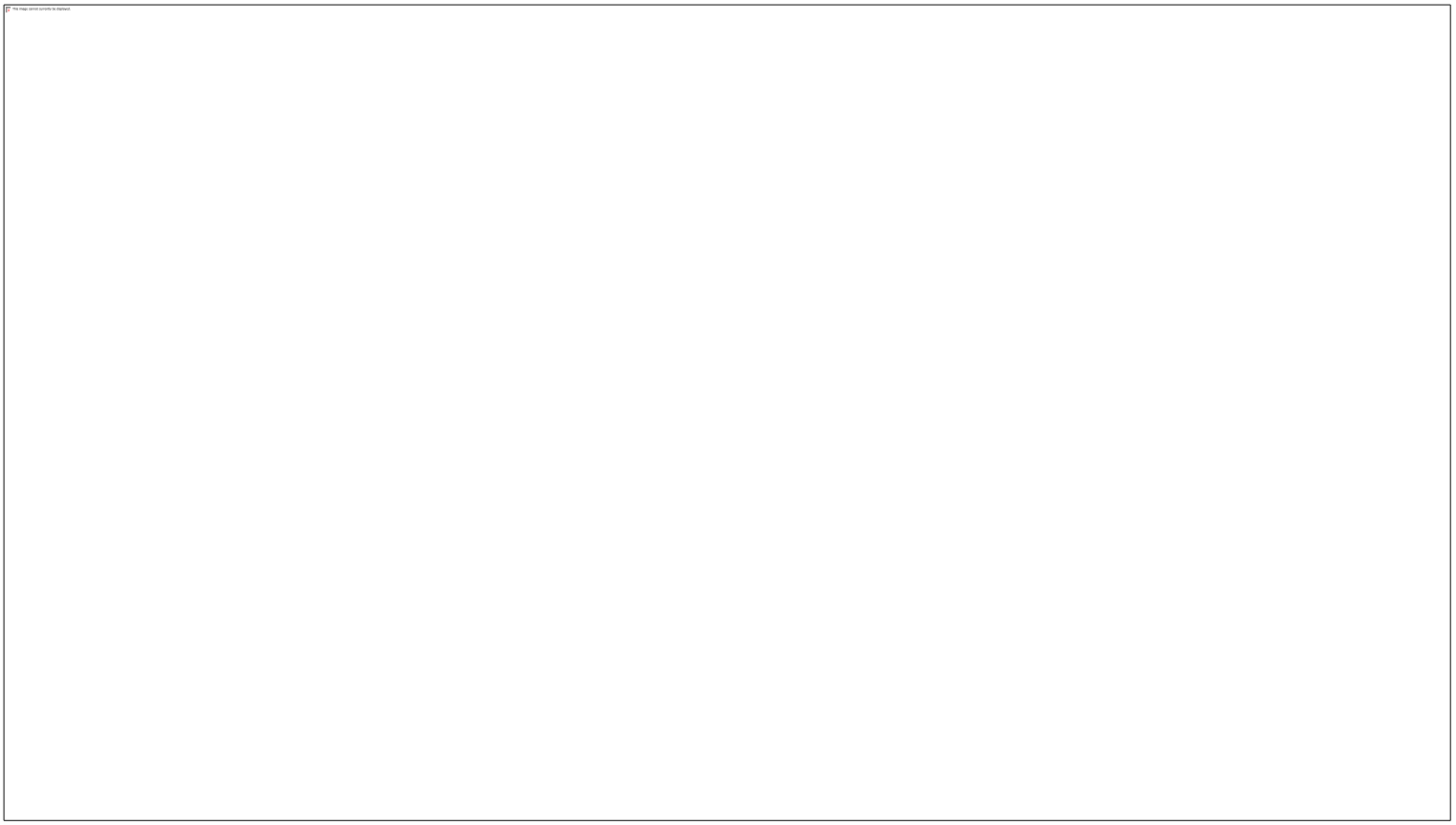
Subsistence farming is a farming system in which crops and livestock are mainly produced to meet the food and other basic needs of the farming household.

7. Commercial farming

Commercial farming is an agricultural system in which crops and livestock are produced mainly for sale and profit.

1.2 Components of an agricultural system

An agricultural system consists of three major components: inputs, processes and outputs.



A. Inputs

Inputs are the resources and materials introduced into an agricultural system to facilitate production.

They include:

Land: Provides the physical space for crop cultivation and livestock rearing.

Labour: Human effort used in ploughing, planting, weeding, spraying, harvesting and animal management.

Capital: Money and financial resources used to purchase land, machinery, fertilisers, seeds and livestock.

Seeds: Selected planting materials used to establish crops.

Fertilisers: Materials added to the soil to improve its nutrient content.

Water: Required for crop growth and livestock survival.

Machinery: Equipment such as tractors, combine harvesters, milking machines and irrigation equipment.

Technology: Scientific knowledge and modern methods used to improve production.

Management: Planning, supervision and decision-making involved in agricultural production.

B. Processes

Processes are the activities carried out to transform agricultural inputs into useful products.

Examples include:

Land preparation.

Planting and sowing.

Fertiliser application.

Irrigation.

Weeding.

Pest and disease control.

Feeding and breeding livestock.

Harvesting crops.

Milking animals.

Slaughtering and processing livestock products.

C. Outputs

Outputs are the products obtained from an agricultural system.

They include:

Food crops such as wheat, maize and rice.

Cash crops such as tea and coffee.

Milk and dairy products.

Beef and other meat products.

Hides and skins.

Wool and other animal fibres.

Agricultural waste used as manure.

Income and employment generated through agricultural activities.

Summary: An agricultural system operates through the interaction of inputs, processes and outputs. The efficiency of the system depends on how well the resources are organised and managed.

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1.3 Major agricultural systems in the world

Agricultural systems can be classified according to the purpose of production, size of farms, nature of crops grown, livestock management and methods of production.

A. Subsistence agriculture

This is a farming system in which agricultural products are mainly produced for consumption by the farmer and their family.

Characteristics:

Production is mainly for household consumption.

Farms are generally small.

Family labour is commonly used.

Simple farming tools such as hoes, pangas and ox-ploughs may be used.

Limited capital is invested.

Traditional farming methods are common.

A variety of crops may be grown on the same farm.

Surplus produce may be sold in local markets.

Examples in Kenya:

Small-scale maize farming in western Kenya.

Bean and maize farming in parts of Kisii.

Mixed farming in rural communities in Narok and Bomet.

B. Commercial agriculture

Commercial agriculture refers to the production of crops and livestock mainly for sale and profit.

Characteristics:

Production is market-oriented.

Large amounts of capital may be invested.

Modern machinery and technology are commonly used.

Specialised agricultural knowledge is required.

Improved seeds and animal breeds are used.

Production is often organised for local and international markets.

Processing and storage facilities may be available.

Farm management is professionally organised.

Examples:

Commercial wheat farming in Narok.

Tea farming in Kericho.

Commercial coffee production in Brazil.

Dairy farming in New Zealand.

C. Plantation agriculture

This is one of the main agricultural systems studied in this sub-strand.

1.4 Plantation agriculture in the world



Plantation agriculture involves the cultivation of crops on extensive areas of land, mainly for commercial purposes.

The crops are usually grown on specialised farms or estates and may be processed before being transported to local or international markets.

Examples of plantation crops include:

Tea.

Coffee.

Sugarcane.

Rubber.

Cocoa.

Oil palm.

Sisal.

Bananas.

Cotton.

Characteristics of plantation agriculture

1. **Large land holdings:** Plantation farms occupy extensive areas of land to facilitate commercial production.

2. **Specialisation:** A plantation usually concentrates on one major crop, although other crops may be grown.

3. **Commercial production:** Crops are produced mainly for sale rather than household consumption.

4. **High capital investment:** Money is required for land acquisition, machinery, fertilisers, chemicals, processing facilities and transport.

5. **Employment of labour:** Workers are employed to undertake planting, pruning, weeding, harvesting and processing.

6. **Scientific farming methods:** Modern techniques such as soil testing, improved seedlings, irrigation and pest control may be applied.

7. **Processing facilities:** Some plantations have factories where harvested crops are processed.

8. **Transport infrastructure:** Roads, railways and other transport systems facilitate the movement of produce.

9. **Organised management:** Production is supervised by farm managers, agricultural officers and other specialists.

10. **Export orientation:** Some plantation products are produced mainly for international markets.

11. **Specialised equipment:** Machinery such as tractors, sprayers, pruning machines and processing equipment may be used.

12. **Dependence on climate:** Each plantation crop requires suitable climatic and soil conditions.

Factors favouring plantation agriculture

Physical factors

1. Climate

Adequate rainfall supports crop growth.

Suitable temperatures promote germination, flowering and maturity.

For example, tea thrives in cool and wet highland environments.

2. Soil fertility

Deep, well-drained and fertile soils support healthy crop growth.

Volcanic soils in parts of Kenya favour tea and coffee cultivation.

3. Relief

Gentle slopes favour mechanisation and farm operations.

Highland areas may provide favourable temperatures for tea and coffee.

4. Water availability

Reliable rainfall and irrigation water support production.

Water is also needed in crop processing.

5. Length of growing season

A long growing season allows crops to mature and may support multiple harvesting seasons.

Human factors

Availability of capital.

Availability of skilled and unskilled labour.

Availability of extensive land.

Good transport networks.

Availability of processing industries.

Access to domestic and international markets.

Government agricultural policies.

Availability of agricultural research and extension services.

Political stability.

Access to modern farming technology.

Advantages of plantation agriculture

It creates employment opportunities for farm workers and factory employees.

It generates foreign exchange through the export of crops.

It provides raw materials for industries.

It promotes the development of roads, electricity and communication infrastructure.

It generates government revenue through taxes and other charges.

It encourages agricultural research and technological development.

It promotes the development of rural settlements and trading centres.

It provides income to farmers and agricultural companies.

It contributes to food security where food crops are cultivated.

It encourages the growth of transport and marketing services.

Disadvantages of plantation agriculture

1. **Monoculture:** Growing one crop repeatedly may deplete particular soil nutrients.

2. **Pest and disease outbreaks:** Concentration on one crop can increase vulnerability to certain pests and diseases.

3. **Land degradation:** Poor agricultural practices may cause soil erosion and loss of soil fertility.

4. **High capital requirements:** Establishing and maintaining plantations requires substantial financial investment.

5. **Market fluctuations:** Changes in international prices may reduce farmers' earnings.

6. **Environmental destruction:** Clearing natural vegetation to establish plantations may destroy habitats.

7. **Chemical pollution:** Excessive application of fertilisers and pesticides may contaminate water and soil.

8. **Labour exploitation:** Workers may experience low wages, poor working conditions and seasonal unemployment.

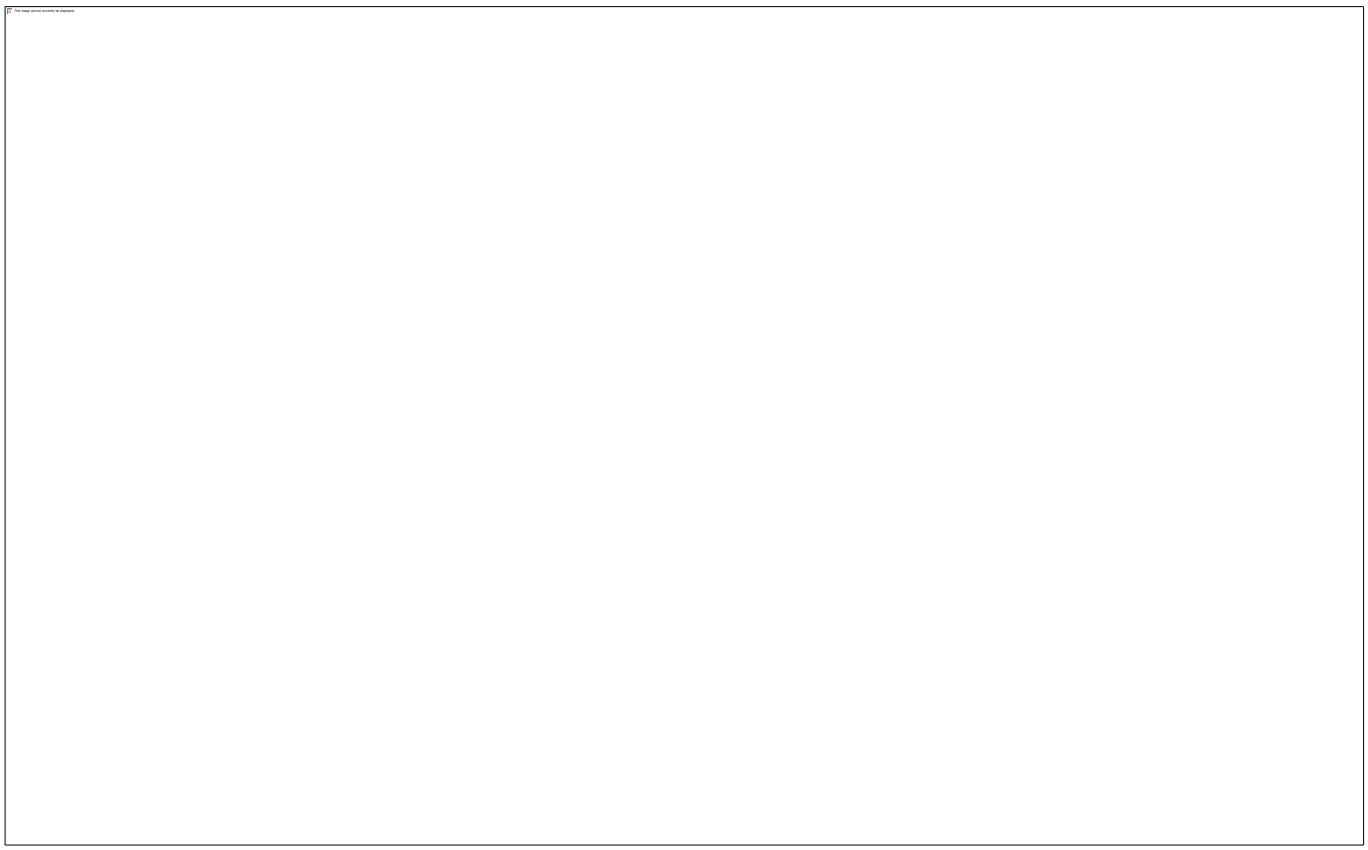
9. **Dependence on export markets:** International trade restrictions and changing demand can affect production.

10. **Competition for land:** Large estates may limit land availability for small-scale farmers and other activities.

2.0 Case studies of major agricultural activities in the world

The following case studies compare agricultural production in Kenya and selected countries. They illustrate how physical and human factors influence agricultural systems.

2.1 Wheat farming in Kenya and Russia



A. Wheat farming in Kenya

Wheat is an important cereal crop grown mainly for human consumption and commercial purposes.

It is used in making flour, bread, cakes, biscuits, chapatis and other food products.

Major wheat-growing areas in Kenya

Narok County.

Nakuru County.

Uasin Gishu County.

Trans Nzoia County.

Laikipia County.

Nyandarua County.

Meru highlands in suitable areas.

Conditions favouring wheat farming in Kenya

Physical factors

Cool temperatures in highland areas favour wheat growth.

Moderate rainfall supports germination and crop development.

Fertile volcanic and loamy soils support crop production.

Gently sloping land allows mechanised farming.

Suitable altitude provides favourable growing temperatures.

A relatively dry period during harvesting assists crop drying.

Human factors

Availability of large farms in areas such as Narok.

Availability of tractors and combine harvesters.

Access to agricultural credit.

Availability of improved wheat varieties.

Presence of research and extension services.

Availability of local markets and milling industries.

Good road networks connecting farms to markets.

Methods of wheat farming in Kenya

Land preparation using tractors and ploughs.

Harrowing to produce a suitable seedbed.

Planting certified wheat seeds.

Applying fertilisers to improve soil fertility.

Controlling weeds through mechanical or chemical methods.

Controlling pests and diseases.

Harvesting using combine harvesters.

Drying and cleaning the harvested grains.

Storing wheat in suitable facilities.

Transporting wheat to milling industries and markets.

Challenges facing wheat farming in Kenya

Unreliable rainfall and prolonged drought.

High costs of fertilisers, fuel and machinery.

Competition from imported wheat.

Pests and diseases, including wheat rust.

Land fragmentation in some farming areas.

Soil degradation and declining fertility.

Inadequate storage facilities.

Price fluctuations.

Limited access to affordable agricultural credit.

Post-harvest losses.

Possible solutions

Use drought-tolerant and disease-resistant varieties.

Improve access to certified seeds.

Encourage mechanisation.

Promote crop rotation.

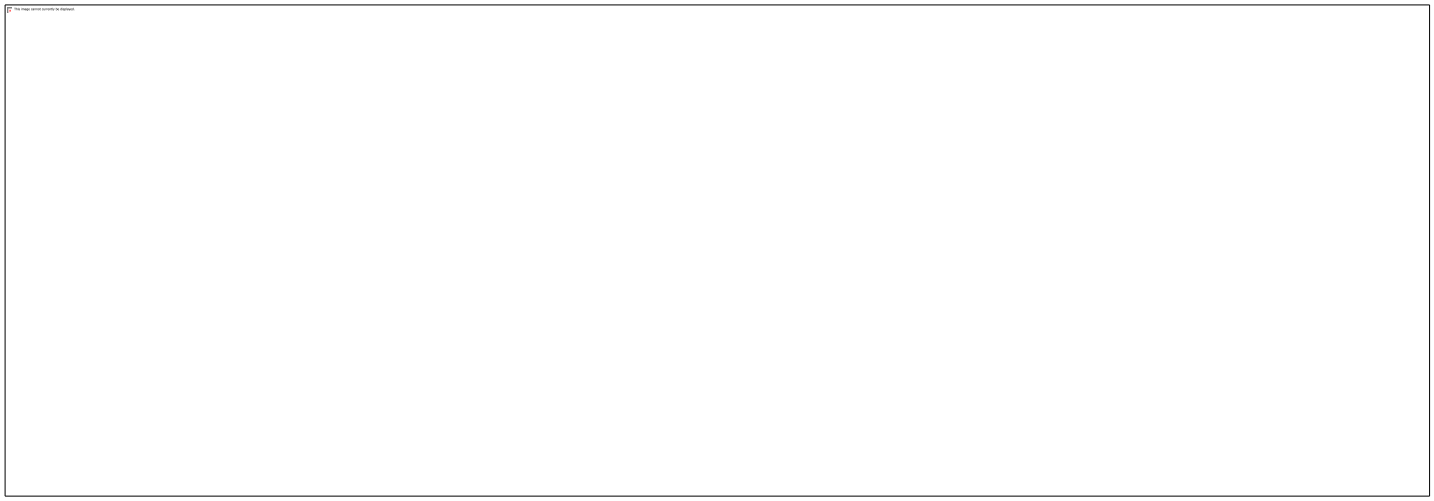
Improve grain storage facilities.

Strengthen agricultural extension services.

Improve access to affordable credit.

Support local wheat farmers through appropriate agricultural policies.

B. Wheat farming in Russia



Russia is among the world's important wheat-producing countries. Wheat is cultivated extensively in its agricultural plains and steppe regions.

Major wheat-growing regions

Southern Russia.

North Caucasus region.

Volga region.

Central Black Earth region.

Western Siberian agricultural region.

Conditions favouring wheat farming in Russia

Physical factors

Extensive plains provide large areas of cultivable land.

Fertile chernozem soils support high agricultural productivity.

Warm summers support wheat growth and maturity.

Relatively dry conditions during harvesting favour grain collection.

Extensive steppe grasslands provide suitable agricultural land.

Suitable summer daylight conditions support crop growth in some regions.

Human factors

Availability of extensive agricultural land.

High levels of mechanisation.

Availability of modern agricultural machinery.

Government support and agricultural research.

Developed transport systems.

Availability of grain storage and processing facilities.

Access to international markets.

Methods of wheat farming in Russia

Large-scale land preparation using tractors.

Mechanised sowing.

Application of fertilisers.

Use of improved seed varieties.

Chemical and mechanical weed control.

Mechanised harvesting using combine harvesters.

Grain drying, grading and storage.

Transportation to domestic and export markets.

Challenges facing wheat farming in Russia

Extremely cold winters.

Short growing seasons in northern areas.

Drought in some agricultural regions.

Soil erosion and degradation.

Changing climatic conditions.

High machinery and fuel costs.

Transport challenges in remote areas.

Agricultural trade restrictions and market uncertainties.

C. Comparison between wheat farming in Kenya and Russia

Kenya	Russia
Mainly grown in highland and plateau areas.	Mainly grown in extensive plains and steppe regions.
Relatively small national production compared with Russia.	One of the world's major wheat producers.
Production occurs in favourable highland climatic conditions.	Production depends heavily on summer growing seasons.
Some farms use machinery while others rely on manual labour.	Extensive mechanisation is common on large farms.
Domestic demand is supplemented by imports.	Significant quantities are exported.
Land holdings vary considerably in size.	Extensive commercial farms are common.

Learning point: Both countries grow wheat commercially, but differences in land size, climate, technology and market organisation influence their production levels.

2.2 Maize farming in Kenya and Mexico



A. Maize farming in Kenya

Maize is one of the most important staple food crops in Kenya. It is consumed in different forms, including ugali, porridge and roasted maize.

It is also used in animal feeds and food-processing industries.

Major maize-growing areas in Kenya

Trans Nzoia.

Uasin Gishu.

Bungoma.

Kakamega.

Nandi.

Nakuru.

Narok.

Kericho.

parts of Western and Nyanza regions.

Conditions favouring maize farming in Kenya

Moderate to high rainfall in major growing regions.

Warm temperatures suitable for maize growth.

Fertile loamy and volcanic soils.

Availability of extensive agricultural land.

Suitable growing seasons.

Availability of improved seed varieties.

Access to agricultural extension services.

Availability of labour.

Developed local markets.

Government agricultural support programmes.

Methods of maize farming in Kenya

Clearing and preparing land.

Ploughing and harrowing.

Planting certified maize seeds.

Applying basal fertilisers.

Top-dressing with appropriate fertilisers.

Thinning and gap filling where necessary.

Weeding.

Controlling pests such as fall armyworm.

Harvesting mature cobs.

Drying and shelling maize.

Proper storage to prevent aflatoxin contamination and pest damage.

Marketing and processing the grain.

Challenges facing maize farming in Kenya

Unreliable rainfall.

Fall armyworm infestation.

Maize lethal necrosis disease.

High input costs.

Inadequate storage.

Aflatoxin contamination.

Poor market prices.

Land fragmentation.

Soil fertility decline.

Limited access to affordable credit.

Solutions

Promote irrigation and water harvesting.

Use certified and disease-resistant seeds.

Apply integrated pest management.

Improve grain drying and storage.

Promote soil conservation.

Encourage crop rotation and intercropping where suitable.

Strengthen agricultural extension services.

Improve access to markets and agricultural credit.

B. Maize farming in Mexico



Mexico is historically important in maize domestication. Maize remains a major food crop and an important part of Mexican culture and agriculture.

It is used to prepare foods such as tortillas, tamales and other traditional dishes.

Major maize-growing regions

Sinaloa.

Jalisco.

Guanajuato.

Michoacán.

Chiapas.

Estado de México.

Puebla.

Conditions favouring maize farming in Mexico

Warm temperatures in many growing regions.

Seasonal rainfall in major agricultural areas.

Irrigation facilities in some commercial farming regions.

Fertile volcanic soils in suitable areas.

Availability of indigenous maize varieties.

Availability of improved hybrid seeds.

Large domestic demand for maize.

Agricultural research and technology.

Availability of agricultural labour.

Developed food-processing industries.

Methods of maize farming in Mexico

Traditional cultivation using local seed varieties.

Mechanised cultivation in commercial farming areas.

Irrigation in dry agricultural regions.

Use of fertilisers and improved seeds.

Weed and pest control.

Harvesting and drying of cobs.

Processing into flour and other products.

Marketing through domestic and international supply chains.

Challenges facing maize farming in Mexico

Drought and water shortages.

Soil erosion in sloping areas.

Climate change.

Small and fragmented farms in some regions.

Competition from imported maize.

High agricultural production costs.

Pests and crop diseases.

Unequal access to irrigation and modern technology.

C. Comparison between maize farming in Kenya and Mexico

Kenya	Mexico
Maize is a major staple food crop.	Maize is a major staple and culturally important crop.
Common in the highlands and western regions.	Grown in several climatic and geographical regions.
Production ranges from small-scale to large-scale.	Both traditional and commercial systems are practised.
Ugali is a common maize food.	Tortillas are a common maize food.
Rain-fed farming is widespread.	Both rain-fed and irrigated farming occur.
Production faces storage and pest challenges.	Production faces drought and water availability challenges.

2.3 Coffee farming in Kenya and Brazil



Coffee is an important beverage crop grown commercially in tropical and subtropical regions.

The beans are processed and roasted to produce coffee, which is consumed locally and exported internationally.

A. Coffee farming in Kenya

Kenya produces high-quality Arabica coffee, which is valued in international markets for its flavour and aroma.

Major coffee-growing areas in Kenya

Kiambu.

Nyeri.

Kirinyaga.

Murang'a.

Embu.

Meru.

Machakos.

Thika region.

parts of Kisii and Bungoma.

Conditions favouring coffee farming in Kenya

Physical factors

Moderate temperatures in highland areas.

Reliable rainfall.

Deep, well-drained volcanic soils.

Suitable altitude.

Gentle slopes that permit drainage.

Adequate sunshine for fruit development.

Suitable climatic conditions for Arabica coffee.

Human factors

Availability of skilled labour.

Presence of coffee research institutions.

Availability of coffee factories.

Cooperative societies that assist farmers in processing and marketing.

Good transport networks.

Access to local and international markets.

Availability of improved coffee seedlings.

Methods of coffee farming in Kenya

Selecting suitable land.

Preparing the planting holes.

Planting improved coffee seedlings.

Applying manure and fertilisers.

Mulching to conserve soil moisture.

Pruning coffee trees.

Controlling weeds.

Managing pests and diseases.

Harvesting ripe coffee berries.

Pulping and fermenting the beans where the wet-processing method is used.

Washing and drying coffee.

Grading and marketing the processed beans.

Challenges facing coffee farming in Kenya

Fluctuation of international coffee prices.

High production costs.

Coffee berry disease.

Coffee leaf rust.

Climate change.

Delayed payments to farmers.

Limited access to affordable credit.

Ageing coffee trees.

Competition from other land uses.

Poor management of some cooperatives and processing facilities.

Solutions

Plant improved and disease-resistant coffee varieties.

Rehabilitate old coffee plantations.

Strengthen cooperative management.

Improve access to credit.

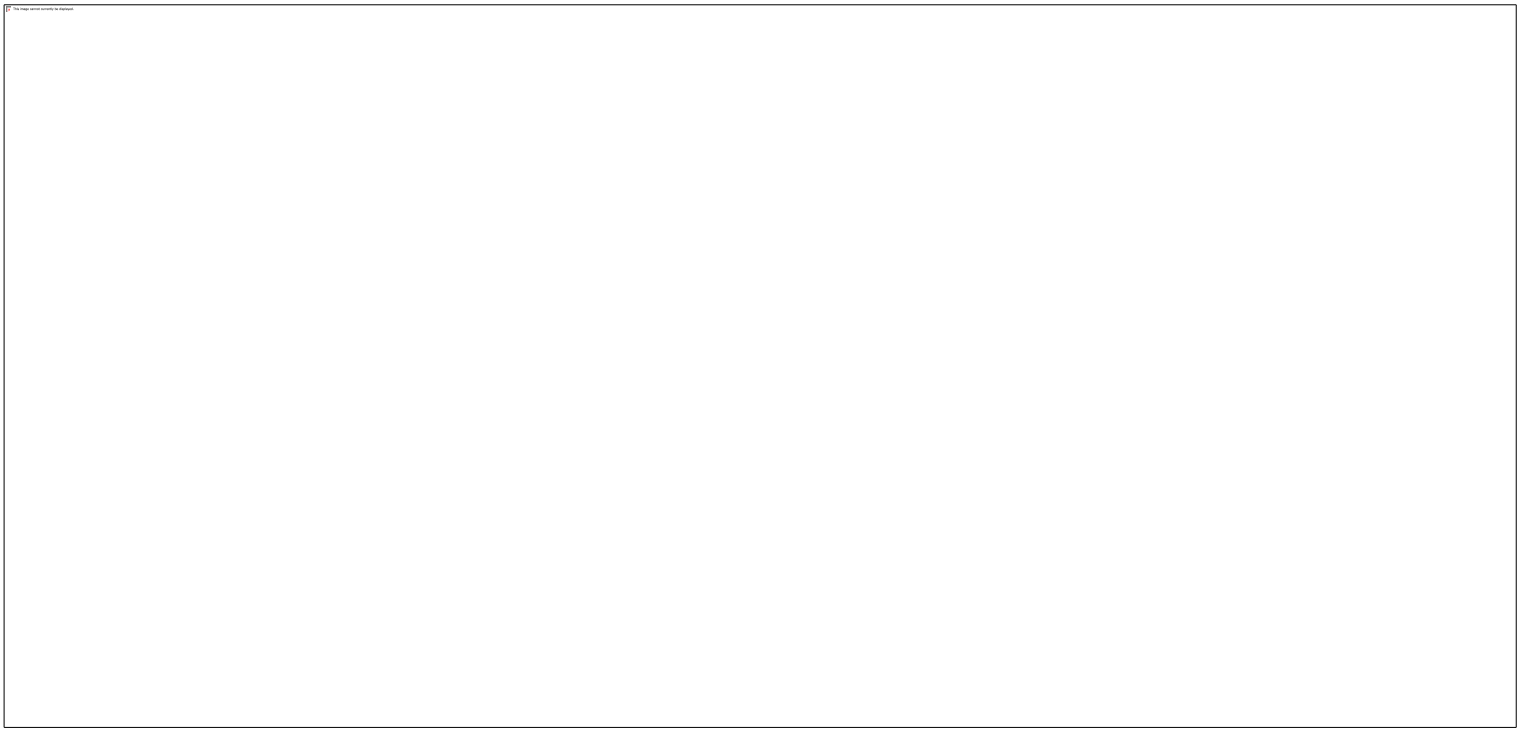
Promote value addition.

Improve market access.

Encourage climate-smart agriculture.

Strengthen agricultural research and extension services.

B. Coffee farming in Brazil



Brazil is the world's leading coffee-producing country. Coffee is an important commercial crop and a major agricultural export.

Major coffee-growing states

Minas Gerais.

Espírito Santo.

São Paulo.

Bahia.

Paraná.

Rondônia.

Brazil produces both Arabica and Robusta (Conilon) coffee.

Conditions favouring coffee farming in Brazil

Extensive areas of suitable agricultural land.

Suitable tropical and subtropical climates.

Well-drained soils.

Adequate rainfall in major coffee-producing areas.

Suitable temperatures for coffee growth.

Large-scale commercial farming.

Availability of modern machinery.

Developed coffee-processing industries.

Good transport and export facilities.

Strong domestic and international markets.

Methods of coffee farming in Brazil

Large-scale establishment of coffee plantations.

Use of improved coffee seedlings.

Mechanised land preparation.

Application of fertilisers.

Irrigation in some regions.

Mechanised and manual harvesting depending on terrain and production system.

Drying and processing of coffee beans.

Grading and packaging.

Transportation to processing centres and export markets.

Challenges facing coffee farming in Brazil

Drought and irregular rainfall.

Frost in some southern coffee-growing areas.

Climate change.

Coffee pests and diseases.

Fluctuating international prices.

Labour shortages and rising labour costs.

Soil degradation.

Environmental pressure from land clearing.

C. Comparison between coffee farming in Kenya and Brazil

Kenya	**Brazil**
Mainly produces Arabica coffee.	Produces Arabica and Robusta coffee.
Coffee farms include smallholder holdings and estates.	Extensive commercial plantations and smallholder farms exist.
Highland regions are important growing areas.	Tropical and subtropical regions support production.
Wet processing is widely practised.	Both wet and dry processing are used.
Production is relatively smaller.	Brazil is the world's leading producer.
Cooperative societies play an important role.	Large commercial companies and organised producer networks are important.

2.4 Tea farming in Kenya and Sri Lanka



Tea is a major plantation crop cultivated mainly in tropical and subtropical highland regions.

It is processed into black tea, green tea and other tea products.

A. Tea farming in Kenya

Kenya is among the world's leading tea producers and exporters. Tea is an important source of employment and foreign exchange.

Major tea-growing areas in Kenya

Kericho.

Bomet.

Nandi.

Nyeri.

Kiambu.

Murang'a.

Kirinyaga.

Embu.

Meru.

Kisii and Nyamira.

Conditions favouring tea farming in Kenya

Physical factors

High and reliable rainfall.

Cool temperatures in highland areas.

Deep, acidic and well-drained soils.

High altitude.

Frequent moisture availability.

Gentle slopes in suitable areas.

Long growing seasons.

Human factors

Availability of labour.

Presence of tea factories.

Good transport infrastructure.

Government support and agricultural research.

Access to international markets.

Availability of improved tea varieties.

Organised smallholder tea production through KTDA-managed structures and private estates.

Methods of tea farming in Kenya

Preparing suitable land.

Establishing tea nurseries.

Planting tea seedlings or vegetatively propagated planting materials.

Applying fertilisers.

Pruning tea bushes.

Regular weeding.

Controlling pests and diseases.

Plucking young tea shoots.

Transporting green leaf to factories.

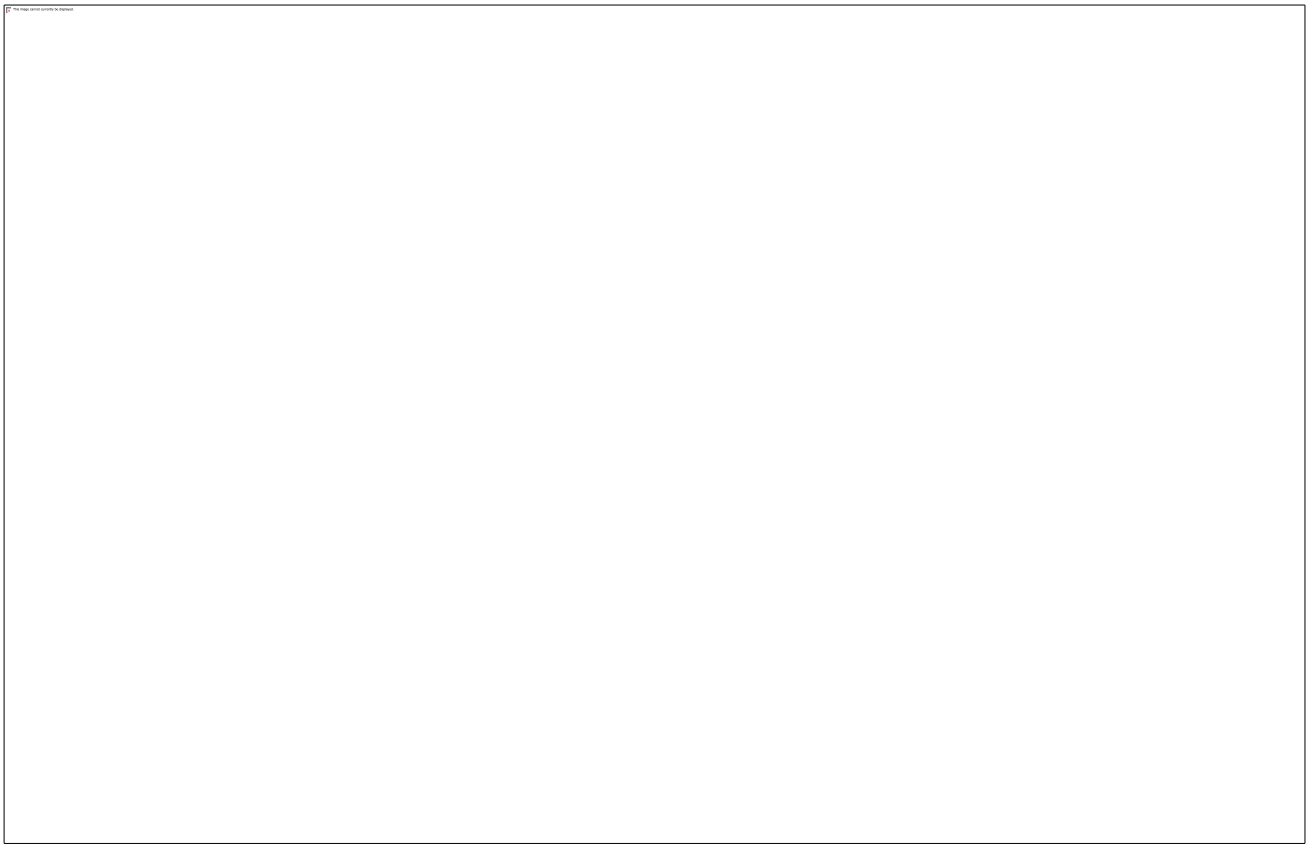
Withering the tea leaves.

Rolling and cutting the leaves.

Fermenting or oxidising black tea.

Drying and grading the processed tea.

Packaging and marketing.



Challenges facing tea farming in Kenya

Climate variability.

High costs of farm inputs.

Low prices during periods of oversupply.

Inadequate roads in some tea-growing areas.

Delays in payment to farmers.

Tea pests and diseases.

Competition in international tea markets.

Labour shortages.

Soil erosion.

Limited diversification of tea products.

Solutions

Improve tea quality and value addition.

Promote climate-smart tea production.

Improve roads and transport facilities.

Strengthen tea marketing organisations.

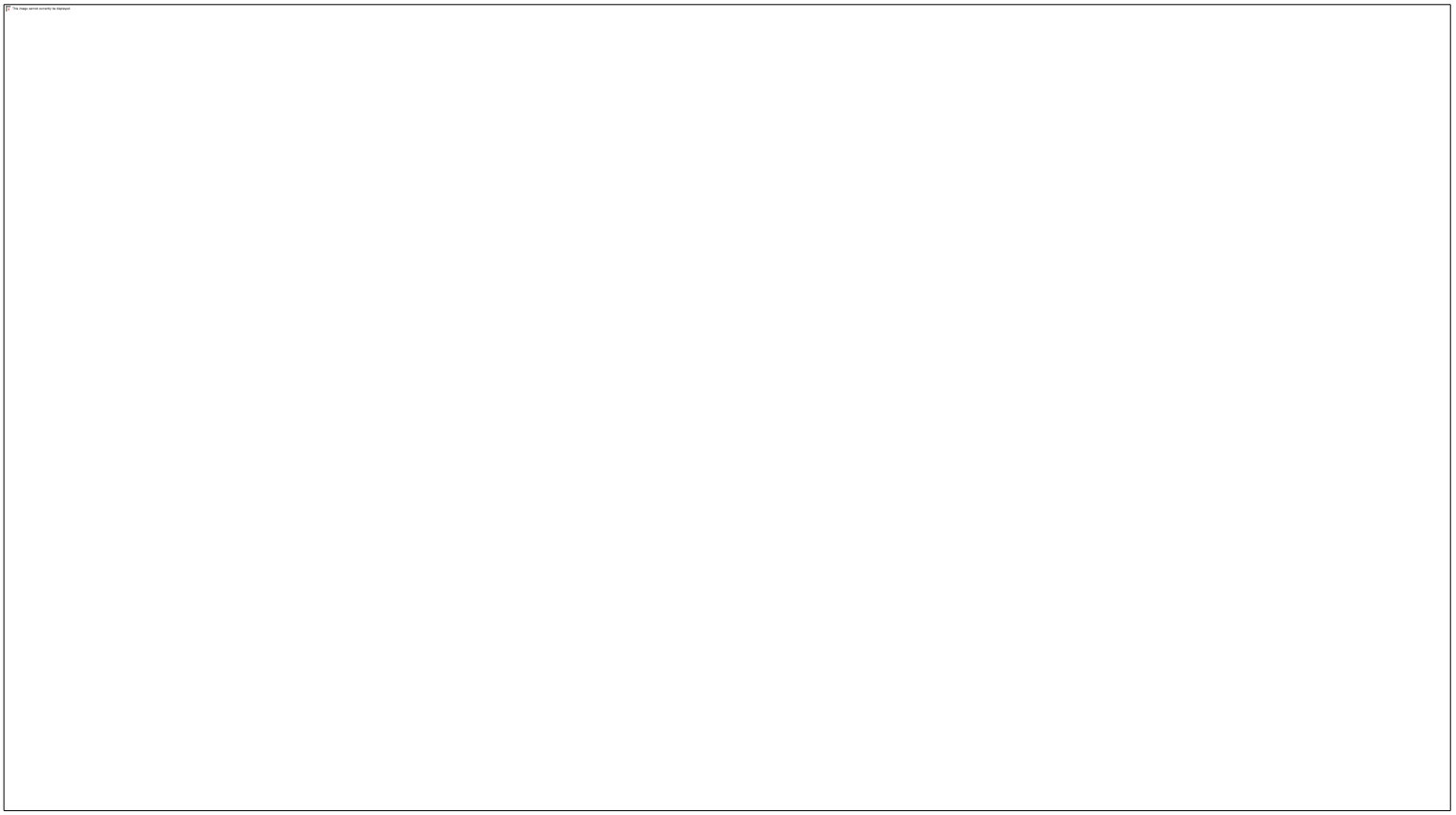
Encourage research into improved tea varieties.

Improve processing efficiency.

Promote diversification of tea products.

Improve access to agricultural inputs.

B. Tea farming in Sri Lanka



Sri Lanka is an important tea-producing and exporting country. Its tea is commonly marketed as Ceylon Tea.

Tea cultivation was introduced during the colonial period and developed into a major plantation industry.

Major tea-growing areas in Sri Lanka

Nuwara Eliya.

Kandy.

Dimbula.

Uva.

Ruhuna.

Sabaragamuwa.

Conditions favouring tea farming in Sri Lanka

High rainfall in suitable tea-growing regions.

Cool temperatures in high-altitude areas.

Fertile and well-drained soils.

Extensive highland areas.

Suitable moisture conditions.

Availability of labour.

Established tea-processing industries.

Developed transport and export networks.

International reputation for tea quality.

Government and private-sector support.

Methods of tea farming in Sri Lanka

Establishing tea estates.

Planting selected tea varieties.

Maintaining tea bushes through pruning.

Applying fertilisers.

Controlling pests and diseases.

Regular plucking.

Transporting leaves to factories.

Processing and grading.

Packaging and branding.

Exporting tea to international markets.

Challenges facing tea farming in Sri Lanka

Climate change.

Rising production costs.

Labour shortages.

Fluctuating international prices.

Soil erosion on steep slopes.

Fertiliser supply challenges.

Competition from other tea-producing countries.

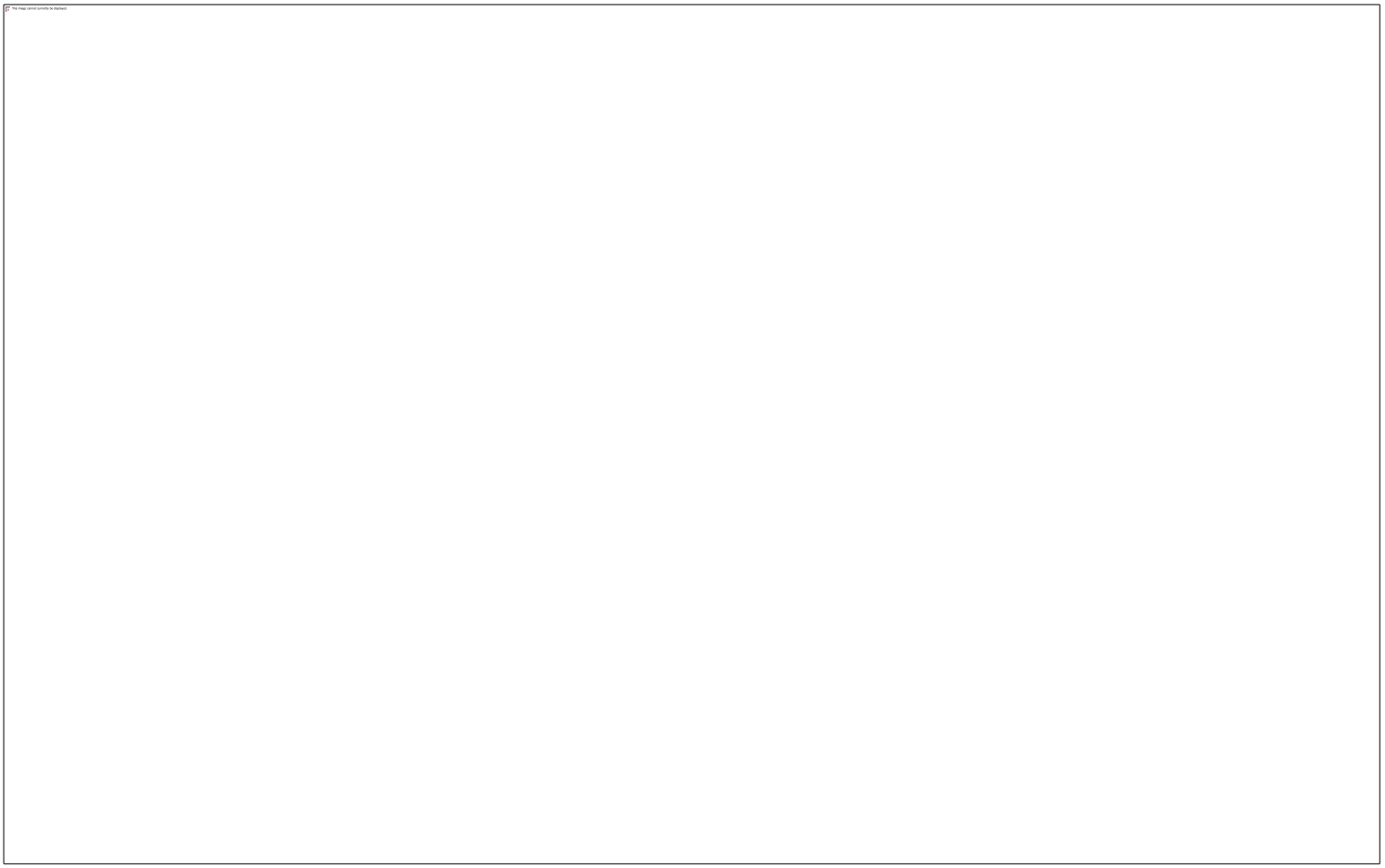
Changes in global consumer demand.

C. Comparison between tea farming in Kenya and Sri Lanka

Kenya	Sri Lanka
Important tea regions include Kericho and Nandi.	Important regions include Nuwara Eliya and Kandy.
Both smallholder and estate farming are practised.	Both estate and smallholder systems exist.
Produces substantial quantities of black tea.	Produces black tea and other specialised tea products.
Tea is an important foreign exchange earner.	Tea is an important export commodity.
Tea is marketed through organised auction and direct sales systems.	Tea is marketed through auctions and other export channels.
Production is concentrated in highland regions.	Production is concentrated in central highlands and other suitable regions.

‘

2.5 Dairy farming in Kenya and New Zealand



Meaning of dairy farming

Dairy farming is the rearing and management of livestock, particularly cattle, for the production of milk and other dairy products.

Dairy products include:

Fresh milk.

Yoghurt.

Butter.

Cheese.

Cream.

Milk powder.

Ghee.

A. Dairy farming in Kenya

Dairy farming is an important livestock activity in Kenya. It provides milk for domestic consumption and raw materials for the dairy-processing industry.

Major dairy farming areas in Kenya

Kiambu.

Nyandarua.

Nakuru.

Uasin Gishu.

Nandi.

Kericho.

Nyeri.

Murang'a.

Meru.

parts of Bomet.

Conditions favouring dairy farming in Kenya

Physical factors

Moderate temperatures.

Reliable rainfall.

Availability of natural pasture.

Fertile soils for fodder production.

Availability of water.

Highland climates that support dairy cattle.

Suitable grazing and fodder-growing land.

Human factors

Availability of improved dairy breeds.

Access to veterinary services.

Availability of animal feeds.

Good transport networks.

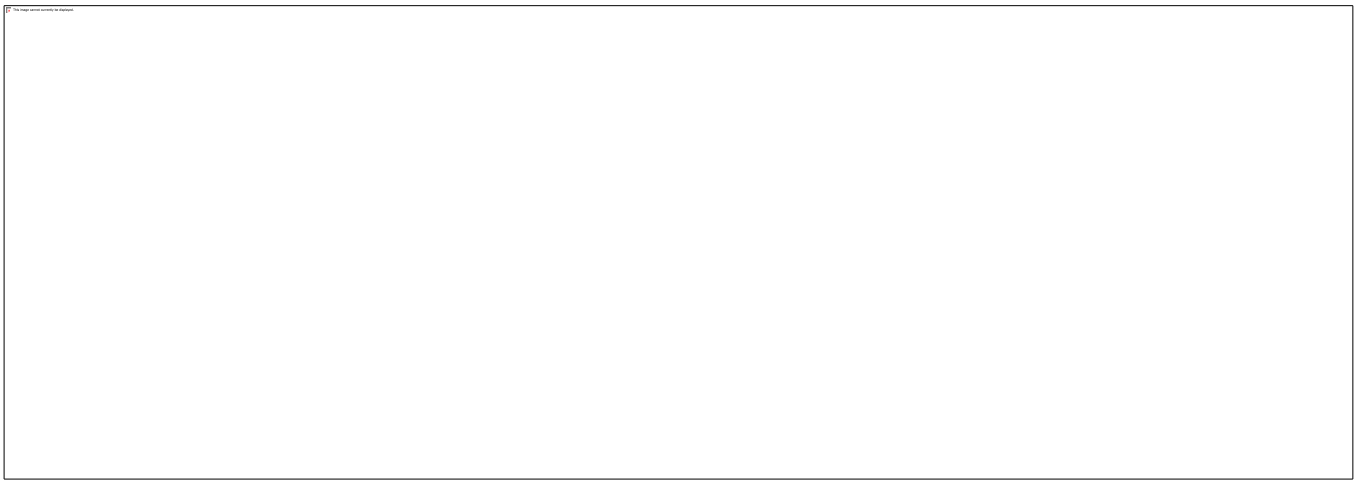
Availability of milk-processing factories.

Access to local markets.

Agricultural training and extension services.

Availability of artificial insemination services.

Common dairy cattle breeds in Kenya



Friesian: A large dairy breed known for high milk production under good management.

Ayrshire: A dairy breed valued for milk production and adaptability.

Jersey: A relatively small breed that produces milk with high butterfat content.

Guernsey: A dairy breed known for milk with relatively high butterfat and protein content.

Methods of dairy farming in Kenya

Selection of suitable dairy breeds.

Construction of appropriate cattle housing.

Provision of adequate fodder and concentrates.

Providing clean drinking water.

Regular vaccination and disease control.

Breeding through natural service or artificial insemination.

Milking under hygienic conditions.

Cooling and storing milk appropriately.

Transporting milk to collection centres.

Marketing milk and dairy products.

Challenges facing dairy farming in Kenya

High cost of animal feeds.

Livestock diseases.

Inadequate veterinary services.

Climate change and drought.

Poor-quality breeding animals.

Fluctuating milk prices.

Inadequate milk cooling facilities.

High costs of veterinary drugs.

Inadequate water supply.

Poor pasture management.

Solutions

Promote fodder conservation through hay and silage making.

Improve access to veterinary services.

Encourage artificial insemination using suitable breeds.

Promote proper animal nutrition.

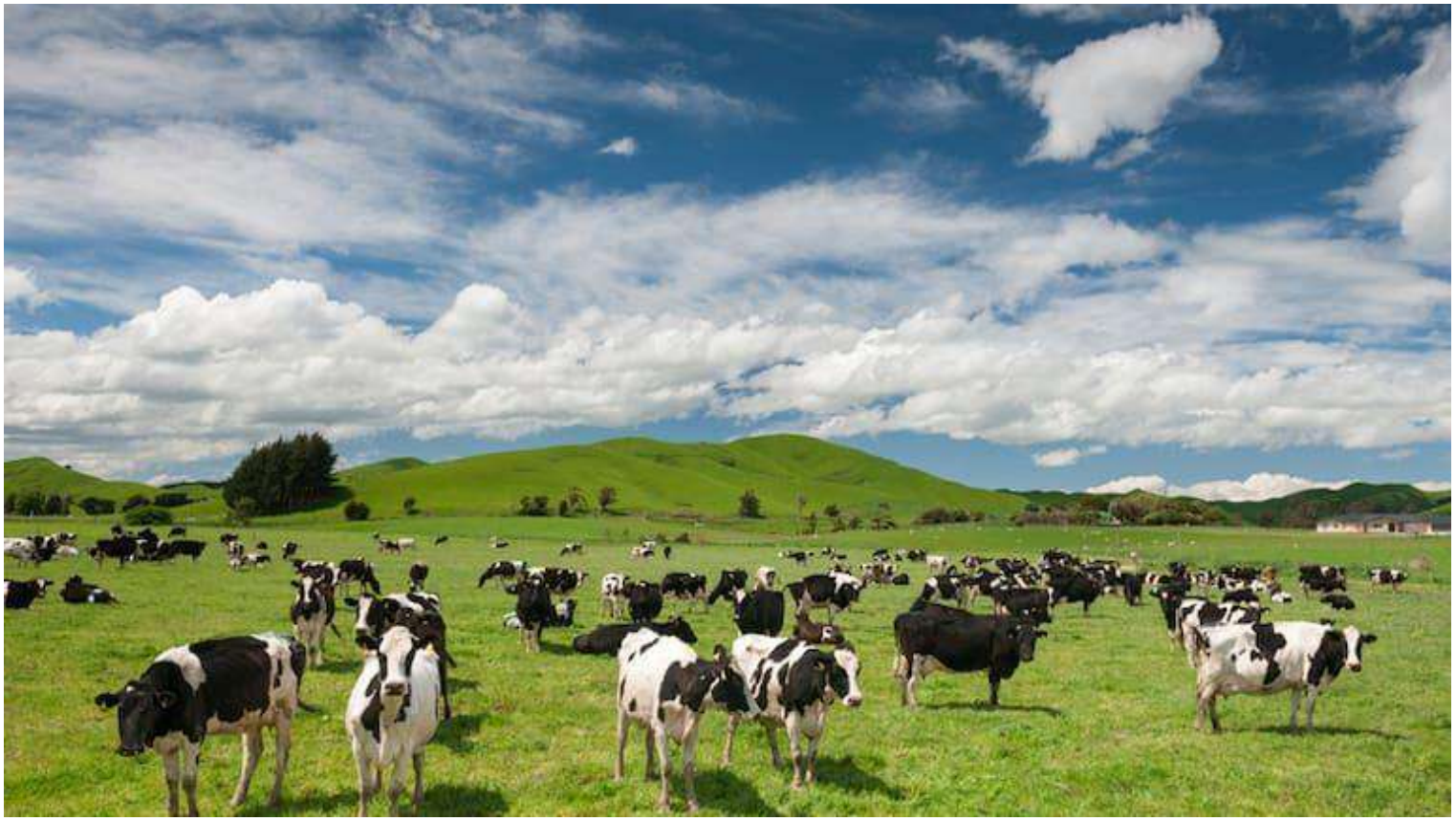
Improve milk cooling and storage.

Encourage dairy farmer cooperatives.

Improve pasture management.

Promote climate-smart dairy farming.

B. Dairy farming in New Zealand



New Zealand is internationally recognised for its highly developed commercial dairy industry.

Dairy farming is an important economic activity, and milk products are major agricultural exports.

Major dairy farming regions

Waikato.

Canterbury.

Taranaki.

Southland.

Manawatū.

Northland.

Conditions favouring dairy farming in New Zealand

Extensive grasslands.

Temperate maritime climate.

Reliable rainfall in major dairy regions.

Availability of clean water.

Fertile soils in suitable agricultural areas.

Large areas of grazing land.

Improved dairy cattle breeds.

Advanced livestock management systems.

Modern milk-processing facilities.

Developed export infrastructure.

Methods of dairy farming in New Zealand

Keeping improved dairy cattle breeds.

Practising pasture-based feeding.

Rotational grazing.

Supplementing pasture with conserved fodder where necessary.

Providing mineral supplements.

Using modern milking machines.

Applying artificial insemination.

Practising herd health management.

Cooling and processing milk.

Manufacturing dairy products for export.

Challenges facing dairy farming in New Zealand

Environmental pollution from livestock waste.

Greenhouse gas emissions, particularly methane.

Drought in some agricultural regions.

High costs of farm management.

International market competition.

Animal welfare concerns.

Nutrient runoff into rivers and lakes.

Fluctuating international dairy prices.

C. Comparison between dairy farming in Kenya and New Zealand

Kenya	New Zealand
Smallholder and large-scale systems are practised.	Large-scale commercial systems are prominent.
Zero-grazing and semi-zero-grazing are common in some regions.	Pasture-based grazing is widespread.
Milk is mainly produced for domestic consumption, with some exports.	A substantial proportion of production is exported.
Feed shortages may occur during dry seasons.	Pasture is a major feed resource, supplemented when necessary.
Mechanisation varies between farms.	High levels of mechanisation and technology are common.
Dairy cooperatives are important in milk collection.	Large dairy processing and marketing organisations are prominent.

2.6 Beef farming in Kenya and Argentina



Meaning of beef farming

Beef farming refers to the rearing of cattle mainly for meat production.

Beef cattle are raised for:

Meat.

Hides and skins.

Manure.

Income from livestock sales.

Breeding stock.

A. Beef farming in Kenya

Beef farming is practised in different parts of Kenya, particularly in the arid and semi-arid lands (ASALs).

It is important for food security, employment, income generation and the livestock-processing industry.

Major beef-producing areas in Kenya

Kajiado.

Narok.

Laikipia.

Samburu.

Isiolo.

Garissa.

Tana River.

Turkana.

Marsabit.

parts of Kitui and Makueni.

Conditions favouring beef farming in Kenya

Physical factors

Extensive grazing land.

Natural grasslands and savannah vegetation.

Relatively low population density in some ranching areas.

Availability of seasonal water sources.

Suitable temperatures for adapted cattle breeds.

Vegetation suitable for grazing livestock.

Human factors

Availability of livestock markets.

Presence of improved beef cattle breeds.

Availability of veterinary services.

Access to roads and transport.

Availability of ranching capital.

Meat-processing facilities.

Access to local and regional markets.

Government livestock development programmes.

Common beef cattle breeds in Kenya

Boran.

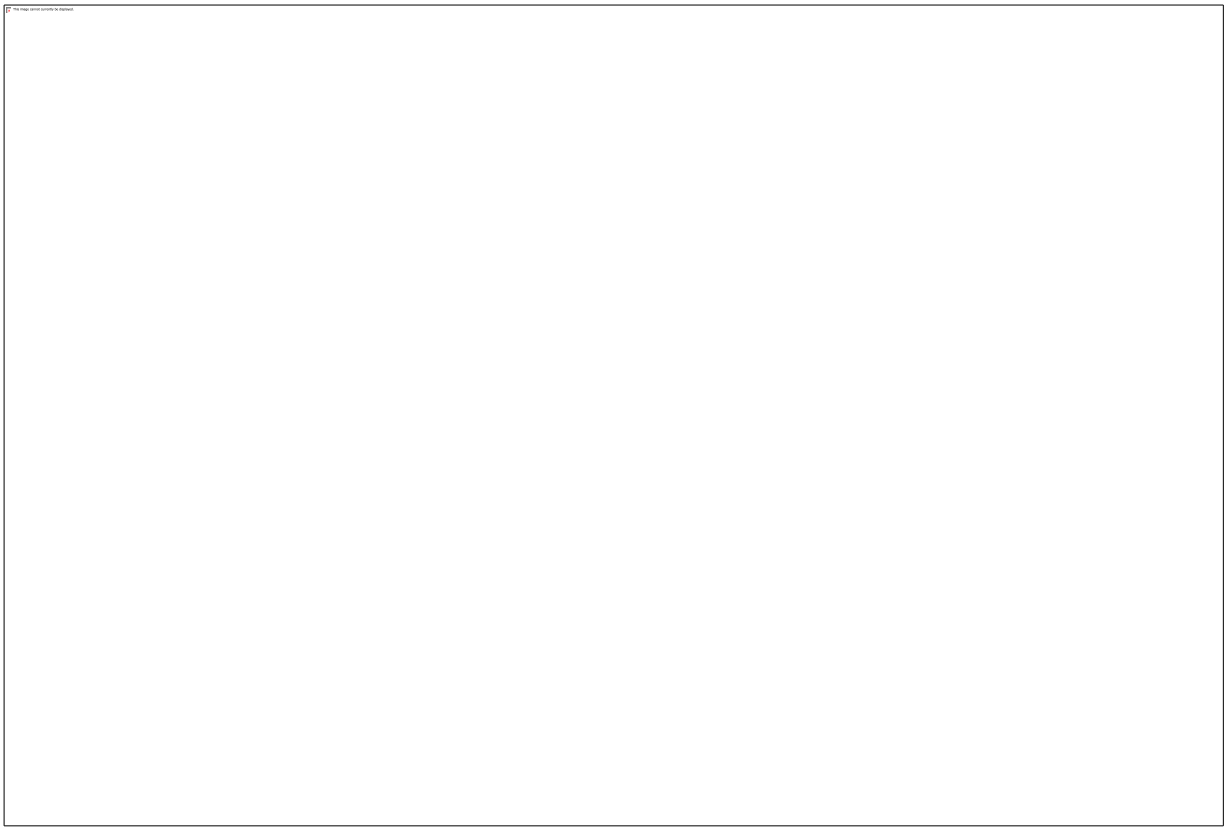
Sahiwal.

Hereford.

Angus.

Charolais.

Indigenous East African Zebu.



Methods of beef farming in Kenya

Selecting suitable cattle breeds.

Establishing grazing paddocks.

Providing adequate water.

Practising rotational grazing.

Supplementary feeding during dry seasons.

Vaccinating animals.

Controlling livestock parasites.

Selecting suitable breeding bulls.

Monitoring animal growth and weight.

Selling mature cattle to markets and abattoirs.

Challenges facing beef farming in Kenya

Prolonged drought.

Inadequate pasture.

Water shortages.

Livestock diseases.

Livestock theft.

Inadequate veterinary services.

Poor market access.

Low livestock prices during drought.

Land subdivision.

Human-wildlife conflicts in some areas.

Overgrazing and soil degradation.

High costs of supplementary feeds.

Solutions

Develop water pans and dams.

Promote rotational grazing.

Encourage drought-tolerant livestock breeds.

Establish fodder banks.

Strengthen veterinary services.

Improve livestock marketing infrastructure.

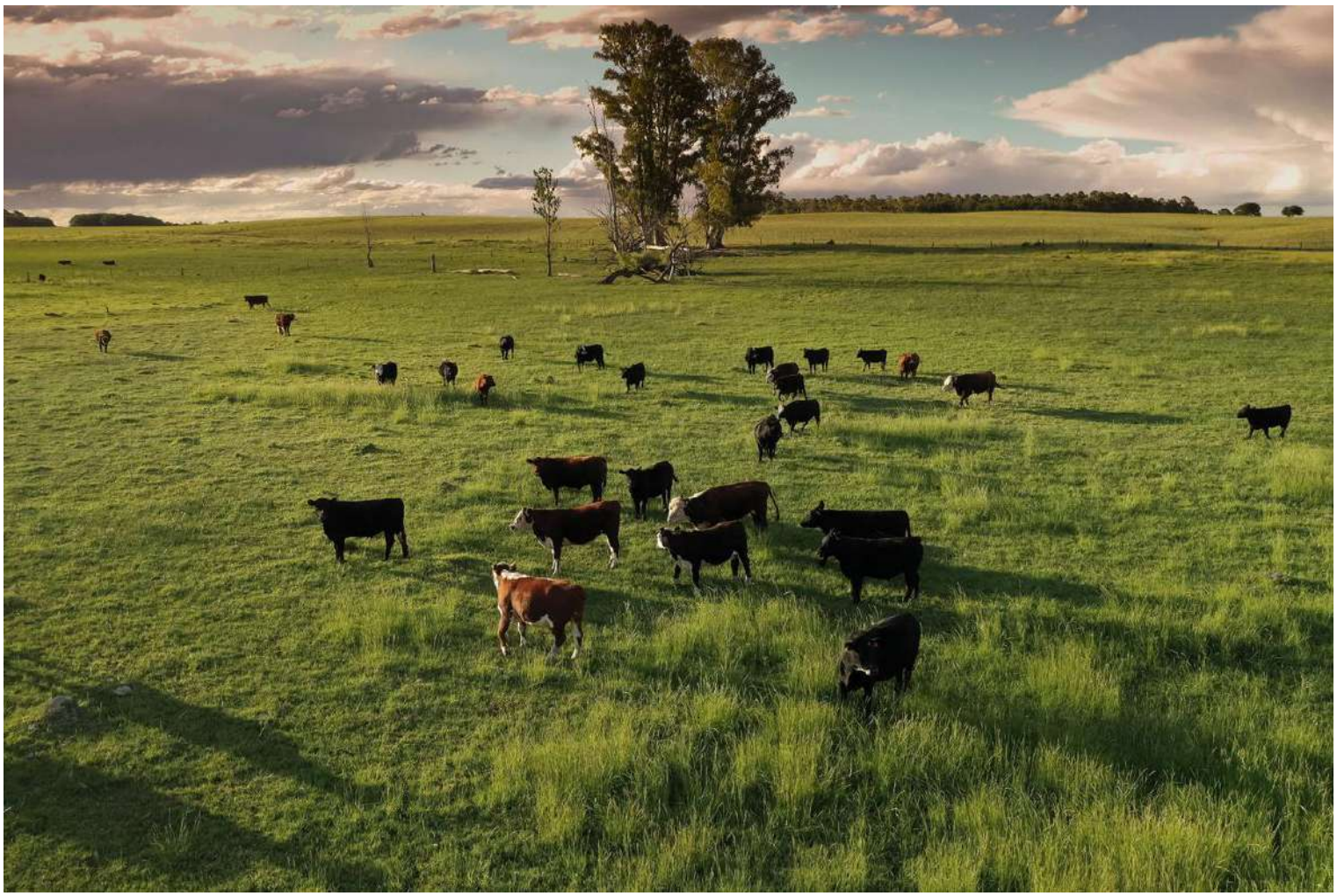
Promote ranching cooperatives.

Improve livestock security.

Encourage rangeland rehabilitation.

Promote early warning systems for drought.

B. Beef farming in Argentina



Argentina is internationally recognised for its beef production and cattle ranching industry.

Beef farming is an important economic activity, particularly in the Pampas region.

Major beef-producing regions

Buenos Aires Province.

Córdoba.

Santa Fe.

Entre Ríos.

La Pampa.

Corrientes.

Conditions favouring beef farming in Argentina

Physical factors

Extensive grasslands in the Pampas region.

Fertile soils that support pasture growth.

Temperate climate.

Adequate rainfall in major grazing areas.

Extensive land for cattle grazing.

Natural pasture vegetation.

Suitable terrain for mechanised livestock management.

Human factors

Availability of extensive ranches.

Established livestock breeding systems.

Availability of improved cattle breeds.

Modern meat-processing industries.

Good transport networks.

Access to domestic and export markets.

Veterinary and livestock research services.

Developed meat marketing systems.

Methods of beef farming in Argentina

Keeping improved beef cattle breeds.

Practising pasture-based livestock production.

Rotational grazing.

Supplementary feeding when necessary.

Selective breeding.

Disease control and vaccination.

Monitoring cattle weight.

Transporting mature animals to processing facilities.

Slaughtering and meat processing.

Packaging and exporting beef.

Challenges facing beef farming in Argentina

Drought.

Pasture degradation.

Fluctuations in international beef prices.

High production costs.

Livestock diseases.

Environmental pressure from land-use changes.

Greenhouse gas emissions.

Competition from other agricultural activities.

Changing domestic and international demand.

C. Comparison between beef farming in Kenya and Argentina

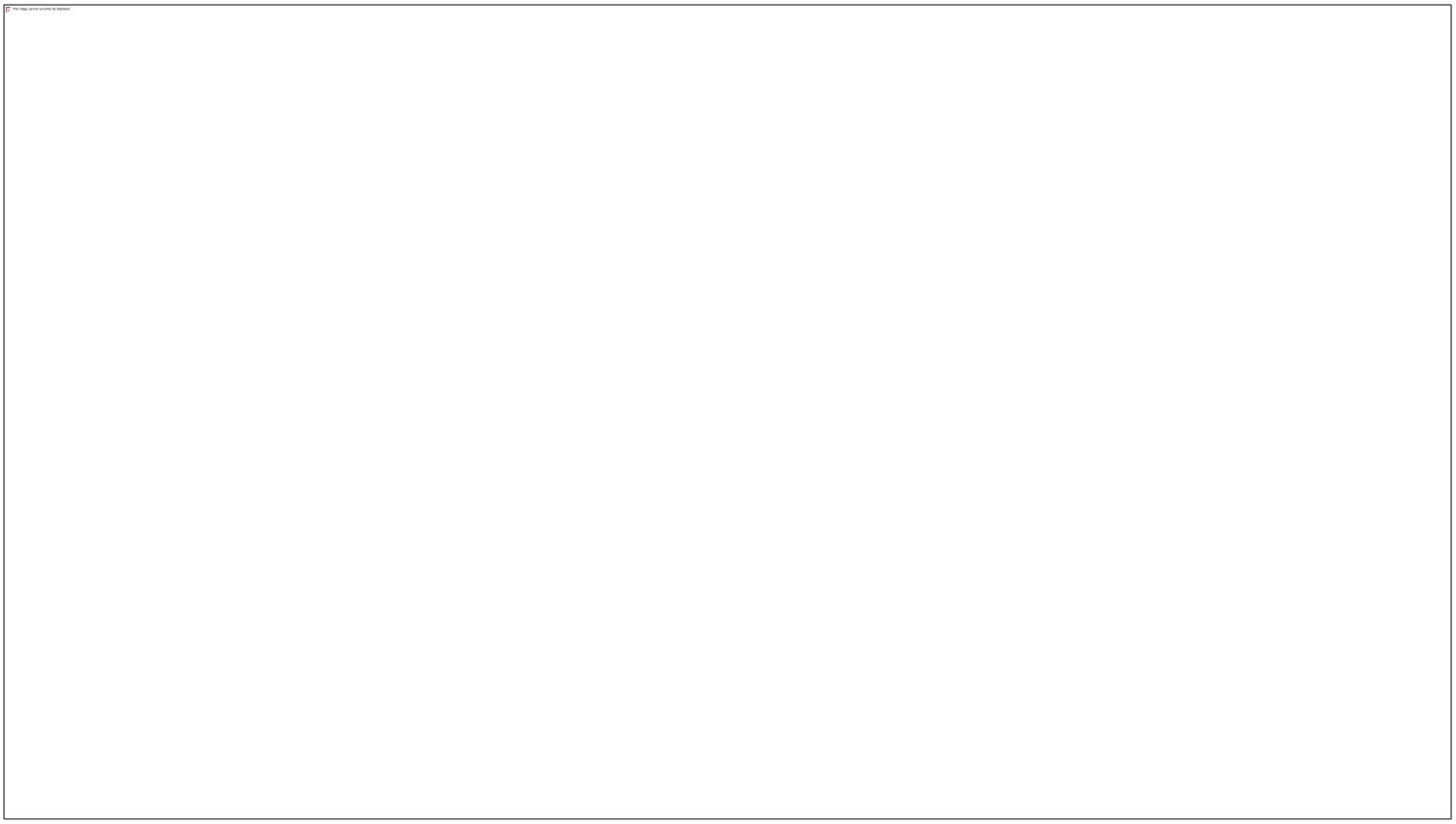
Kenya	**Argentina**
Beef farming is important in ASAL areas.	Beef farming is important in the Pampas and other regions.
Extensive ranching and pastoralism occur.	Commercial ranching and pasture-based systems are common.
Indigenous breeds such as Boran are important.	Improved beef breeds such as Angus and Hereford are important.
Drought is a major challenge in ASAL areas.	Drought is a challenge in some production regions.
Domestic consumption is important.	Beef is produced for domestic and international markets.
Water and pasture shortages can limit production.	Established pasture and meat-processing systems support production.

3.0 Commercial ranching in the world

3.1 Meaning of commercial ranching

Commercial ranching is a system of livestock production in which animals are reared on extensive areas of land mainly for sale and profit.

It involves organised management of livestock, grazing land, water, animal health and marketing.



Characteristics of commercial ranching

Large areas of land are used.

Livestock are kept mainly for commercial purposes.

Improved animal breeds are often used.

Grazing areas are organised into paddocks.

Capital investment is relatively high.

Veterinary services are provided.

Modern livestock management techniques are used.

Water points are established across the ranch.

Livestock are bred for desirable qualities.

Animals are sold when they reach suitable market weights.

Ranches may have facilities such as cattle dips, handling yards and loading ramps.

Production is linked to meat-processing industries and markets.

3.2 Types of ranching

A. Beef ranching

This involves rearing cattle primarily for meat production.

Examples:

Ranching in Laikipia and Kajiado in Kenya.

Ranching in Argentina.

Ranching in Australia.

B. Sheep ranching

This involves rearing sheep for meat, wool and skins.

Examples:

Australia.

New Zealand.

Argentina.

C. Mixed livestock ranching

This involves keeping different livestock species, such as cattle, sheep and goats, on the same ranch.

3.3 Factors influencing the location of commercial ranches

Availability of extensive land.

Presence of natural pasture.

Suitable climate.

Availability of water.

Low population pressure.

Availability of capital.

Good transport infrastructure.

Access to livestock markets.

Availability of veterinary services.

Government policies.

Security of land tenure.

Availability of modern livestock technology.

3.4 Advantages of commercial ranching

It produces large quantities of meat.

It provides employment.

It generates income for ranch owners and workers.

It earns foreign exchange through exports.

It supplies raw materials to leather industries.

It promotes the development of meat-processing industries.

It encourages improvement of livestock breeds.

It promotes infrastructure development.

It supports the development of livestock research.

It contributes to national economic development.

3.5 Disadvantages of commercial ranching

Overgrazing may lead to soil degradation.

Large ranches require substantial capital.

Drought may cause heavy livestock losses.

Livestock diseases can spread rapidly.

Ranching may cause environmental degradation.

Large ranches may reduce land available for other uses.

Livestock production contributes to greenhouse gas emissions.

Fencing may restrict wildlife movement.

Water resources may be depleted.

Conflicts may arise between ranchers and neighbouring communities.

4.0 Distribution of major plantations and ranches in Kenya

Kenya has different agricultural regions because of variations in rainfall, temperature, soils, altitude and relief.

The distribution of plantations and ranches is influenced by these environmental conditions and the availability of markets, labour, capital and infrastructure.

4.1 Distribution of major crop plantations

Crop	Major areas of production
Wheat	Narok, Nakuru, Uasin Gishu, Trans Nzoia, Laikipia and Nyandarua
Maize	Trans Nzoia, Uasin Gishu, Bungoma, Nandi, Nakuru, Kakamega and Narok
Coffee	Kiambu, Nyeri, Kirinyaga, Murang'a, Embu and Meru
Tea	Kericho, Bomet, Nandi, Nyeri, Kiambu, Murang'a, Embu, Meru, Kisii and Nyamira

4.2 Distribution of dairy and beef farms

Type of farming	Major areas
Dairy farming	Kiambu, Nyandarua, Nakuru, Nyeri, Uasin Gishu, Nandi and Kericho
Beef farming	Kajiado, Narok, Laikipia, Samburu, Isiolo, Garissa, Tana River, Turkana and Marsabit

4.3 Regional agricultural patterns in Kenya

A. Central Kenya highlands

Major activities:

Coffee farming.

Tea farming.

Dairy farming.

Horticulture.

Counties include Kiambu, Nyeri, Kirinyaga and Murang'a.

B. Rift Valley region

Major activities:

Wheat farming.

Maize farming.

Dairy farming.

Beef ranching.

Sheep farming.

Counties include Nakuru, Narok, Uasin Gishu, Nandi, Laikipia and Bomet.

C. Western Kenya

Major activities:

Maize farming.

Sugarcane farming.

Dairy farming.

Mixed farming.

Counties include Bungoma, Kakamega, Trans Nzoia and parts of Busia.

D. Eastern Kenya highlands

Major activities:

Coffee farming.

Dairy farming.

Horticulture.

Maize farming.

Counties include Meru, Embu and parts of Machakos.

E. Arid and semi-arid regions

Major activities:

Beef ranching.

Pastoral livestock keeping.

Goat and sheep rearing.

Camel keeping.

Counties include Kajiado, Turkana, Marsabit, Garissa, Isiolo and Samburu.

5.0 Challenges facing large-scale farming in Kenya and possible solutions

Large-scale farming plays an important role in agricultural production, employment creation and economic development. However, farmers face several challenges.

5.1 Climatic challenges

1. Unreliable rainfall

Some agricultural regions experience irregular rainfall.

This affects crop germination and development.

Drought may cause crop failure and livestock deaths.

Solution: Promote irrigation, water harvesting, drought-resistant crops and climate-smart agriculture.

2. Climate change

Rising temperatures affect crop growth.

Changes in rainfall patterns disrupt farming calendars.

Extreme weather events may destroy crops and infrastructure.

Solution: Promote climate-resilient farming technologies and early warning systems.

3. Flooding

Excessive rainfall may destroy crops.

Floods can cause soil erosion.

Livestock may drown or be displaced.

Solution: Improve drainage, construct flood-control structures and avoid cultivation in high-risk areas.

5.2 Economic challenges

1. High cost of farm inputs

Fertilisers, pesticides, seeds, fuel and animal feeds are expensive.

This increases the cost of production.

Solution: Improve access to affordable inputs, credit and appropriate technologies.

2. Fluctuating market prices

Prices of agricultural products may change due to supply and demand.

Farmers may experience reduced profits.

Solution: Improve market information, storage, value addition and organised marketing.

3. Inadequate capital

Some farmers lack money to purchase machinery.

They may be unable to expand or modernise their farms.

Solution: Encourage agricultural financing, cooperatives and accessible credit facilities.

5.3 Technological challenges

1. Inadequate machinery

Some farms lack tractors, harvesters and irrigation equipment.

This delays agricultural operations.

Solution: Promote affordable mechanisation and machinery-hiring services.

2. Limited agricultural knowledge

Some farmers may lack knowledge of modern farming practices.

This can lead to low productivity.

Solution: Strengthen agricultural extension and farmer training programmes.

5.4 Environmental challenges

1. Soil erosion

Removal of vegetation and poor land management expose soil to erosion.

This reduces soil fertility.

Solution: Encourage terracing, contour farming, cover cropping and agroforestry.

2. Soil exhaustion

- Continuous cultivation without replenishing nutrients reduces soil fertility.

Solution: Encourage crop rotation, organic manure and appropriate fertiliser application.

3. Water pollution

- Excessive use of agricultural chemicals may contaminate rivers and groundwater.

Solution: Promote proper chemical application and integrated pest management.

4. Overgrazing

- Excessive livestock numbers destroy pasture and expose soil.

Solution: Promote rotational grazing, controlled stocking and pasture rehabilitation.

5.5 Social and institutional challenges

Land disputes.

Insecurity and livestock theft.

Inadequate agricultural extension services.

Limited access to insurance.

Labour shortages.

Inadequate rural infrastructure.

Human-wildlife conflicts.

Poor agricultural marketing systems.

Possible solutions include improved land management, farmer organisations, security measures, agricultural insurance, rural infrastructure development and stronger agricultural institutions.

6.0 Significance of plantation agriculture and commercial ranching in Kenya

Agriculture contributes to national development through the production of food, creation of employment, provision of raw materials and generation of income.

6.1 Significance of plantation agriculture

1. **Food production:** Tea and coffee provide commercial agricultural products, while food-crop plantations contribute to food supplies.

2. **Employment creation:** Plantations employ workers in land preparation, planting, weeding, harvesting and processing.

3. **Foreign exchange earnings:** Export crops such as tea and coffee generate foreign currency.

4. **Industrial development:** Tea and coffee processing supports manufacturing industries.

5. **Infrastructure development:** Plantations encourage construction of roads, factories, electricity and communication networks.

6. **Government revenue:** Agricultural companies and related businesses contribute through taxes and other levies.

7. **Rural development:** Plantation activities stimulate the development of shopping centres, housing and other services.

8. **Improved technology:** Large-scale farms encourage the use of modern agricultural machinery and improved farming practices.

9. **Market development:** Plantation agriculture supports local and international trade.

10. **Research development:** Agricultural institutions conduct research to improve crop varieties and productivity.

6.2 Significance of commercial ranching

1. **Meat production:** Ranches supply beef for local and international markets.

2. **Employment:** Ranches employ herders, veterinary officers, drivers, managers and other workers.

3. **Foreign exchange:** Exported beef and livestock products generate foreign currency.

4. **Leather industry:** Hides and skins provide raw materials for leather processing.

5. **Income generation:** Ranch owners and livestock traders earn income.

6. **Improved breeds:** Commercial ranching encourages livestock breeding and genetic improvement.

7. **Infrastructure development:** Ranching encourages the development of roads, water facilities and livestock markets.

8. **Research:** Ranches support research into animal nutrition, breeding and disease control.

9. **Food security:** Commercial livestock production increases the availability of animal protein.

10. **Land utilisation:** Suitable rangelands can be used productively for livestock farming.

6.3 Sustainable management of plantation agriculture and ranching

Sustainable agriculture refers to agricultural practices that meet present production needs without damaging the ability of future generations to meet their own needs.

Methods include:

Crop rotation.

Soil conservation.

Agroforestry.

Integrated pest management.

Efficient irrigation.

Proper waste disposal.

Controlled grazing.

Pasture improvement.

Water conservation.

Use of renewable energy.

Protection of biodiversity.

Proper livestock stocking rates.

7.0 Fieldwork in agriculture

Fieldwork is the practical study of geographical features and human activities through direct observation and data collection.

7.1 Meaning of agricultural fieldwork

Agricultural fieldwork refers to the collection of geographical information through direct observation and investigation of farming activities in a particular area.

7.2 Objectives of agricultural fieldwork

A learner should be able to:

Identify agricultural activities in the locality.

Examine farming methods.

Identify agricultural inputs and outputs.

Investigate factors influencing farming.

Identify challenges facing farmers.

Suggest possible solutions.

Develop observation and communication skills.

7.3 Methods of collecting agricultural fieldwork data

1. Observation

Learners observe agricultural activities directly, including crop types, livestock breeds, farming methods and farm equipment.

2. Interview

Learners ask farmers questions about production, challenges, marketing and farm management.

3. Questionnaires

Written questions are used to obtain information from farmers and agricultural workers.

4. Photography

Photographs are taken to provide visual evidence of farming activities, with permission where necessary.

5. Measurement

Learners may measure farm sizes, distances, crop spacing and other relevant features.

6. Note-taking

Important information is recorded during the investigation.

7.4 Preparation for agricultural fieldwork

Identify the study area.

Establish the objectives.

Obtain permission from relevant authorities.

Prepare questions and questionnaires.

Identify the transport arrangements.

Prepare notebooks and writing materials.

Organise learners into groups.

Identify safety precautions.

7.5 Writing an agricultural fieldwork report

A good fieldwork report should contain:

Title of the investigation.

Date and location.

Objectives.

Introduction.

Methods of data collection.

Findings.

Challenges identified.

Possible solutions.

Conclusion.

Recommendations.

REVISION QUESTIONS

GRADE 11 GEOGRAPHY

TOTAL: 80 MARKS

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Instructions: Answer all questions. Choose the correct answer from the alternatives provided.

1. Which of the following best describes plantation agriculture?

A. Growing crops mainly for household consumption.

B. Cultivating crops on extensive land mainly for commercial purposes.

C. Growing different crops on small pieces of land.

D. Rearing livestock without commercial intentions.

2. Which of the following is an example of a plantation crop?

A. Beans.

B. Millet.

C. Tea.

D. Sweet potatoes.

3. Which Kenyan county is an important wheat-producing area?

A. Mombasa.

B. Narok.

C. Kilifi.

D. Kwale.

4. Which physical condition favours wheat farming in Kenya?

A. Extremely high temperatures.

B. Cool temperatures in highland areas.

C. Very low rainfall throughout the year.

D. Permanently waterlogged soils.

5. Russia is an important wheat-producing country mainly because of its:

A. Extensive agricultural plains.

B. Tropical rainforests.

C. Coastal fishing grounds.

D. Mountainous desert regions.

6. Which type of soil is particularly associated with high agricultural productivity in parts of Russia?

A. Chernozem.

B. Desert sand.

C. Saline soil.

D. Peaty soil.

7. Maize is an important staple food crop in Kenya because it is used to prepare:

A. Ugali.

B. Cheese.

C. Butter.

D. Tea.

8. Mexico is historically important in maize farming because it is:

A. The original home of wheat.

B. A centre of maize domestication.

C. The world's main tea producer.

D. The origin of coffee cultivation.

9. Which Kenyan counties are well known for coffee production?

A. Garissa and Wajir.

B. Kiambu and Nyeri.

C. Turkana and Marsabit.

D. Kilifi and Lamu.

10. Which coffee variety is widely cultivated in Kenya?

A. Arabica.

B. Robusta only.

C. Liberica only.

D. Excelsa only.

11. Brazil is internationally recognised as:

A. The leading coffee-producing country.

B. The leading tea-producing country.

C. The leading wheat-importing country.

D. The world's largest dairy-consuming country.

12. Which of the following is a major tea-growing county in Kenya?

A. Kericho.

B. Garissa.

C. Mandera.

D. Tana River.

13. Tea farming is favoured in the Kenyan highlands mainly by:

A. High temperatures and desert conditions.

B. Cool temperatures and reliable rainfall.

C. Permanent waterlogging.

D. Very low humidity.

14. Sri Lankan tea is commonly marketed internationally as:

A. Arabica tea.

B. Ceylon Tea.

C. Pampas Tea.

D. Russian Tea.

15. Which country is internationally recognised for highly developed pasture-based dairy farming?

A. New Zealand.

B. Egypt.

C. Saudi Arabia.

D. Libya.

16. Which cattle breed is widely used for dairy production in Kenya?

A. Friesian.

B. Boran.

C. Zebu beef type only.

D. Ankole only.

17. The main product of dairy farming is:

A. Wool.

B. Milk.

C. Hides.

D. Timber.

18. Which of the following is a major dairy-producing region in New Zealand?

A. Waikato.

B. Sahara.

C. Amazon Basin.

D. Pampas.

19. Commercial ranching refers to:

A. Keeping animals mainly for household consumption.

B. Rearing livestock extensively for commercial purposes.

C. Cultivating crops on small farms.

D. Fishing in inland lakes.

20. Which region of Argentina is particularly associated with commercial beef ranching?

A. Pampas.

B. Sahara.

C. Tundra.

D. Amazon Basin.

21. Which of the following is an important beef-producing county in Kenya?

A. Kajiado.

B. Mombasa.

C. Nairobi.

D. Lamu.

22. Which cattle breed is particularly associated with beef production in Kenya?

A. Boran.

B. Jersey.

C. Guernsey.

D. Ayrshire.

23. One major advantage of plantation agriculture is that it:

A. Discourages industrial development.

B. Generates foreign exchange.

C. Eliminates employment opportunities.

D. Prevents agricultural research.

24. Which of the following is a major disadvantage of monoculture?

A. Increased crop diversity.

B. Reduced risk of specialised pest attacks.

C. Increased vulnerability to certain pests and diseases.

D. Improved biodiversity in all circumstances.

25. Which practice is most suitable for controlling overgrazing in commercial ranches?

A. Continuous grazing without control.

B. Rotational grazing.

C. Increasing livestock beyond carrying capacity.

D. Removing all pasture vegetation.

26. Which of the following is a major challenge facing Kenyan wheat farmers?

A. Lack of international demand for all wheat products.

B. Competition from imported wheat.

C. Excessive snowfall in all growing regions.

D. Permanent frost throughout the year.

27. What is the main purpose of artificial insemination in dairy farming?

A. Improving livestock breeding.

B. Drying milk.

C. Increasing soil fertility.

D. Controlling weeds.

28. Which of the following is an appropriate solution to frequent drought in beef ranching areas?

A. Overstocking livestock.

B. Establishing water pans and fodder banks.

C. Clearing all vegetation.

D. Abandoning pasture management.

29. Which of the following is an important output of commercial ranching besides meat?

A. Hides and skins.

B. Tea leaves.

C. Wheat flour.

D. Coffee beans.

30. Which method of data collection involves asking farmers questions directly?

A. Observation.

B. Interview.

C. Mapping.

D. Measurement.

SECTION B: STRUCTURED QUESTIONS (50 MARKS)

Instructions: Answer all questions.

31. Agricultural systems (8 marks)

a) Define the term agriculture. (2 marks)

b) Explain three characteristics of plantation agriculture. (3 marks)

c) State three differences between subsistence agriculture and commercial agriculture. (3 marks)

32. Wheat and maize farming (8 marks)

a) Name two wheat-growing counties in Kenya. (2 marks)

b) Explain three physical factors favouring wheat farming in Russia. (3 marks)

c) State three challenges facing maize farmers in Kenya. (3 marks)

33. Coffee and tea farming (8 marks)

a) Identify two coffee-growing counties in Kenya. (2 marks)

b) Explain three conditions favouring tea farming in Kenya. (3 marks)

c) State three economic benefits of coffee farming to Kenya. (3 marks)

34. Dairy farming (8 marks)

a) Define dairy farming. (2 marks)

b) Identify two dairy cattle breeds commonly kept in Kenya. (2 marks)

c) Explain four factors favouring commercial dairy farming in New Zealand. (4 marks)

35. Commercial beef ranching (9 marks)

a) Define commercial ranching. (2 marks)

b) Identify three major beef-producing areas in Kenya. (3 marks)

c) Explain four challenges facing commercial beef ranching in Kenya. (4 marks)

36. Large-scale farming and fieldwork (9 marks)

a) State three challenges facing large-scale farming in Kenya. (3 marks)

b) Explain three ways of improving sustainable agricultural production in Kenya. (3 marks)

c) State three methods of collecting information during agricultural fieldwork. (3 marks)

ANSWERS AND MARKING SCHEME

Section A: Multiple-choice answers

Question	Answer	Question	Answer
1	B	16	A
2	C	17	B
3	B	18	A
4	B	19	B
5	A	20	A
6	A	21	A
7	A	22	A
8	B	23	B
9	B	24	C
10	A	25	B
11	A	26	B
12	A	27	A
13	B	28	B
14	B	29	A
15	A	30	B

Section B: Suggested marking scheme

31. Agricultural systems (8 marks)

a) Agriculture is the practice of cultivating crops and rearing animals for food, income, industrial raw materials and other human needs. (2 marks)

b) Characteristics of plantation agriculture:

It involves cultivation on extensive areas of land. (1)

It concentrates on one major crop or a limited number of crops. (1)

Production is mainly for commercial purposes. (1)

c) Differences:

Subsistence agriculture	**Commercial agriculture**
Mainly for household consumption.	Mainly for sale and profit.
Usually small-scale.	May be large-scale.
Often relies on family labour.	May employ hired labour.

Award 1 mark for each valid difference.

32. Wheat and maize farming (8 marks)

a) Any two:

Narok.

Nakuru.

Uasin Gishu.

Trans Nzoia.

Laikipia.

Nyandarua.

(1 mark each)

b) Factors favouring wheat farming in Russia:

Extensive plains provide large areas for cultivation.

Fertile chernozem soils support crop growth.

Warm summers favour wheat development.

Suitable rainfall supports crop growth in major regions.

Mechanisation supports extensive production.

(Any three, 1 mark each)

c) Challenges facing maize farming in Kenya:

Unreliable rainfall.

Fall armyworm infestation.

Maize diseases.

High costs of farm inputs.

Poor storage facilities.

Aflatoxin contamination.

Fluctuating market prices.

(Any three, 1 mark each)

33. Coffee and tea farming (8 marks)

a) Any two:

Kiambu.

Nyeri.

Kirinyaga.

Murang'a.

Embu.

Meru.

(1 mark each)

b) Conditions favouring tea farming:

Reliable rainfall supports continuous growth.

Cool temperatures favour tea production.

Fertile, well-drained soils support healthy tea bushes.

Highland altitude provides favourable climatic conditions.

Availability of moisture supports regular leaf production.

(Any three, 1 mark each)

c) Economic benefits of coffee farming:

Generates foreign exchange through exports.

Creates employment.

Provides raw materials to coffee-processing industries.

Generates income for farmers.

Promotes transport and marketing services.

Contributes to government revenue.

(Any three, 1 mark each)

34. Dairy farming (8 marks)

a) Dairy farming is the rearing and management of livestock mainly for milk production. (2 marks)

b) Any two:

Friesian.

Ayrshire.

Jersey.

Guernsey.

(1 mark each)

c) Factors favouring dairy farming in New Zealand:

Extensive grasslands provide pasture.

Temperate maritime climate favours pasture growth.

Reliable rainfall supports grass production.

Availability of improved dairy breeds.

Modern milking and processing technology.

Developed transport and export infrastructure.

Access to international markets.

(Any four, 1 mark each)

35. Commercial beef ranching (9 marks)

a) Commercial ranching is a livestock production system in which animals are reared on extensive land mainly for sale and profit. (2 marks)

b) Any three:

Kajiado.

Narok.

Laikipia.

Samburu.

Isiolo.

Garissa.

Tana River.

Turkana.

Marsabit.

(1 mark each)

c) Challenges:

Drought reduces pasture and water availability.

Livestock diseases cause animal deaths and reduce productivity.

Livestock theft leads to financial losses.

Inadequate veterinary services affect animal health.

Overgrazing causes pasture degradation.

Poor transport limits access to markets.

High supplementary feed costs increase production expenses.

Human-wildlife conflicts may cause livestock losses.

(Any four, 1 mark each)

36. Large-scale farming and fieldwork (9 marks)

a) Challenges:

High cost of farm inputs.

Unreliable rainfall.

Inadequate capital.

Soil erosion.

Pests and diseases.

Poor transport and storage facilities.

Market price fluctuations.

(Any three, 1 mark each)

b) Ways of improving sustainable agricultural production:

Practising crop rotation to maintain soil fertility and reduce pest build-up.

Using irrigation efficiently to reduce dependence on rainfall.

Practising controlled grazing to prevent overgrazing.

Applying organic manure to improve soil structure.

Planting trees to reduce soil erosion.

Using integrated pest management to reduce chemical pollution.

Promoting drought-resistant crop varieties.

(Any three, 1 mark each)

c) Methods of collecting fieldwork information:

Observation.

Interviews.

Questionnaires.

Photography.

Measurement.

Note-taking.

(Any three, 1 mark each)

Suggested practical projects

Project 1: Mapping agricultural activities in Kenya

Learners should:

Obtain an outline map of Kenya.

Identify major wheat-producing counties.

Mark major maize-producing counties.

Locate coffee-growing areas.

Locate tea-growing areas.

Identify major dairy farming regions.

Mark major beef ranching areas.

Prepare a key showing the agricultural activities.

Display the completed map.

Project 2: Investigating farming in the locality

Learners should:

Identify a nearby farm.

Seek permission to visit.

Identify the crops or livestock kept.

Examine farming methods.

Identify agricultural inputs.

Investigate production challenges.

Suggest possible solutions.

Prepare and present a fieldwork report.

Project 3: Agricultural debate

Debate the motion:

Plantation agriculture and commercial ranching contribute more to Kenya's economic development than small-scale farming.

Learners should support their arguments using geographical examples and evidence.

12.0 Key geographical terms to remember

Term	Meaning
Agriculture	Cultivation of crops and rearing of animals.
Plantation	Large-scale commercial crop-growing estate.
Ranching	Rearing livestock on extensive managed land.
Monoculture	Growing one crop over a given area.
Mechanisation	Use of machinery in agricultural production.
Irrigation	Artificial application of water to crops.
Crop rotation	Growing different crops on the same land in a planned sequence.
Pasture	Vegetation used for feeding livestock.
Zero-grazing	Keeping livestock in confined housing and bringing feed to them.
Agribusiness	Commercial activities associated with agricultural production, processing and

	marketing.
Value addition	Processing agricultural products to increase their usefulness and market value.
Sustainable agriculture	Farming that meets present needs while conserving resources for future generations.

SUB-STRAND 3.2: WILDLIFE

1.0 INTRODUCTION TO WILDLIFE

1.1 Meaning of Wildlife

Wildlife refers to all undomesticated living organisms, including animals, birds, reptiles, amphibians, insects and other organisms that naturally exist in their habitats.

Wildlife occurs in different natural environments such as:

Forests.

Grasslands and savannahs.

Mountains.

Wetlands and swamps.

Rivers and lakes.

Deserts and semi-arid regions.

Coastal and marine environments.

Examples of wildlife in Kenya:

Mammals: elephants, lions, leopards, buffaloes, zebras, giraffes and rhinoceroses.

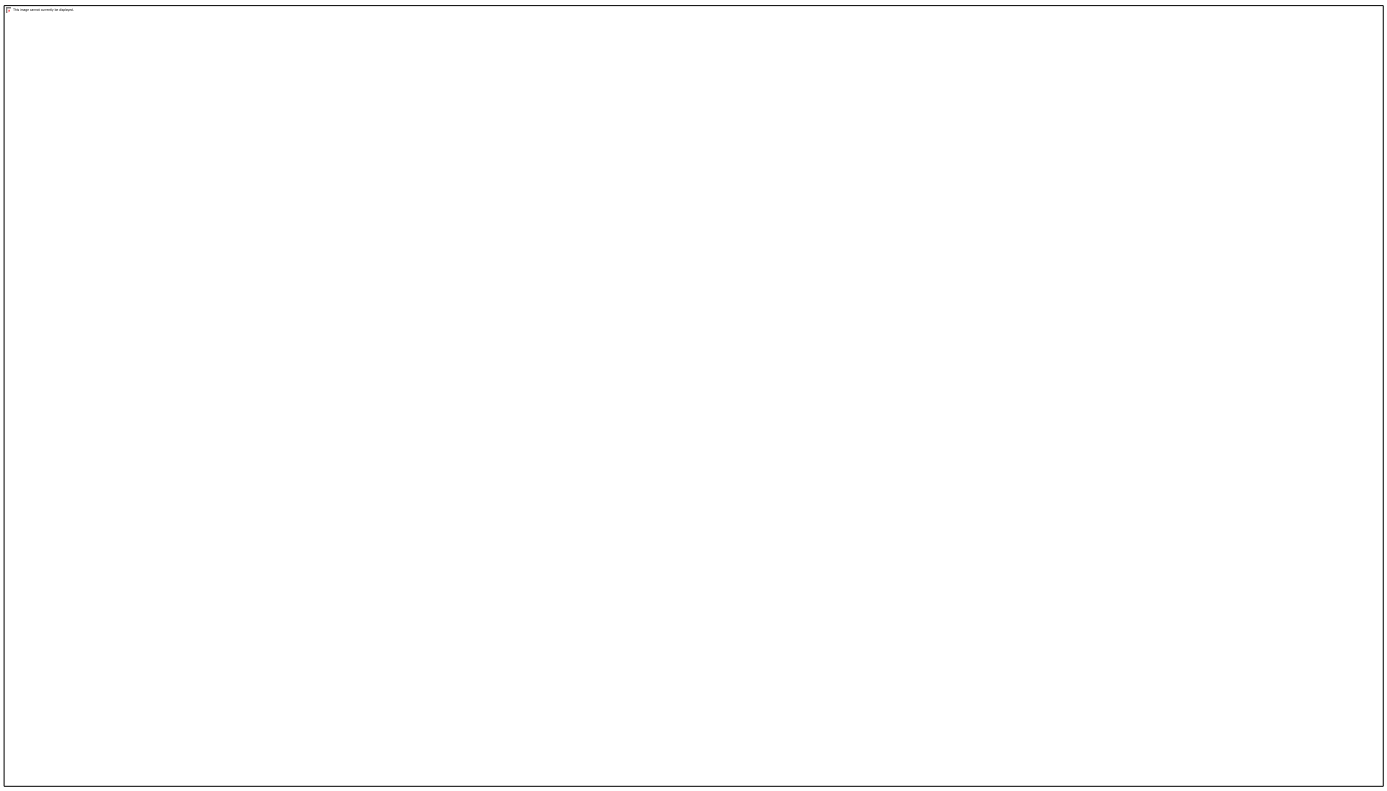
Birds: ostriches, flamingos, eagles, crowned cranes and vultures.

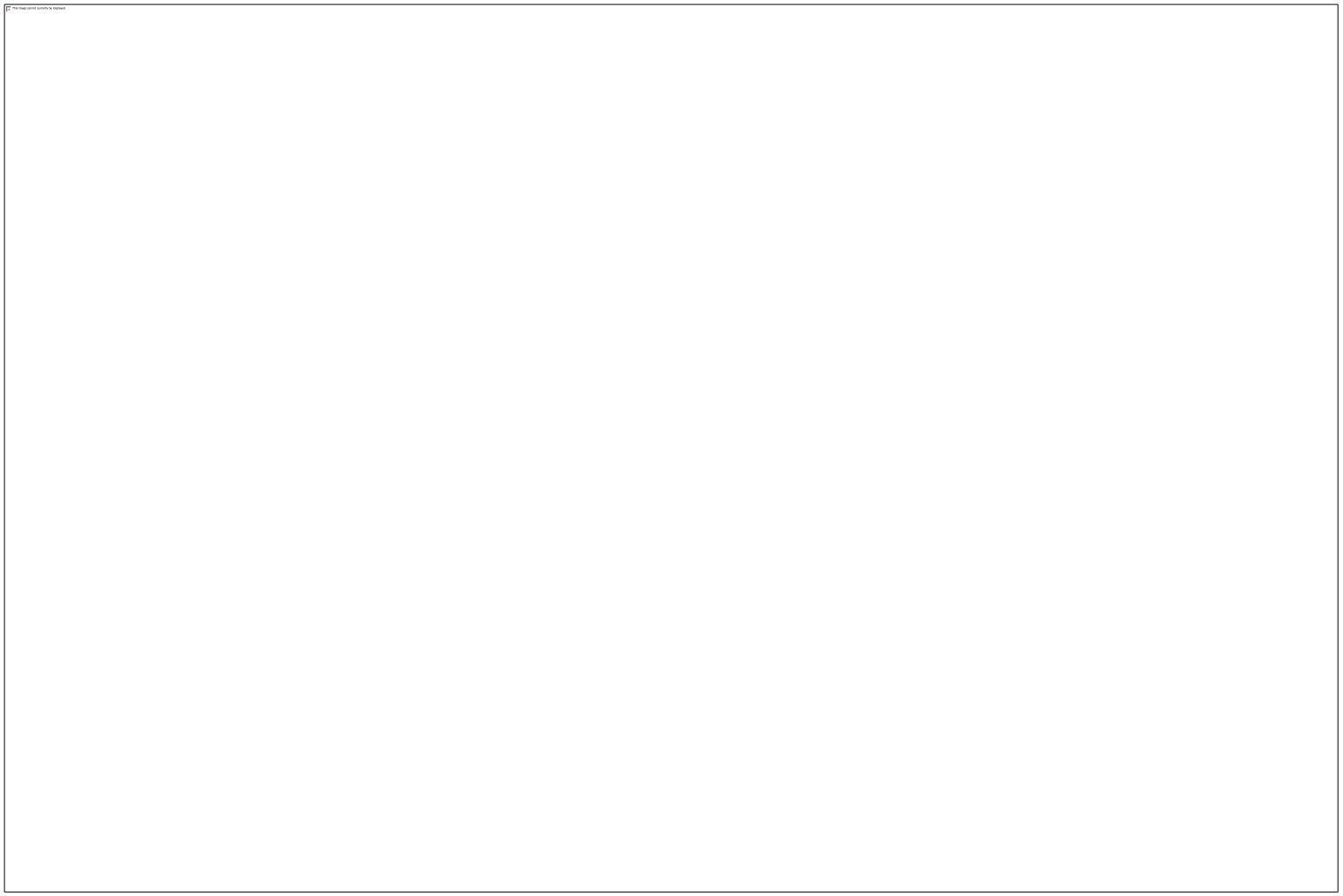
Reptiles: crocodiles, tortoises, chameleons and snakes.

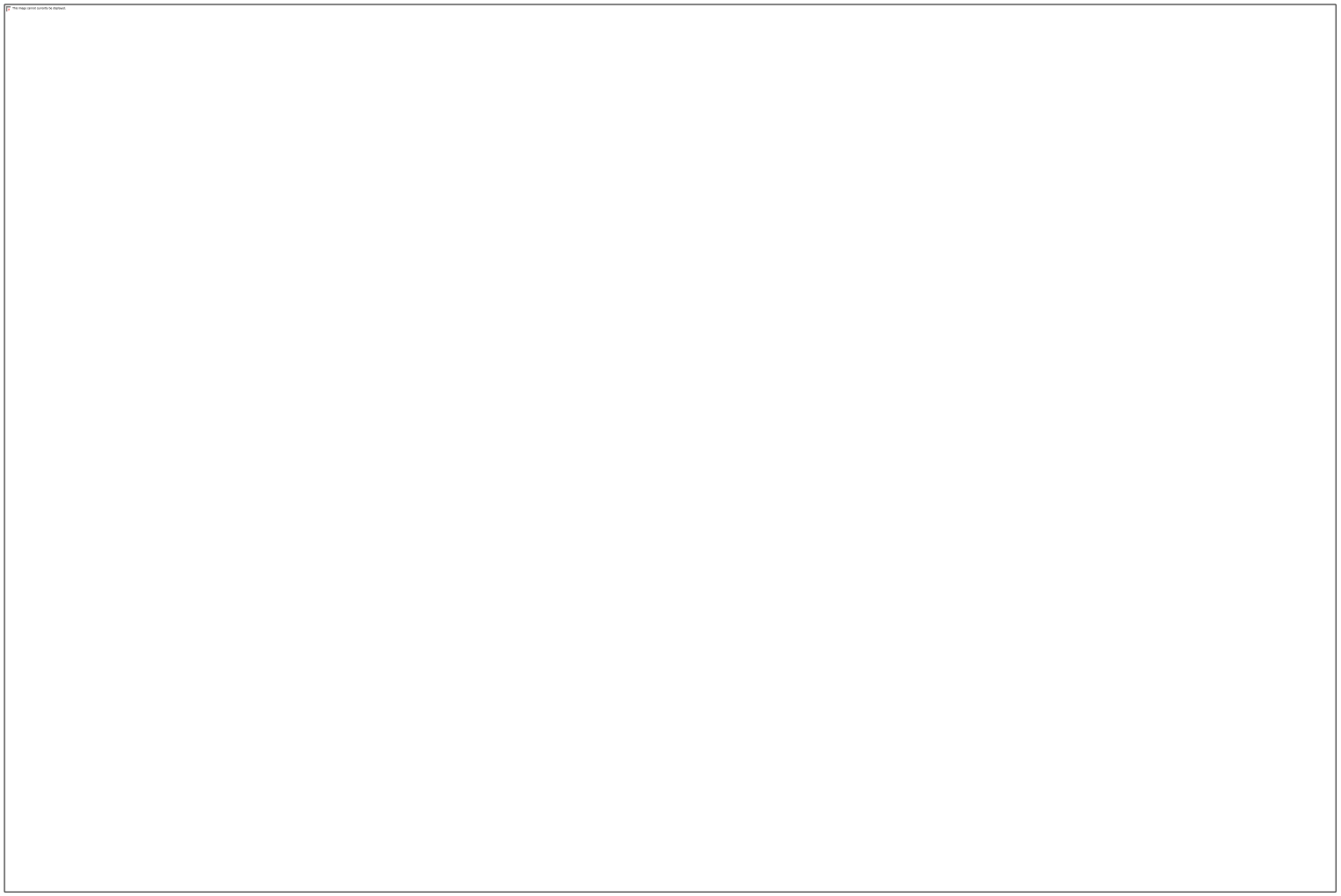
Amphibians: frogs and toads.

Aquatic wildlife: fish, dolphins and marine turtles.

Insects: butterflies, bees, beetles and grasshoppers.







1.2 Meaning of Wildlife Conservation

Wildlife conservation refers to the protection, preservation and sustainable management of wild animals, plants and their natural habitats to ensure their survival for present and future generations.

It involves:

Protecting endangered species from extinction.

Preventing illegal hunting and killing of wildlife.

Maintaining natural habitats.

Controlling human activities that threaten wildlife.

Promoting responsible tourism.

Educating communities on the importance of wildlife.

Restoring degraded ecosystems.

1.3 Meaning of Wildlife Management

Wildlife management refers to the planned control, protection, monitoring and sustainable utilisation of wildlife populations and their habitats to maintain ecological balance and reduce conflicts between wildlife and human beings.

It involves:

Monitoring wildlife populations.

Controlling poaching.

Managing national parks and reserves.

Controlling wildlife diseases.

Managing human-wildlife conflicts.

Restoring wildlife habitats.

Promoting sustainable tourism.

1.4 Importance of Studying Wildlife in Geography

The study of wildlife is important because it helps learners to:

Understand the relationship between wildlife and the physical environment.

Explain how climate influences the distribution of animals.

Understand the effects of human activities on wildlife.

Appreciate the economic importance of wildlife tourism.

Identify wildlife conservation challenges.

Develop skills in map reading and interpretation.

Promote environmental responsibility.

Understand the relationship between wildlife, communities and sustainable development.

2.0 WILDLIFE HABITATS AND ECOSYSTEMS

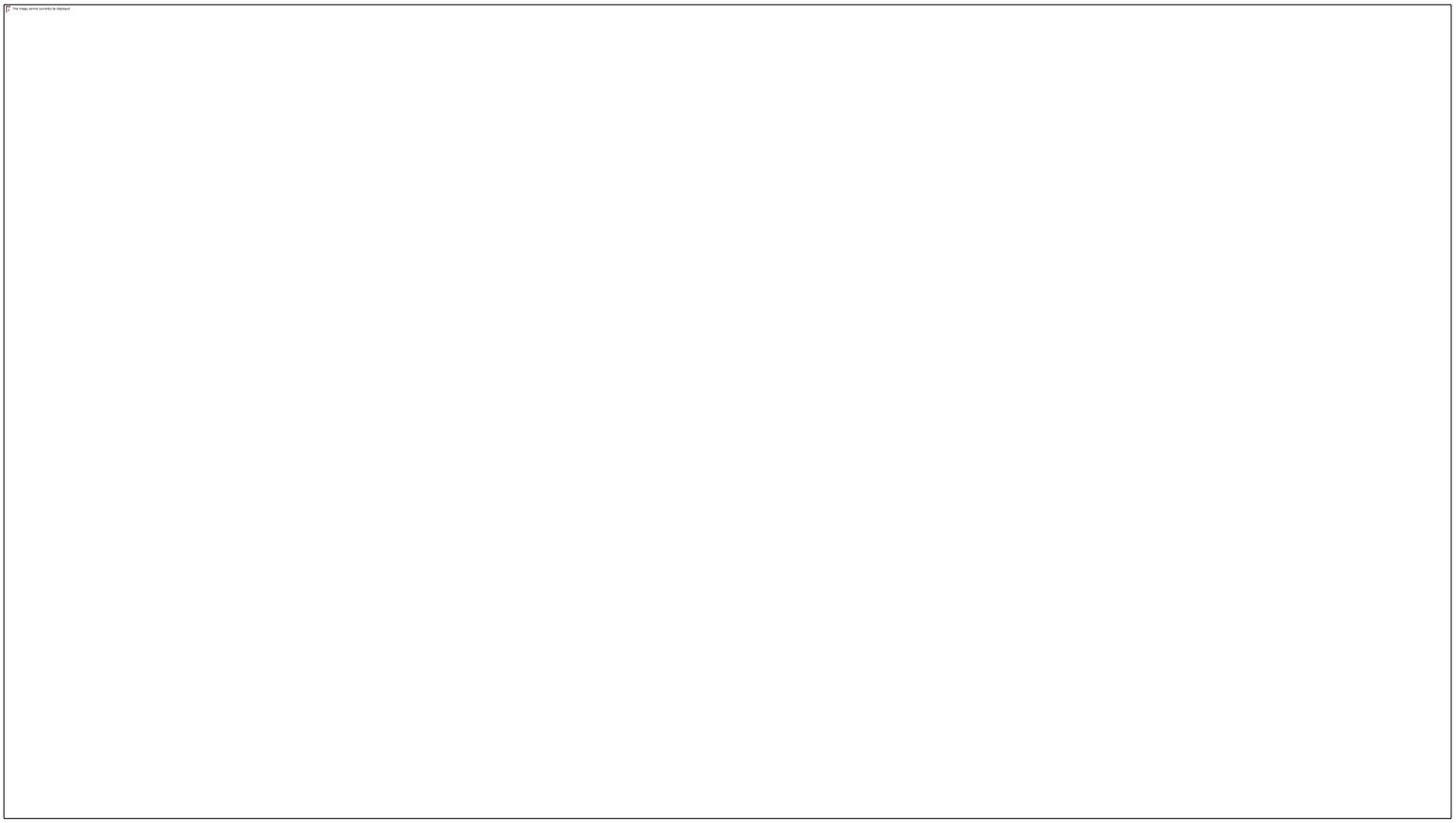
2.1 Meaning of a Wildlife Habitat

A wildlife habitat is the natural environment in which a particular animal or organism lives, obtains food, reproduces and finds shelter.

A suitable habitat provides the basic requirements necessary for survival.

2.2 Types of Wildlife Habitats in Kenya

A. Savannah grasslands



These are open grass-covered areas with scattered trees and shrubs.

Characteristics:

Dominated by grasses.

Have scattered acacia and other trees.

Support large populations of grazing animals.

Experience seasonal rainfall.

Have wet and dry seasons.

Examples in Kenya:

Maasai Mara.

Amboseli.

Tsavo.

Nairobi National Park.

Wildlife found here:

Zebras.

Wildebeests.

Elephants.

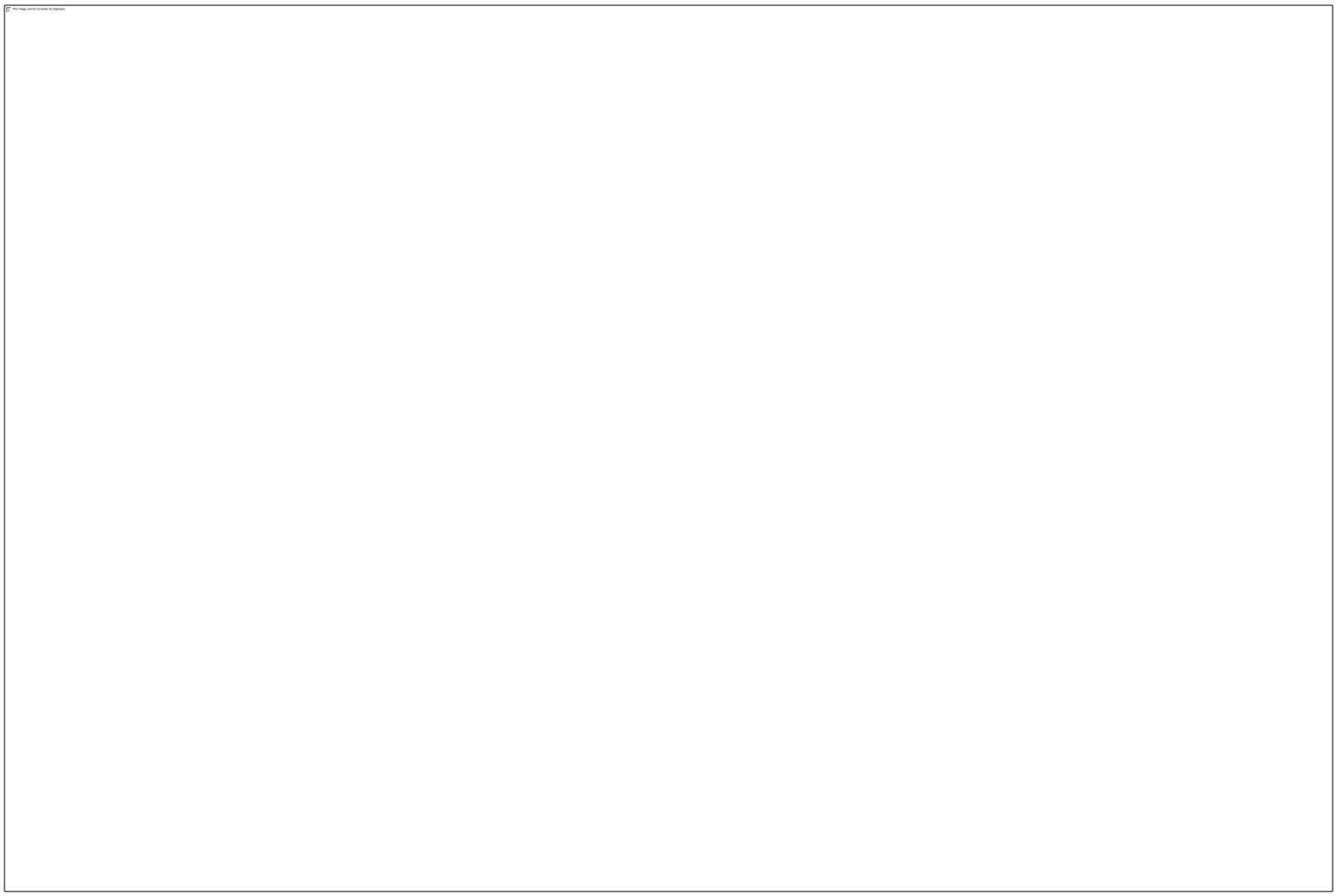
Giraffes.

Lions.

Cheetahs.

Buffaloes.

B. Forest habitats



Forests are habitats dominated by trees and other vegetation.

Characteristics:

Have dense vegetation.

Provide shade and shelter.

Support numerous bird and insect species.

Have varied food sources.

Often experience relatively high humidity.

Examples in Kenya:

Mau Forest.

Kakamega Forest.

Arabuko-Sokoke Forest.

Mount Kenya Forest.

Wildlife found here:

Monkeys.

Forest elephants.

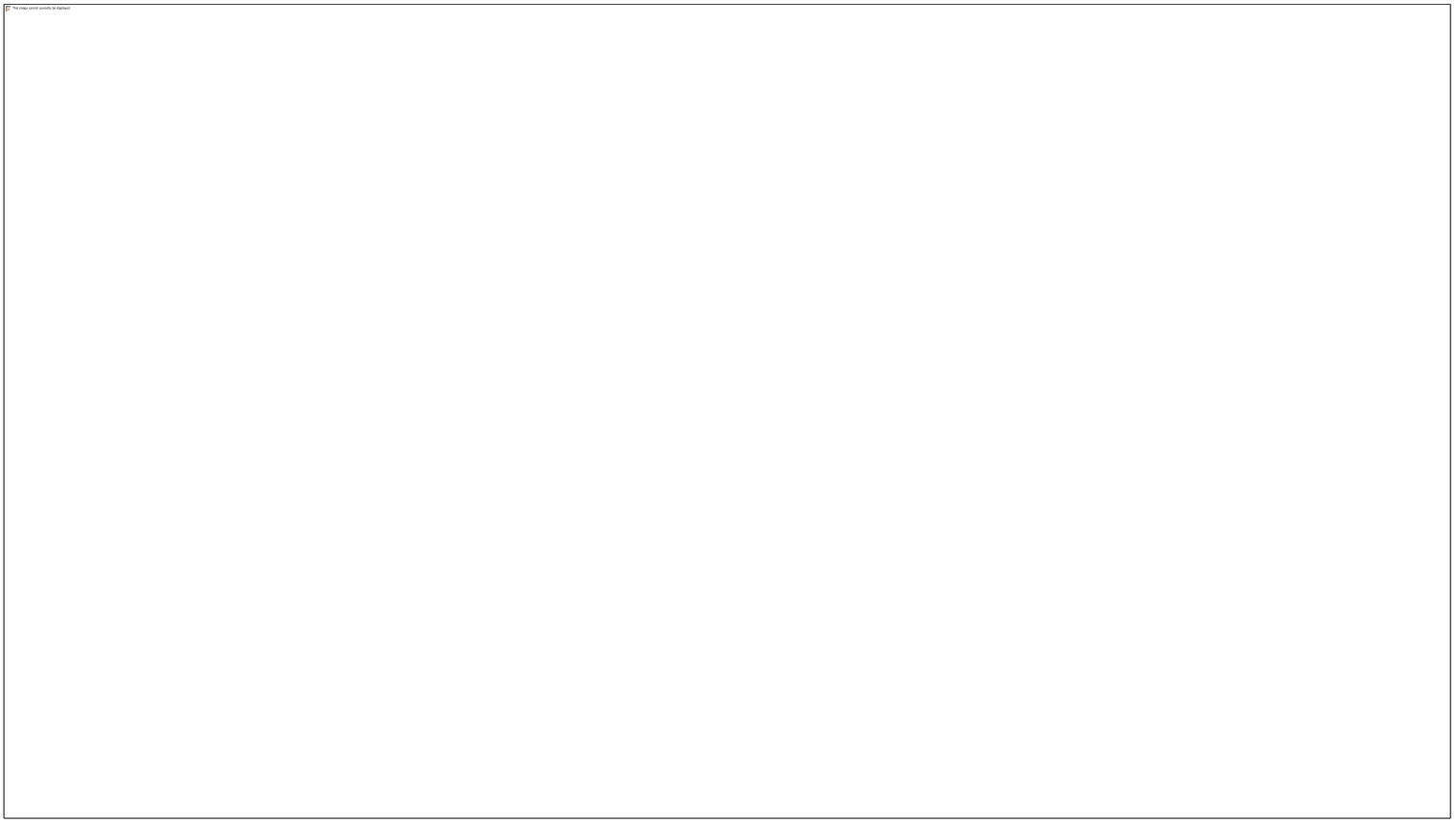
Bushbucks.

Birds.

Butterflies.

Leopards.

C. Wetland habitats



Wetlands are areas where the soil is permanently or seasonally covered with water or remains waterlogged.

Characteristics:

Have abundant water.

Support aquatic vegetation.

Provide breeding grounds for birds and fish.

Support amphibians and reptiles.

Examples:

Lake Nakuru.

Lake Naivasha.

Yala Swamp.

Lake Victoria wetlands.

Tana River wetlands.

Wildlife found here:

Flamingos.

Hippos.

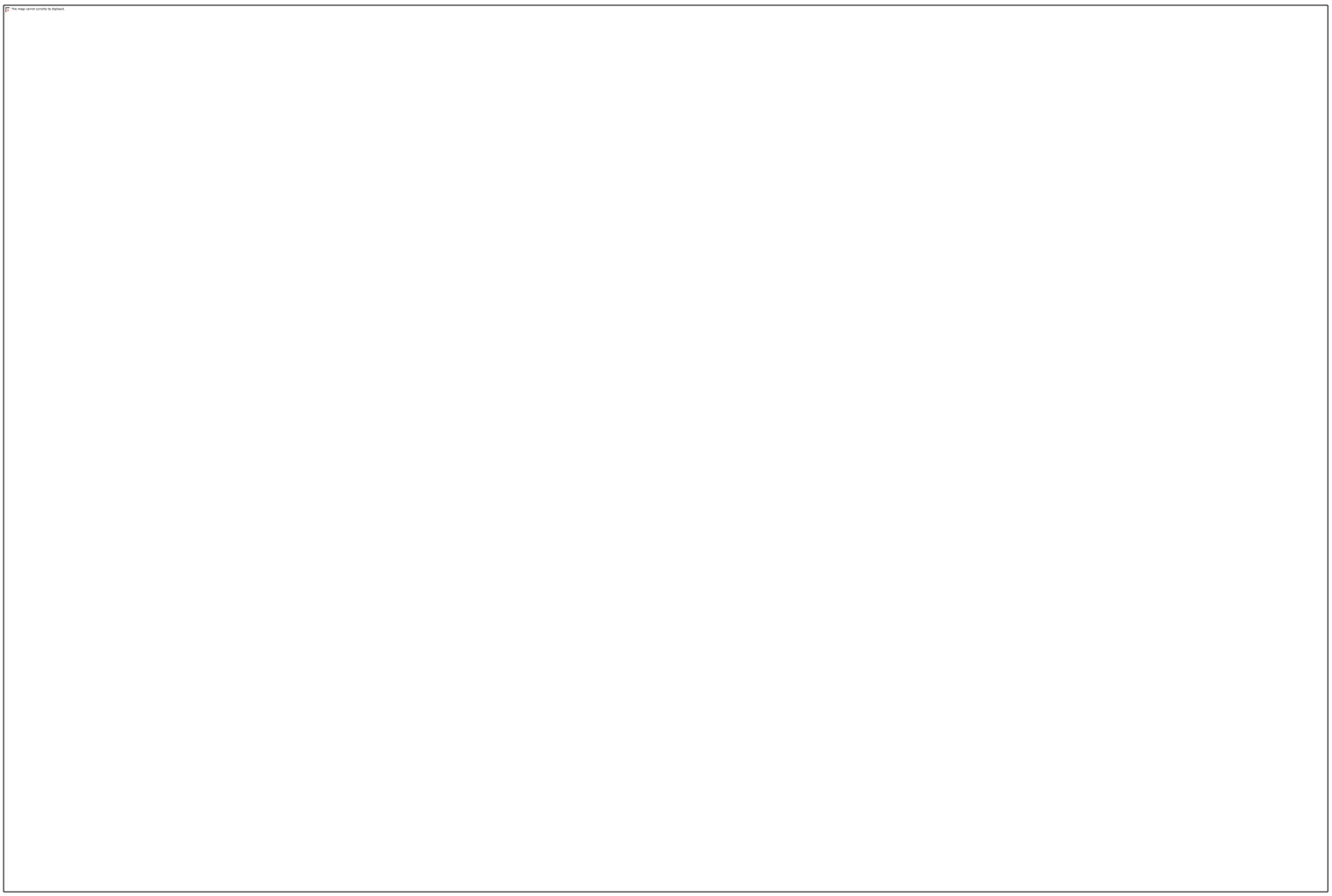
Crocodiles.

Fish.

Pelicans.

Waterfowl.

D. Mountain habitats



These are habitats found in mountainous areas, especially at high altitudes.

Characteristics:

Experience low temperatures at high elevations.

Have different vegetation zones.

Some areas have steep slopes and rocky surfaces.

Support specialised wildlife species.

Examples:

Mount Kenya.

Aberdare Ranges.

Mount Elgon.

Wildlife found here:

Mountain bongos.

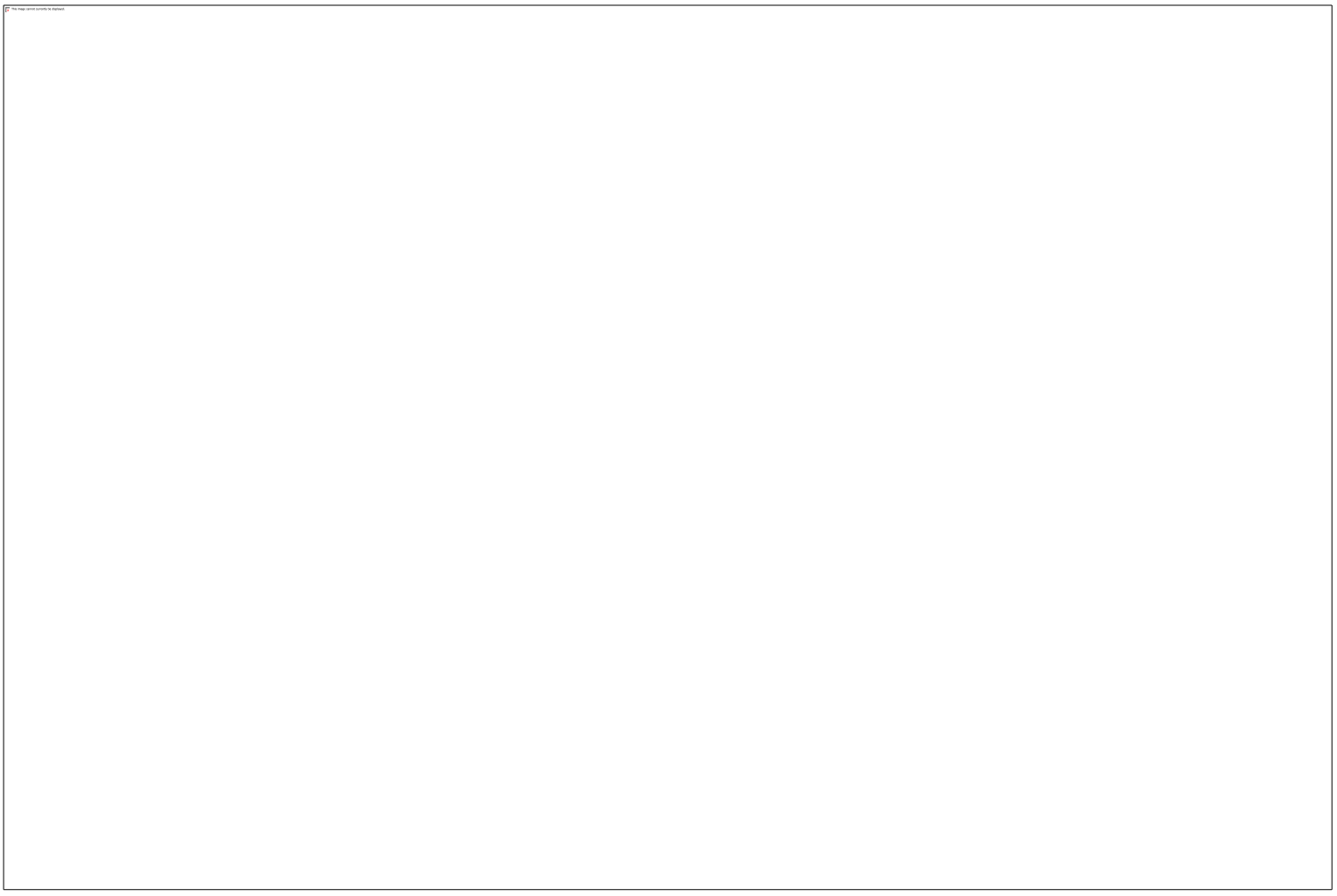
Hyenas.

Leopards.

Rock hyraxes.

Various mountain birds.

E. Semi-arid and desert habitats



These are dry environments characterised by low and unreliable rainfall.

Characteristics:

Sparse vegetation.

High temperatures in many areas.

Limited surface water.

Drought-resistant plants.

Wildlife adapted to water scarcity.

Examples:

Samburu.

Isiolo.

Turkana.

Northern Kenya.

Wildlife found here:

Grevy's zebra.

Gerenuk.

Reticulated giraffe.

Somali ostrich.

Beisa oryx.

3.0 CATEGORIES OF WILDLIFE PROTECTED AREAS

Wildlife in Kenya is protected through different conservation areas. These areas differ in their management, permitted activities and levels of protection.

3.1 National Parks

A national park is a large area of land or water set aside and protected by the government for the conservation of wildlife, natural vegetation and scenic features.

National parks are managed primarily for biodiversity conservation, research, education and tourism.

Characteristics of national parks

They are legally protected areas.

Wildlife and natural habitats receive protection.

Human activities are regulated.

Poaching and illegal exploitation of wildlife are prohibited.

Tourism activities are controlled.

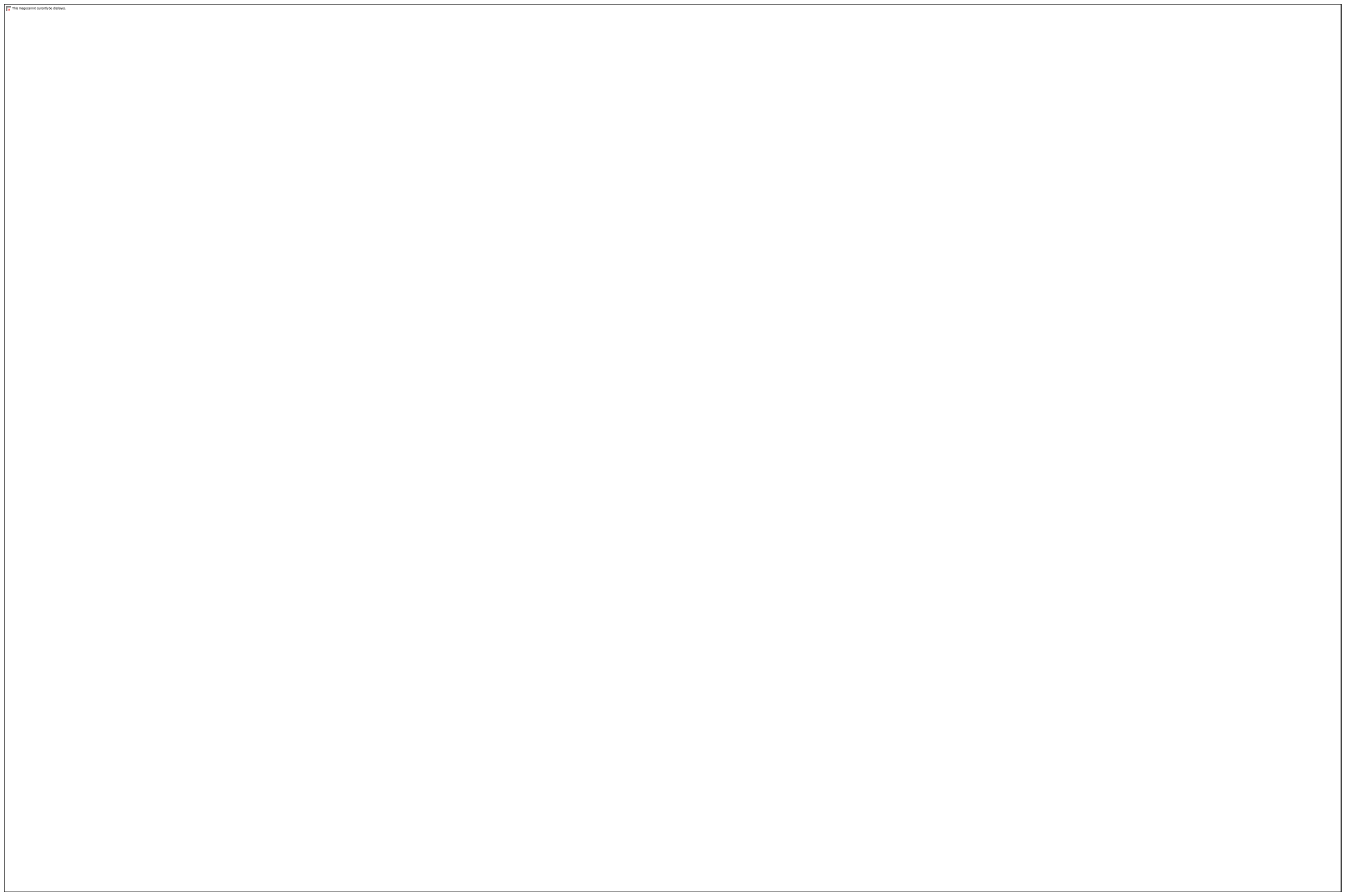
Research and environmental education are encouraged.

Infrastructure development is restricted to protect the environment.

They are managed by authorised conservation agencies.

Examples of national parks in Kenya





Nairobi National Park – famous for wildlife living close to a major city.

Amboseli National Park – known for elephants and views of Mount Kilimanjaro.

Tsavo East National Park – famous for elephants and extensive savannah landscapes.

Tsavo West National Park – known for varied landscapes, wildlife and Mzima Springs.

Lake Nakuru National Park – known for rhinos, birds and flamingos.

Mount Kenya National Park – protects mountain ecosystems.

Aberdare National Park – protects montane forests and mountain wildlife.

Meru National Park – supports elephants, lions and other wildlife.

Hell's Gate National Park – known for dramatic scenery, geothermal features and wildlife.

3.2 Game Reserves

A game reserve is an area of land set aside for the protection and management of wild animals and their habitats, with regulated human activities.

Game reserves may be managed by national or county governments, depending on their legal status.

Characteristics of game reserves

They protect wildlife from uncontrolled exploitation.

They provide habitats for different animal species.

They support tourism and recreation.

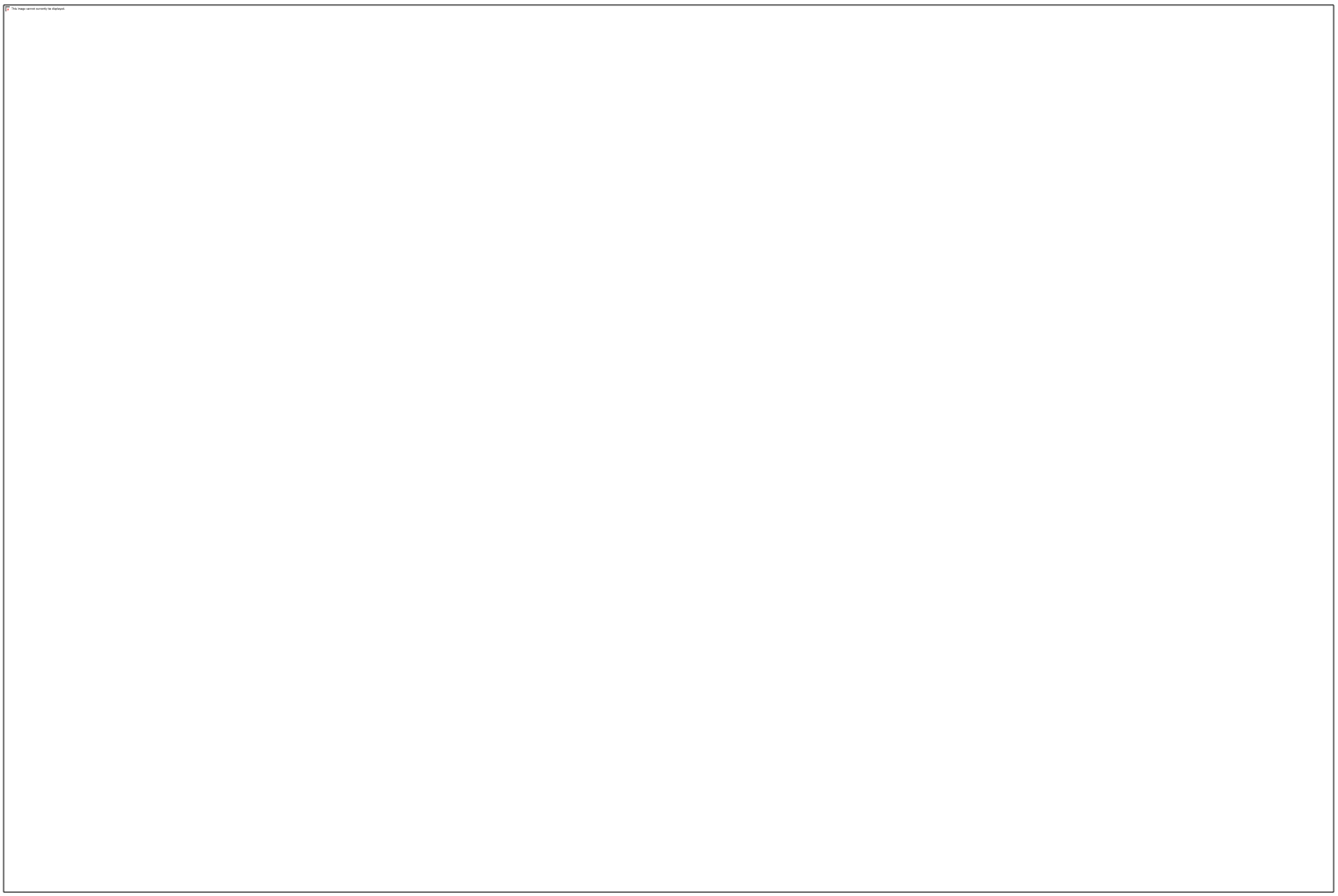
They may permit certain regulated human activities depending on their management rules.

They support wildlife research.

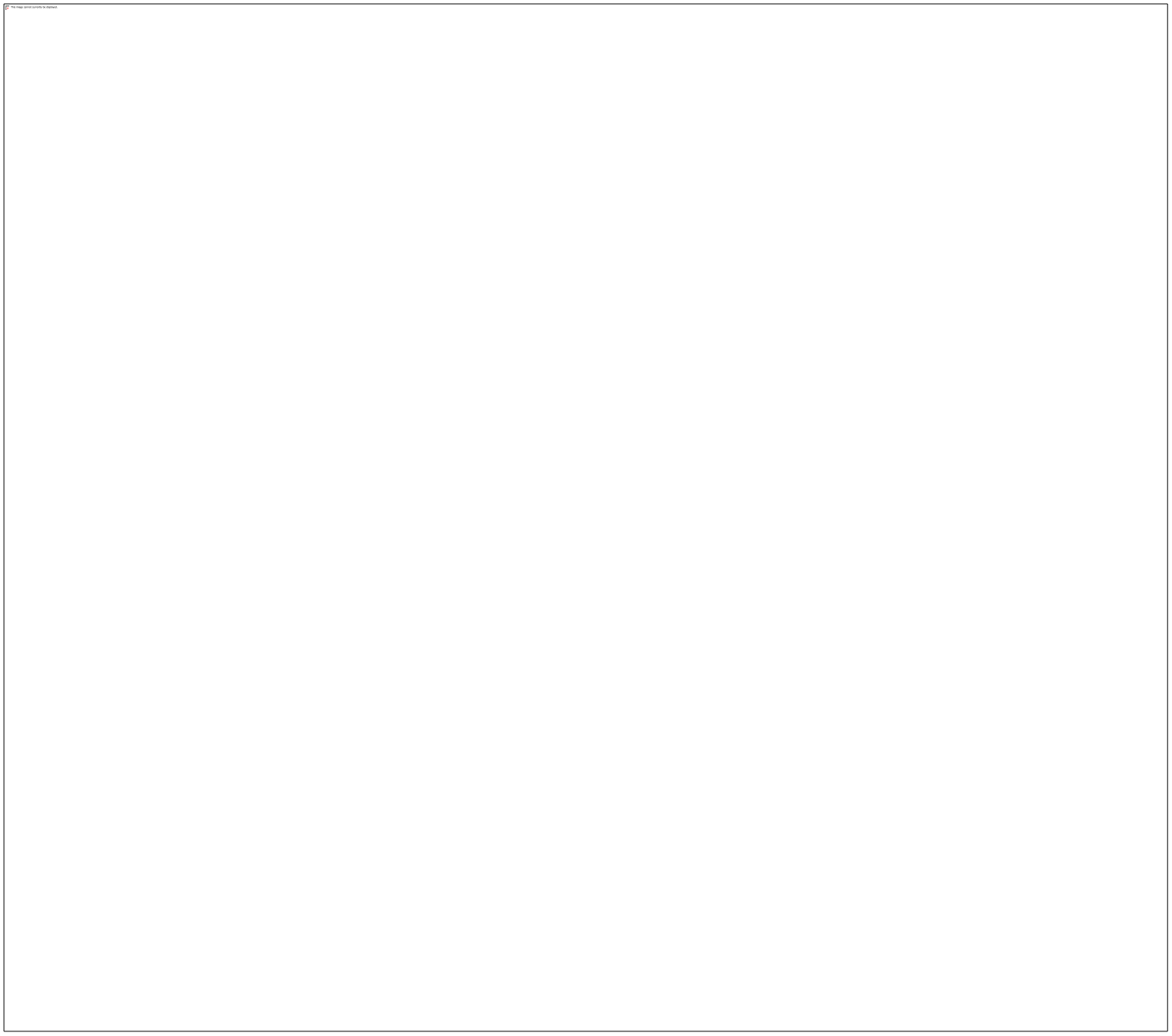
They help reduce the loss of endangered species.

They may be managed in partnership with local communities.

Examples of game reserves in Kenya







Maasai Mara National Reserve – famous for the wildebeest migration and large predators.

Samburu National Reserve – protects Grevy's zebras, gerenuks and reticulated giraffes.

Buffalo Springs National Reserve – supports wildlife adapted to semi-arid conditions.

Shimba Hills National Reserve – known for sable antelopes and forest wildlife.

Bisanadi National Reserve – protects wildlife habitats adjacent to Meru National Park.

Note: The Maasai Mara is a national reserve, not a national park. This distinction is important in Geography examinations.

3.3 Wildlife Sanctuaries

A wildlife sanctuary is a protected area established to provide a safe environment for particular wild animals or groups of species, especially threatened or endangered species.

Sanctuaries may protect animals in their natural habitats or provide specialised care and rehabilitation.

Characteristics of wildlife sanctuaries

They provide safe breeding environments.

They protect endangered animal species.

They support wildlife rehabilitation.

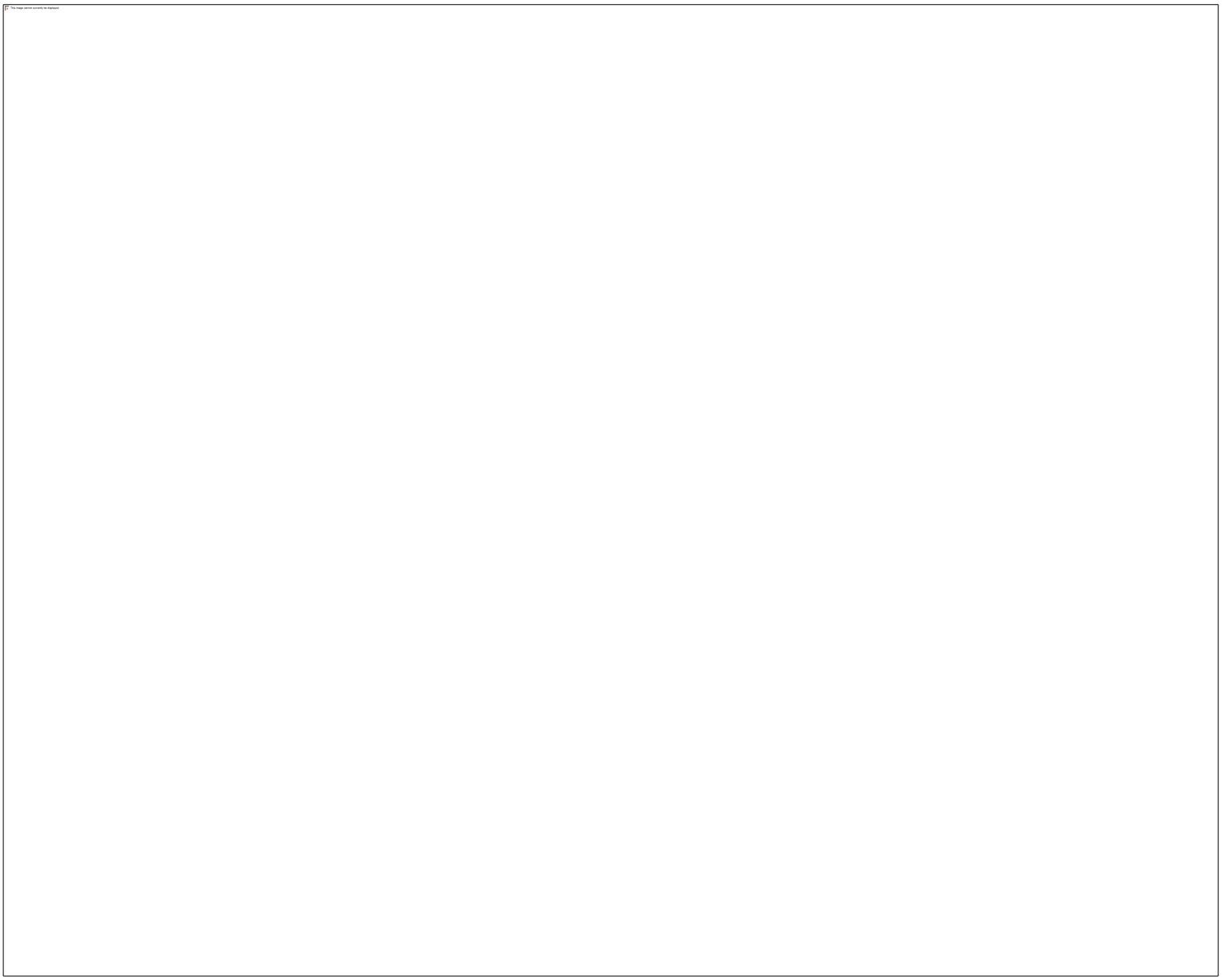
They promote scientific research.

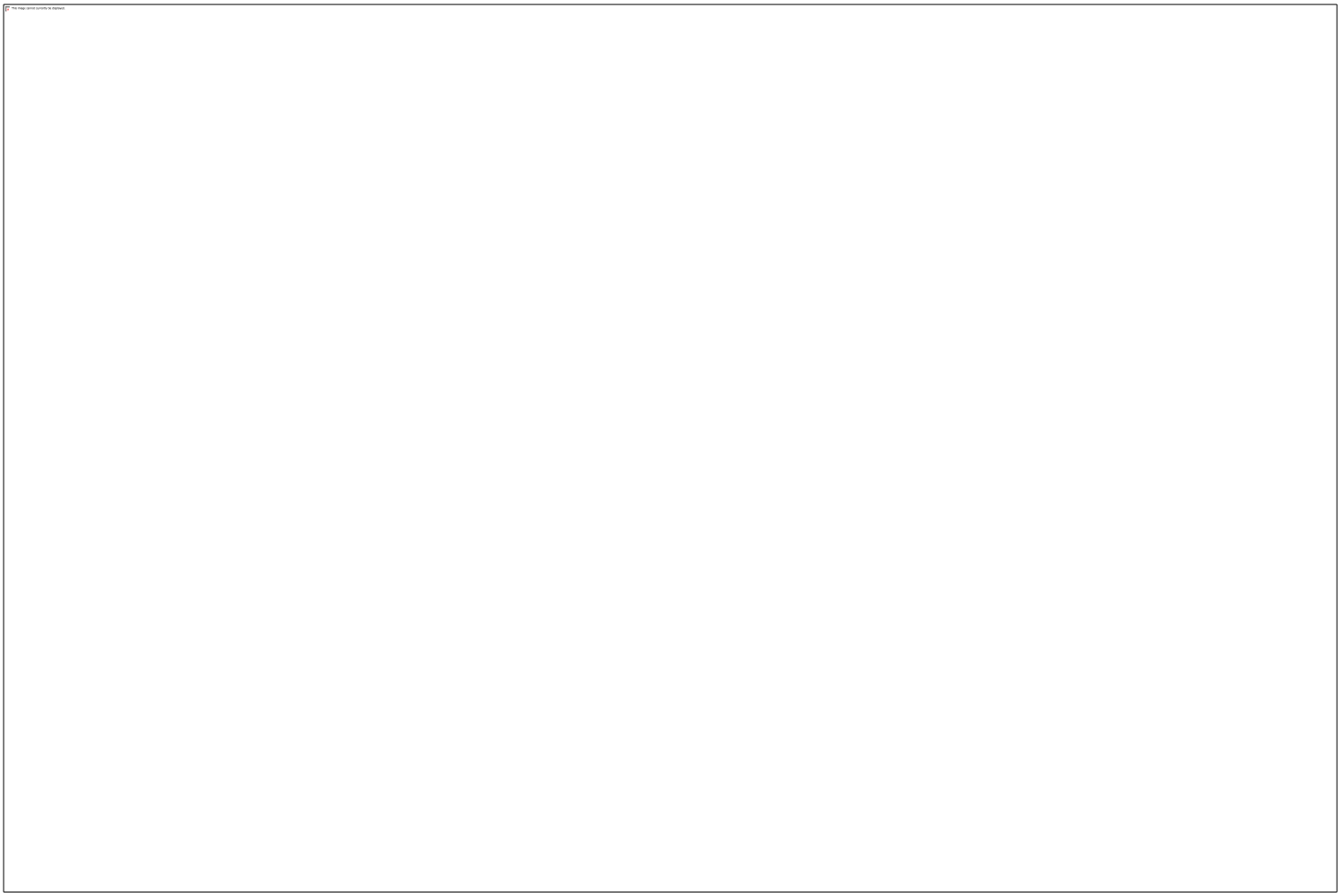
They provide environmental education.

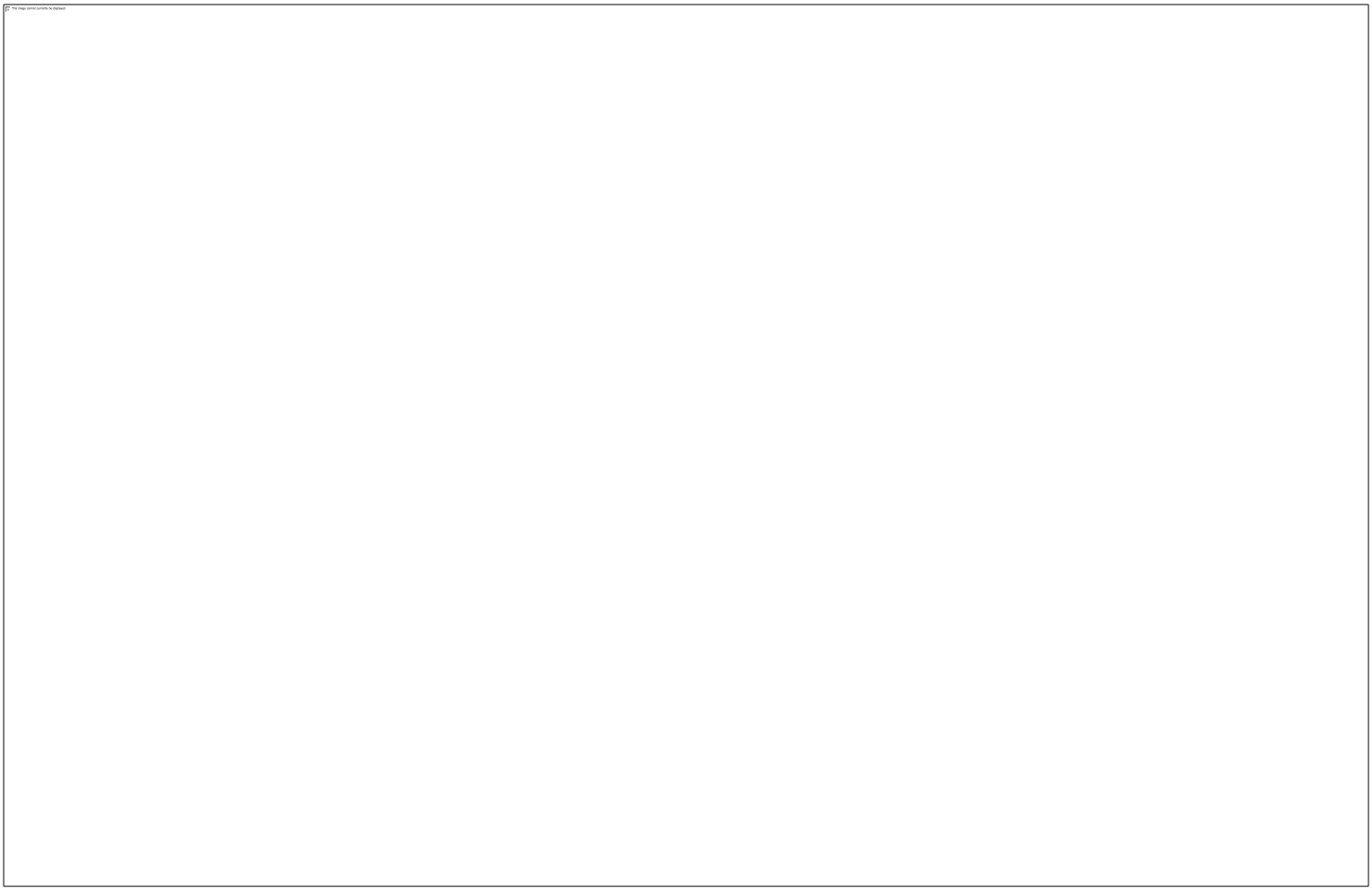
They support rescue and treatment of injured animals.

They help increase populations of threatened species.

Examples of wildlife sanctuaries in Kenya







Ol Pejeta Conservancy – famous for rhino conservation and the protection of endangered species.

David Sheldrick Wildlife Trust – rescues and rehabilitates orphaned elephants and rhinos.

Kisumu Impala Sanctuary – provides protection for impalas and other wildlife.

Sweetwaters Chimpanzee Sanctuary – provides a home for rescued chimpanzees.

3.4 Differences Between National Parks, Game Reserves and Wildlife Sanctuaries

National parks	Game reserves	Wildlife sanctuaries
Protect entire ecosystems and wildlife.	Protect wildlife populations and habitats.	Often focus on particular species or groups of animals.
Generally managed by national conservation authorities.	May be managed by national or county authorities.	May be managed by government agencies, trusts or conservation organisations.
Tourism is regulated.	Tourism and other permitted activities are regulated.	Tourism and access depend on the sanctuary's rules.
Usually cover extensive areas.	Vary in size.	May be relatively small or extensive.
Protect natural habitats and biodiversity.	Protect wildlife and their habitats.	May provide specialised breeding, rescue and rehabilitation.

Important: The precise legal classification and permitted activities of protected areas depend on the relevant Kenyan laws and management arrangements.

4.0 FACTORS INFLUENCING THE DISTRIBUTION OF WILDLIFE IN KENYA

4.1 Meaning of Wildlife Distribution

Wildlife distribution refers to the geographical pattern or arrangement of different species of wild animals in various parts of the world.

Wildlife is not evenly distributed because different animal species require different environmental conditions for survival.

Some animals are commonly found in forests, while others occupy grasslands, wetlands, mountains and semi-arid environments.

For example:

Elephants occur in Amboseli, Tsavo and Samburu.

Flamingos occur in suitable alkaline lakes such as Lake Nakuru and Lake Bogoria.

Grevy's zebras are mainly associated with northern Kenya.

Mountain bongos are associated with forest habitats in the Aberdare ecosystem and Mount Kenya region.

4.2 Physical Factors Influencing Wildlife Distribution

These are natural environmental conditions that determine where different wildlife species can survive.

1. Climate

Climate refers to the average weather conditions of a place over a long period of time.

It includes rainfall, temperature, humidity, sunshine and wind.

Climate influences wildlife distribution in the following ways:

Rainfall: Areas receiving adequate rainfall support abundant vegetation, which provides food for herbivores. For example, the Maasai Mara supports large populations of wildebeests and zebras because of its grasslands.

Temperature: Different animals have different temperature requirements. Some species thrive in hot savannah environments, while others are adapted to cool mountain forests.

Humidity: High humidity supports certain forest and wetland organisms, while low humidity favours animals adapted to dry environments.

Seasonal rainfall: Seasonal rainfall influences the availability of water and pasture, causing animals to migrate in search of food.

Drought: Prolonged drought reduces vegetation and water availability, forcing wildlife to move to areas with better conditions.

2. Availability of Water

Water is essential for the survival of wildlife.

It influences wildlife distribution through:

Providing drinking water for animals.

Supporting aquatic organisms such as fish and crocodiles.

Encouraging the growth of vegetation used as food.

Providing breeding grounds for amphibians and aquatic birds.

Supporting wetland ecosystems.

Attracting herbivores and predators to water points.

Examples:

Elephants and other animals are attracted to water sources in Tsavo.

Hippos are commonly found in rivers and lakes.

Flamingos are associated with suitable saline and alkaline lakes.

Crocodiles inhabit rivers and lakes such as Lake Victoria and the Tana River.

3. Vegetation

Vegetation refers to the natural plant cover of an area.

Vegetation influences wildlife distribution because:

It provides food for herbivorous animals.

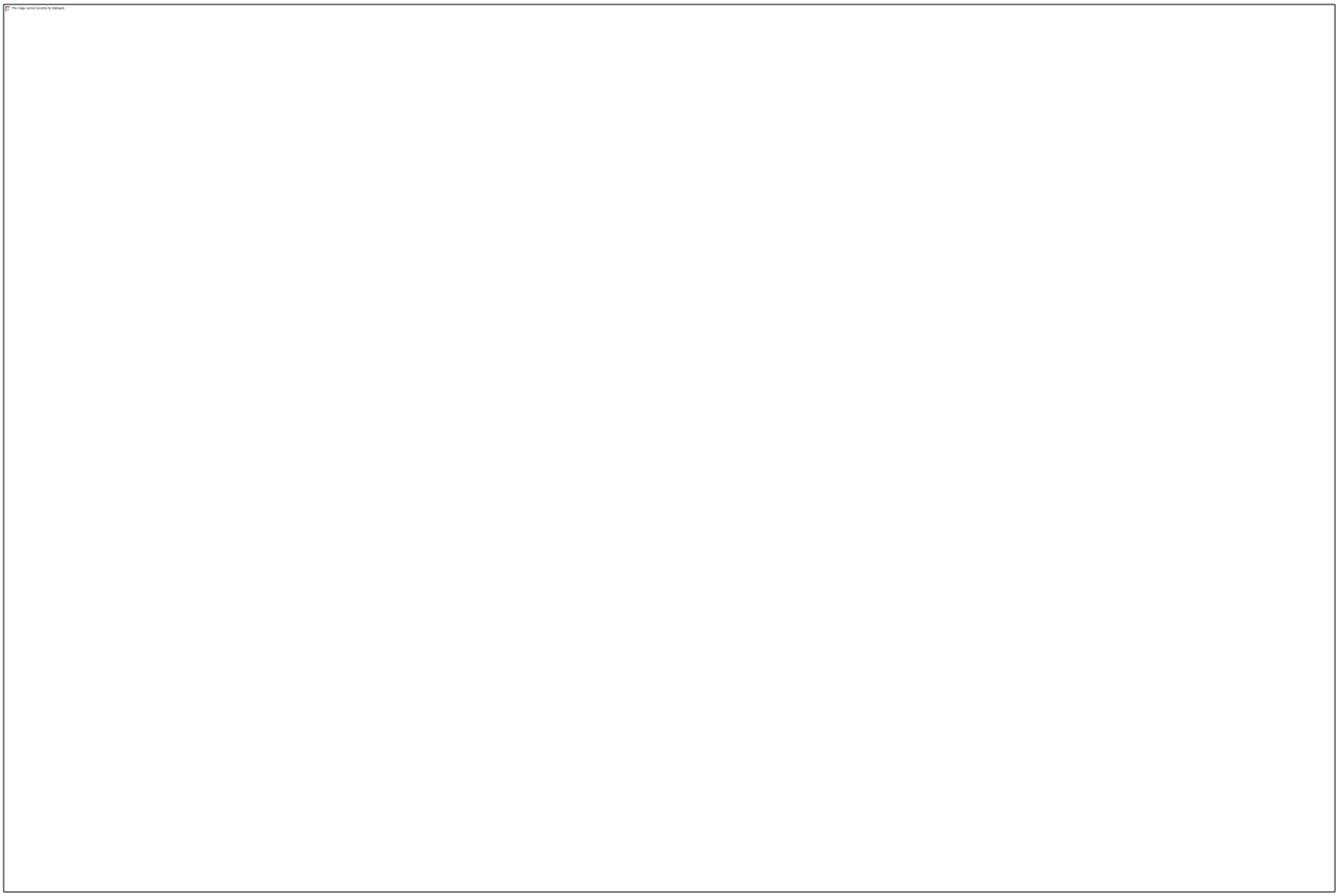
It offers shelter and protection from predators.

It provides nesting materials for birds.

Forests provide habitats for monkeys, forest elephants and other forest animals.

Grasslands support grazing animals such as zebras, wildebeests and antelopes.

Aquatic vegetation supports fish and water birds.



4. Relief and Altitude

Relief refers to the physical features and variations in the height of the land surface.

Altitude is the height of a place above sea level.

Their influence includes:

High-altitude areas generally experience lower temperatures, favouring cold-adapted species.

Lowland grasslands support many grazing animals.

Steep mountainous areas may restrict the movement of some large animals.

Valleys and depressions may contain water and support vegetation.

Mountain forests provide habitats for specialised wildlife.

Differences in altitude create different vegetation zones, resulting in different animal habitats.

Examples:

Mountain bongos occur in montane forest habitats.

Rock hyraxes occur in rocky mountainous environments.

Zebras and wildebeests are commonly found in open grasslands.

5. Soil Types

Soil influences wildlife distribution indirectly through its effect on vegetation.

Fertile soils support abundant plant growth, providing food for herbivores.

Poor soils may support sparse vegetation, limiting the number of grazing animals.

Waterlogged soils support wetland vegetation and aquatic organisms.

Sandy soils support specialised vegetation and animals adapted to dry environments.

Soil composition influences the type of vegetation that develops in an area.

6. Drainage and Water Bodies

Drainage refers to the arrangement and movement of rivers, streams, lakes and other water bodies in an area.

It influences wildlife distribution by:

Providing permanent and seasonal water sources.

Supporting aquatic ecosystems.

Creating breeding grounds for fish and amphibians.

Supporting vegetation along riverbanks.

Attracting birds and mammals.

Providing migration corridors for some animal species.

7. Natural Vegetation Zones and Habitat Diversity

Areas with different types of natural vegetation support different wildlife species.

For example:

Savannah vegetation supports grazers and large predators.

Dense forests support forest-dwelling animals.

Wetlands support aquatic birds and amphibians.

Mountain vegetation supports specialised highland species.

Coastal vegetation supports animals adapted to mangroves and marine environments.

4.3 Human Factors Influencing Wildlife Distribution

Human activities can either encourage wildlife conservation or cause wildlife populations to decline.

1. Agricultural Activities

Agriculture influences wildlife distribution through:

Clearing natural vegetation to establish farms.

Draining wetlands for crop production.

Using pesticides that may poison wildlife.

Fencing farms and blocking wildlife migration routes.

Human settlement around wildlife habitats.

Competition for water and grazing land.

For example, expansion of crop farming around wildlife dispersal areas may restrict the movement of elephants and other animals.

2. Urbanisation and Settlement

Urbanisation refers to the growth and expansion of towns and cities.

It influences wildlife distribution through:

Destruction of natural habitats to create space for buildings.

Construction of roads and railways across wildlife habitats.

Increased noise and human disturbance.

Pollution of rivers and lakes.

Increased human-wildlife conflicts.

Fragmentation of wildlife habitats.

3. Tourism Development

Tourism may positively or negatively influence wildlife distribution.

Positive effects:

Provides income for wildlife conservation.

Encourages the establishment of protected areas.

Creates employment for local communities.

Supports wildlife research.

Negative effects:

Excessive tourist vehicles may disturb animals.

Uncontrolled tourism infrastructure may destroy habitats.

Littering and pollution may affect wildlife.

Off-road driving may damage vegetation.

4. Poaching and Illegal Hunting

Poaching refers to the illegal hunting, capturing or killing of wild animals.

It influences wildlife distribution by:

Reducing animal populations.

Causing local extinction of certain species.

Disrupting breeding patterns.

Reducing genetic diversity.

Forcing animals to move away from dangerous areas.

Increasing the vulnerability of endangered species.

5. Industrialisation

Industrial activities affect wildlife distribution through:

Destruction of habitats during mining and construction.

Pollution of air, water and soil.

Noise from industrial machinery.

Disposal of toxic industrial waste.

Increased demand for land and natural resources.

6. Wildlife Conservation Policies

Government policies and conservation programmes influence wildlife distribution.

Establishment of national parks protects wildlife populations.

Creation of wildlife corridors allows animal movement.

Anti-poaching laws discourage illegal hunting.

Community conservancies encourage local participation.

Habitat restoration enables wildlife to return to degraded areas.

7. Infrastructure Development

Construction of roads, railways, dams and power lines may influence wildlife distribution.

Roads may divide animal habitats.

Railways may obstruct migration routes.

Dams may alter aquatic ecosystems.

Power lines may cause injuries or deaths to birds.

Fencing may prevent animals from accessing water and grazing grounds.

4.4 Summary of Factors Influencing Wildlife Distribution

Physical factors	Human factors
Climate	Agriculture
Rainfall	Urbanisation
Temperature	Industrialisation
Water availability	Poaching
Vegetation	Tourism
Relief and altitude	Infrastructure
Soil types	Conservation policies
Drainage	Human settlement

5.0 DISTRIBUTION AND LOCATION OF WILDLIFE PROTECTED AREAS IN EAST AFRICA

5.1 Meaning of East Africa

East Africa is a geographical region of the African continent consisting of countries located in the eastern part of Africa.

For this sub-strand, the main East African countries considered include:

Kenya.

Uganda.

Tanzania.

Rwanda.

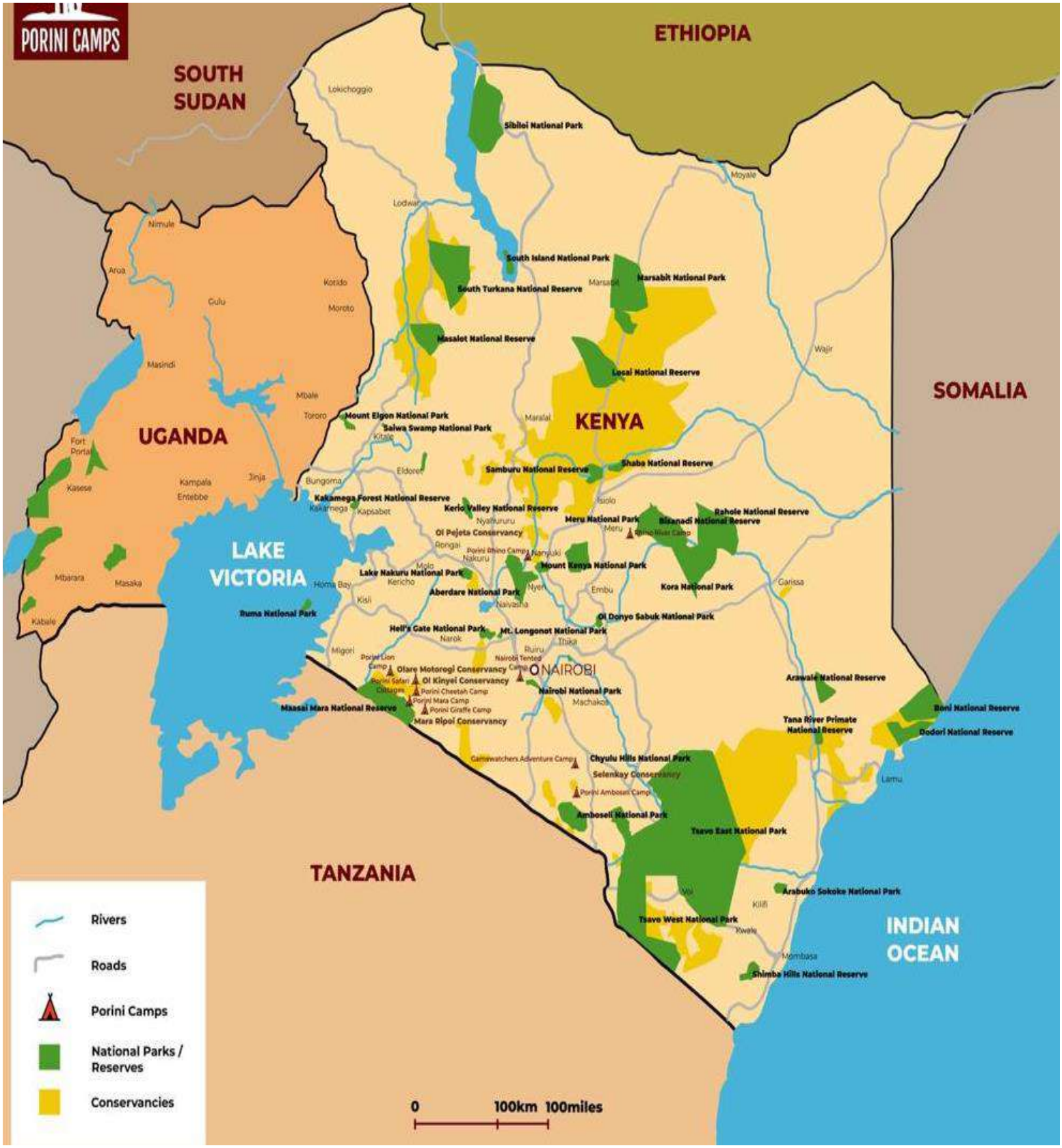
Burundi.

South Sudan.

The East African region has diverse wildlife resources because of its varied climate, vegetation, relief and drainage systems.

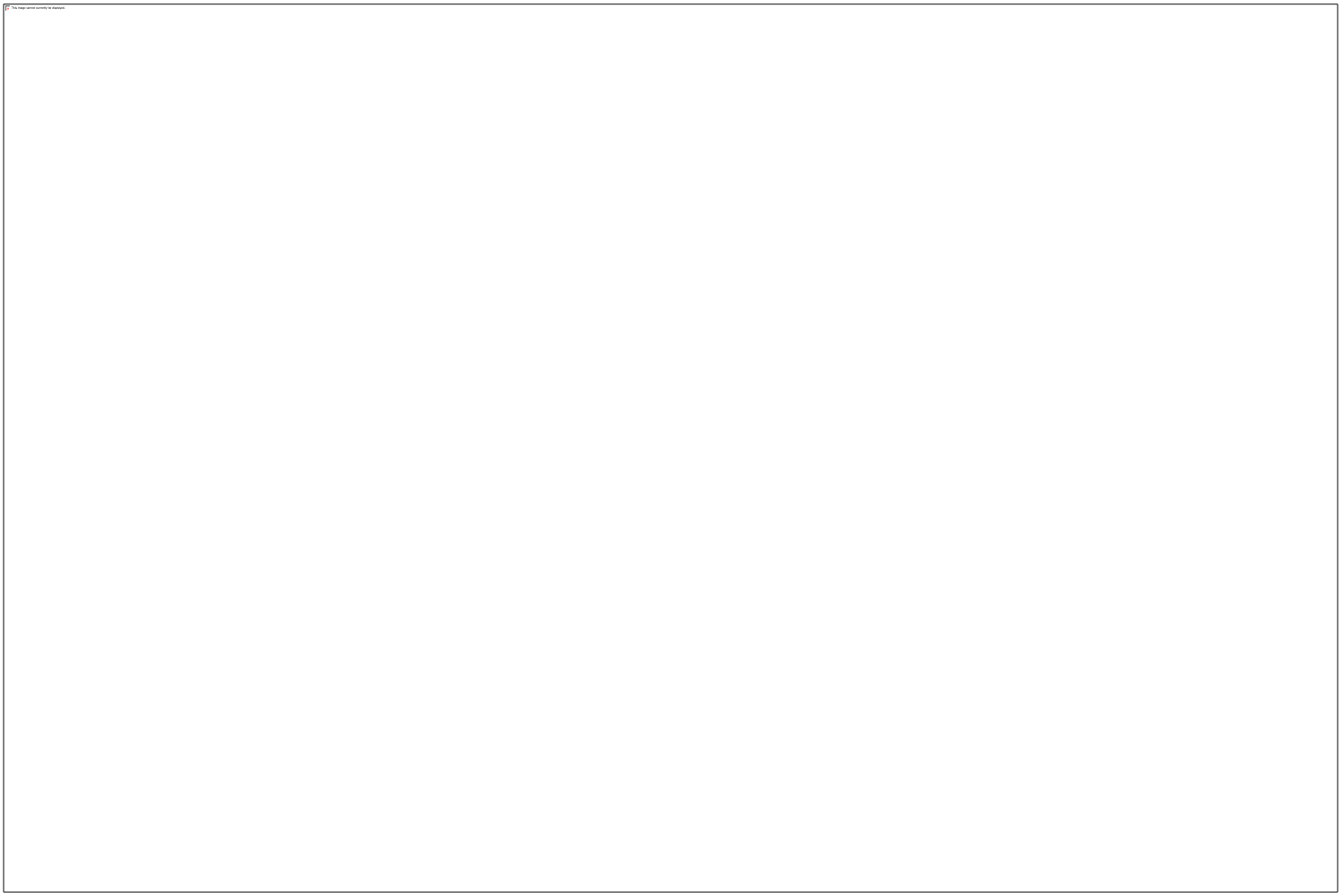
5.2 Major Wildlife Conservation Areas in East Africa

A. Wildlife conservation areas in Kenya



Protected area	Location	Major wildlife
Nairobi National Park	Nairobi	Lions, rhinos, giraffes and zebras
Amboseli National Park	Kajiado	Elephants, lions and zebras
Tsavo East National Park	Taita-Taveta	Elephants, lions and giraffes
Tsavo West National Park	Taita-Taveta	Elephants, rhinos and leopards
Lake Nakuru National Park	Nakuru	Rhinos, flamingos and buffaloes
Meru National Park	Meru	Elephants, lions and Grevy's zebras
Mount Kenya National Park	Central Kenya	Mountain wildlife
Aberdare National Park	Central Kenya	Mountain bongos, elephants and leopards
Maasai Mara National Reserve	Narok	Wildebeests, lions and cheetahs
Samburu National Reserve	Samburu	Grevy's zebras, gerenuks and elephants
Shimba Hills National Reserve	Kwale	Sable antelopes and elephants
Buffalo Springs National Reserve	Isiolo	Elephants, gerenuks and zebras

B. Wildlife conservation areas in Tanzania





Protected area	Location	Major wildlife
Serengeti National Park	Northern Tanzania	Wildebeests, zebras, lions and cheetahs
Ngorongoro Conservation Area	Northern Tanzania	Rhinos, lions, elephants and buffaloes
Tarangire National Park	Northern Tanzania	Elephants, zebras and giraffes
Lake Manyara National Park	Northern Tanzania	Flamingos, elephants and tree-climbing lions
Ruaha National Park	Central Tanzania	Elephants, lions and wild dogs
Nyerere National Park	Southern Tanzania	Elephants, hippos and crocodiles

C. Wildlife conservation areas in Uganda

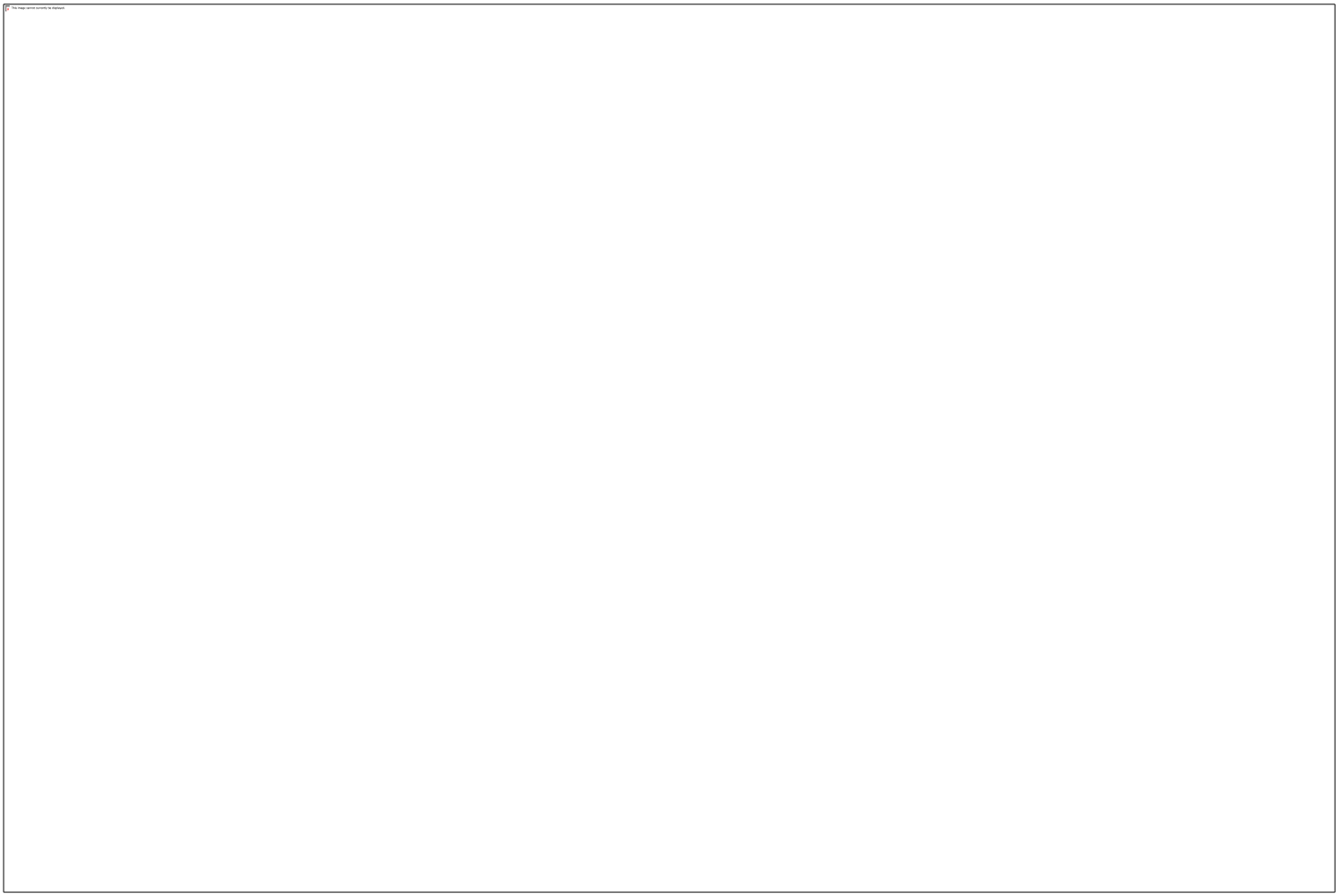




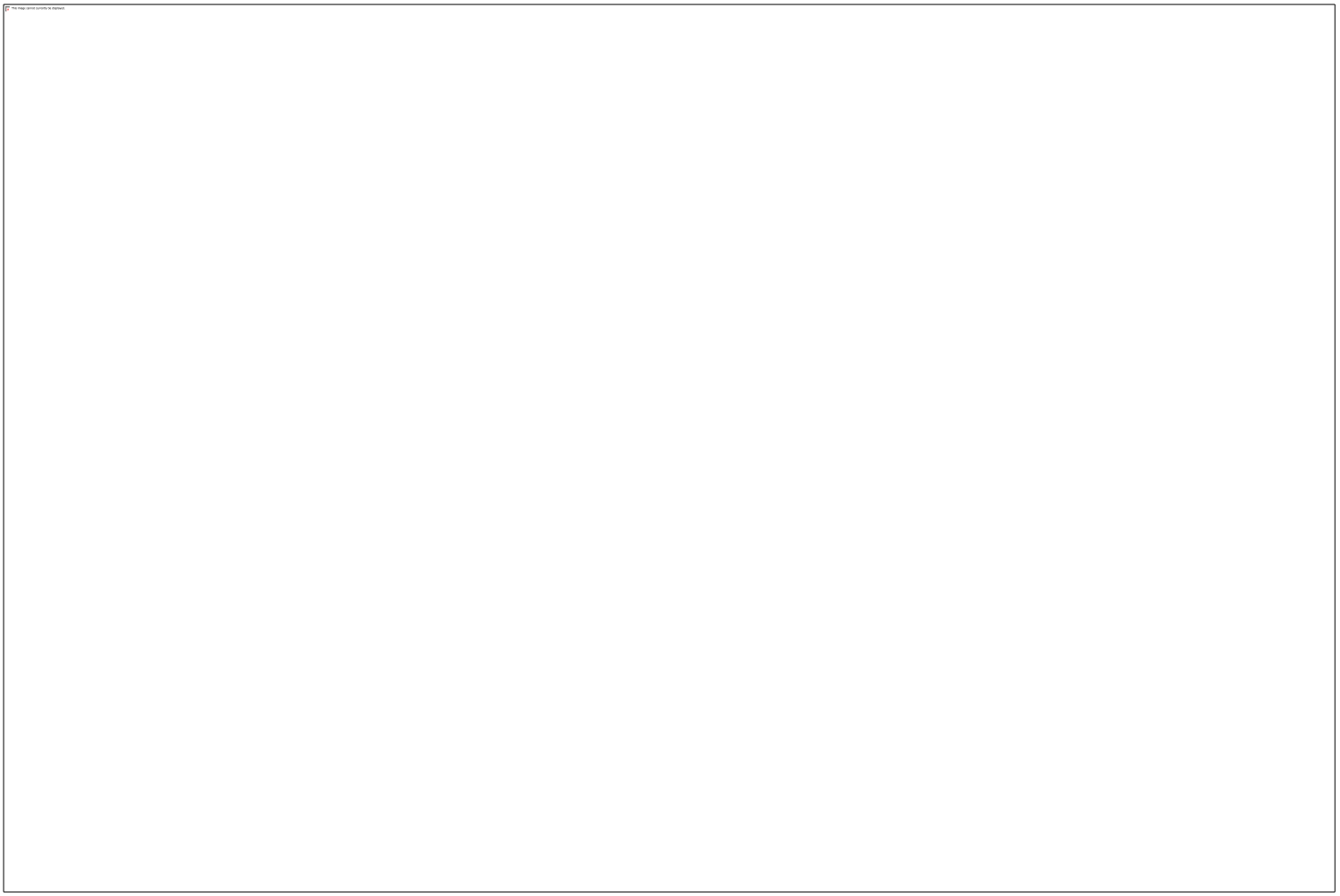
Protected area	Location	Major wildlife
Queen Elizabeth National Park	Western Uganda	Elephants, lions, hippos and buffaloes
Murchison Falls National Park	Northwestern Uganda	Giraffes, elephants and crocodiles

Bwindi Impenetrable National Park	Southwestern Uganda	Mountain gorillas and forest birds
Kibale National Park	Western Uganda	Chimpanzees and forest monkeys
Kidepo Valley National Park	Northeastern Uganda	Lions, cheetahs and giraffes
Lake Mburo National Park	Western Uganda	Zebras, impalas and buffaloes

D. Wildlife conservation areas in Rwanda







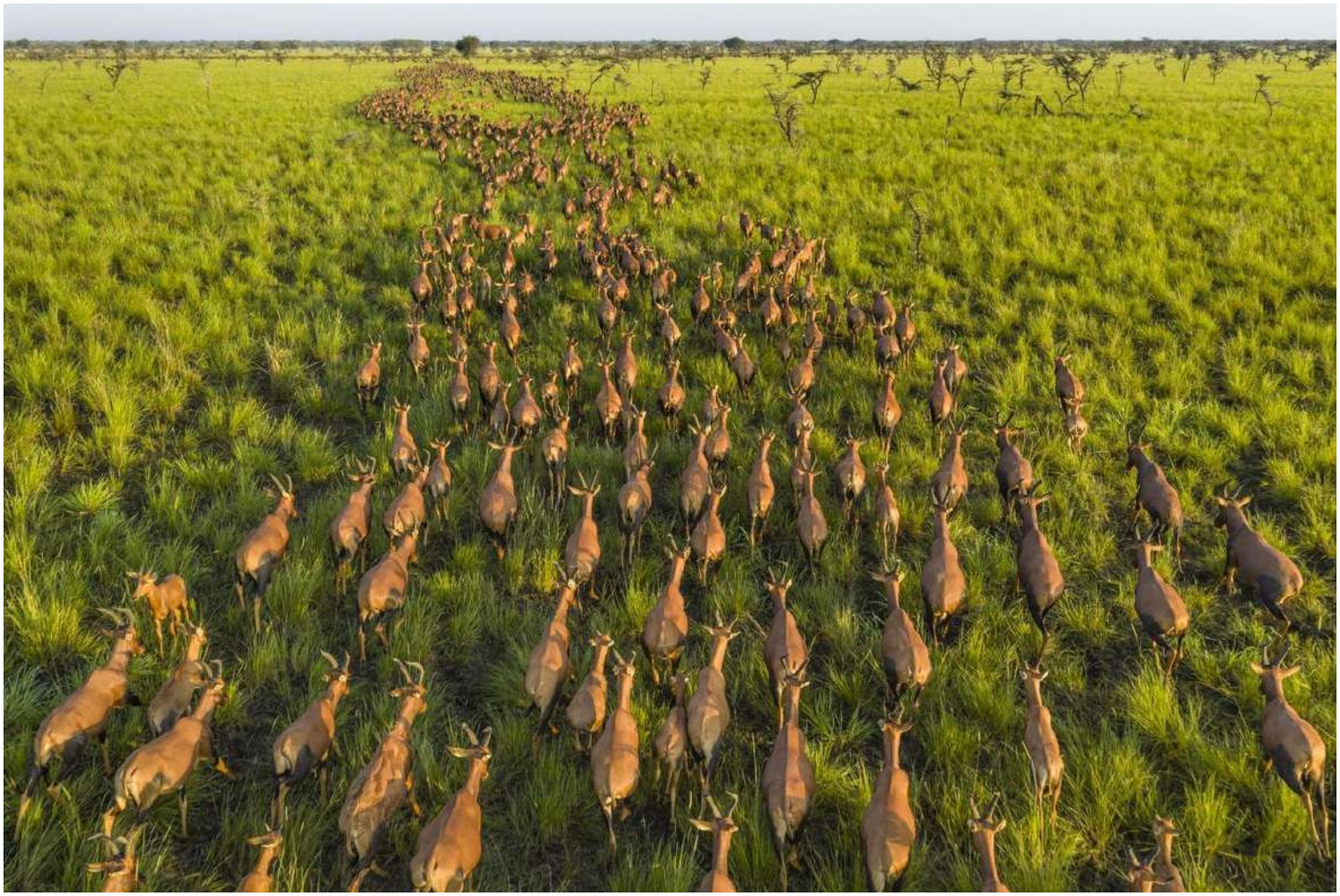
Protected area	Location	Major wildlife
Volcanoes National Park	Northwestern Rwanda	Mountain gorillas and golden monkeys
Akagera National Park	Eastern Rwanda	Elephants, lions, rhinos and giraffes
Nyungwe National Park	Southwestern Rwanda	Chimpanzees and forest monkeys

E. Wildlife conservation areas in Burundi



Protected area	Location	Major wildlife
Ruvubu National Park	Northeastern Burundi	Antelopes, hippos and primates
Kibira National Park	Northwestern Burundi	Monkeys, chimpanzees and forest birds

F. Wildlife conservation areas in South Sudan



Protected area	Location	Major wildlife
Boma National Park	Eastern South Sudan	White-eared kob and other antelopes
Bandingilo National Park	Central South Sudan	Antelopes and migratory wildlife
Nimule National Park	Southern South Sudan	Elephants, hippos and buffaloes

5.3 Importance of Mapping Wildlife Conservation Areas

Locating protected areas on maps is important because it enables learners to:

Identify the geographical distribution of wildlife resources.

Understand the relationship between wildlife and physical features.

Compare the distribution of protected areas in different countries.

Identify major wildlife tourism destinations.

Understand cross-border wildlife movements.

Develop map-reading and interpretation skills.

Appreciate the need for regional wildlife conservation.

5.4 Practical Activity: Drawing a Map of East Africa Showing Wildlife Conservation Areas

Activity

Using an outline map of East Africa:

Identify the countries of Kenya, Uganda, Tanzania, Rwanda, Burundi and South Sudan.

Locate the major national parks and game reserves in each country.

Use different symbols to represent national parks, game reserves and sanctuaries.

Provide a suitable map key.

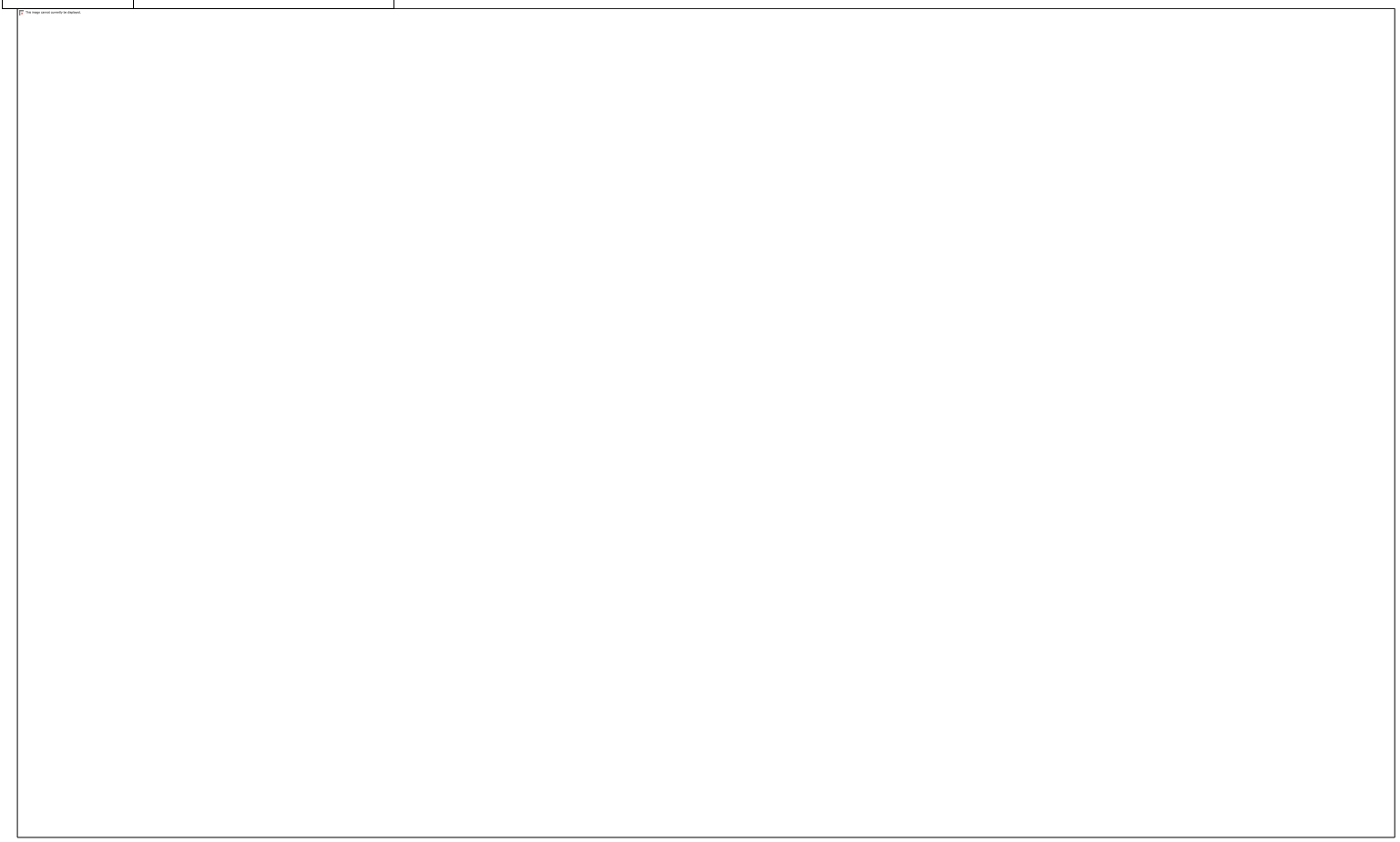
Indicate the direction of north.

Give the map a suitable title.

Display the completed map for discussion.

Suggested map key

Symbol	**Meaning**
▲	National park
●	Game reserve
■	Wildlife sanctuary



6.0 PROBLEMS FACING WILDLIFE IN EAST AFRICA

Wildlife in East Africa faces numerous natural and human-induced challenges. These challenges threaten animal populations, destroy habitats and interfere with ecological balance.

6.1 Poaching and Illegal Wildlife Trade

Poaching is the illegal hunting, capturing or killing of wild animals.

It is one of the major threats to wildlife conservation in East Africa.

Causes of poaching

Demand for ivory from elephant tusks.

Demand for rhino horns.

Demand for animal skins and body parts.

Illegal trade in live animals.

Poverty and unemployment.

Weak enforcement of wildlife protection laws.

International demand for wildlife products.

Effects of poaching

Reduces wildlife populations.

Threatens endangered species with extinction.

Disrupts food chains and food webs.

Reduces tourism revenue.

Causes loss of biodiversity.

Interferes with breeding patterns.

Encourages illegal wildlife trafficking.



6.2 Habitat Destruction

Habitat destruction refers to the removal, degradation or alteration of natural environments where wildlife lives.

Causes

Deforestation.

Agricultural expansion.

Human settlement.

Mining and quarrying.

Road construction.

Industrial development.

Charcoal burning.

Uncontrolled livestock grazing.

Effects

Wildlife loses food and shelter.

Animals are forced to migrate.

Breeding grounds are destroyed.

Animal populations decline.

Competition for limited resources increases.

Some species become locally extinct.

6.3 Human-Wildlife Conflicts

Human-wildlife conflict occurs when wildlife and human beings compete for resources or when the activities of one negatively affect the other.

Examples in Kenya

Elephants destroying crops in communities bordering Tsavo and Amboseli.

Lions attacking livestock in pastoral communities.

Hippos damaging crops near lakes.

Crocodiles attacking people and livestock near rivers.

Baboons destroying crops in farming areas.

Causes

Expansion of human settlements into wildlife habitats.

Competition for water.

Destruction of wildlife corridors.

Shortage of natural food during drought.

Increasing human population.

Encroachment into protected areas.

Livestock grazing within wildlife habitats.

Effects

Loss of human life.

Injury to people and animals.

Destruction of crops.

Loss of livestock.

Increased hostility towards wildlife.

Retaliatory killing of wild animals.

Economic losses to communities.

Reduced support for conservation.



6.4 Climate Change

Climate change refers to long-term changes in temperature, rainfall patterns and other climatic conditions.

Effects on wildlife

Prolonged drought reduces water and pasture.

Increased temperatures affect animal survival.

Changing rainfall patterns interfere with breeding seasons.

Wetlands may dry up, destroying aquatic habitats.

Rising temperatures may force animals to migrate.

Extreme weather events destroy habitats.

Changes in vegetation affect food availability.

Kenyan examples

Drought in northern Kenya affects elephants, zebras and other wildlife.

Reduced water levels in wetlands affect aquatic birds.

Changes in rainfall influence the availability of pasture in the Maasai Mara ecosystem.

6.5 Diseases and Parasites

Wildlife is affected by diseases caused by viruses, bacteria, fungi and parasites.

Examples include:

Anthrax.

Foot-and-mouth disease.

Rabies.

Tuberculosis.

Tick-borne diseases.

Effects

Cause deaths among wild animals.

Reduce breeding success.

Spread between domestic and wild animals.

Reduce wildlife populations.

Increase the cost of wildlife management.

Threaten endangered species.

6.6 Pollution

Pollution refers to the introduction of harmful substances into the environment.

Types of pollution affecting wildlife

A. Water pollution

Industrial waste entering rivers and lakes.

Agricultural chemicals flowing into wetlands.

Oil spills affecting marine ecosystems.

Plastic waste swallowed by aquatic animals.

B. Air pollution

Industrial emissions.

Smoke from burning vegetation.

Dust from construction activities.

Vehicle emissions.

C. Soil pollution

Pesticides and herbicides.

Improper disposal of solid waste.

Chemical spills.

Industrial waste.

Effects of pollution

Poisoning of wildlife.

Death of aquatic organisms.

Destruction of breeding grounds.

Contamination of food chains.

Reduced reproductive success.

Degradation of natural habitats.

6.7 Invasive Alien Species

An invasive alien species is a non-native organism introduced into an ecosystem that spreads and causes harm to native species, habitats or the environment.

Examples and effects

Invasive plants may replace indigenous vegetation.

Water hyacinth can obstruct water movement and interfere with aquatic ecosystems.

Invasive plants may reduce the availability of food for native wildlife.

Some introduced animals may compete with native species for food and habitats.

6.8 Human Population Growth

Increasing human population puts pressure on wildlife resources through:

Expansion of settlements.

Increased demand for agricultural land.

Increased demand for water and fuelwood.

Encroachment into protected areas.

Construction of infrastructure.

Increased human-wildlife conflict.

6.9 Inadequate Funding

Wildlife conservation requires adequate financial resources.

Inadequate funding causes:

Shortage of trained wildlife personnel.

Poor maintenance of protected areas.

Inadequate patrol equipment.

Limited wildlife research.

Weak conservation education programmes.

Inadequate veterinary services.

6.10 Political Instability and Insecurity

Political instability and insecurity in some parts of East Africa affect wildlife conservation through:

Disruption of conservation programmes.

Illegal hunting and wildlife trafficking.

Destruction of wildlife habitats.

Reduced tourism activities.

Limited movement of wildlife officers.

Weak enforcement of conservation laws.

6.11 Bushfires

Bushfires are uncontrolled fires that destroy natural vegetation.

Causes

Careless burning of vegetation.

Lightning.

Land clearing.

Arson.

Uncontrolled charcoal production.

Effects

Death of animals.

Destruction of nesting sites.

Loss of vegetation.

Destruction of food sources.

Increased soil erosion.

Displacement of wildlife.

6.12 Overgrazing

Overgrazing occurs when livestock consume vegetation faster than it can naturally regenerate.

It affects wildlife through:

Competition for pasture.

Destruction of vegetation.

Soil compaction.

Increased soil erosion.

Reduced availability of food.

Degradation of wildlife habitats.

6.13 Summary of Problems Facing Wildlife

Problem	Major effect
Poaching	Reduces wildlife populations
Habitat destruction	Removes food and shelter
Climate change	Changes habitats and water availability
Pollution	Poisons wildlife and ecosystems
Human-wildlife conflict	Causes injuries, deaths and economic losses
Diseases	Cause animal deaths
Bushfires	Destroy vegetation and habitats
Overgrazing	Reduces pasture
Invasive species	Compete with native species
Inadequate funding	Weakens conservation programmes
Political instability	Disrupts conservation activities

7.0 POSSIBLE SOLUTIONS TO PROBLEMS FACING WILDLIFE IN EAST AFRICA

Wildlife conservation requires cooperation between governments, local communities, conservation organisations, researchers and international agencies.

7.1 Strengthening Anti-Poaching Measures

Employ more trained wildlife rangers.

Increase patrols in protected areas.

Use surveillance cameras and drones where appropriate.

Introduce effective wildlife crime investigation.

Enforce strict penalties against poachers.

Strengthen border controls to prevent illegal wildlife trafficking.

Promote public reporting of wildlife crimes.

7.2 Protection and Restoration of Wildlife Habitats

Establish and maintain protected areas.

Replant indigenous trees in degraded forests.

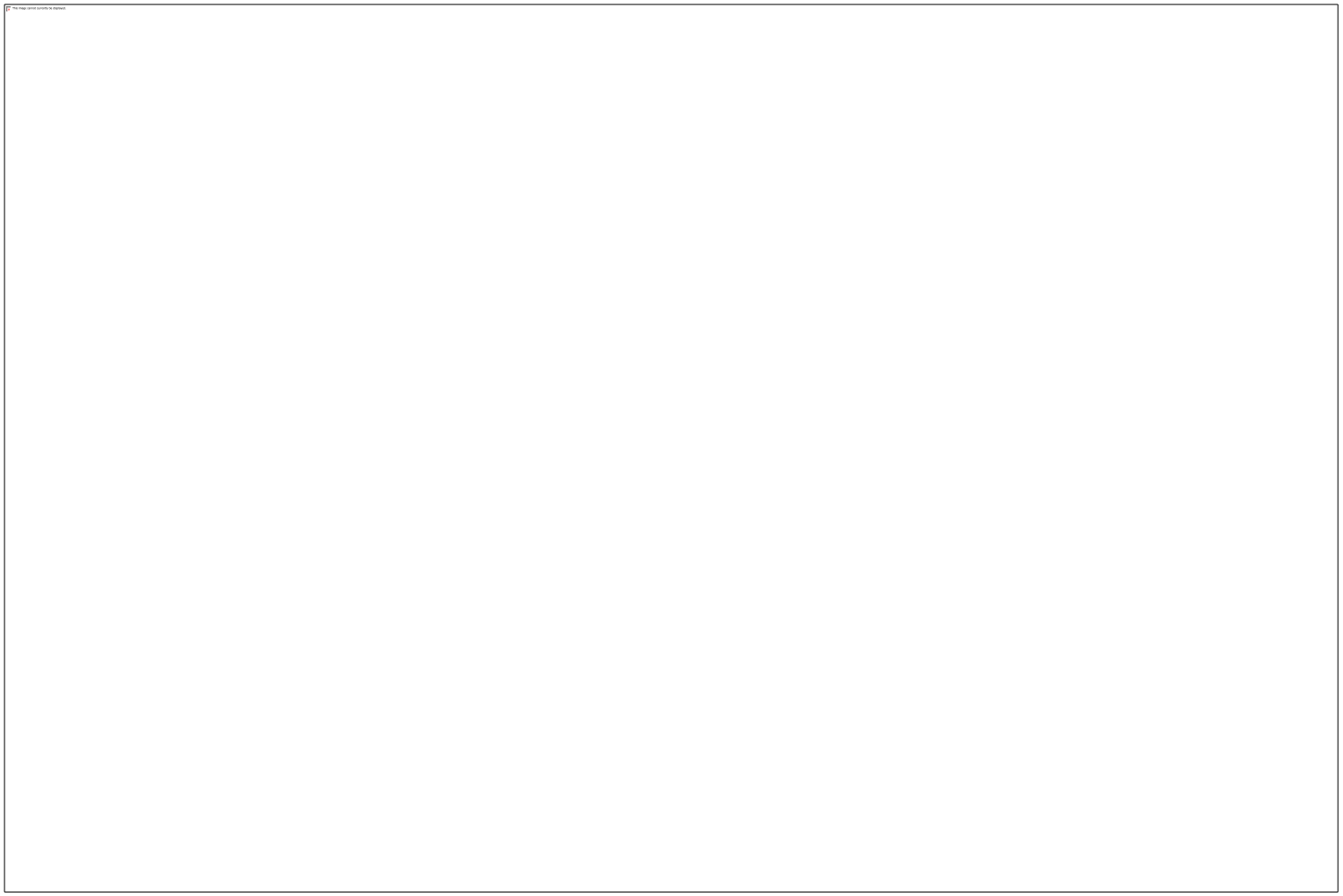
Restore wetlands.

Control deforestation.

Prevent settlement in important wildlife habitats.

Protect breeding grounds.

Establish wildlife corridors between fragmented habitats.



7.3 Controlling Human-Wildlife Conflicts

Construct suitable electric fences around vulnerable farms and settlements.

Establish wildlife corridors.

Develop early-warning systems.

Construct predator-proof livestock enclosures.

Promote appropriate livestock herding practices.

Provide timely compensation where legally applicable.

Educate communities on safe ways of living alongside wildlife.

Use non-lethal deterrents to keep animals away from farms.

7.4 Promoting Community-Based Wildlife Conservation

Community-based conservation involves the participation of local people in the protection and sustainable management of wildlife resources.

Measures include:

Establishing community conservancies.

Involving local communities in conservation decisions.

Sharing tourism benefits with communities.

Providing employment opportunities.

Supporting community education programmes.

Encouraging sustainable land-use practices.

Promoting community wildlife monitoring.

Example: Community conservancies in northern Kenya help communities participate in wildlife protection while benefiting from conservation-related activities.

7.5 Controlling Pollution

Treat industrial waste before disposal.

Prevent dumping of plastics in rivers and lakes.

Promote proper waste disposal.

Reduce the use of harmful agricultural chemicals.

Enforce environmental protection laws.

Conduct environmental awareness campaigns.

Encourage recycling.

7.6 Managing Climate Change

Plant indigenous trees.

Protect forests and wetlands.

Promote sustainable land use.

Establish water points where appropriate and ecologically safe.

Restore degraded ecosystems.

Reduce greenhouse gas emissions.

Develop wildlife adaptation and monitoring programmes.

7.7 Controlling Wildlife Diseases

Conduct regular wildlife health monitoring.

Provide veterinary services.

Monitor diseases at the wildlife-livestock interface.

Control the spread of infectious diseases.

Conduct scientific research.

Educate communities on disease prevention.

Coordinate veterinary services across borders.

7.8 Promoting Environmental Education

Teach learners about wildlife conservation.

Organise wildlife conservation clubs.

Conduct community awareness campaigns.

Use radio, television and digital media.

Organise school visits to protected areas.

Encourage responsible tourism.

Promote conservation competitions.

7.9 Promoting Sustainable Tourism

Sustainable tourism refers to tourism activities that meet present needs while protecting natural resources and ensuring future generations can also benefit.

Measures include:

Regulating the number of tourist vehicles in sensitive areas.

Preventing littering.

Restricting off-road driving.

Developing environmentally friendly tourism facilities.

Employing local communities.

Supporting wildlife research through tourism revenue.

Enforcing visitor codes of conduct.

7.10 Providing Adequate Funding

Allocate sufficient government funds.

Encourage private-sector investment in conservation.

Support conservation organisations.

Promote responsible tourism.

Encourage international conservation partnerships.

Improve financial accountability.

7.11 Strengthening Regional Cooperation

Wildlife does not recognise political boundaries. Some species move between countries in search of food, water and suitable breeding environments.

East African countries should:

Share wildlife research information.

Conduct joint anti-poaching operations.

Protect transboundary ecosystems.

Coordinate wildlife disease surveillance.

Share conservation technology.

Develop common wildlife protection policies.

Protect cross-border migration routes.

8.0 STRATEGIES FOR MANAGING AND CONSERVING WILDLIFE IN KENYA

8.1 Meaning of Wildlife Management Strategies

Wildlife management strategies are planned actions, policies and methods used to protect wildlife populations, conserve habitats and promote the sustainable use of wildlife resources.

Kenya has adopted various strategies to protect wildlife and promote sustainable conservation.

8.2 Establishment of National Parks and Game Reserves

The establishment of protected areas is one of the main wildlife conservation strategies in Kenya.

How this strategy works:

Identifies important wildlife habitats.

Legally protects selected areas.

Restricts destructive human activities.

Provides suitable breeding environments.

Promotes wildlife research.

Encourages regulated tourism.

Supports endangered species conservation.

Examples include:

Nairobi National Park.

Amboseli National Park.

Tsavo East National Park.

Maasai Mara National Reserve.

Samburu National Reserve.

8.3 Establishment of Wildlife Sanctuaries

Sanctuaries provide special protection for threatened or rescued animals.

Examples:

Ol Pejeta's rhino conservation programmes.

David Sheldrick Wildlife Trust's elephant rescue and rehabilitation work.

Sweetwaters Chimpanzee Sanctuary.

8.4 Enactment and Enforcement of Wildlife Laws

Kenya uses legal measures to protect wildlife.

The Wildlife Conservation and Management Act, 2013 provides the main national legal framework for wildlife conservation and management.

Its importance includes:

Regulating wildlife-related activities.

Protecting endangered species.

Controlling illegal hunting.

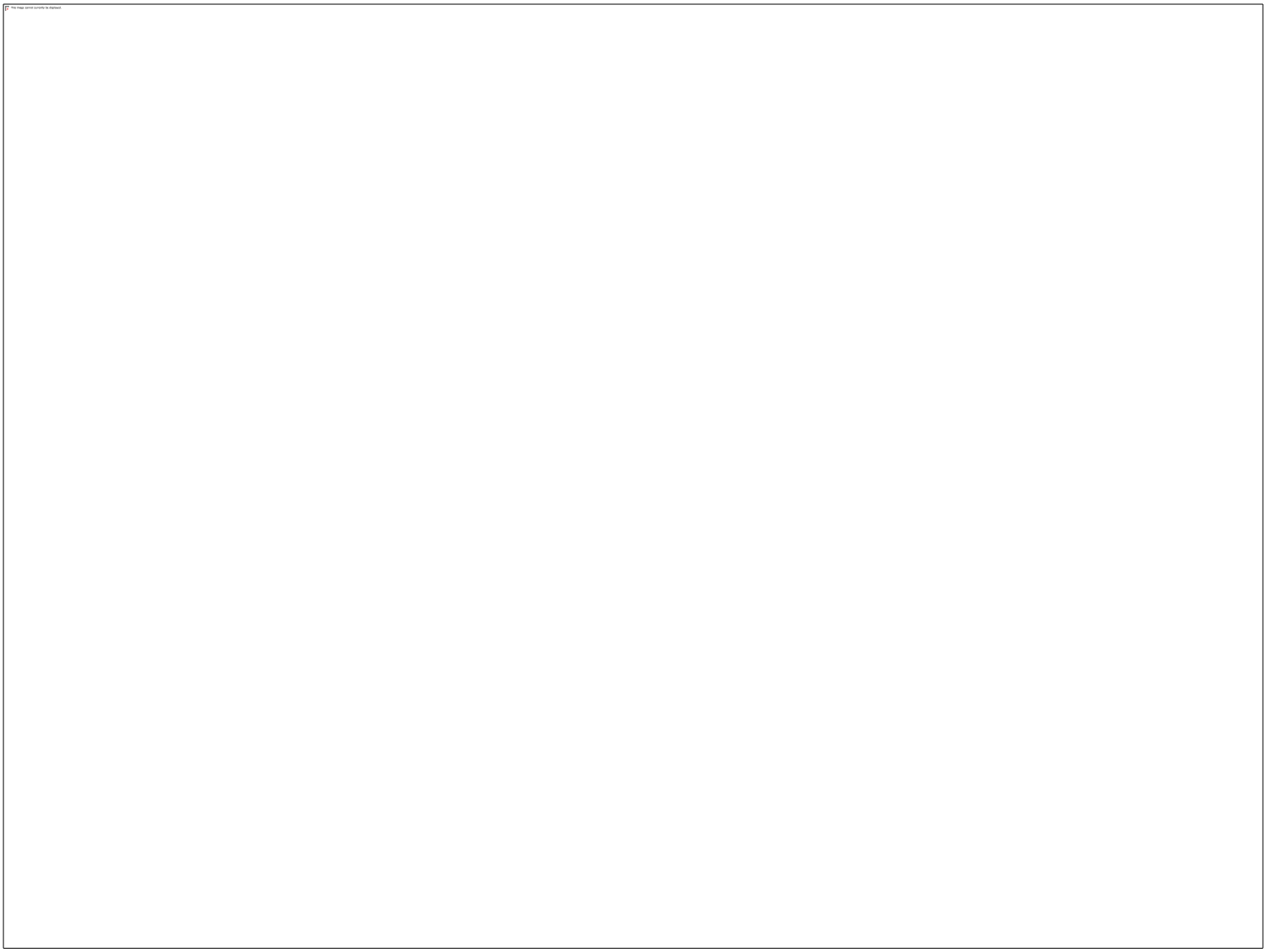
Providing for wildlife conservation and management.

Supporting community participation.

Providing for penalties for wildlife-related offences.

Establishing mechanisms for wildlife conservation governance.

8.5 Establishment of the Kenya Wildlife Service



Kenya Wildlife Service (KWS)

KWS is a government conservation agency responsible for conserving and managing wildlife in Kenya, particularly in national parks and national reserves under its mandate.

Functions of KWS

Protecting wildlife from poaching.

Managing national parks and other protected areas under its jurisdiction.

Conducting wildlife research and monitoring.

Promoting wildlife conservation education.

Managing human-wildlife conflicts.

Supporting wildlife rescue and veterinary operations.

Enforcing wildlife conservation laws.

Promoting sustainable wildlife tourism.

Collaborating with local and international conservation organisations.

Supporting the protection of endangered species.

8.6 Community Wildlife Conservancies

Community conservancies involve local communities in the management and conservation of wildlife.

Strategies used include:

Establishing community-managed conservation areas.

Employing community wildlife scouts.

Developing sustainable grazing plans.

Sharing tourism revenue.

Protecting wildlife migration corridors.

Encouraging community participation in decision-making.

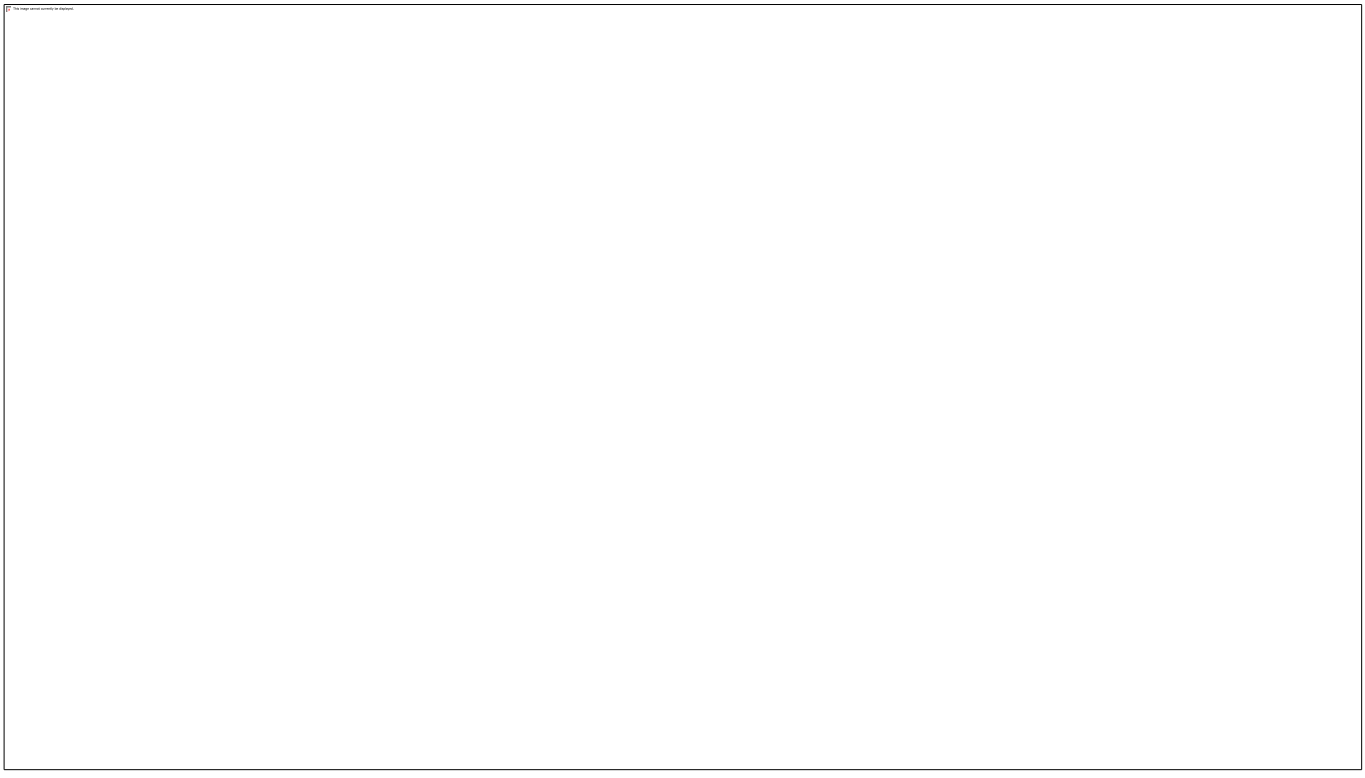
Supporting alternative livelihoods.

Examples: Conservancies in the Maasai Mara ecosystem and northern Kenya.

8.7 Wildlife Corridors and Dispersal Areas

A wildlife corridor is a natural or managed strip of land that connects separated wildlife habitats and enables animals to move between them.

A dispersal area is land outside or around a protected area that wildlife uses for movement, feeding and other activities.



Importance of wildlife corridors

Allow animals to migrate freely.

Connect fragmented habitats.

Improve access to water and pasture.

Allow animals to find breeding partners.

Maintain genetic diversity.

Reduce isolation of wildlife populations.

Support seasonal migration.

8.8 Wildlife Breeding Programmes

These programmes involve the controlled breeding of threatened wildlife species to increase their populations.

Methods include:

Establishing breeding centres.

Providing suitable breeding habitats.

Monitoring reproduction.

Protecting pregnant animals and young ones.

Reintroducing selected animals into suitable natural habitats where appropriate.

Examples include conservation breeding programmes for endangered rhinos.

8.9 Wildlife Rescue and Rehabilitation

Wildlife rescue involves saving injured, abandoned or endangered animals.

Rehabilitation involves providing care and treatment to animals so that they can recover and, where possible, return to their natural habitats.

Activities include:

Rescuing injured animals.

Treating sick animals.

Raising orphaned animals.

Providing temporary shelter.

Releasing recovered animals into suitable habitats.

Monitoring released animals.

8.10 Research and Wildlife Monitoring

Research helps conservation authorities understand wildlife populations and their environmental requirements.

Activities include:

Counting animal populations.

Tracking animal movements.

Monitoring breeding patterns.

Studying wildlife diseases.

Monitoring habitat conditions.

Identifying threatened species.

Using satellite tracking and camera traps.

8.11 Wildlife Education and Awareness

Wildlife education promotes responsible attitudes towards wildlife.

Strategies include:

Organising conservation clubs in schools.

Conducting public awareness campaigns.

Organising wildlife field trips.

Using environmental documentaries.

Encouraging community participation.

Publishing conservation information.

8.12 International and Regional Cooperation

Kenya collaborates with other countries and international organisations to promote wildlife conservation.

Examples of organisations and frameworks include:

United Nations Environment Programme (UNEP) – supports environmental conservation initiatives.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) – regulates international trade in endangered wildlife species.

Convention on Biological Diversity (CBD) – promotes biodiversity conservation and sustainable use.

East African Community (EAC) – supports regional cooperation, including environmental and wildlife conservation.

8.13 Control of Wildlife Diseases

Kenya promotes wildlife health through:

Veterinary services.

Disease surveillance.

Research.

Monitoring of wildlife-livestock interactions.

Treatment of injured and sick animals.

Disease prevention and control programmes.

8.14 Compensation and Support for Communities

Human-wildlife conflict may cause injuries, deaths and damage to property.

Compensation arrangements and community support programmes help to:

Reduce hostility towards wildlife.

Encourage community participation.

Support people affected by wildlife.

Promote peaceful coexistence.

Increase public confidence in conservation programmes.

8.15 Promotion of Ecotourism

Ecotourism refers to responsible travel to natural environments that promotes environmental conservation and benefits local communities.

It supports wildlife conservation through:

Generating revenue for protected areas.

Creating employment.

Supporting local businesses.

Funding conservation programmes.

Encouraging environmental awareness.

Promoting the protection of natural habitats.

9.0 SIGNIFICANCE OF WILDLIFE TO THE COMMUNITY

Wildlife plays an important role in the economic, social, cultural and environmental development of communities.

9.1 Economic Significance

1. Source of foreign exchange

Wildlife tourism attracts international tourists who spend money on accommodation, transport, park entry and other tourism services.

This generates foreign exchange for Kenya.

2. Employment creation

Wildlife conservation and tourism create employment opportunities for:

Tour guides.

Tour drivers.

Hotel workers.

Park rangers.

Wildlife researchers.

Veterinary officers.

Conservation educators.

Tour operators.

Community wildlife scouts.

Craft traders.

3. Government revenue

The government earns revenue through:

Park entry charges.

Tourism-related taxes.

Licences and permits.

Conservation-related services.

Tourism business activities.

4. Development of infrastructure

Wildlife tourism encourages the development of:

Roads.

Hotels.

Lodges.

Airports.

Communication networks.

Health facilities.

Water supply systems.

These facilities may also benefit local communities.

5. Promotion of local businesses

Wildlife tourism creates markets for:

Handicrafts.

Cultural products.

Food products.

Transport services.

Accommodation.

Locally produced goods.

6. Attraction of investment

Wildlife resources encourage investment in:

Tourism facilities.

Conservation projects.

Research centres.

Hospitality businesses.

Community conservancies.

9.2 Environmental Significance

1. Maintenance of ecological balance

Wildlife plays an important role in maintaining the balance of natural ecosystems.

For example:

Predators control herbivore populations.

Herbivores influence vegetation growth.

Scavengers remove dead animal remains.

2. Pollination

Some wildlife species, especially bees, butterflies, birds and bats, assist in the pollination of flowering plants.

Pollination supports plant reproduction and agricultural production.

3. Seed dispersal

Some animals eat fruits and disperse seeds through their droppings or by carrying them to different locations.

This promotes vegetation regeneration.

4. Control of pests

Some birds, reptiles and mammals feed on insects and other organisms that may damage crops.

5. Nutrient cycling

Wildlife contributes to nutrient cycling through feeding, excretion and decomposition.

These processes help maintain soil fertility.

6. Maintenance of biodiversity

Wildlife conservation protects different animal and plant species, preventing the loss of biodiversity.

7. Maintenance of food chains and food webs

Wildlife forms part of interconnected feeding relationships.

For example:



Grass → Grasshopper → Lizard → Snake → Eagle.

9.3 Educational Significance

Wildlife provides opportunities for:

Geography field studies.

Biological research.

Environmental education.

Ecological studies.

Wildlife photography.

Scientific discovery.

Practical learning.

Students learn about animal behaviour, habitats, food chains, biodiversity and conservation.

9.4 Scientific and Research Significance

Wildlife supports scientific research in various fields.

Examples:

Animal behaviour studies.

Veterinary research.

Genetic studies.

Disease research.

Climate change research.

Ecological monitoring.

Conservation technology development.

9.5 Social and Cultural Significance

Wildlife is important in the social and cultural lives of many Kenyan communities.

Some animals have cultural and symbolic significance.

Wildlife is used in cultural stories and traditional education.

Wildlife tourism promotes interaction between different communities.

Conservation activities encourage community cooperation.

Traditional knowledge contributes to understanding local ecosystems.

Wildlife attracts visitors who learn about local cultures.

9.6 Recreational and Aesthetic Significance

Wildlife provides opportunities for:

Game viewing.

Bird watching.

Wildlife photography.

Nature walks.

Camping.

Nature-based recreation.

Film production.

Wildlife also contributes to the beauty of natural landscapes.

9.7 International Recognition

Kenya's wildlife resources promote the country's international reputation.

Wildlife attracts international visitors.

Kenya becomes recognised as an important wildlife tourism destination.

International conservation partnerships are strengthened.

The country gains opportunities to host environmental conferences.

Wildlife documentaries promote Kenya internationally.

9.8 Genetic and Biological Resources

Wildlife contains genetic resources that are important for:

Scientific research.

Biodiversity conservation.

Understanding evolution.

Maintaining healthy ecosystems.

Future biological discoveries.

9.9 Ecosystem Services

Wildlife contributes to ecosystem services that support human survival.

These include:

Pollination.

Seed dispersal.

Nutrient recycling.

Pest control.

Maintenance of ecological balance.

Support of healthy ecosystems.

9.10 Significance of Wildlife to the Kenyan Community: Summary Table

Area	Significance
Economy	Generates tourism income
Employment	Creates jobs
Government	Generates revenue
Environment	Maintains ecological balance
Agriculture	Supports pollination and pest control
Education	Provides learning opportunities
Research	Supports scientific discoveries
Culture	Preserves cultural heritage
Recreation	Provides leisure activities
International relations	Promotes Kenya internationally
Biodiversity	Protects different species
Infrastructure	Encourages development of facilities

10.0 SUSTAINABLE UTILISATION OF WILDLIFE RESOURCES

10.1 Meaning of Sustainable Utilisation

Sustainable utilisation refers to the use of natural resources in a manner that meets present needs without reducing the ability of future generations to benefit from those resources.

In wildlife management, it involves ensuring that human activities do not destroy wildlife populations or their habitats.

10.2 Principles of Sustainable Wildlife Utilisation

Conservation: Wildlife populations should be protected against extinction.

Responsible tourism: Tourism should not damage natural habitats.

Community participation: Local communities should be involved in wildlife management.

Equitable benefit sharing: Communities should benefit from wildlife resources.

Habitat protection: Natural habitats should be maintained.

Scientific management: Wildlife resources should be managed using research and reliable information.

Intergenerational responsibility: Wildlife resources should be protected for future generations.

Legal compliance: Wildlife activities should follow established conservation laws.

10.3 Challenges to Sustainable Utilisation

Increasing human population.

Competition for land and water.

Poaching.

Inadequate funding.

Climate change.

Habitat destruction.

Conflicts between wildlife and communities.

Unsustainable tourism practices.

11.0 FIELD STUDY ON WILDLIFE

11.1 Meaning of a Field Study

A field study is an organised investigation carried out outside the classroom to collect first-hand information about geographical features and human activities.

A wildlife field study involves observing wildlife, habitats, conservation activities and the relationship between wildlife and communities.

11.2 Objectives of a Wildlife Field Study

A wildlife field study enables learners to:

Identify different wildlife species.

Describe wildlife habitats.

Examine factors influencing wildlife distribution.

Identify conservation measures.

Investigate problems facing wildlife.

Understand the importance of wildlife to communities.

Develop observation and recording skills.

Appreciate the need for wildlife conservation.

11.3 Preparation for a Wildlife Field Study

Before conducting a field study, learners should:

Identify the study area.

Obtain permission from relevant authorities.

Formulate objectives.

Prepare a work schedule.

Identify methods of data collection.

Prepare observation sheets.

Assemble necessary equipment.

Arrange transport where necessary.

Observe safety requirements.

Identify relevant resource persons.

11.4 Equipment Used During a Wildlife Field Study

Equipment	Use
Notebook	Recording observations
Pen or pencil	Writing information
Camera	Taking photographs
Binoculars	Observing distant animals
Map	Locating the study area
GPS device	Recording geographical positions
Field guide	Identifying wildlife species
Recording sheets	Collecting organised data
First-aid kit	Handling minor emergencies

11.5 Methods of Data Collection

1. Direct observation

Learners observe animals and record:

Animal species.

Number of animals.

Habitat type.

Feeding behaviour.

Movement patterns.

Human activities.

2. Interviews

Learners interview:

Wildlife officers.

Local residents.

Tour guides.

Conservation workers.

Possible interview questions:

What wildlife species are found in this area?

What factors influence their distribution?

What problems affect wildlife?

What measures are used to protect wildlife?

How does the community benefit from wildlife?

3. Photography

Photographs are taken to provide visual evidence of:

Wildlife species.

Vegetation.

Water sources.

Wildlife habitats.

Conservation facilities.

4. Questionnaires

Questionnaires are used to collect information from community members about wildlife conservation.

5. Document analysis

Learners examine:

Maps.

Wildlife reports.

Conservation publications.

Tourism brochures.

Digital resources.

11.6 Safety Precautions During a Wildlife Field Study

Learners should follow instructions from the teacher and wildlife officers.

They should maintain safe distances from wild animals.

They should not feed or provoke animals.

They should remain within designated areas.

They should avoid making unnecessary noise.

They should not litter the environment.

They should use authorised paths and vehicles.

They should carry drinking water.

They should avoid touching unknown plants and animals.

They should move in groups under supervision.

11.7 Presentation of a Wildlife Field Study Report

A good field study report should contain:

Title of the study.

Date of the study.

Location of the study.

Objectives.

Methods of data collection.

Equipment used.

Findings.

Challenges encountered.

Recommendations.

Conclusion.

11.8 Sample Wildlife Field Study Report

Title: A Field Study on Wildlife Conservation in a Local Wildlife Protected Area.

Location: Lake Nakuru National Park, Nakuru County.

Objectives:

To identify wildlife species found in the area.

To examine wildlife habitats.

To investigate problems facing wildlife.

To identify conservation strategies.

To establish the importance of wildlife to the community.

Methods used:

Direct observation.

Photography.

Interviews with wildlife officers.

Note-taking.

Sample findings:

The area supports rhinos, buffaloes, giraffes and various bird species.

Wetland and grassland habitats support different wildlife species.

Conservation officers monitor wildlife populations.

Tourism contributes to the local economy.

Human activities outside protected areas may affect wildlife habitats.

Challenges identified:

Habitat pressure.

Climate variability.

Human-wildlife conflict.

Pollution risks.

Invasive plant species.

Recommendations:

Strengthen habitat protection.

Promote environmental education.

Improve wildlife monitoring.

Encourage responsible tourism.

Support community participation.

Conclusion:

The field study demonstrated that wildlife is an important natural resource that contributes to environmental conservation, education and economic development. Sustainable management is necessary to protect wildlife for future generations.

12.0 CAREER OPPORTUNITIES RELATED TO WILDLIFE

The study and conservation of wildlife provide several career opportunities.

Career	Main responsibilities
Wildlife officer	Protects and manages wildlife
Wildlife researcher	Studies animal populations and behaviour
Tour guide	Guides tourists in wildlife areas
Veterinary officer	Treats sick and injured animals
Conservation educator	Teaches communities about conservation
Ecologist	Studies relationships between organisms and their environment
Wildlife photographer	Takes wildlife photographs
Park manager	Oversees protected area operations
Environmental scientist	Studies environmental issues
Conservation journalist	Communicates wildlife conservation information
Tourism officer	Promotes tourism activities
Wildlife veterinarian	Provides specialised animal health services

Sample conservation message:



REVISION EXERCISES

SUB-STRAND 3.2: WILDLIFE

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Instructions: Answer all questions. Choose the correct answer from the alternatives A, B, C and D.

1. Which of the following statements best describes wildlife?

A. Animals kept by human beings for domestic purposes.

B. All undomesticated organisms living in their natural environments.

C. Animals kept in zoological gardens only.

D. Plants grown for commercial purposes.

2. The term wildlife conservation refers to:

A. Hunting animals for commercial purposes.

B. Keeping animals in artificial environments.

C. Protecting and managing wildlife and their habitats.

D. Removing wild animals from their natural environments.

3. Which of the following is an example of a wildlife habitat?

A. Shopping centre.

B. Industrial area.

C. Savannah grassland.

D. Railway station.

4. Which climatic element influences wildlife distribution by determining the availability of water and pasture?

A. Rainfall.

B. Wind direction.

C. Atmospheric pressure.

D. Sunshine duration.

5. The distribution of flamingos around alkaline lakes is mainly influenced by:

A. Availability of suitable food and water conditions.

B. Presence of high mountains.

C. Availability of mineral deposits.

D. Presence of dense forests.

6. Which of the following wildlife species is commonly associated with the semi-arid regions of northern Kenya?

A. Mountain gorilla. B. Grevy's zebra.

C. Mountain bongo. D. Chimpanzee.

7. Which of the following is a human factor influencing wildlife distribution?

A. Altitude.

B. Rainfall.

C. Agricultural expansion.

D. Soil type.

8. Which of the following protected areas is located in Nairobi?

A. Amboseli National Park.

B. Nairobi National Park.

C. Meru National Park.

D. Tsavo East National Park.

9. The Maasai Mara is best classified as a:

A. National park.

B. Marine reserve.

C. National reserve.

D. Forest reserve.

10. Which wildlife conservation area in Kenya is particularly associated with Grevy's zebra and gerenuk?

A. Samburu National Reserve.

B. Nairobi National Park.

C. Aberdare National Park.

D. Mount Kenya National Park.

11. Which of the following national parks is located in Tanzania?

A. Lake Nakuru National Park.

B. Amboseli National Park.

C. Serengeti National Park.

D. Meru National Park.

12. Bwindi Impenetrable National Park is found in:

A. Kenya. B. Tanzania.

C. Uganda. D. Rwanda.

13. Volcanoes National Park, famous for mountain gorillas, is located in:

A. Rwanda.

B. Burundi.

C. Kenya.

D. South Sudan.

14. Which of the following is a major cause of poaching in East Africa?

A. Environmental education.

B. Demand for ivory and rhino horns.

C. Establishment of wildlife corridors.

D. Wildlife population monitoring.

15. The destruction of natural vegetation to create agricultural land mainly causes:

A. Habitat degradation. B. Increased biodiversity.

C. Wildlife population growth. D. Improved breeding conditions.

16. Which of the following best explains human-wildlife conflict?

A. Cooperation between wildlife researchers.

B. Competition between human beings and wild animals for resources.

C. Interaction between different wild animal species.

D. Movement of tourists between national parks.

17. Prolonged drought affects wildlife mainly by:

A. Increasing water availability.

B. Increasing natural vegetation.

C. Reducing food and water resources.

D. Increasing breeding grounds.

18. Which of the following is an example of water pollution affecting wildlife?

A. Planting indigenous trees.

B. Discharging untreated industrial waste into rivers.

C. Establishing wildlife corridors.

D. Constructing wildlife observation centres.

19. Invasive alien species affect wildlife by:

A. Increasing the availability of all natural habitats.

B. Competing with native species for resources.

C. Preventing all forms of pollution.

D. Improving the survival of every native species.

20. Which of the following measures is most effective in reducing poaching?

A. Increasing illegal hunting.

B. Encouraging wildlife trafficking.

C. Strengthening anti-poaching patrols.

D. Destroying wildlife habitats.

21. A wildlife corridor is important because it:

A. Prevents all wildlife movement.

B. Connects fragmented wildlife habitats.

C. Encourages illegal hunting.

D. Restricts animals to one location.

22. The main responsibility of the Kenya Wildlife Service is to:

A. Promote commercial farming.

B. Manage and conserve wildlife within its mandate.

C. Construct residential houses.

D. Control all agricultural activities.

23. Which Kenyan law provides the principal legal framework for wildlife conservation and management?

A. Wildlife Conservation and Management Act, 2013.

B. Traffic Act, 2012.

C. Education Act, 2013.

D. Employment Act, 2007.

24. Community-based wildlife conservation mainly involves:

A. Excluding local communities from conservation activities.

B. Involving local communities in wildlife management.

C. Encouraging unrestricted hunting.

D. Replacing natural habitats with settlements.

25. Which of the following is an example of wildlife rehabilitation?

A. Clearing a forest for farming.

B. Treating an injured elephant and preparing it for possible release.

C. Hunting animals for their skins.

D. Draining a wetland.

26. Which wildlife activity generates foreign exchange for Kenya?

A. Illegal wildlife trade.

B. Destruction of natural habitats.

C. Wildlife tourism.

D. Uncontrolled bush burning.

27. Wildlife contributes to agricultural production through:

A. Pollination and pest control. B. Destruction of all crops.

C. Increasing soil pollution. D. Reducing seed production.

28. Which of the following activities is most suitable during a wildlife field study?

A. Provoking wild animals.

B. Feeding wild animals without permission.

C. Observing and recording animal behaviour.

D. Entering restricted areas without permission.

29. Which equipment is most suitable for observing distant animals during a wildlife field study?

A. Thermometer.

B. Binoculars.

C. Rain gauge.

D. Soil auger.

30. The most appropriate way of promoting sustainable wildlife utilisation is to:

A. Encourage uncontrolled hunting.

B. Promote responsible tourism and habitat protection.

C. Allow unrestricted settlement in protected areas.

D. Encourage illegal wildlife trade.

SECTION B: STRUCTURED QUESTIONS (50 MARKS)

Instructions: Answer all questions. Write your answers clearly and give relevant examples where necessary.

QUESTION 1: INTRODUCTION TO WILDLIFE (8 MARKS)

a) Define the term wildlife. (2 marks)

b) State three examples of wildlife habitats found in Kenya. (3 marks)

c) Differentiate between a national park and a wildlife sanctuary. (3 marks)

QUESTION 2: FACTORS INFLUENCING WILDLIFE DISTRIBUTION (8 MARKS)

a) Explain four physical factors influencing the distribution of wildlife in Kenya. (4 marks)

b) Explain four human activities that influence the distribution of wildlife in Kenya. (4 marks)

QUESTION 3: WILDLIFE DISTRIBUTION IN EAST AFRICA (8 MARKS)

a) Name two national parks found in each of the following countries:

i. Kenya. (2 marks)

ii. Tanzania. (2 marks)

b) State four major considerations when drawing a map showing wildlife conservation areas in East Africa. (4 marks)

QUESTION 4: PROBLEMS FACING WILDLIFE (8 MARKS)

a) Explain four problems facing wildlife in East Africa. (4 marks)

b) Explain four effects of human-wildlife conflict on communities and wildlife conservation. (4 marks)

QUESTION 5: WILDLIFE MANAGEMENT AND CONSERVATION (9 MARKS)

a) State three functions of the Kenya Wildlife Service. (3 marks)

b) Explain three strategies that can be used to manage and conserve wildlife in Kenya. (6 marks)

QUESTION 6: SIGNIFICANCE OF WILDLIFE TO THE COMMUNITY (9 MARKS)

a) Explain five economic benefits of wildlife to the Kenyan community. (5 marks)

b) Explain four environmental benefits of wildlife conservation. (4 marks)

SECTION A: ANSWER KEY

For teacher use and self-assessment.

Question	Answer	Question	Answer
1	B	16	B
2	C	17	C
3	C	18	B
4	A	19	B
5	A	20	C
6	B	21	B

7	C	22	B
8	B	23	A
9	C	24	B
10	A	25	B
11	C	26	C
12	C	27	A
13	A	28	C
14	B	29	B
15	A	30	B

SECTION B: STRUCTURED QUESTIONS (50 MARKS)

Instructions: Award marks for any relevant and correctly explained points. Accept other valid responses not included in this marking scheme.

QUESTION 1: INTRODUCTION TO WILDLIFE (8 MARKS)

a) Define the term wildlife. (2 marks)

- Wildlife refers to all undomesticated animals and plants that exist naturally in their habitats. (2 marks)

b) State three examples of wildlife habitats found in Kenya. (3 marks)

Award 1 mark each for any three:

1. Forests.
2. Grasslands and savannahs.
3. Wetlands and swamps.
4. Rivers and lakes.
5. Mountains.
6. Semi-arid and arid areas.
7. Coastal and marine environments.

c) Differentiate between a national park and a wildlife sanctuary. (3 marks)

- National park: A protected area established and managed to conserve wildlife and natural ecosystems, with human activities such as settlement and livestock grazing generally restricted. (2 marks)
- Wildlife sanctuary: A protected area established to provide a safe habitat for wildlife, often with some controlled human activities or community involvement permitted. (1 mark)

QUESTION 2: FACTORS INFLUENCING WILDLIFE DISTRIBUTION (8 MARKS)

a) Explain four physical factors influencing the distribution of wildlife in Kenya. (4 marks)

Award 1 mark each for any four well-explained points.

1. Climate: Areas receiving adequate rainfall and experiencing favourable temperatures support abundant vegetation and water, attracting different wildlife species.
2. Vegetation: Different animals occupy habitats that provide suitable food, shelter and breeding grounds.
3. Relief and altitude: Some animals prefer lowland plains, while others are adapted to mountainous or highland environments.
4. Availability of water: Wildlife is concentrated near rivers, lakes, swamps and other permanent water sources.
5. Soil type: Soil influences the type of vegetation growing in an area, thereby affecting the availability of food and habitats.

6. Drainage patterns: Areas with reliable rivers and wetlands provide water and suitable breeding habitats for various wildlife species.

b) Explain four human activities that influence the distribution of wildlife in Kenya. (4 marks)

Award 1 mark each for any four well-explained points.

1. Deforestation: Clearing forests destroys natural habitats and forces wildlife to migrate to other areas.
2. Agriculture: Expansion of farms into wildlife habitats reduces grazing areas and disrupts animal movement.
3. Urbanisation and settlement: Construction of towns, roads and buildings destroys or fragments wildlife habitats.
4. Poaching: Illegal hunting reduces wildlife populations and may lead to the disappearance of certain species from some areas.
5. Mining and quarrying: Extraction of minerals destroys habitats and disturbs wildlife through noise and pollution.
6. Livestock keeping: Overgrazing and competition for pasture and water may force wild animals to move elsewhere.
7. Tourism development: Poorly managed tourism facilities and activities may disturb wildlife, while responsible tourism can support conservation.

QUESTION 3: WILDLIFE DISTRIBUTION IN EAST AFRICA (8 MARKS)

a) Name two national parks found in each of the following countries:

i. Kenya. (2 marks)

Award 1 mark each for any two:

- Maasai Mara National Reserve is not a national park; do not accept it for this question.
- Nairobi National Park.
- Tsavo East National Park.
- Tsavo West National Park.
- Amboseli National Park.
- Lake Nakuru National Park.
- Mount Kenya National Park.
- Aberdare National Park.
- Meru National Park.
- Hell's Gate National Park.

ii. Tanzania. (2 marks)

Award 1 mark each for any two:

- Serengeti National Park.
- Tarangire National Park.
- Lake Manyara National Park.
- Ruaha National Park.
- Mikumi National Park.
- Kilimanjaro National Park.
- Ngorongoro Conservation Area is a conservation area, not a national park; do not accept it.

- Nyerere National Park.

b) State four major considerations when drawing a map showing wildlife conservation areas in East Africa. (4 marks)

Award 1 mark each for any four:

1. Giving the map a suitable title.
2. Drawing a neat and accurate outline of East Africa.
3. Using an appropriate scale.
4. Showing national boundaries correctly.
5. Indicating the locations of major national parks and wildlife reserves accurately.
6. Using appropriate symbols to represent conservation areas.
7. Providing a clear key or legend.
8. Indicating direction using a north arrow.
9. Labelling major geographical features where necessary.

QUESTION 4: PROBLEMS FACING WILDLIFE (8 MARKS)

a) Explain four problems facing wildlife in East Africa. (4 marks)

Award 1 mark each for any four well-explained points.

1. Poaching: Illegal hunting reduces animal populations, particularly elephants and rhinoceroses, for products such as ivory and horns.
2. Habitat destruction: Deforestation, farming and settlement reduce natural habitats and breeding grounds.
3. Drought: Prolonged lack of rainfall causes shortages of water and pasture, resulting in wildlife deaths and migration.
4. Human-wildlife conflict: Animals may destroy crops, kill livestock or attack people, leading to retaliatory killing.
5. Climate change: Changes in rainfall patterns and rising temperatures affect wildlife habitats, food supplies and breeding cycles.
6. Pollution: Chemicals, plastics and other waste contaminate water and food sources, harming wildlife.
7. Diseases: Wildlife may suffer from infectious diseases, sometimes transmitted by domestic animals.
8. Wildfires: Uncontrolled fires destroy vegetation, nesting sites and animal habitats.
9. Illegal wildlife trade: Trafficking of live animals and wildlife products threatens endangered species.

b) Explain four effects of human-wildlife conflict on communities and wildlife conservation. (4 marks)

Award 1 mark each for any four well-explained points.

1. Loss of human life and injuries: Wild animals may attack and injure or kill people.
2. Destruction of crops: Elephants and other wild animals may destroy crops, causing food shortages and financial losses.
3. Loss of livestock: Predators such as lions and hyenas may kill domestic animals, reducing household income.
4. Retaliatory killing of wildlife: Communities may kill animals in revenge, reducing wildlife populations.
5. Increased poverty: Families may lose their sources of livelihood through crop destruction and livestock losses.
6. Negative attitudes towards conservation: Communities may oppose wildlife conservation when they experience repeated losses.
7. Displacement of communities: Persistent conflict may force people to move away from affected areas.

8. Increased conservation costs: Governments and conservation organisations spend more resources on compensation, fencing and conflict management.

QUESTION 5: WILDLIFE MANAGEMENT AND CONSERVATION (9 MARKS)

a) State three functions of the Kenya Wildlife Service. (3 marks)

Award 1 mark each for any three:

1. Protecting and conserving wildlife in Kenya.
2. Managing national parks, national reserves and wildlife sanctuaries under its mandate.
3. Combating poaching and illegal wildlife trade.
4. Enforcing wildlife conservation laws and regulations.
5. Promoting wildlife research and monitoring.
6. Educating the public on wildlife conservation.
7. Managing human-wildlife conflicts.
8. Promoting sustainable wildlife-based tourism.
9. Supporting wildlife rescue and rehabilitation.

b) Explain three strategies that can be used to manage and conserve wildlife in Kenya. (6 marks)

Award 2 marks each for any three well-explained strategies.

1. Establishment of protected areas: Creating national parks, game reserves and sanctuaries provides safe habitats where wildlife can breed and survive with reduced human interference.

2. Anti-poaching measures: Employing wildlife rangers, conducting patrols and enforcing wildlife laws helps prevent illegal hunting and wildlife trafficking.

3. Community participation: Involving local communities in conservation projects encourages them to protect wildlife and benefit from conservation activities.

4. Habitat restoration: Planting trees, restoring degraded forests and protecting wetlands improves wildlife habitats and increases food and water availability.

5. Wildlife corridors: Establishing and protecting migration routes enables animals to move between habitats in search of food, water and breeding grounds.

6. Public education: Educating communities and learners about the importance of wildlife encourages responsible behaviour and support for conservation.

7. Human-wildlife conflict management: Constructing appropriate fences, using early-warning systems and providing compensation mechanisms reduces conflict between people and wildlife.

8. Research and monitoring: Studying wildlife populations, migration patterns and diseases helps conservation authorities make informed management decisions.

9. Regulation of tourism: Controlling tourist numbers and activities reduces disturbance to animals and protects fragile habitats.

QUESTION 6: SIGNIFICANCE OF WILDLIFE TO THE COMMUNITY (9 MARKS)

a) Explain five economic benefits of wildlife to the Kenyan community. (5 marks)

Award 1 mark each for any five well-explained points.

1. Tourism revenue: Wildlife attracts local and international tourists who generate income through park entry fees, accommodation and other tourism services.

2. Employment creation: Wildlife conservation and tourism provide jobs for tour guides, game rangers, drivers, hotel workers and researchers.
3. Foreign exchange earnings: International tourists spend foreign currency in Kenya, contributing to national income.
4. Development of infrastructure: Tourism encourages the construction and improvement of roads, airports, hotels and communication facilities.
5. Business opportunities: Local communities earn income by selling crafts, souvenirs, food and other products to tourists.
6. Government revenue: The government collects taxes, licences and park fees from tourism-related activities.
7. Research and education: Wildlife supports scientific research and educational activities that create employment and professional opportunities.
8. Investment opportunities: Wildlife tourism attracts investment in hotels, lodges, transport and conservation enterprises.

b) Explain four environmental benefits of wildlife conservation. (4 marks)

Award 1 mark each for any four well-explained points.

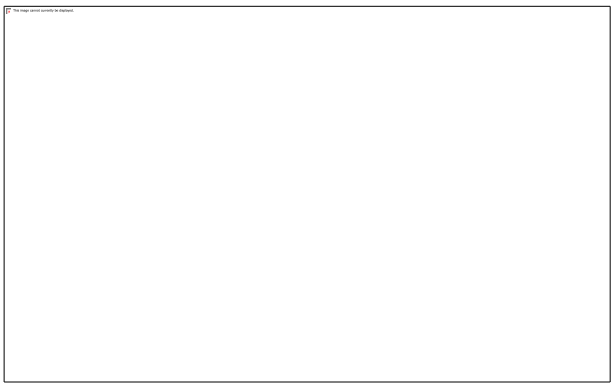
1. Maintenance of ecological balance: Wildlife helps maintain food chains and food webs by regulating populations of different organisms.
2. Seed dispersal: Some animals disperse seeds through their droppings, supporting natural vegetation regeneration.
3. Pollination: Certain wildlife species, including bats and insects, help pollinate flowering plants.
4. Nutrient cycling: Animal waste and decomposing organisms return nutrients to the soil, improving ecosystem productivity.
5. Soil conservation: Vegetation protected through wildlife conservation helps reduce soil erosion.
6. Biodiversity protection: Conservation protects different plant and animal species from extinction.
7. Habitat protection: Conserving wildlife habitats also protects forests, wetlands, rivers and other ecosystems.
8. Climate regulation: Conserved forests and other natural habitats store carbon and help regulate local and global climates.

SUMMARY NOTES ACTION OF WATER IN ARID AREAS

- Receives short occasional rains causing flash floods which erode transport and deposit large loads of materials produced by weathering.
- Water action is short lived.

Resultant Features of Water Action in Arid Areas

a. **Wadis**



- Wide deep steep sided dry valley in a desert
- Strong surface runoff and flash floods form rills.
- Rills are enlarged into gullies.
- Flash floods flow into gullies widening and deepening them to form wadis.

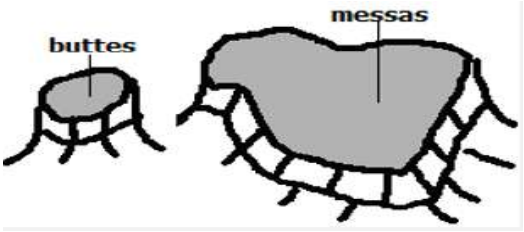
Characteristics

- Wide and deep
- Steep with cliff like walls
- flat floor
- Dry (lack permanent drainage)

b. **Dry River Valleys**

- Valleys in arid areas through which streams flow during the wet season and dry up in dry season e.g. in Turkana, Wajir and Mandera.

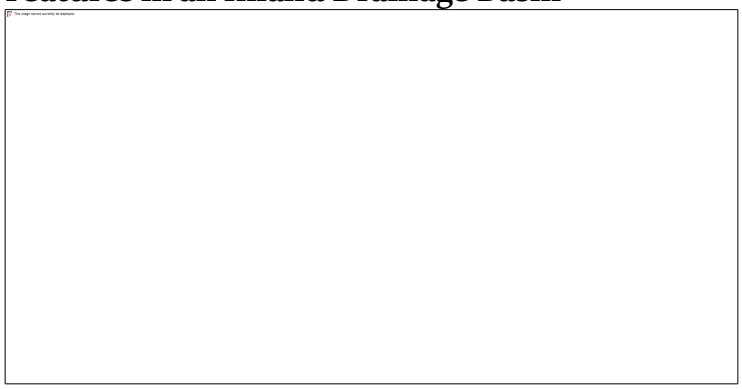
c. **Mesas and Buttes**



Mesas - Extensive table like residual hills found in arid areas.
Buttes - Smaller blocks of table like residual hills found in arid areas.

- First there are sedimentary rocks occurring in layers with a resistant one on top and a less resistant below.
- Weathering breaks the hard cap.
- Then sheet floods break the surface and carries materials away.
- Large outstanding blocks are left which are called mesas.
- Mesas may be eroded farther to form smaller blocks called buttes.

Features in an Inland Drainage Basin



- Gently sloping rock surface formed at the edges of desert uplands.
    - A steep/scarp slope of a highland is eroded by sheet flooding reducing its height.
- The process continues causing the scarp slope to shift its position upwards.
- The gently sloping surface of 6-7◦results at the foot of the upland.

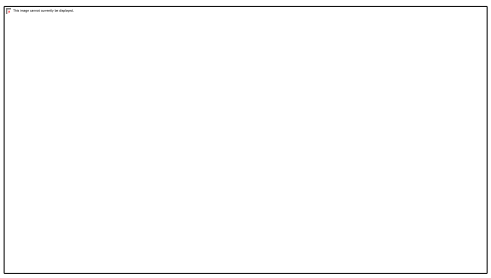
d. **Playas/sebkha**

- Extensive inland drainage basin in a desert formed by deflation or crustal warping or a small fluctuating salty lake contained in an inland drainage basin in a desert formed when water from torrential outpours flows into the basin by multiple temporary streams e.g. Chemchane sebkha in Mauritania.

e. **Peripediment**

- Zone of thick alluvial deposits at the edge of playas in form of alkaline crust of mud, sand and gravel formed when streams deposit a lot of materials at the edge of the playa. Materials dry up leaving a hard salty crustal surface called **Salina/salar** g. in Arizona desert in U.S.A.

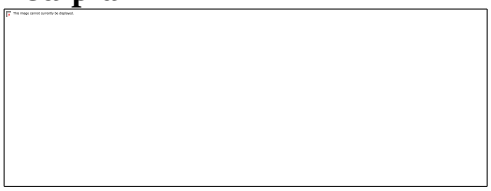
f. **Pediment**



g. **Peneplain**

- Low level plain formed when pediments are eroded to form a low level plain.

h. **Pediplain**



- Extensive low and gently sloping lands common in deserts.
- Pediments surrounding a highland are extended by sheet erosion.
- With time the highland is reduced to a residual hill like Inselbergs.
- The hill is eventually eroded forming a continuous plain(Pediplain)

i. **Inselbergs**

- Prominent residual rocks in a desert.
- Formed by extension of pediments into upland areas.

Types
Bonhardt - Steep isolated round topped mass of rock rising steeply from desert surface.

- Dissection of plateau by streams producing steep sided valleys.
- The plateau is further eroded forming remnant hills e.g. Sugar Loaf Mountain in Rio de Janeiro in Brazil.

Castle kopje – Residual rocks in a desert found in groups.

- Formed from break down of Bonhardt with closely spaced joints.
- Or deep withering of a plateau edges.
- Weathered rocks are then removed by water reducing plateau into Inselbergs e.g. Nzambani rock in Kitui.

Significance of Deserts and Desert Features

Positive

1. Loess soils are used for agriculture because they are very fertile e.g. in Huang He valley and Ukraine.
2. Loess soils in Europe and china have dug in caves which are inhabited during winter to provide warmth.

3. Desert features are a tourist attraction e.g. rock pedestals, Yardangs, Zeugen and sand dunes.
4. Oasis in deflation hollows are sources of water for domestic use.
5. Oasis water is also used for irrigation such as of date palms.
6. Deserts are good sites for testing military weapons, military training and experimenting ground for aircraft because they are sparsely populated.
7. The scarce vegetation in deserts such as shrubs can be used in livestock keeping e.g. goats, camels etc.
8. The hot sun in deserts can be harnessed to provide electricity for lighting, pumping of water, etc.
9. Seasonal streams can be dammed to supply water to surrounding areas e.g. Kigombo dam in Mbororo in Taita which supplies water to Voi town.

Negative

1. Some desert features can prevent physical development e.g. sand dunes can bury roads and it is difficult to construct bridges across wadis.
2. Sand dunes can cover oasis and settlements.
3. Sand dunes may destroy rich agricultural land.
4. High temperatures, shortage of water, unreliable rainfall and lack of transport and communication infrastructure discourage settlement.

Under/Ground Water

- Water that exists beneath the earth's surface in pore spaces in soil and rocks.

Sources of Ground Water

a. **Rain Water**
   - Some rain water which percolates and is trapped after meeting an impermeable rock.

b. **Melt Water**
   - Water that infiltrates into the ground when snow melts during spring and summer.

c. **Surface Water**
   - Water from rivers, seas, swamps, oceans, lakes and ponds that seep into the ground.

d. **Magmatic/Plutonic Water**
   - Water trapped in rocks beneath surface during vulcanicity

Factors Influencing Existence of Ground Water

a. **Precipitation**
   - For ground water to exist precipitation must exceed evaporation.
   - Light rain falling over a long period of time infiltrates more than heavy short lived downpour.

b. **Slope**
   - On flat and gently sloping areas rain water has ample time to infiltrate because it remains in one place for a long time.

- On steep areas there is low infiltration since a lot of water turns into runoff because of getting less time to percolate.

c. **Nature of Rocks**

- There is a greater possibility of existence of ground water where there are permeable surface rocks.
- Ground water exists where impermeable rock overlie an impermeable one so that when water infiltrates and percolates underground it's trapped by impermeable rock and accumulates above it.
  - **Aquifer** - permeable rock which is permanently saturated with water.
  - **Permeable rocks** - Rocks which allow water to pass through them.

Types

- **Porous** - Those with pores/airspaces between rock grains through which water passes e.g. sandstone, limestone and chalk.
- **Pervious** - Ones with cracks fractures and joints through which water enters and passes e.g. granite, limestone and chalk.

- **Impermeable rocks** - Ones which don't allow water to pass through them.

Types

- **Aquifuge** - Impenetrable impermeable rocks e.g. gabbro, shale and slate.
- **Aquiclude** - Porous rocks which absorb water and expand narrowing air spaces between grains preventing water to percolate downwards e.g. clay.

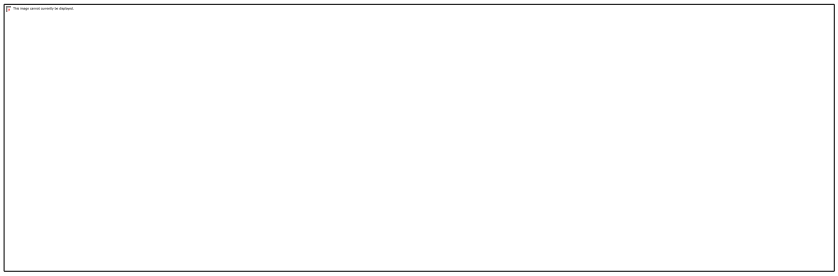
d. **Vegetation Cover**

- Plants break the speed of rain drops causing drops to hit the ground gently giving rain water ample time to percolate.
- On bare surfaces most of precipitation flows away as run off.

e. **Level of Saturation of Ground**

- Infiltration is more on dry ground because it has wide open air spaces while and less on a ground whose air spaces are saturated with water.

Water Table



- Water that infiltrates and percolates into the ground fills air spaces creating zones of saturation whose upper levels are called water tables.

Zones of Saturation

a. **Zone of Non-saturation**

- Zone of permeable through which water passes but doesn't remain in the pores for a long time.
- Well sunk to this zone doesn't contain any water.

b. **Zone of Intermittent Saturation**

- Zone which during the rain season the rocks are saturated with water while during the dry season they are unsaturated.
- **Temporary water table** - Upper level of ground water in the zone of intermittent saturation.
- Zone of non-saturation and that of intermittent saturation are called **vadose zone**.

c. **Zone Of Permanent Saturation**

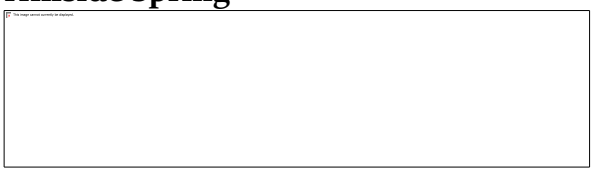
- Zone where pores spaces are permanently filled with water.
- **Permanent water table** - Upper level of ground water in the zone of permanent saturation.
- Presence of ground water leads to formation of springs, wells boreholes and artesian basins.

Springs

- Place where water flows out naturally onto the earth's surface along a slope.

Ways/Modes Formation

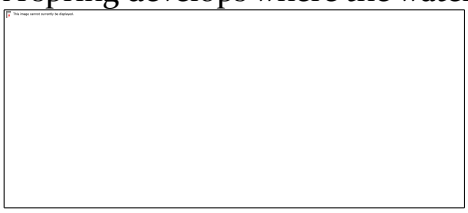
a. **Hillside Spring**



- Type formed where a permeable rock lies above an impermeable one on a hill and water comes out at the junction of those two rock layers.

b. **Dyke Spring**

- Type formed where an igneous dike cuts across a layer of permeable rock.
- Ground water on the upslope side is trapped causing water table on that side to rises.
- A spring develops where the water table is exposed on the surface.



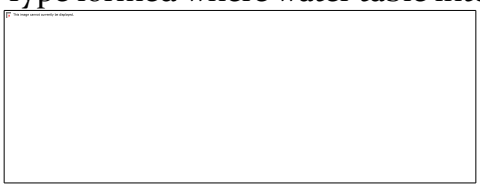
c. **Vauclusian Spring**

- Type formed on a limestone hill or escarpment overlying an impermeable layer.
- Limestone rock becomes saturated with water.
- Water comes out of the ground where water table appears on the surface.

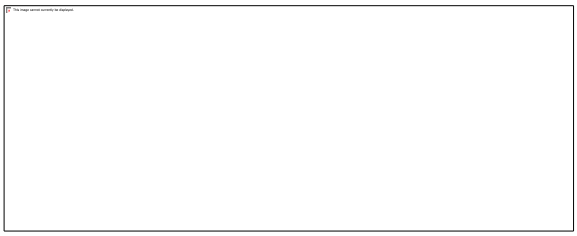


d. **Valley Spring**

- Type formed where water table intersects the surface along the side of the valley.



Artesian Basins



- Saucer shaped depression consisting of a layer of permeable rock sandwiched between two impermeable rocks and the whole system forms a syncline.

Characteristics

- One or both ends are exposed on the surface on a rainy area or beneath a lake.
- Water enters at the exposed end or ends.
- With time the permeable rock is saturated with water and becomes an aquifer e.g. between Chad and Egypt across Quattara depression.

Artesian Well

- Well sunk into the aquifer of an artesian basin from which water will come out without being pumped.

Ideal Conditions for Formation of an Artesian Well

- Aquifer to be sandwiched between impermeable rocks to prevent evaporation and percolation.
- Aquifer to be exposed in a region which is a source of water e.g. rainy area or lake.
- Aquifer to dip from the region of water intake.
- Mouth of the well to be at a lower level than the intake area to develop hydraulic pressure which will force water out.

Problems Associated With Artesian Wells

- Water may be hot due to high temperatures.
- Water may be salty because of water taking long to percolate through rocks thus dissolving large quantities of mineral salts.
- Water may fail to come out naturally when water is drawn faster than it's being replaced in the source region and necessitating pumping.

Significance of Underground Water

- Source of rivers and their tributaries.
- Source of water for domestic and industrial use e.g. wells, springs, boreholes and oasis.
- Used in agriculture e.g. oasis water is used for irrigation of date palms.

- Influences settlements due to the availability of water e.g. in deserts people settle near oasis and spring line settlements in limestone areas.
- Hot springs are a tourist attraction and their water is trapped and pumped into houses through pipes for heating during winter e.g. in Iceland.
- Underground streams help in keeping some lakes fresh e.g. L. Naivasha.

Action of Water in Limestone Areas (Karst Region)

- **Karst region** - Region where the surface and the ground is covered with limestone rocks.

- **Karst scenery** - Unique features in a Karst region resulting from the action of water e.g. Shimoni caves at the coast of Kenya.

- When calcium carbonate is exposed a weak carbonic acid formed by rain dissolving CO_2 it's dissolved to form calcium hydrogen carbonate which is removed from the rock in solution resulting in surface and underground features in such a limestone region.

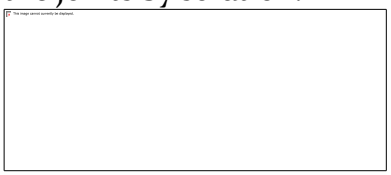
Factors Influencing Development of Karst Scenery

a. Surface rock and the rock below should be hard and well jointed for acid water to percolate and cause solution to happen e.g. limestone, chalk or dolomite.
b. Climate should be hot to speed chemical weathering and humid for availability of rain which is a solvent.
c. Should have a lot of vegetation to release CO2.
d. Water table to be far below the surface so that the whole limestone rock is not dissolved and underground features fail to be formed.

Surface Features in Limestone Areas

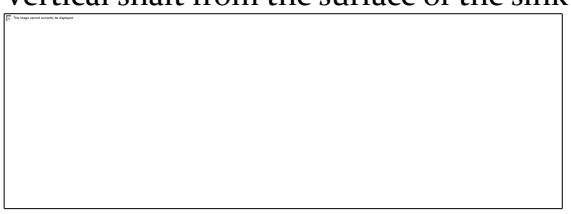
a. **Grikes and Clints**

Clints - Blocks of limestone rock left standing when water infiltrates through the limestone rocks widening and deepening the joints.
Grikes - Deep groves or gullies formed when rainwater infiltrates through limestone rocks widening the joints by solution.



b. **Swallow/Sink Holes**

- Deep vertical holes formed on limestone rocks when solution extends the grikes.
- Referred to as swallow/sink holes because surface runoff or river water may disappear through them as a waterfall and come out of the ground as a vauclusian spring further downhill.
- Vertical shaft from the surface of the sink hole down into the ground is called **ponor**.



c. **Dry Valley**

- Steep valleys with no permanent streams on limestone surface at the section between the swallow hole and where the river emerges.

d. **Karst Window**

- Small outlet to the surface from a cavern formed when continuous carbonation at the surface causes the roof of the cave to collapse.

e. **Limestone Gorge**

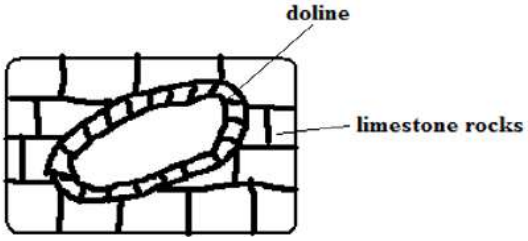
- Deep steep sided river valley in limestone rocks formed when the swallowed river causes solution to continue underground causing the roof of underground water course to collapse.

f. **Karst Bridge**

- Small section left joining the roof between the karst window and gorge.

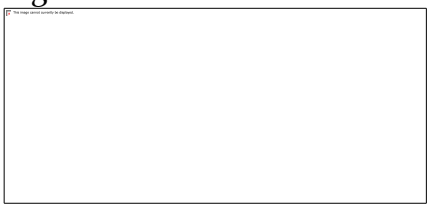
g. **Dolines**

- Elliptical hollow with gently sloping sides on the surface of a limestone region formed when several swallow holes collapse and merge.



h. **Uvala**

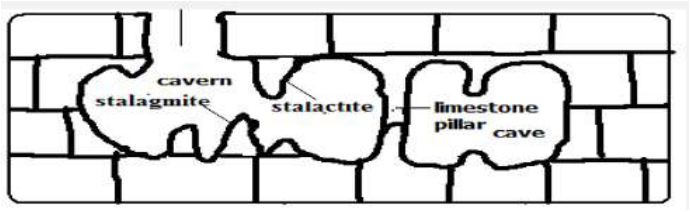
- Depression which may be as wide as 1 km in diameter formed on the surface of limestone regions when several dolines collapse and merge.



i. **Polje**

- Largest, shallow, elliptical and flat floored depressions on a limestone region formed when several uvalas collapse and merge.
- May become a temporary lake or may be covered by a marsh.

Underground Features in Limestone Areas



a. **Stalactites**

- Finger like masses of calcite hanging vertically from the roof of a limestone cave or cavern formed by repeated evaporation of water and giving off of carbon dioxide from drops of water containing calcium bicarbonate hanging from the roof of the cave causing crystallisation of calcium bicarbonate into calcite.

b. **Stalactite**

- Stumpy rock masses of calcite which grow from the floor of a limestone cave upwards formed by repeated dripping of solution of calcium bicarbonate from the end of stalactite to the floor of a limestone cave then it spreads out and crystallizes.

c. **Limestone Pillars**

- Pillar like structures in limestone caves formed when stalactites and stalagmites grow towards each other, stalagmite grows until it touches the roof of a cave or when a stalactite grows until it touches the floor of the cave.

d. **Limestone caves**

- Underground chambers or cavities in limestone rocks.
    - Underground rivers dissolve limestone in horizontal joints forming a horizontal tunnel.
    - Surface water and underground water percolates through the joints into the tunnel enlarging it forming a **phreatic cave**e. cave below the water table.
    - The water flows out at the vauclusian spring lowering the water table causing the phreatic cave to become a limestone **cave**.
    - Continued solution from water percolating through the caves roof widens and lowers its floor to form a larger cave called limestone **cavern**g. Carls band cave in New Mexico U.S.A.

Significance of Karst Scenery

Positive

1. Features in karst scenery are a tourist attraction e.g. caves, gorges, stalactites, stalagmites, etc.
2. Limestone rock is used in the manufacture of cement e.g. cement factory at Bamburi in Mombasa and Athi River.
3. Limestone blocks are also used for building.
4. Limestone regions are very good for grazing particularly sheep because the surface is dry.
5. Large villages called spring line settlements form at the line of vauclusian springs due to the availability of water.

Negative

1. Limestone landscape discourages settlement because the surface is rocky, soils are thin and unsuitable for agriculture, surface is rugged with features like grikes and Clints and the water supply is inadequate due to rivers disappearing into swallow holes.

Glaciation

- Action of moving ice.

Glacier

- Mass of ice moving outward from an area of accumulation.

- Formed when snow accumulates on the surface, lower layers are compressed to a harder mass resulting in opaque ice due to air bubbles and accumulation continues compression lower layers squeezing out air forming glassy ice called glacier.

Types

- **Cirque glacier** - ice occupying a cirque.
- **Valley glacier** - Ice confined within a valley
- **Piedmont glacier**: Glacier formed when valley glaciers converge at the foot of the mountain.

Ice bergs - Large mass of ice floating in the ocean formed when an ice sheet moves to the sea e.g. in Arctic and N. Atlantic Ocean.

Ice sheet - Continuous mass of ice covering a large area on the earth's surface.

Ice caps - Ice covering the mountain peak.

Snow line - Line beyond which there is a permanent snow cover.

Ways of Ice Movement

a. **Plastic Flowage**
   - Movement of ice like a viscous liquid.
   - Great pressure is exerted at the bottom sides and centre causing some ice particles to melt slightly and move slowly down hill like a viscous liquid.

b. **Basal Slip**
   - Movement of ice by sliding over the underlying rock.
   - Pressure is exerted on deepest layers of ice in contact with the rock beneath causing melting.
   - A film of water is created which acts as a lubricant between the ice and the rock causing ice to slip and slide over the rock and move down slope.

c. **Extrusion Flow**
   - Movement of ice by spreading out.
   - Ice accumulates building to great thickness at the centre causing compression of layers of ice beneath.
   - The layers beneath are forced to spread out where there is less pressure.

d. **Internal Shearing**
   - Breaking of ice into smaller pieces which move alongside one another.
   - Uneven movement causes ice to develop cracks on the surface.
   - The glacier breaks into smaller pieces which move alongside each other down slope.

Factors Influencing Ice Movement

a. **Gradient of the Land**
   - Ice moves faster on steep slopes than on gentle slopes due to the influence of gravity.

b. **Season**

- Ice movement is faster in summer due to frequent thawing melting compared to winter when thawing is rare.

c. **Friction**

- Central parts of ice move faster than sides and bottom which are in contact with rock beneath due to friction.

d. **Thickness of Ice**

- Thicker masses of ice cause more pressure between them and rocks beneath which cause slight melting and therefore faster movement.

Glacial Erosion

Processes/Ways in Which Ice Erodes

a. **Plucking**

- Pulling away of parts of a rock at the base of glacier when the ice freezes into the cracks of a well jointed rock.

b. **Abrasion**

- Scratching of the underlying ground by stones and boulders carried by the ice as the glacier moves.

Factors Influencing Glacial Erosion

a. **Nature of Underlying Rock**

- Abrasion is more effective on soft rocks than hard rocks.
- Well jointed and faulted rocks are more eroded than those which are not because cracks and joints enable water to enter rocks and freeze which facilitates plucking.

b. **Gradient of Slope**

- Glacier on steep slopes moves faster and has greater kinetic energy to erode than slow moving glacier

c. **Thickness of Ice**

- Thick ice is heavier and exerts greater pressure on rock debris making them to abrade the underlying rock more effectively.

d. **Availability of Debris**

- The more the rock debris the more effective abrasion will be since it acts as abrasive tools.
- Too heavy debris makes erosion impossible since ice is not able to transport it but glides over it without acting on the rock below.

Erosion Features

On Glaciated Highlands

a. **Cirque**



- Arm chair shaped depression on glaciated slopes of high mountains.
- Snow accumulates into a shallow depression on the side of a mountain.
- Freezing in winter and thawing in summer causes rocks to wither and break up resulting in enlargement of the hollow.
- Accumulated ice advances by slipping down slope.
- A deep crevice called bergshrund develops at the top of ice due to unequal movement.
- Freezing occur deep down the bergshrund causing the back wall and sides to be steepened by plucking.
- Plucked debris is carried forward scratching the floor of the basin deepening it forming the cirque, corrie or cwm.
- Water from melting snow may accumulate in a cirque to form a tarn e.g. Teleki tarn.

b. **Arêtes**

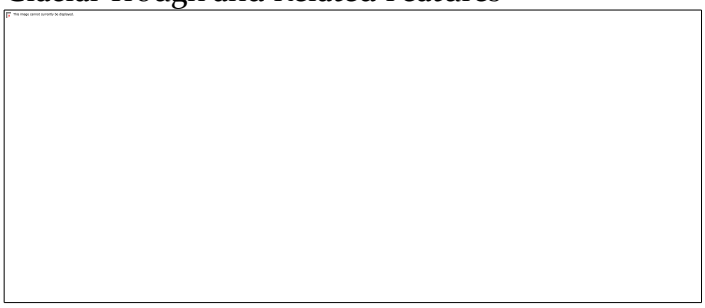
- Narrow knife- edged steep ridge separating two cirques.
- Formed when two cirques cut backwards on adjacent sides of a mountain leaving a narrow steep ridge separating them.

c. **Pyramidal Peaks**

- Sharp steep sided peak at the top of a mountain.
- Formed when three or more cirques erode on mountain side towards each other leaving a sharp pointed rock separating them at the top of the mountain e.g. Corydon and Delamere on Mt. Kenya.

d. **Glacial Trough**

- Glacial Trough and Related Features



- Wide flat bottomed valley with steep sides on a glaciated highland.
- Ice accumulates in a v-shaped valley.
- Plucking and abrasion by ice occurs.
- The v-shaped valley is deepened, widened and straightened to become a glacial trough.
- Glaciated trough may be submerged to form a fiord.

e. **Truncated Spurs**

- Interlocking spurs of former river valleys which are eroded and straightened by valley glacier.

Erosion Features on Glaciated Lowlands

a. **Roche Mountonnee**



- Rock outcrop with a long smooth gentle slope on the upstream side and a rugged steep slope on the downstream side found on glaciated lowland.
- Formed ice acts on a rock on its way causing the side facing the upstream side to be polished by abrasion resulting into a smooth gentle slope and the downstream side is affected by plucking resulting in a rugged steep slope leaving a rock outcrop standing just above the surface.

b. **Crag and Tail**



Crag - projection of resistant rock which protects a mass of softer rock on the downstream side of the glacier.

- The ice moves over and around over the resistant rock eroding it slightly by abrasion.
- Cracks develop on the upstream side causing the ice to move and pluck materials from the resistant rock leaving a projection of resistant rock with a steep rugged upstream side is formed.

Tail - elongated feature on the downstream side of the crag formed by formed by material deposited by the glacier on the downstream side and the weaker rock.

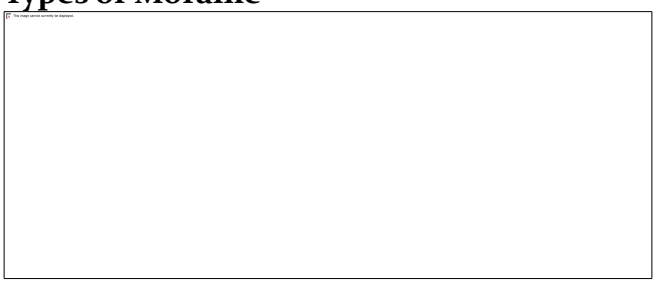
c. **Depressional Lakes**

- Depressions filled with water from melting ice found in glaciated lowlands.
- Formed when soft rocks are scooped out by moving ice sheet forming depressions which are filled with water to form a lake.

Glacial Deposition

- Material carried by the glacier is called moraine.

Types of Moraine



a. **Ground/sub-glacier moraine** - load carried at the base of the glacier.

b. **Englacial mora**ine - load within the glacier.

c. **Lateral moraine** - load carried at the sides of the glacier.

d. **Medial moraine** - load carried in the centre of the valley by glacier.

e. **Terminal/recessional moraine** - load deposited at the point where a glacier melts.

Types of Glacial Deposits/Drift:

a. Till - directly deposited by ice on melting in unstratified manner.

b. Fluvial - materials deposited by water from the melting ice in stratified manner.

Causes of Glacial Deposition

a. **Amount of glacial drift**

- When ground moraine is too much the glacier glides over it leaving it behind.

b. **Weight of glacier**

- When more ice is added to a stationary glacier pressure is exerted at the base causing melting and the material which was embedded in the ice is dropped.

c. **Climatic change**

- During summer and spring ice melts depositing some materials the glacier was carrying.

d. **Friction beneath the ice**

- Friction between ice and surface reduces ice speed causing heavy materials to be deposited beneath ice sheets.

e. **Slope**

- Lowlands allow glacier to accumulate a lot of materials which are finally deposited by melting ice.

Features Resulting From Glacial Deposition

a. **Till Plain**



- Extensive area of flat relief resulting from burying of former valleys and hills by glacial deposits.

b. **Erratics**

- Large boulders of resistant rocks transported by glacier from highland and deposited on the till plain.

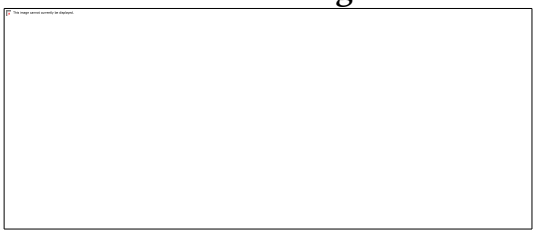
c. **Drumlins**



- Long egg shaped hills deposited and shaped under an ice sheet of very broad glacier.

- Glacier deposits boulder clay at the valley bottom due to friction between the bed rock and the boulder clay.
- With more deposition large mounds of deposits are formed.
- The moving ice streamlines the till that has been deposited irregularly resulting into the upstream sides of the till being steep but smoothed.

d. **Terminal Moraine Ridge**



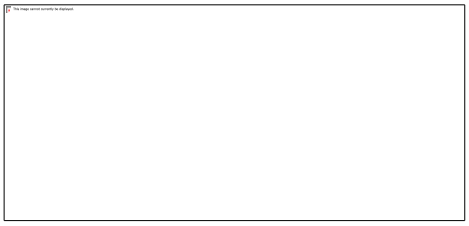
- Ridge like feature formed by extensive deposition of moraine along the edge of an ice sheet.
- Ice remains stagnant for a very long time.
- The ice at the edges of sheet melt and a lot of materials are deposited.

e. **Eskers**



- Long winding ridge composed of gravel formed by glacial deposition.
- Streams carrying large amounts of load flow fast in a sub-glacial tunnel parallel to the direction of moving ice.
- When the ice melts the tunnels collapse causing streams to slow down and deposit much of the load forming a ridge.

f. **Kame**

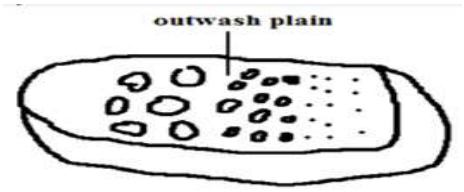


- Isolated hill made of sand and gravel which have been deposited in strata by glacial water.

g. **Kame Terrace**

- Ridge of sand and gravel occurring in narrow lakes that exist between the glacier and an adjacent highland.

h. **Outwash Plains**



- Wide gently sloping plain composed of gravel and sand formed by glacial deposition.
- Formed when finer materials of terminal moraine are deposited in very thick layers over an extensive area forming a plain.

Significance of Glaciation

Positive

1. Some outwash plains have fertile morainic soils suitable for agriculture e.g. Canadian prairies where wheat is grown.
2. Water falls on hanging valleys are used for generation of H.E.P.
3. Glaciated highlands are a tourist attraction especially during winter when sporting activities such as skiing and ice skating are carried out.
4. Glacial lakes such as great lakes of N.America provide natural route ways and fish sources e.g. L.Superior and Huron.
5. Glaciated mountains are catchment areas for permanent rivers.
6. Sheltered water of fiords is a suitable bleeding ground of fish as natural harbours.
7. Sand excavated from outwash plains and eskers is used for construction.

Negative

1. Land in glaciated areas can't be fully utilised for agriculture due to being marshy because of boulder clay deposits e.g. central Ireland.
2. Infertile sands deposited in outwash plains make land unsuitable for agriculture.
3. Numerous lakes formed as a result of morainic deposits reduce the land available for agriculture.
4. Settlement and transportation in glaciated landscape is difficult due to ruggedness caused by glacial action.

STRAND 3.0: HUMAN AND ECONOMIC ACTIVITIES

SUB-STRAND 3.3: TOURISM

1.0 INTRODUCTION TO TOURISM

1.1 Meaning of Tourism

Tourism refers to the movement of people from their usual places of residence to other places for leisure, recreation, business, education, religious activities, adventure, cultural experiences or other purposes, for a temporary period.

- People who travel for tourism are known as **tourists**.
- The places visited by tourists are called **tourist destinations**.
- The activities undertaken by tourists during their visits are known as **tourist activities**.
- The industry that provides goods and services to tourists is called the **tourism industry**.
- Tourism involves travelling, accommodation, entertainment, transport, sightseeing and other recreational activities.

Examples of tourism in Kenya:

1. Visiting the Maasai Mara National Reserve to observe wildlife.
2. Visiting Mombasa to enjoy coastal beaches.
3. Climbing Mount Kenya for adventure.
4. Visiting the National Museums of Kenya to learn about the country's history.
5. Visiting Lake Nakuru National Park to observe flamingos and other wildlife.
6. Visiting cultural villages to learn about the traditions of different Kenyan communities.

1.2 Important Terms Used in Tourism

1. Tourist

A person who travels outside their usual environment and stays temporarily at a destination for purposes such as leisure, business, education or recreation.

2. Tourist attraction

A natural or human-made feature that encourages people to visit a particular place.

Examples:

- Wildlife in Maasai Mara.
- Beaches in Diani.
- Mount Kenya.
- The Eiffel Tower in France.
- Historical monuments and museums.

3. Tourist destination

A place that attracts visitors because of its natural beauty, wildlife, cultural heritage, historical importance or recreational facilities.

4. Tourism industry

All businesses, organisations and services involved in providing facilities and experiences for tourists.

Examples include:

- Hotels and restaurants.
- Tour operators.
- Travel agencies.
- Airlines.
- Tourist guides.
- Car hire companies.

5. Hospitality

The friendly reception, accommodation, entertainment and care provided to visitors.

6. Ecotourism

A form of responsible tourism that involves visiting natural environments while conserving the environment and improving the welfare of local communities.

7. Sustainable tourism

Tourism that meets the needs of present tourists and host communities while protecting environmental, cultural and economic resources for future generations.

8. Excursion

A short organised journey to a place of interest for educational, recreational or sightseeing purposes.

1.3 Characteristics of Tourism

Tourism has the following characteristics:

1. **Movement of people:** Tourism involves travelling from one place to another.
2. **Temporary stay:** Tourists normally stay at destinations for a limited period before returning home.
3. **Different purposes:** People travel for leisure, business, education, adventure, religion and other reasons.
4. **Use of transport:** Tourists use road, railway, air and water transport.
5. **Demand for accommodation:** Many tourists require hotels, lodges, campsites and other accommodation facilities.
6. **Consumption of services:** Tourists purchase food, transport, entertainment, guiding and other services.
7. **Presence of attractions:** Tourism depends on natural or human-made attractions.
8. **Seasonal variations:** Tourist numbers may increase or decrease depending on weather, holidays and other seasonal factors.
9. **Economic activities:** Tourism creates business opportunities and employment.
10. **Cultural interaction:** Tourism brings together people from different communities, countries and cultural backgrounds.

1.4 Components of the Tourism Industry

The tourism industry consists of several interconnected components.

a) Attractions

These are features that motivate tourists to visit a destination.

Examples:

- Wildlife reserves.
- Beaches.
- Mountains.
- Historical sites.
- Cultural festivals.

b) Accommodation

Facilities where tourists stay during their visits.

Examples:

- Hotels.

- Lodges.
- Resorts.
- Guest houses.
- Campsites.
- Holiday apartments.

c) Transport

Services that enable tourists to travel to and within destinations.

Examples:

- Airlines.
- Railways.
- Buses.
- Tourist vans.
- Boats and ships.

d) Food and beverage services

Businesses that provide meals and drinks to tourists.

Examples:

- Restaurants.
- Hotels.
- Cafeterias.
- Catering establishments.

e) Travel and tour services

Businesses that organise and facilitate tourist journeys.

Examples:

- Travel agencies.
- Tour operators.
- Tourist guides.
- Car hire companies.

f) Entertainment and recreation

Facilities and activities that provide enjoyment to tourists.

Examples:

- Swimming.
- Wildlife viewing.
- Mountain climbing.
- Cultural performances.

- Water sports.







Illustration 1: Examples of tourist attractions and recreational activities in Kenya and France.

2.0 TYPES OF TOURISM IN THE WORLD

Tourism is classified into different types depending on the destination, purpose of travel, activities undertaken and geographical movement of tourists.

2.1 Domestic Tourism

Domestic tourism refers to travelling by people within their own country for leisure, recreation, education, business or other purposes.

A domestic tourist does not cross an international boundary when travelling.

Examples in Kenya:

- A family from Nairobi visiting Maasai Mara.
- Learners from Kisumu visiting the National Museums of Kenya.
- Residents of Eldoret visiting Lake Nakuru National Park.
- A group from Mombasa travelling to Mount Kenya.
- Kenyans visiting the coastal beaches during school holidays.

Characteristics of domestic tourism

1. It takes place within national boundaries.
2. It involves citizens or residents travelling within their country.
3. It does not require international travel documents.

4. It encourages citizens to appreciate their country's attractions.
5. It can be undertaken during weekends, public holidays and school holidays.
6. It supports local hotels, transport companies and other businesses.

Importance of domestic tourism

- Promotes national unity.
- Encourages appreciation of national heritage.
- Creates employment for local people.
- Supports local businesses.
- Reduces dependence on foreign tourists.
- Encourages citizens to conserve national attractions.

2.2 International Tourism

International tourism refers to travelling from one country to another for leisure, business, education, recreation or other purposes.

It involves crossing international boundaries.

Examples:

- A tourist from Germany visiting Kenya.
- A Kenyan travelling to France for sightseeing.
- A British tourist visiting Amboseli National Park.
- A French family travelling to Tanzania for a holiday.

Characteristics

1. It involves travelling across national boundaries.
2. It may require passports and visas.
3. It may involve exchanging currencies.
4. It exposes tourists to different cultures and lifestyles.
5. It often involves long-distance transport.
6. It generates foreign exchange for the destination country.

Importance

- Promotes international understanding.
- Earns foreign exchange.
- Encourages cultural exchange.
- Promotes international cooperation.
- Creates employment opportunities.
- Encourages investment in tourism facilities.

2.3 Inbound Tourism

Inbound tourism refers to visits made by non-residents of a country into that country.

It focuses on foreign visitors entering a particular country.

Examples:

- American tourists visiting Kenya.
- German tourists visiting Maasai Mara.
- French tourists visiting Mount Kenya.
- Japanese visitors travelling to Mombasa.

Importance of inbound tourism

- Generates foreign exchange.
- Promotes the country's international image.
- Creates employment.
- Encourages investment in hotels and transport.
- Promotes cultural interaction.

2.4 Outbound Tourism

Outbound tourism refers to the movement of residents of a particular country to other countries for tourism purposes.

Examples:

- Kenyans travelling to France for holidays.
- Kenyan families visiting Dubai.
- French citizens travelling to Kenya.
- Kenyan tourists visiting South Africa.

Importance

- Promotes international cultural exchange.
- Encourages international understanding.
- Provides opportunities for education and recreation.
- Promotes international business relationships.

2.5 Wildlife Tourism

Wildlife tourism involves travelling to places where tourists can observe, photograph and learn about wild animals in their natural habitats.

Kenya is internationally recognised for its wildlife tourism.

Examples of wildlife tourist destinations in Kenya:

1. Maasai Mara National Reserve.
2. Amboseli National Park.
3. Tsavo East National Park.
4. Tsavo West National Park.

5. Lake Nakuru National Park.
6. Samburu National Reserve.
7. Nairobi National Park.
8. Meru National Park.

Activities undertaken

- Game drives.
- Bird watching.
- Wildlife photography.
- Guided nature walks.
- Wildlife conservation education.







Illustration 2: Wildlife tourism attractions in Kenya.

2.6 Beach and Coastal Tourism

Beach tourism involves travelling to coastal areas to enjoy beaches, marine environments and recreational activities associated with the sea.

Examples in Kenya:

- Diani Beach.
- Nyali Beach.
- Watamu.
- Malindi.
- Bamburi Beach.
- Lamu Island.
- Tiwi Beach.

Activities

1. Swimming.
2. Sunbathing.
3. Boat riding.
4. Deep-sea fishing.
5. Snorkelling.
6. Scuba diving.
7. Water sports.
8. Viewing coral reefs.
9. Sailing and dhow excursions.

Importance

- Generates income for coastal communities.
- Creates employment.
- Encourages investment in hotels and resorts.
- Promotes marine conservation.
- Encourages cultural interaction between visitors and local communities.


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2.7 Cultural Tourism

Cultural tourism involves travelling to destinations to experience, understand and appreciate the traditions, beliefs, lifestyles, artistic expressions and heritage of different communities.

Examples in Kenya:

- Visiting Maasai cultural villages.
- Experiencing traditional dances among the Kalenjin.
- Visiting Lamu Old Town to learn about Swahili culture.
- Attending cultural festivals.
- Visiting Bomas of Kenya.
- Learning traditional crafts and beadwork.

Cultural tourism activities

1. Watching traditional dances.
2. Learning traditional songs.
3. Visiting cultural museums.
4. Observing traditional ceremonies.
5. Learning traditional food preparation.
6. Purchasing traditional artefacts.

7. Participating in cultural festivals.

Importance

- Preserves cultural heritage.
- Creates income for local communities.
- Promotes cultural understanding.
- Encourages respect for cultural diversity.
- Promotes national cohesion.

2.8 Historical Tourism

Historical tourism involves travelling to places associated with important historical events, people, buildings and developments.

Examples in Kenya:

- Fort Jesus in Mombasa.
- Gedi Ruins in Kilifi County.
- Karen Blixen Museum in Nairobi.
- Koitalel Arap Samoei Museum in Nandi.
- Lamu Old Town.
- Hyrax Hill Museum in Nakuru.

Activities

- Visiting historical monuments.
- Studying archaeological remains.
- Learning about colonial history.
- Exploring ancient settlements.
- Visiting museums and historical buildings.




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2.9 Adventure Tourism

Adventure tourism involves travelling to destinations to participate in exciting, challenging or physically demanding activities.

Examples in Kenya:

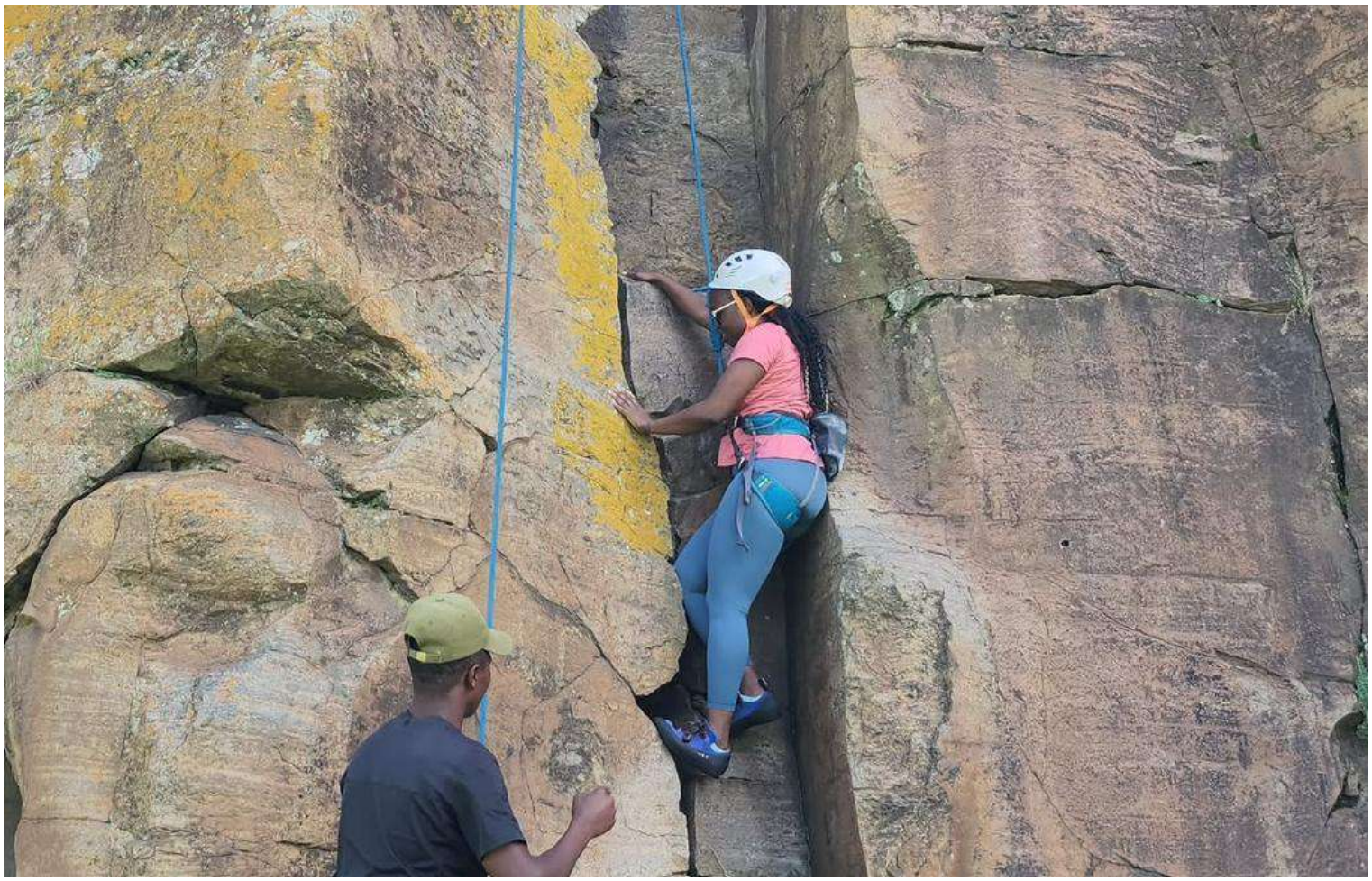
- Mountain climbing on Mount Kenya.
- White-water rafting along River Tana.
- Rock climbing at Hell's Gate National Park.
- Hiking in the Aberdare Ranges.
- Mountain biking in selected highland areas.
- Camel trekking in northern Kenya.

Adventure tourism activities

1. Mountain climbing.
2. Hiking.
3. Rock climbing.
4. Rafting.
5. Mountain biking.
6. Camping.

7. Paragliding.
8. Nature trekking.







2.10 Sports Tourism

Sports tourism involves travelling to participate in or watch sporting activities and competitions.

Examples:

- International athletes visiting Iten, Kenya, for athletics training.
- Tourists attending the World Athletics Championships.
- Football fans travelling to watch international matches.
- Golf tourists visiting Kenyan golf courses.
- Cycling competitions and marathons.

Importance

- Promotes sporting talent.
- Creates employment.
- Generates income.
- Promotes international relations.
- Improves the country's image.

2.11 Educational Tourism

Educational tourism involves travelling to places for learning, research, academic activities or educational experiences.

Examples:

- Learners visiting museums.
- Geography students visiting the Great Rift Valley.
- University students conducting field research in Maasai Mara.
- Learners visiting agricultural research institutions.
- International students visiting Kenya for educational programmes.

Importance

- Provides practical learning experiences.
- Promotes research.
- Develops knowledge and skills.
- Encourages environmental awareness.
- Promotes educational exchange.

2.12 Religious Tourism

Religious tourism involves travelling to places considered important for religious worship, pilgrimage, spiritual experiences or religious education.

Examples in Kenya:

- Visiting the Holy Family Basilica in Nairobi.
- Visiting the ACK Cathedral in Nairobi.
- Visiting religious pilgrimage centres.
- Travelling to religious conferences and gatherings.

International examples:

- Muslims travelling to Mecca in Saudi Arabia.
- Christians visiting Jerusalem.
- Hindus visiting Varanasi in India.
- Catholics visiting Lourdes in France.

2.13 Medical Tourism

Medical tourism involves travelling to another place or country to receive medical treatment, healthcare services or specialised medical procedures.

Examples:

- Foreign patients visiting Kenya for selected specialised medical services.
- Kenyans travelling abroad for specialised treatment.
- Patients travelling to India for specialised surgery.

Factors encouraging medical tourism

1. Availability of specialised medical facilities.
2. Qualified medical personnel.

3. Affordable treatment costs.
4. Modern medical equipment.
5. Good transport and accommodation facilities.

2.14 Ecotourism

Ecotourism involves responsible travel to natural areas that conserves the environment, supports local communities and promotes environmental education.

Examples in Kenya:

- Visiting community conservancies in Laikipia.
- Nature-based tourism in Maasai Mara conservancies.
- Guided forest walks in Kakamega Forest.
- Bird watching in wetlands.
- Community conservation projects in northern Kenya.

Principles of ecotourism

1. Conservation of biodiversity.
2. Protection of natural habitats.
3. Minimising pollution.
4. Respecting local cultures.
5. Supporting local communities economically.
6. Educating tourists about environmental conservation.

2.15 Business Tourism

Business tourism involves travelling to attend business meetings, conferences, exhibitions, trade fairs and professional events.

Examples:

- International business conferences in Nairobi.
- Investors visiting Kenya for trade negotiations.
- Delegates attending conferences at the Kenyatta International Convention Centre.
- Business people attending exhibitions in France.

Importance

- Promotes investment.
- Encourages business partnerships.
- Creates employment.
- Generates income for hotels and transport companies.
- Promotes international trade.

2.16 Rural Tourism

Rural tourism involves visiting countryside areas to experience rural lifestyles, landscapes, agricultural activities and traditional community practices.

Examples in Kenya:

- Visiting tea-growing areas in Kericho.
- Visiting coffee farms in Kiambu.
- Visiting flower farms in Naivasha.
- Experiencing pastoral lifestyles in Narok.
- Visiting agricultural communities in Trans Nzoia.

Activities

- Farm visits.
- Learning agricultural practices.
- Participating in traditional food preparation.
- Nature walks.
- Visiting rural markets.
- Experiencing village lifestyles.

2.17 Agro-tourism

Agro-tourism refers to tourism activities carried out on farms or agricultural establishments where visitors learn about or participate in agricultural activities.

Examples in Kenya:

- Visiting tea plantations in Kericho.
- Visiting coffee farms in Kiambu.
- Visiting flower farms in Naivasha.
- Visiting dairy farms in Nyandarua.
- Learning about horticultural production.

Importance

- Provides additional income to farmers.
- Promotes agricultural education.
- Creates markets for farm products.
- Encourages agricultural innovation.
- Diversifies rural economic activities.

2.18 Urban Tourism

Urban tourism involves visiting towns and cities to enjoy cultural, recreational, historical, shopping, entertainment and business facilities.

Examples in Kenya:

- Visiting Nairobi city.
- Visiting Mombasa city.
- Visiting Kisumu city.
- Visiting Nakuru city.

Tourist attractions in urban areas

- Museums.
- Shopping malls.
- Historical buildings.
- Parks and gardens.
- Entertainment centres.
- Restaurants.
- Cultural centres.

2.19 Gastronomic or Culinary Tourism

This is tourism involving travel to experience the food, beverages and culinary traditions of different communities.

Examples in Kenya:

- Experiencing coastal Swahili cuisine.
- Tasting traditional Kalenjin dishes.
- Experiencing Maasai traditional food culture.
- Visiting food festivals in Nairobi.
- Learning traditional food preparation.

Importance

- Promotes local foods.
- Creates markets for agricultural products.
- Preserves traditional cooking practices.
- Supports restaurants and food businesses.

2.20 Space Tourism

Space tourism involves travelling beyond the Earth's atmosphere for recreational, adventure or other commercial purposes.

It is an emerging form of tourism mainly associated with highly specialised commercial spaceflight companies.

Examples:

- Commercial suborbital space flights.
- Private orbital space travel.

Note: Some tourism categories overlap. For example, a person visiting a wildlife conservancy while hiking may be participating in both ecotourism and adventure tourism.

3.0 FACTORS INFLUENCING TOURISM IN KENYA AND FRANCE

Tourism development and the number of tourists visiting a country are influenced by physical, human, economic, political, technological and social factors.

Kenya and France are important tourist destinations, but they attract tourists through different combinations of natural and human-made attractions.

3.1 Physical Factors Influencing Tourism in Kenya

1. Attractive climate

- Kenya experiences varied climatic conditions that attract tourists.
- Many parts of the country experience warm and favourable weather for outdoor recreational activities.
- Coastal areas experience warm tropical conditions suitable for beach tourism.
- Highland areas have relatively cool temperatures that attract visitors seeking pleasant climatic conditions.
- Favourable weather encourages wildlife viewing, sightseeing, hiking and beach activities.

Examples:

- Mombasa and Diani attract beach tourists because of their warm coastal climate.
- Nairobi attracts visitors because of its relatively mild highland climate.
- Mount Kenya attracts mountain climbers because of its unique mountain climate.

2. Abundant wildlife

- Kenya has a wide variety of wildlife species.
- Wildlife includes elephants, lions, leopards, buffaloes, rhinoceroses, giraffes, zebras and antelopes.
- The presence of the Big Five attracts international tourists.
- Wildlife reserves and national parks provide opportunities for game viewing and photography.
- Seasonal wildlife migration increases the attractiveness of some destinations.

Examples:

- Maasai Mara is famous for the annual wildebeest migration.
- Amboseli is known for large elephant herds.
- Lake Nakuru is famous for birdlife, including flamingos.
- Samburu is known for unique northern wildlife species.



3. Beautiful physical features

Kenya has attractive physical landscapes that support tourism.

These include:

- Mountains.
- Valleys.
- Lakes.
- Rivers.
- Waterfalls.
- Forests.
- Plateaus.
- Coastal features.

Examples:

- Mount Kenya attracts mountain climbers.
- The Great Rift Valley attracts sightseeing tourists.
- Lake Naivasha supports boating and bird watching.
- Thomson's Falls attracts sightseeing visitors.
- Hell's Gate National Park attracts adventure tourists.

4. Attractive coastline

- Kenya has an Indian Ocean coastline with sandy beaches.
- The coastline has coral reefs, marine parks and beautiful islands.

- These features attract both local and international tourists.
- The coast supports swimming, sailing, diving, snorkelling and fishing.

Examples: Diani, Watamu, Malindi, Nyali and Lamu.

5. Rich biodiversity

- Kenya has different ecosystems, including forests, savannah grasslands, wetlands, mountains and marine ecosystems.
- These support many plant and animal species.
- Biodiversity attracts researchers, nature lovers, photographers and conservation tourists.

6. Scenic landscapes

- Kenya has beautiful landscapes that attract photographers and sightseeing tourists.
- The combination of mountains, wildlife, lakes, forests and open grasslands provides diverse tourist experiences.

Examples:

- The Great Rift Valley escarpments.
- The snow-capped peaks of Mount Kenya.
- The savannah grasslands of Maasai Mara.
- The landscapes of Amboseli.

3.2 Human Factors Influencing Tourism in Kenya

1. Improved transport infrastructure

- Well-developed roads enable tourists to access tourist destinations.
- Airports facilitate international and domestic travel.
- Rail transport supports movement between major towns.
- Reliable transport reduces travel time and costs.

Examples:

- Jomo Kenyatta International Airport.
- Moi International Airport.
- The Standard Gauge Railway.
- Roads connecting Nairobi to Maasai Mara and other parks.

2. Political stability and security

- Tourists prefer destinations where their safety is assured.
- Political stability encourages international investment.
- Peaceful conditions promote confidence among tour operators and travel agencies.
- Effective security arrangements encourage tourist visits.

3. Government promotion of tourism

- The government promotes Kenya through tourism campaigns and international exhibitions.

- Tourism organisations market Kenya's attractions.
- Government support encourages investment in tourism facilities.
- Tourism policies support conservation and destination development.

4. Availability of accommodation facilities

- Kenya has hotels, lodges, resorts, guest houses and campsites.
- Different accommodation categories serve tourists with different budgets.
- Quality accommodation encourages longer stays.
- Hospitality services improve tourist experiences.

5. Hospitality of local communities

- Friendly and welcoming communities create positive tourist experiences.
- Cultural interaction encourages tourists to revisit destinations.
- Local guides provide information about attractions.
- Community participation promotes cultural tourism.

6. Cultural diversity

- Kenya has many ethnic communities with diverse traditions, languages, dances, food and cultural practices.
- Cultural diversity attracts tourists interested in learning about different ways of life.
- Cultural festivals and traditional performances enhance tourism.

7. Wildlife conservation policies

- Establishment of national parks, national reserves and conservancies protects wildlife.
- Conservation ensures continued availability of wildlife attractions.
- Anti-poaching programmes help protect endangered species.
- Community conservancies encourage local participation.

8. Availability of trained personnel

- Kenya has tour guides, hotel managers, chefs, wildlife experts and hospitality workers.
- Skilled workers improve service delivery.
- Professional tourist guides provide accurate information and enhance visitor satisfaction.

9. Marketing and advertising

- Kenya's tourist attractions are advertised through television, radio, social media, websites and international tourism exhibitions.
- Effective marketing creates awareness of tourist destinations.
- Digital marketing enables tourists to plan and book their trips.

10. Availability of communication technology

- Internet services enable tourists to access destination information.
- Online booking systems simplify travel arrangements.

- Digital payment services make transactions easier.
- Social media promotes attractions through photographs, videos and reviews.

11. Historical and cultural attractions

- Historical buildings, museums and archaeological sites attract tourists interested in heritage.
- Kenya's historical links with Arab, Portuguese, British and other cultures provide diverse heritage attractions.

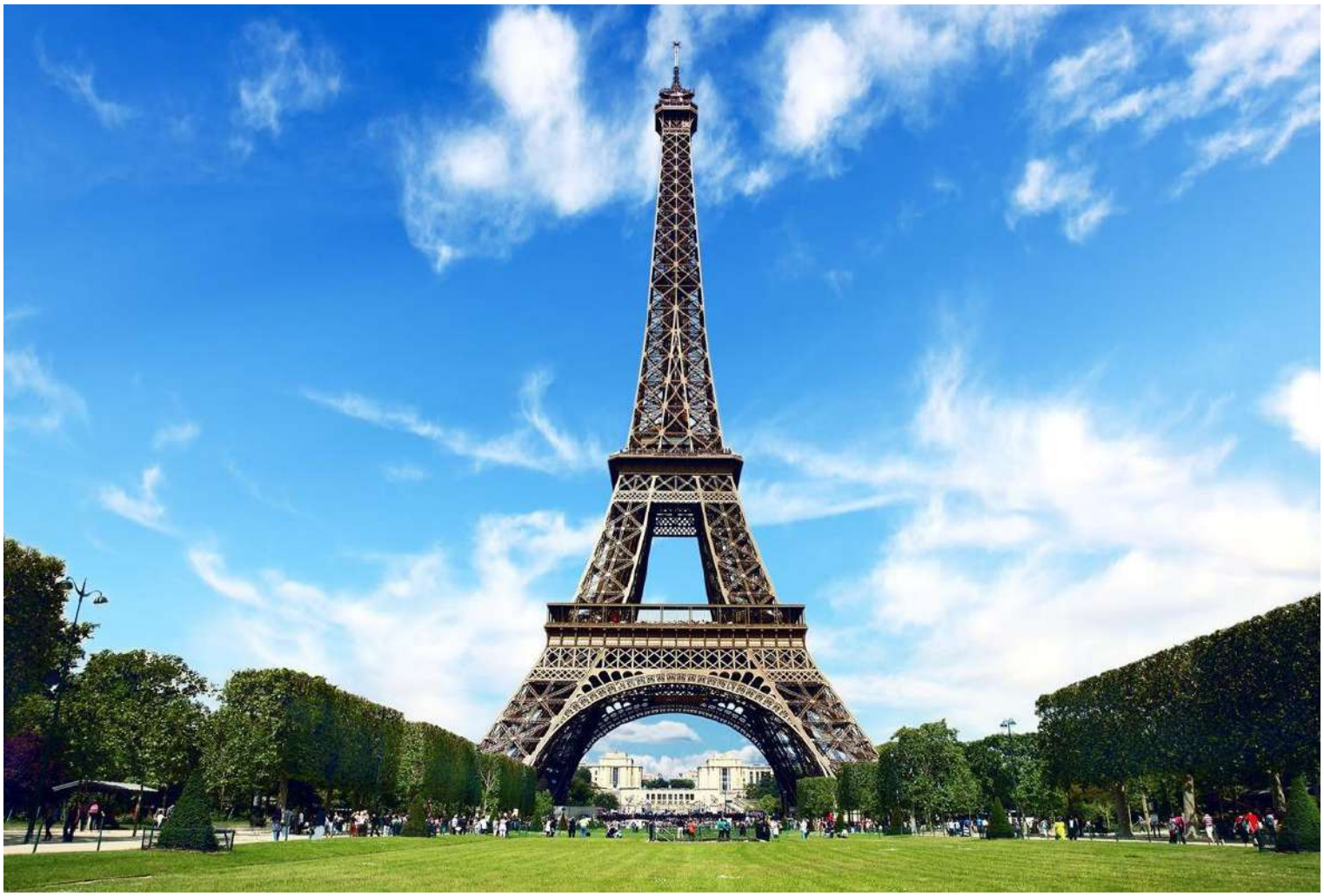
Examples: Fort Jesus, Lamu Old Town and Gedi Ruins.

12. Availability of financial services

- Banks, foreign exchange bureaux and digital payment services facilitate tourist transactions.
- International tourists can access currency exchange facilities.
- Convenient financial services improve the travel experience.

3.3 Factors Influencing Tourism in France

France is one of the world's leading tourist destinations. It attracts visitors because of its historical heritage, cultural attractions, beautiful landscapes, modern infrastructure, fashion, cuisine and recreational facilities.



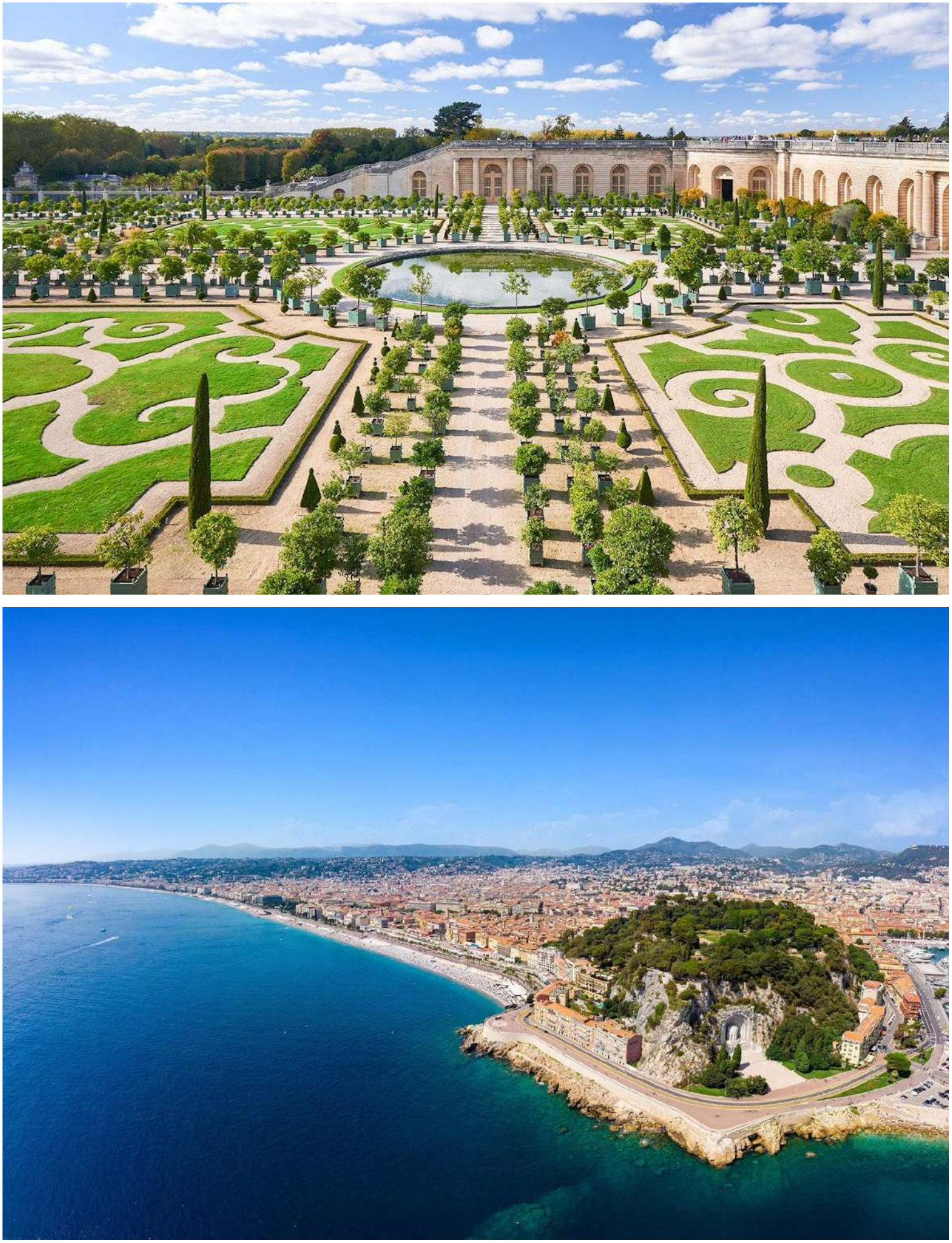


Illustration 3: Major tourist attractions in France.

A. Physical Factors

1. Favourable climate

- France experiences different climatic conditions in different regions.
- The Mediterranean climate in southern France attracts tourists interested in beaches and outdoor recreation.
- The Alpine climate attracts tourists interested in skiing and mountain activities.
- Mild weather in some regions encourages sightseeing and cultural tourism.

2. Beautiful physical features

France has diverse physical features that attract tourists.

These include:

- Mountains.
- Rivers.
- Lakes.
- Coastlines.
- Forests.
- Valleys.
- Countryside landscapes.

Examples:

- The French Alps attract mountain climbers and skiers.
- The Pyrenees attract hikers and adventure tourists.
- The River Seine attracts sightseeing tourists in Paris.
- The Mediterranean coastline attracts beach tourists.

3. Attractive coastlines

- France has coastlines along the Mediterranean Sea, Atlantic Ocean and English Channel.
- The coastlines have sandy beaches, attractive resorts and beautiful coastal towns.
- These features encourage swimming, sailing, sunbathing and other recreational activities.

Examples:

- Nice.
- Cannes.
- Saint-Tropez.
- Biarritz.

4. Attractive mountain scenery

- The French Alps provide spectacular mountain landscapes.
- Mountain scenery attracts photographers and nature lovers.

- Snow-covered mountains support winter tourism.
- Mountain valleys provide opportunities for hiking and camping.

5. Beautiful countryside

- France has attractive rural landscapes, vineyards, farms and traditional villages.
- These features encourage rural and agro-tourism.
- Visitors enjoy wine-growing regions, traditional villages and scenic countryside.

B. Human Factors

1. Rich historical heritage

- France has many historical buildings, monuments, castles and museums.
- These attractions provide opportunities for historical and educational tourism.
- The country's history attracts visitors interested in art, architecture and European civilisation.

Examples:

- Eiffel Tower.
- Palace of Versailles.
- Louvre Museum.
- Notre-Dame Cathedral.
- Mont-Saint-Michel.

2. Well-developed transport infrastructure

- France has an extensive railway network.
- High-speed trains connect major cities.
- Modern airports facilitate international travel.
- Well-maintained roads enable easy movement between tourist destinations.
- Efficient public transport makes sightseeing easier.

3. Advanced accommodation facilities

- France has international hotels, resorts, guest houses and holiday apartments.
- Different accommodation facilities serve different categories of tourists.
- High standards of hospitality encourage visitors to stay longer.

4. Political stability and security

- A stable political environment encourages tourism investment.
- Effective security services help protect visitors.
- Political stability increases confidence among international tourists.

5. Government support and promotion

- The government supports tourism development through policies, infrastructure investment and international promotion.

- Tourism organisations market French attractions.
- Conservation policies help protect cultural and natural heritage.

6. Cultural attractions

- France is famous for art, music, fashion, architecture, literature and festivals.
- Its cultural heritage attracts visitors from different parts of the world.
- Cultural events encourage tourists to visit throughout the year.

7. International reputation

- France is internationally recognised for fashion, art, cuisine, architecture and luxury tourism.
- Its global reputation encourages tourists to visit.
- Famous destinations such as Paris have strong international appeal.

8. Development of shopping facilities

- France is famous for fashion houses, designer products, perfumes and shopping centres.
- Shopping attracts tourists interested in luxury goods and fashion.
- Paris is an important international shopping destination.

9. Availability of skilled labour

- France has trained personnel in hospitality, tourism management, transport and customer service.
- Professional services improve tourist satisfaction.
- Skilled tour guides provide information about historical and cultural attractions.

10. Availability of communication technology

- Online booking systems simplify hotel and transport reservations.
- Digital maps help tourists locate attractions.
- Internet services enable visitors to access destination information.
- Social media promotes French tourist attractions.

11. Development of entertainment facilities

- France has theatres, museums, art galleries, amusement parks and sporting facilities.
- These provide entertainment for tourists.
- Disneyland Paris is an example of a major entertainment attraction.

12. International events and conferences

- France hosts international conferences, exhibitions, fashion events and sporting competitions.
- These events attract business and sports tourists.
- Major events increase demand for accommodation, transport and hospitality services.

3.4 Comparison of Factors Influencing Tourism in Kenya and France

Kenya	France

Famous for wildlife tourism.	Famous for cultural and historical tourism.
Has extensive savannah wildlife reserves.	Has famous historical monuments and museums.
Has tropical coastal beaches.	Has Mediterranean and Atlantic coastlines.
Mount Kenya attracts mountain climbers.	French Alps attract skiers and mountain climbers.
Cultural diversity attracts cultural tourists.	Art, fashion and cuisine attract cultural tourists.
Wildlife migration attracts international visitors.	Famous cities and heritage sites attract visitors.
Tourism is supported by national parks and conservancies.	Tourism is supported by museums, monuments and developed resorts.
Safari tourism is a major attraction.	Urban, cultural, shopping and winter tourism are major attractions.

Similarities between Kenya and France

1. Both countries have attractive physical features.
2. Both have historical and cultural attractions.
3. Both have developed transport networks.
4. Both have accommodation and hospitality facilities.
5. Both promote tourism through advertising and international marketing.
6. Both attract domestic and international tourists.
7. Both experience challenges associated with environmental conservation.
8. Both depend on tourism to generate employment and income.

4.0 SIGNIFICANCE OF TOURISM IN KENYA

Tourism is an important economic and social activity in Kenya. It contributes to national development by generating income, creating employment, promoting cultural understanding and supporting environmental conservation.

The significance of tourism can be discussed under economic, social, cultural, environmental and political benefits.

4.1 Economic Significance of Tourism

1. Source of foreign exchange

- International tourists spend money on accommodation, transport, food, entertainment and other services.
- Foreign visitors pay for services using foreign currencies or converted local currency.
- This enables Kenya to earn foreign exchange.
- Foreign exchange supports international trade and payments.

Example: International tourists visiting Maasai Mara and Diani spend money on accommodation, transport and recreational activities.

2. Creation of employment opportunities

Tourism creates direct, indirect and induced employment.

Direct employment includes:

- Hotel workers.
- Tour guides.
- Drivers.
- Chefs.
- Travel agents.
- Park wardens.
- Tour operators.
- Restaurant employees.

Indirect employment includes:

- Farmers supplying hotels with food.
- Construction workers building hotels.
- Manufacturers supplying hotel equipment.
- Suppliers of cleaning materials.
- Transport service providers.

Induced employment arises when people employed in tourism spend their income on other goods and services, creating further jobs in the economy.

3. Development of infrastructure

- Tourism encourages the construction and improvement of roads.
- Airports are expanded to accommodate visitors.
- Electricity and water supply systems may be improved.
- Communication networks are developed.
- Public facilities may be upgraded in tourist destinations.

Examples:

- Improvement of roads leading to national parks.
- Development of airports serving tourist destinations.
- Construction of bridges and access roads.

4. Source of government revenue

- Tourism businesses pay taxes and licence fees.
- Tourists may pay park entry fees and other charges.
- Hotels and restaurants pay business-related taxes.
- Tourism activities contribute to government revenue.
- The government uses revenue to provide public services.

5. Promotes entrepreneurship

Tourism creates opportunities for individuals and groups to establish businesses.

Examples include:

- Tour companies.
- Hotels.
- Restaurants.
- Curio shops.
- Car hire businesses.
- Tourist photography services.
- Cultural entertainment groups.
- Camping businesses.

6. Encourages investment

- Tourism attracts both local and foreign investors.
- Investors establish hotels, resorts, restaurants and transport businesses.
- Investment increases economic activities.
- It contributes to the expansion of the private sector.

7. Promotes regional development

- Tourism encourages development in areas away from major towns.
- Rural communities can benefit from tourism activities.
- Tourist facilities may stimulate the development of roads, markets and communication services.
- Less-developed regions may attract investment because of their tourist attractions.

Examples:

- Wildlife tourism in Narok County.
- Cultural tourism in Samburu County.
- Coastal tourism in Kwale County.
- Nature tourism in Kakamega County.

8. Creates markets for local products

- Hotels and restaurants purchase agricultural products from local farmers.
- Tourists purchase traditional crafts and souvenirs.
- Local communities sell food, clothing, artwork and other products.
- Tourism increases demand for locally manufactured goods.

9. Promotes diversification of the economy

- Tourism provides an alternative source of income apart from agriculture, manufacturing and other economic activities.

- It reduces excessive dependence on a single economic sector.
- It creates opportunities for people with different skills.

10. Improves the balance of payments

- International tourists bring money into Kenya.
- Earnings from international visitors contribute to service exports.
- Tourism receipts help offset expenditure on imported goods and services.

4.2 Social Significance of Tourism

1. Promotes national unity

- Domestic tourism encourages Kenyans to visit different parts of the country.
- People interact with communities from different cultural backgrounds.
- This encourages mutual understanding and national identity.
- It reduces prejudice and stereotypes.

2. Promotes cultural exchange

- Tourists learn about the traditions of host communities.
- Local people interact with visitors from other countries.
- People exchange ideas, knowledge, languages and experiences.
- This promotes mutual respect.

3. Promotes education and research

- Students visit tourist sites to gain practical knowledge.
- Researchers study wildlife, vegetation, climate and cultural heritage.
- Tourism promotes environmental education.
- Field trips help learners connect classroom knowledge with real-life situations.

4. Improves living standards

- Tourism creates income-generating opportunities.
- Communities may use earnings to improve housing, education and healthcare.
- Increased business activities improve household incomes.
- Tourism can support community development projects.

5. Promotes recreation and leisure

- Tourism provides opportunities for relaxation and entertainment.
- People enjoy holidays away from their normal working environments.
- Recreational activities promote physical and mental well-being.

6. Encourages interaction among people

- Tourism brings together people from different regions and countries.
- It promotes friendship and cooperation.

- It improves understanding of different lifestyles and beliefs.

7. Promotes community development

- Tourism may support construction of schools, health facilities and community centres.
- Community-based tourism provides opportunities for local participation.
- Some tourism businesses support community projects.

4.3 Cultural Significance of Tourism

1. **Preservation of cultural heritage:** Tourism encourages communities to protect traditional dances, songs, artefacts and historical sites.

2. **Promotion of traditional crafts:** Tourists create markets for beadwork, carvings, baskets, pottery and other cultural products.

3. **Preservation of historical sites:** Income generated from tourism may support restoration and maintenance of historical monuments.

4. **Promotion of traditional knowledge:** Tourists learn about traditional medicine, farming methods, food preparation and other cultural practices.

5. **Promotion of cultural identity:** Tourism encourages communities to appreciate their cultural heritage.

6. **Development of cultural centres:** Communities may establish centres for displaying traditional artefacts and conducting cultural performances.

7. **Promotion of intercultural understanding:** People learn to respect the traditions and beliefs of others.

4.4 Environmental Significance of Tourism

1. Promotes wildlife conservation

- Wildlife tourism creates economic incentives for protecting animals.
- National parks and reserves receive revenue from visitors.
- Conservation organisations use funds to protect endangered species.

2. Encourages forest conservation

- Forests attract nature tourists.
- Tourism may generate funds for forest protection and restoration.
- Community forest initiatives encourage sustainable resource management.

3. Promotes environmental education

- Tourists learn about environmental challenges.
- Guided nature walks provide opportunities to study ecosystems.
- Environmental education encourages responsible behaviour.

4. Supports protection of natural heritage

- Tourism encourages the preservation of mountains, lakes, beaches, waterfalls and other natural attractions.
- Conservation initiatives help maintain the beauty of tourist destinations.

5. Encourages community participation in conservation

- Local people may participate in conservancy management.
- Communities benefit economically from protecting wildlife.
- This encourages responsible use of natural resources.

4.5 Political and International Significance of Tourism

1. Tourism improves Kenya's international image.
2. It strengthens diplomatic relations through interaction among visitors from different countries.
3. It promotes international cooperation.
4. It encourages peaceful coexistence.
5. It provides opportunities for international conferences and diplomatic meetings.
6. It promotes Kenya's cultural and natural heritage internationally.
7. It encourages international partnerships in conservation and development.

5.0 PROBLEMS FACING TOURISM IN KENYA AND POSSIBLE SOLUTIONS

Despite its importance, tourism in Kenya faces various challenges. These problems affect tourist numbers, investment, income generation, environmental conservation and the sustainability of tourist destinations.

5.1 Insecurity and Terrorism

Explanation

- Acts of terrorism, crime, robbery and insecurity discourage tourists from visiting affected areas.
- Tourists may cancel planned holidays because of security concerns.
- Travel advisories may discourage visitors from particular destinations.
- Tourism businesses may suffer financial losses.

Examples:

- Security concerns in some border and coastal regions.
- Terrorist attacks and related security threats.

Possible solutions

1. Strengthen security surveillance in tourist destinations.
2. Increase police patrols in tourist areas.
3. Improve intelligence gathering.
4. Strengthen cooperation between security agencies and local communities.
5. Provide emergency response services.
6. Promote accurate security information to tourists.

5.2 Political Instability

Explanation

- Political unrest may disrupt transport and tourism activities.

- Demonstrations and violence can discourage visitors.
- Political uncertainty reduces investor confidence.
- Tour operators may cancel trips because of safety concerns.

Solutions

- Promote peaceful political competition.
- Strengthen democratic institutions.
- Encourage dialogue and national unity.
- Protect tourists and tourism facilities.
- Maintain political stability.

5.3 Poor Transport Infrastructure

Explanation

- Some tourist destinations are served by poorly maintained roads.
- Poor roads increase travel time and transport costs.
- Some areas become inaccessible during rainy seasons.
- Limited public transport may discourage tourists from visiting remote attractions.

Solutions

1. Construct and maintain roads leading to tourist attractions.
2. Improve railway and air transport.
3. Develop access roads to remote tourist destinations.
4. Improve road signage.
5. Encourage investment in reliable tourist transport services.

5.4 Environmental Degradation

Explanation

- Pollution reduces the attractiveness of tourist destinations.
- Deforestation destroys natural habitats.
- Poor waste disposal affects beaches, forests and parks.
- Soil erosion damages landscapes.
- Destruction of coral reefs affects marine tourism.

Solutions

1. Enforce environmental conservation laws.
2. Promote proper waste management.
3. Encourage tree planting.
4. Protect wildlife habitats.
5. Promote environmental education.

6. Encourage sustainable tourism practices.
7. Control pollution in tourist destinations.

5.5 Poaching and Illegal Wildlife Trade

Explanation

- Poaching reduces populations of important wildlife species.
- Some endangered animals may become extinct.
- Reduced wildlife numbers make parks less attractive to tourists.
- Illegal wildlife trade threatens biodiversity.

Solutions

- Strengthen anti-poaching patrols.
- Increase penalties for wildlife crimes.
- Improve community participation in conservation.
- Use modern wildlife monitoring technology.
- Educate communities on the importance of wildlife.
- Support alternative livelihoods for communities living near protected areas.

5.6 Human-Wildlife Conflict

Explanation

- Wild animals may destroy crops and property.
- Elephants and other wildlife may kill or injure people.
- Predators may attack livestock.
- Communities may retaliate by killing wild animals.
- Such conflicts threaten conservation and tourism.

Solutions

1. Construct appropriate wildlife barriers.
2. Establish wildlife corridors.
3. Provide timely compensation for verified losses.
4. Educate communities about wildlife conservation.
5. Introduce early-warning systems.
6. Improve land-use planning around wildlife habitats.
7. Promote community conservancies.

5.7 Seasonal Nature of Tourism

Explanation

- Tourist numbers may increase during particular seasons.
- Some destinations experience low visitor numbers during rainy seasons.

- Hotels and tour companies may experience reduced income during low seasons.
- Seasonal unemployment may occur.

Solutions

- Diversify tourist attractions.
- Promote domestic tourism throughout the year.
- Develop conference tourism.
- Organise cultural festivals and sporting events.
- Promote educational and rural tourism.
- Develop all-weather tourism facilities.

5.8 High Cost of Tourism Services

Explanation

- Accommodation, transport and park charges may be expensive for some tourists.
- High operational costs increase the prices of tourism packages.
- Expensive services may discourage domestic tourists.
- Kenya may face competition from destinations offering lower-cost packages.

Solutions

1. Develop affordable accommodation facilities.
2. Promote budget tourism packages.
3. Encourage competition among service providers.
4. Offer special domestic tourism packages.
5. Improve operational efficiency.
6. Promote affordable transport services.

5.9 Competition from Other Tourist Destinations

Explanation

- Kenya competes with other countries for international tourists.
- Countries such as Tanzania, South Africa, Egypt, France and Mauritius offer attractive tourism products.
- Aggressive international marketing by competitors may reduce Kenya's market share.

Solutions

- Improve the quality of tourism services.
- Diversify tourism products.
- Promote Kenya's unique attractions.
- Use effective international marketing.
- Improve customer service.

- Encourage innovation in tourism.

5.10 Disease Outbreaks and Health Emergencies

Explanation

- Disease outbreaks may discourage international travel.
- Governments may impose travel restrictions during serious health emergencies.
- Tourists may cancel holidays due to health concerns.
- Tourism businesses may experience losses.

Solutions

1. Strengthen public health systems.
2. Maintain hygiene standards in hotels and restaurants.
3. Provide medical facilities in major tourist destinations.
4. Improve emergency response systems.
5. Provide accurate health information to visitors.
6. Encourage responsible travel practices.

5.11 Climate Change

Explanation

- Rising temperatures may affect wildlife habitats.
- Drought reduces water and pasture availability for wildlife.
- Changing rainfall patterns may affect tourism seasons.
- Coastal erosion threatens beaches.
- Coral bleaching damages marine ecosystems.
- Extreme weather may disrupt tourism activities.

Solutions

- Promote climate adaptation programmes.
- Protect forests and wetlands.
- Restore degraded ecosystems.
- Promote renewable energy in tourism facilities.
- Improve water conservation.
- Support climate-resilient infrastructure.

5.12 Inadequate Marketing and Promotion

Explanation

- Some Kenyan attractions are not sufficiently known internationally.
- Limited advertising reduces awareness of lesser-known destinations.

- Poor digital marketing may limit access to international markets.
- Overdependence on a few popular attractions limits tourism growth.

Solutions

1. Increase international advertising.
2. Use social media platforms.
3. Develop professional tourism websites.
4. Participate in international tourism exhibitions.
5. Promote lesser-known tourist destinations.
6. Encourage travel influencers and content creators to showcase Kenya responsibly.

5.13 Shortage of Skilled Personnel

Explanation

- Some tourist destinations lack adequately trained workers.
- Poor customer service may discourage repeat visits.
- Language barriers may affect communication.
- Lack of specialised guides may reduce the quality of tourist experiences.

Solutions

- Strengthen tourism and hospitality training.
- Organise professional development programmes.
- Employ qualified tourist guides.
- Promote foreign language training.
- Encourage customer service training.

5.14 Poor Waste Management

Explanation

- Littering reduces the attractiveness of tourist sites.
- Plastic waste may harm wildlife and marine organisms.
- Poor sanitation creates health risks.
- Pollution may destroy natural attractions.

Solutions

1. Provide waste collection facilities.
2. Promote recycling.
3. Discourage single-use plastics.
4. Organise regular cleaning exercises.
5. Enforce anti-littering regulations.
6. Educate tourists and local communities.

5.15 Land-Use Conflicts

Explanation

- Expansion of settlements and farming may interfere with wildlife habitats.
- Construction may block wildlife migration routes.
- Human activities may reduce available grazing land.
- Conflicts may arise between conservation interests and community development needs.

Solutions

- Establish wildlife corridors.
- Promote proper land-use planning.
- Involve communities in conservation decisions.
- Protect critical wildlife habitats.
- Encourage compatible economic activities around conservation areas.

5.16 Other Problems Facing Tourism in Kenya

1. Limited access to finance by small tourism businesses.
2. Corruption and poor management of tourism resources.
3. Destruction of historical monuments.
4. Overcrowding in popular tourist destinations.
5. Unreliable electricity and water supply in remote areas.
6. Limited accessibility for tourists with disabilities.
7. Global economic recessions that reduce travel expenditure.
8. Negative international publicity.
9. Illegal construction near beaches and protected areas.
10. Inadequate interpretation facilities at some tourist sites.

6.0 SUSTAINABLE TOURISM IN KENYA

6.1 Meaning of Sustainable Tourism

Sustainable tourism refers to tourism that takes full account of its current and future economic, social and environmental impacts while meeting the needs of tourists, tourism businesses, the environment and host communities.

It involves developing tourism in a way that generates benefits without destroying the resources on which tourism depends.

Sustainable tourism aims to balance three major dimensions:

1. Economic sustainability.
2. Social and cultural sustainability.
3. Environmental sustainability.







6.2 Principles of Sustainable Tourism

1. Environmental conservation

- Protect wildlife and their habitats.
- Conserve forests, wetlands and water bodies.
- Prevent pollution.
- Protect biodiversity.

2. Community participation

- Involve local people in tourism planning.
- Encourage communities to own and manage tourism enterprises.
- Include local people in decision-making.

3. Economic benefits to local communities

- Employ local people.
- Purchase goods from local suppliers.
- Support community businesses.
- Ensure that tourism income benefits host communities.

4. Respect for cultural heritage

- Protect traditional practices and historical sites.

- Respect the beliefs of host communities.
- Promote cultural activities without exploitation.
- Preserve historical monuments.

5. Responsible use of resources

- Avoid wasting water and electricity.
- Promote renewable energy.
- Reduce unnecessary consumption.
- Use resources efficiently.

6. Fair distribution of tourism benefits

- Ensure that different groups benefit from tourism.
- Promote opportunities for women and young people.
- Support small and medium-sized enterprises.

7. Environmental education

- Educate tourists about responsible behaviour.
- Train tour guides on conservation.
- Promote environmental awareness among local communities.

8. Long-term planning

- Develop tourism policies that consider future generations.
- Monitor the effects of tourism.
- Control activities that threaten tourist attractions.

6.3 Ways of Promoting Sustainable Tourism in Kenya

1. Strengthening wildlife conservation programmes.
2. Promoting community conservancies.
3. Encouraging eco-friendly accommodation facilities.
4. Improving waste management in tourist destinations.
5. Protecting marine parks and coral reefs.
6. Promoting domestic tourism.
7. Encouraging the use of renewable energy in hotels.
8. Protecting forests and water catchment areas.
9. Supporting local cultural tourism enterprises.
10. Controlling overcrowding in sensitive tourist attractions.
11. Promoting responsible tourist behaviour.
12. Enforcing environmental laws.
13. Encouraging sustainable transport.

14. Supporting local agricultural suppliers.
15. Educating tourists about conservation.
16. Promoting recycling and reduction of plastic waste.

6.4 Benefits of Sustainable Tourism

- Protects natural attractions for future generations.
- Creates long-term employment opportunities.
- Improves the welfare of host communities.
- Preserves cultural heritage.
- Reduces environmental pollution.
- Encourages responsible investment.
- Supports wildlife conservation.
- Strengthens community participation.
- Improves Kenya's international reputation.
- Makes tourism more resilient to environmental and economic changes.

7.0 STRATEGIES FOR PROMOTING TOURISM IN THE LOCAL COMMUNITY

Local communities have an important role in identifying, developing and promoting tourism attractions.

Tourism does not have to depend only on famous national parks, mountains and beaches. Local communities can develop attractions based on their natural environments, cultural heritage, historical sites, agricultural activities and unique lifestyles.

7.1 Identification of Local Tourist Attractions

Communities should identify natural and human-made features that can attract visitors.

These include:

Natural attractions

- Rivers and waterfalls.
- Hills and mountains.
- Forests.
- Lakes and wetlands.
- Scenic landscapes.
- Unique plant and animal species.

Human-made attractions

- Historical buildings.
- Museums.

- Cultural centres.
- Traditional settlements.
- Religious buildings.
- Historical monuments.

Cultural attractions

- Traditional dances.
- Traditional foods.
- Local languages.
- Traditional clothing.
- Crafts and beadwork.
- Cultural festivals.

Agricultural attractions

- Tea farms.
- Dairy farms.
- Flower farms.
- Coffee plantations.
- Horticultural farms.
- Livestock farms.

7.2 Development of Local Tourism Products

Communities should develop activities that tourists can participate in.

Examples include:

1. Guided nature walks.
2. Cultural dance performances.
3. Traditional food preparation demonstrations.
4. Farm visits.
5. Bird watching.
6. Hiking.
7. Traditional craft-making.
8. Historical site visits.
9. Camping.
10. Photography tours.

7.3 Establishment of Cultural Centres

A cultural centre is a facility established to preserve, display and promote the cultural heritage of a particular community or several communities.

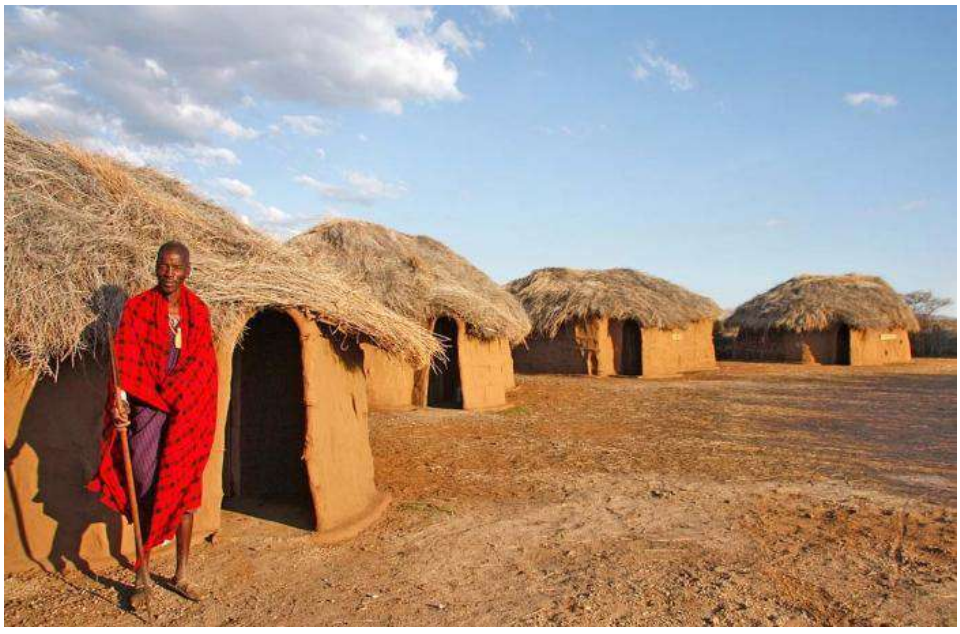
A school or local community can establish a cultural centre to attract visitors and provide educational experiences.

Features of a cultural centre

- Traditional houses.
- Traditional clothing displays.
- Musical instruments.
- Traditional tools.
- Cultural photographs.
- Traditional crafts.
- Historical information.
- Food preparation demonstrations.
- Cultural performance areas.
- Exhibition rooms.

Activities in a cultural centre

1. Displaying traditional artefacts.
2. Performing traditional dances.
3. Teaching visitors traditional songs.
4. Demonstrating traditional food preparation.
5. Exhibiting traditional tools.
6. Conducting cultural competitions.
7. Organising cultural festivals.
8. Providing guided cultural tours.







7.4 Community Participation in Tourism

- Encourage residents to participate in tourism planning.

- Establish community tourism groups.
- Train local people as tourist guides.
- Encourage local ownership of tourism businesses.
- Involve youth and women in tourism activities.
- Establish community conservancies.
- Encourage community contributions to conservation.

7.5 Improvement of Local Infrastructure

Communities should work with relevant authorities to improve facilities required by tourists.

These include:

- Roads.
- Footpaths.
- Public toilets.
- Water supply.
- Electricity.
- Communication networks.
- Signposts.
- Parking facilities.
- Waste disposal facilities.

7.6 Marketing and Advertising Local Attractions

Local communities can promote tourism through:

1. Social media platforms.
2. Community websites.
3. Brochures and posters.
4. Local radio stations.
5. Television programmes.
6. Tourism exhibitions.
7. School events.
8. Community festivals.
9. Travel agencies.
10. Partnerships with tour operators.

7.7 Training Local People

- Train residents in hospitality and customer care.
- Provide tour guiding skills.
- Teach basic foreign languages.

- Train community members in entrepreneurship.
- Provide training in food preparation and accommodation management.
- Teach environmental conservation practices.

7.8 Conservation of Local Attractions

- Protect forests and water bodies.
- Prevent destruction of historical sites.
- Control pollution.
- Promote tree planting.
- Prevent illegal hunting.
- Maintain cultural sites.
- Encourage responsible tourist behaviour.

7.9 Development of Local Tourism Events

Communities can organise events that attract visitors.

Examples:

- Cultural festivals.
- Agricultural shows.
- Traditional music festivals.
- Sports competitions.
- Environmental conservation days.
- Local food festivals.
- Art and craft exhibitions.

7.10 Partnerships and Collaboration

Local communities should work with:

- County governments.
- National government tourism agencies.
- Schools and universities.
- Hotels and restaurants.
- Tour operators.
- Conservation organisations.
- Community-based organisations.
- Local businesses.

These partnerships provide funding, skills, equipment, publicity and technical support.

7.11 Example: Designing a Tourism Promotion Strategy for a Local Community in Kenya

A community around a scenic hill, river or cultural heritage site can develop the following strategy.

Strategy	Activities
Identify attractions	Map natural, historical and cultural sites.
Develop facilities	Construct footpaths, toilets and visitor information centres.
Train guides	Train local youth in tour guiding and hospitality.
Promote culture	Organise traditional dances and cultural exhibitions.
Market attractions	Advertise through websites and social media.
Protect the environment	Organise clean-up and tree-planting activities.
Establish partnerships	Work with county governments and tour operators.
Monitor progress	Collect visitor feedback and assess tourism impacts.

8.0 TOURISM AS A MEDIUM FOR NATIONAL COHESION

8.1 Meaning of National Cohesion

National cohesion refers to the state of unity, peaceful coexistence, mutual respect, cooperation and a shared sense of belonging among people living in a country despite their differences.

In Kenya, national cohesion involves people from different ethnic, religious, cultural, social and economic backgrounds living and working together peacefully.

8.2 Meaning of Tourism as a Medium for National Cohesion

Tourism acts as a medium for national cohesion because it brings together people from different communities and regions, enabling them to interact, share experiences, appreciate cultural diversity and develop a common national identity.

For example, when learners from Turkana visit the Kenyan coast, they interact with coastal communities and learn about their culture, history, food and lifestyle.

Such interactions promote understanding and national unity.

8.3 Ways Tourism Promotes National Cohesion in Kenya

1. Encourages interaction among different communities

- Domestic tourism brings people from different parts of Kenya together.
- Tourists interact with host communities.
- Such interactions promote friendship and mutual understanding.
- It reduces social divisions.

2. Promotes appreciation of cultural diversity

- Tourists experience different traditions, languages, food and dances.
- People learn to respect other communities.
- Cultural diversity becomes a source of national pride.

3. Reduces ethnic stereotypes and prejudice

- Interaction enables people to understand the lifestyles of other communities.
- It challenges negative assumptions about particular ethnic groups.

- It encourages tolerance and acceptance.

4. Promotes a shared national identity

- Visiting national parks, museums and historical sites helps citizens appreciate their shared heritage.
- Citizens develop pride in Kenya.
- Tourism encourages the understanding that different communities belong to one nation.

5. Encourages peaceful coexistence

- Tourism promotes dialogue and interaction.
- People learn to cooperate in providing tourism services.
- It encourages peaceful relationships between host communities and visitors.

6. Promotes inter-community cooperation

- Different communities can work together in tourism businesses.
- Communities may jointly manage conservancies and cultural centres.
- Cooperation strengthens relationships.

7. Creates shared economic opportunities

- Tourism creates employment for people from different backgrounds.
- People cooperate in hotels, transport businesses and tourist enterprises.
- Economic interdependence encourages unity.

8. Promotes cultural exchange

- Visitors learn traditional songs, dances, foods and customs.
- Host communities learn about visitors' cultures.
- Cultural exchange promotes respect and understanding.

9. Encourages national celebrations

- National tourism events bring people together.
- Cultural festivals provide opportunities for interaction.
- People celebrate their shared national identity.

10. Promotes understanding of national history

- Visits to museums and historical sites enable citizens to learn about the country's history.
- Citizens appreciate the contributions of different communities to national development.
- This encourages a sense of shared heritage.

11. Promotes intergenerational learning

- Young people learn traditional practices from older generations.
- Cultural tourism helps preserve community knowledge.
- This strengthens cultural identity while promoting national appreciation.

12. Encourages cooperation in environmental conservation

- Communities from different regions can work together to conserve wildlife and natural resources.
- Shared conservation projects encourage collective responsibility.

8.4 Examples of Tourism Activities that Promote National Cohesion

1. School educational trips to national parks.
2. Cultural exchange programmes between schools.
3. National music and cultural festivals.
4. Visits to museums and historical sites.
5. Inter-county sports tourism events.
6. Domestic family holidays.
7. Community-based cultural tourism.
8. National environmental conservation campaigns.
9. Inter-community tourism exhibitions.
10. Student exchange programmes.

8.5 Challenges that May Prevent Tourism from Promoting National Cohesion

1. Ethnic discrimination.
2. Negative stereotypes.
3. Political interference.
4. Insecurity.
5. Unequal distribution of tourism benefits.
6. Cultural exploitation.
7. Poor relations between tourists and host communities.
8. High travel costs that limit domestic tourism.
9. Language barriers.
10. Limited access to tourism facilities by disadvantaged communities.

8.6 Ways of Strengthening the Role of Tourism in National Cohesion

- Promote affordable domestic tourism.
- Organise inter-county cultural exchange programmes.
- Encourage school excursions across different regions.
- Ensure fair sharing of tourism benefits.
- Promote respect for all Kenyan cultures.
- Encourage inclusive tourism employment.
- Support community-based tourism.
- Organise national tourism festivals.
- Strengthen peace education.

- Encourage responsible media coverage of different communities.

9.0 THE FUTURE OF TOURISM IN KENYA

9.1 Introduction

The future of tourism in Kenya depends on how effectively the country manages its natural and cultural resources, improves infrastructure, adopts modern technology, addresses security challenges and promotes sustainable tourism.

Kenya has significant potential to expand its tourism industry because of its wildlife, beaches, mountains, cultural diversity, historical heritage and geographical location.

9.2 Emerging Opportunities in the Future of Tourism in Kenya

1. Growth of domestic tourism

- More Kenyans may travel within the country for leisure and education.
- Affordable holiday packages can encourage domestic travel.
- Increased awareness of local attractions can expand domestic tourism.
- Schools and institutions can organise more educational trips.

2. Growth of digital tourism marketing

- Social media can help promote lesser-known attractions.
- Online booking systems can simplify travel arrangements.
- Virtual tours can introduce tourists to destinations before visiting.
- Digital payment systems can improve convenience.

3. Expansion of ecotourism

- Growing awareness of environmental conservation may increase demand for responsible tourism.
- Community conservancies can provide additional attractions.
- Eco-lodges and nature-based tourism can attract environmentally conscious visitors.

4. Growth of cultural tourism

- Cultural centres can preserve traditional heritage.
- Cultural festivals can attract local and international tourists.
- Traditional crafts and performances can create new income opportunities.

5. Development of adventure tourism

- Mountain climbing, hiking, cycling and water sports may attract more tourists.
- Kenya can develop adventure tourism in its mountains, rivers, forests and valleys.
- Adventure activities can diversify the country's tourism products.

6. Expansion of conference tourism

- Kenya can attract international conferences and exhibitions.
- Nairobi and other major cities can benefit from business tourism.
- Improved conference facilities can attract international organisations and business delegates.

7. Growth of medical tourism

- Improved healthcare facilities may attract international patients.
- Specialised healthcare services may create new tourism opportunities.
- Medical tourism can support investment in healthcare and hospitality.

8. Expansion of agro-tourism

- Agricultural farms can develop educational and recreational experiences.
- Visitors can learn about tea, coffee, dairy and horticultural production.
- Agro-tourism can provide additional income for farmers.

9. Growth of community-based tourism

- Communities can establish tourism enterprises.
- Local people can offer guided walks, cultural performances and accommodation.
- Tourism income can support local development.

10. Development of marine tourism

- Kenya can further develop diving, sailing, sport fishing and marine wildlife viewing.
- Marine conservation can strengthen coastal tourism.
- Improved coastal facilities can attract more visitors.

11. Use of artificial intelligence and smart technology

- Artificial intelligence can support personalised travel recommendations.
- Digital platforms can improve customer service.
- Smart booking systems can simplify travel planning.
- Data analysis can help tourism businesses understand visitor preferences.

12. Development of accessible tourism

- Tourism facilities can be designed to accommodate persons with disabilities.
- Accessible transport, accommodation and visitor facilities can widen participation.
- Inclusive tourism can benefit more citizens and international visitors.

9.3 Strategies for Improving the Future of Tourism in Kenya

1. Strengthening security in tourist destinations.
2. Improving road, air and railway infrastructure.
3. Promoting sustainable wildlife conservation.
4. Investing in modern accommodation facilities.
5. Training tourism and hospitality personnel.
6. Promoting domestic tourism.
7. Diversifying tourism products.
8. Strengthening international marketing.

9. Encouraging private-sector investment.
10. Promoting community participation.
11. Developing digital tourism services.
12. Protecting historical and cultural attractions.
13. Improving waste management.
14. Promoting affordable tourism packages.
15. Developing climate-resilient tourism infrastructure.
16. Encouraging research and innovation.
17. Improving cooperation between county and national governments.
18. Supporting small tourism enterprises.

9.4 Possible Challenges to the Future of Tourism in Kenya

- Climate change.
- Environmental degradation.
- Insecurity.
- Global economic instability.
- Competition from other destinations.
- High operational costs.
- Limited investment in some regions.
- Loss of biodiversity.
- Overdependence on wildlife tourism.
- Disease outbreaks.
- Technological inequalities.
- Shortage of skilled personnel.

9.5 The Role of Young People in the Future of Tourism

Young people can contribute to tourism development by:

1. Training as professional tour guides.
2. Establishing tourism-related businesses.
3. Promoting local attractions through digital platforms.
4. Participating in environmental conservation.
5. Preserving traditional music, dances and crafts.
6. Developing tourism applications and websites.
7. Organising cultural festivals.
8. Participating in community tourism projects.
9. Promoting responsible travel.

10. Conducting research on local tourist attractions.

10.0 TOURISM FIELD STUDY AND EDUCATIONAL EXCURSIONS

10.1 Meaning of a Field Study in Tourism

A tourism field study is an organised visit to a tourist attraction or tourism establishment to observe, investigate and collect information about tourism activities.

It provides learners with practical experiences that complement classroom learning.

10.2 Objectives of a Tourism Field Study

By undertaking a tourism field study, learners should be able to:

1. Identify different types of tourism.
2. Identify natural and human-made tourist attractions.
3. Observe tourism activities.
4. Investigate factors influencing tourism development.
5. Examine the importance of tourism to local communities.
6. Identify challenges facing tourism.
7. Suggest ways of promoting sustainable tourism.
8. Appreciate cultural diversity.
9. Develop observation and research skills.
10. Promote environmental conservation.

10.3 Examples of Tourist Destinations for Geography Field Studies in Kenya

Destination	Main geographical tourism focus
Maasai Mara	Wildlife tourism and conservation
Lake Nakuru	Bird watching and wildlife
Mount Kenya	Mountain tourism and adventure
Hell's Gate	Geomorphology and adventure tourism
Fort Jesus	Historical tourism
Lamu Old Town	Cultural and historical tourism
Kakamega Forest	Ecotourism and biodiversity
Lake Naivasha	Water-based tourism and bird watching
Amboseli	Wildlife and mountain scenery
Gedi Ruins	Archaeological and historical tourism

10.4 Preparation for a Tourism Field Study

Before undertaking a field study, learners should:

1. Identify the destination to be visited.

2. Establish the objectives of the study.
3. Obtain permission from the school administration.
4. Identify the transport arrangements.
5. Prepare a budget.
6. Contact the management of the tourist destination.
7. Prepare observation checklists.
8. Prepare interview questions.
9. Identify the equipment required.
10. Establish safety guidelines.

10.5 Methods of Collecting Information During a Field Study

1. Observation

Learners directly observe tourist attractions, facilities and activities.

2. Interviewing

Learners ask tour guides, hotel workers, local residents and park officials questions about tourism.

3. Photography

Photographs are taken to provide visual evidence of tourist attractions and activities, subject to site rules.

4. Note-taking

Learners record important information observed or obtained from respondents.

5. Questionnaires

Questionnaires are used to collect information from tourists, workers and local communities.

6. Mapping

Learners identify the location and distribution of tourist attractions using maps.

10.6 Safety Measures During a Tourism Field Study

- Follow instructions given by teachers and guides.
- Avoid wandering away from the group.
- Do not feed or provoke wild animals.
- Avoid touching dangerous plants or animals.
- Use designated pathways.
- Keep the environment clean.
- Carry drinking water and basic first-aid supplies.
- Observe safety instructions at beaches and water bodies.
- Respect local cultures and property.
- Avoid entering restricted areas.

10.7 Activities After the Field Study

Learners should:

1. Organise the information collected.
2. Analyse the findings.
3. Prepare reports.
4. Draw maps and illustrations where necessary.
5. Discuss challenges observed.
6. Suggest solutions to tourism problems.
7. Present findings to classmates.
8. Reflect on lessons learnt.

11.0 IMPORTANT TOURIST ATTRACTIONS IN KENYA

Kenya has a wide variety of tourist attractions distributed across different counties. These attractions include wildlife, mountains, lakes, beaches, forests, historical monuments and cultural sites.

11.1 Major Wildlife Tourism Attractions



1. Maasai Mara National Reserve

- Famous for the wildebeest migration.
- Supports lions, elephants, cheetahs and other wildlife.
- Attracts local and international tourists.



2. Amboseli National Park

- Famous for large elephant herds.
- Offers views of Mount Kilimanjaro.

- Attracts wildlife photographers.



3. Tsavo East National Park

- Known for extensive wilderness.
- Famous for red elephants.
- Supports diverse wildlife.



4. Lake Nakuru National Park

- Known for birdlife.
- Supports rhinoceroses and other wildlife.
- Attracts bird watchers and nature lovers.



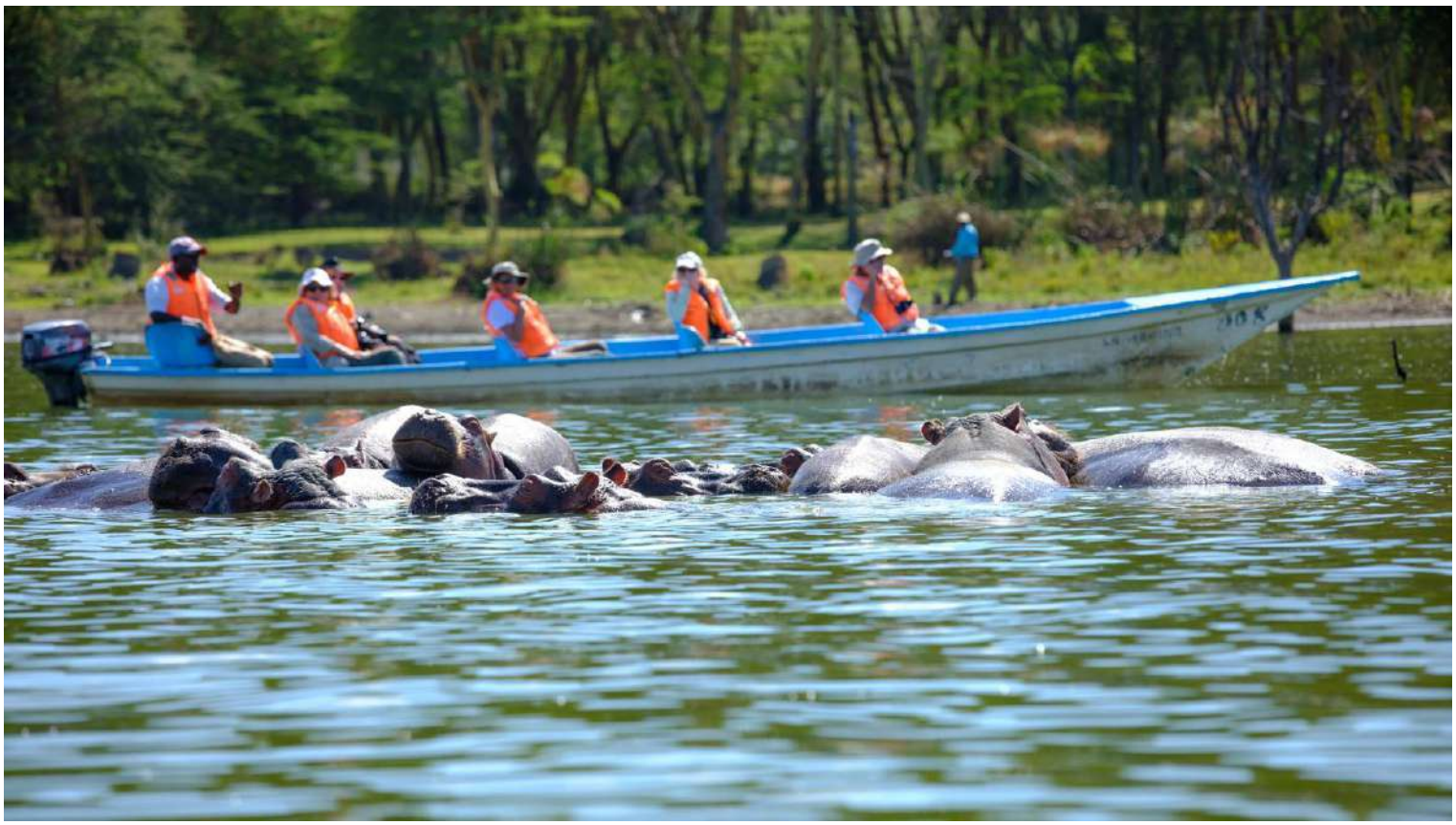
5. Samburu National Reserve

- Famous for unique northern wildlife.
- Attracts visitors interested in wildlife photography.
- Supports community conservation initiatives.

11.2 Major Physical and Scenic Attractions







1. **Mount Kenya:** Attracts climbers, hikers and nature lovers.
2. **Great Rift Valley:** Attracts sightseeing tourists because of its escarpments, lakes and scenic landscapes.

3. **Thomson's Falls:** Attracts tourists interested in waterfalls and photography.
4. **Lake Naivasha:** Supports boat excursions, bird watching and nature tourism.
5. **Kakamega Forest:** Attracts nature lovers, bird watchers and researchers.

11.3 Major Coastal and Marine Attractions







1. **Diani Beach:** Famous for white sandy beaches and water sports.
2. **Fort Jesus:** A major historical attraction.
3. **Lamu Old Town:** Famous for Swahili culture and traditional architecture.
4. **Watamu Marine National Park:** Attracts visitors interested in coral reefs and marine biodiversity.
5. **Malindi:** Known for coastal recreation and marine tourism.

12.0 KEY GEOGRAPHICAL CONCEPTS IN TOURISM

Concept	Meaning
Tourist attraction	A feature that attracts visitors to a destination.
Tourism infrastructure	Facilities and systems that support tourism, such as roads, airports and communication networks.
Tourism carrying capacity	The maximum number of visitors a destination can accommodate without unacceptable environmental, social or visitor-experience damage.
Tourist seasonality	Changes in tourist numbers according to seasons or particular periods of the year.
Tourist expenditure	Money spent by tourists on goods and services during their visits.
Tourism leakage	The proportion of tourism revenue that leaves the destination economy instead of benefiting the local economy.
Community-based tourism	Tourism owned, managed or significantly supported by local communities.
Ecotourism	Responsible tourism to natural areas that supports conservation and local

	communities.
Heritage tourism	Travel to places of historical, cultural or archaeological importance.
Destination management	Planning and coordinating activities to develop and manage a tourist destination.
Tourism diversification	Expanding the range of tourism products and experiences offered by a destination.
Hospitality	The provision of friendly reception, accommodation and services to visitors.
Tourist itinerary	A planned schedule of places to visit and activities to undertake during a journey.
Tourism sustainability	Developing tourism while maintaining its economic, environmental and social benefits over time.

13.0 SUMMARY OF THE SUB-STRAND

Tourism is an important human and economic activity involving temporary travel to places outside people's usual environments for various purposes.

The major types of tourism include domestic, international, inbound, outbound, wildlife, beach, cultural, historical, adventure, sports, educational, religious, medical, ecotourism, business, rural, agro-tourism and urban tourism.

Kenya attracts tourists because of its wildlife, physical features, climate, cultural diversity, historical attractions, beaches and improving infrastructure. France attracts tourists because of its cultural heritage, historical monuments, beautiful landscapes, transport networks, fashion and cuisine.

Tourism contributes to Kenya's economic development through foreign exchange earnings, employment creation, investment, government revenue and infrastructure development. It also promotes cultural exchange, education, environmental conservation and national cohesion.

However, the sector faces challenges such as insecurity, environmental degradation, poaching, human-wildlife conflict, climate change, poor infrastructure and international competition.

Sustainable tourism, effective marketing, community participation, conservation, infrastructure development and improved security are essential for the future growth of tourism in Kenya.

The future of tourism in Kenya depends on the country's ability to protect its attractions, improve tourism services, embrace innovation and ensure that local communities benefit from tourism development.

REVISION AND ASSESSMENT QUESTIONS

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Instructions: Answer all the questions. Choose the correct answer from the alternatives A, B, C and D.

1. Which of the following statements best describes tourism?

A. The permanent movement of people from one country to another.

B. The movement of people away from their usual environment for leisure, business or other purposes.

C. The movement of goods from one geographical region to another.

D. The permanent settlement of people in a foreign country.

2. Which of the following is an example of domestic tourism?

A. A Kenyan visiting France for a holiday.

B. A French tourist visiting Kenya.

C. A Kenyan visiting Mombasa from Nairobi for a holiday.

D. A Kenyan travelling to Tanzania for business.

3. A tourist who travels from Kenya to France is participating in:

A. Outbound tourism.

B. Inbound tourism.

C. Domestic tourism.

D. Local tourism.

4. Which of the following is an example of wildlife tourism in Kenya?

A. Visiting a tea factory in Kericho.

B. Attending a business conference in Nairobi.

C. Visiting a historical museum in France.

D. Viewing elephants and lions in Amboseli National Park.

5. Which physical factor strongly influences the development of tourism in coastal Kenya?

A. Availability of manufacturing industries.

B. Warm tropical climate and attractive beaches.

C. High population density.

D. Availability of financial institutions.

6. The presence of the Eiffel Tower in France promotes tourism mainly because it is a:

A. Natural geographical feature.

B. Wildlife conservation area.

C. Historical and cultural attraction.

D. Agricultural attraction.

7. Which of the following is a major tourist attraction found in Kenya?

A. Maasai Mara National Reserve.

B. Mount Everest.

C. Sahara Desert.

D. Eiffel Tower.

8. Which of the following factors has contributed to the development of tourism in France?

A. Absence of historical monuments.

B. Lack of transport networks.

C. Limited cultural attractions.

D. Rich cultural heritage and well-developed infrastructure.

9. Which type of tourism involves travelling to experience the traditions, lifestyles and cultural practices of communities?

A. Medical tourism.

B. Cultural tourism.

C. Sports tourism.

D. Business tourism.

10. Which of the following is an example of adventure tourism?

A. Attending a business meeting.

B. Visiting a historical museum.

C. Mountain climbing and white-water rafting.

D. Attending a religious service.

11. One major economic contribution of tourism to Kenya is:

A. Generation of foreign exchange earnings.

B. Reduction of all forms of trade.

C. Elimination of agricultural activities.

D. Reduction of employment opportunities.

12. Tourism promotes employment in Kenya through:

A. Reducing demand for accommodation.

B. Discouraging investment in transport.

C. Closing hospitality businesses.

D. Creating jobs in hotels, tour companies and transport services.

13. Which of the following is a social benefit of tourism?

A. Increased environmental pollution.

B. Promotion of cultural exchange and understanding.

C. Destruction of historical sites.

D. Increased insecurity in tourist destinations.

14. Which of the following is a major challenge facing tourism in Kenya?

A. Availability of diverse wildlife.

B. Attractive coastal beaches.

C. Insecurity and negative travel advisories.

D. Rich cultural heritage.

15. Poaching affects tourism in Kenya because it:

A. Reduces wildlife populations and threatens wildlife attractions.

B. Increases the number of wildlife species.

C. Improves wildlife conservation.

D. Increases tourist confidence.

16. Which of the following measures can help reduce human-wildlife conflict?

A. Destroying wildlife habitats.

B. Encouraging illegal hunting.

C. Blocking wildlife migration routes.

D. Establishing wildlife corridors and compensation programmes.

17. Sustainable tourism refers to tourism that:

A. Focuses only on increasing the number of visitors.

B. Meets present needs while conserving resources for future generations.

C. Encourages uncontrolled development of tourist facilities.

D. Excludes local communities from tourism activities.

18. Which of the following is an example of ecotourism in Kenya?

A. Constructing industries within national parks.

B. Hunting endangered wildlife for trophies.

C. Visiting a community conservation area while supporting environmental protection.

D. Clearing forests to construct hotels.

19. Which institution plays an important role in promoting tourism in Kenya?

A. Kenya Tourism Board.

B. Kenya National Examinations Council.

C. Teachers Service Commission.

D. Kenya Revenue Authority.

20. Tourism can promote national cohesion in Kenya by:

A. Encouraging discrimination among communities.

B. Promoting competition between ethnic groups.

C. Discouraging cultural interaction.

D. Encouraging people from different communities to interact and appreciate one another.

21. Which of the following is an example of religious tourism?

A. Visiting a wildlife sanctuary.

B. Travelling to a holy site for religious purposes.

C. Attending a sports competition.

D. Visiting an agricultural exhibition.

22. Which of the following is a major attraction for beach tourism in Kenya?

A. Mountain peaks of the Aberdares.

B. Tea plantations in Kericho.

C. Sandy beaches along the Indian Ocean coast.

D. Savannah grasslands in Laikipia.

23. The term inbound tourism refers to:

A. Foreign visitors travelling into a particular country.

B. Citizens travelling outside their country.

C. People travelling within their own country.

D. People moving permanently to another country.

24. Which of the following is a likely effect of seasonality in tourism?

A. Constant tourist arrivals throughout the year.

B. Elimination of fluctuations in hotel demand.

C. Equal distribution of tourist income every month.

D. Variation in tourist arrivals during different periods of the year.

25. Which of the following activities can promote community-based tourism?

A. Excluding local residents from tourism planning.

B. Establishing cultural centres and community-managed tourist attractions.

C. Restricting visitors from interacting with local communities.

D. Destroying traditional cultural sites.

26. Climate change may negatively affect tourism in Kenya through:

A. Increasing the reliability of all tourist seasons.

B. Eliminating droughts and floods.

C. Causing extreme weather events and affecting wildlife habitats.

D. Improving all natural tourist attractions.

27. Which of the following is an example of educational tourism?

A. Travelling to visit a geographical site or participate in a learning excursion.

B. Travelling to attend a football match.

C. Travelling to purchase household goods.

D. Travelling to visit relatives permanently.

28. Which of the following strategies can improve Kenya's international tourism competitiveness?

A. Reducing tourism marketing.

B. Neglecting tourist facilities.

C. Restricting international visitors.

D. Improving infrastructure, security and destination marketing.

29. A school cultural centre can promote tourism by:

A. Discouraging learners from appreciating different cultures.

B. Displaying traditional artefacts, dances, foods and cultural practices.

C. Preventing interaction among communities.

D. Promoting the destruction of cultural heritage.

30. Which of the following best describes the future of tourism in Kenya?

A. Dependence on wildlife tourism alone.

B. Abandonment of domestic tourism.

C. Growth through diversification, technology, sustainability and community participation.

D. Restriction of tourism to major cities.

SECTION B: STRUCTURED QUESTIONS (50 MARKS)

Instructions: Answer all questions. Write your answers clearly and provide relevant examples where necessary.

QUESTION 1: INTRODUCTION TO TOURISM (8 MARKS)

a) Define the term tourism. (2 marks)

b) Differentiate between domestic tourism and international tourism. (2 marks)

c) Identify four types of tourism practised in the world. (4 marks)

QUESTION 2: FACTORS INFLUENCING TOURISM IN KENYA AND FRANCE (8 MARKS)

a) Explain four physical factors that have favoured the development of tourism in Kenya. (4 marks)

b) Explain four human factors that have contributed to the development of tourism in France. (4 marks)

QUESTION 3: SIGNIFICANCE OF TOURISM IN KENYA (9 MARKS)

a) Explain five economic benefits of tourism to Kenya. (5 marks)

b) Describe four social and cultural benefits of tourism to the Kenyan population. (4 marks)

QUESTION 4: PROBLEMS FACING TOURISM IN KENYA AND THEIR SOLUTIONS (9 MARKS)

a) Explain five problems facing the tourism industry in Kenya. (5 marks)

b) Suggest four measures that can be taken to address the problems facing tourism in Kenya. (4 marks)

QUESTION 5: SUSTAINABLE TOURISM AND COMMUNITY PARTICIPATION (8 MARKS)

a) Define the term sustainable tourism. (2 marks)

b) Explain three strategies that local communities can use to promote tourism in their areas. (3 marks)

c) State three ways through which establishing a cultural centre in a school can contribute to tourism promotion. (3 marks)

QUESTION 6: TOURISM AND NATIONAL COHESION (8 MARKS)

a) Explain four ways through which tourism promotes national cohesion in Kenya. (4 marks)

b) Suggest four strategies that Kenya can adopt to improve the future of its tourism industry. (4 marks)

GRADE 11 GEOGRAPHY

MARKING SCHEME – STRAND 3.0: HUMAN AND ECONOMIC ACTIVITIES

SUB-STRAND 3.3: TOURISM

COMPETENCY-BASED EDUCATION

TOTAL: 80 MARKS

Instructions to Examiners:

1. Award marks according to the marking points provided.
2. Accept any other relevant and correct geographical response.
3. Award marks for correctly explained points where explanations are required.
4. Do not award marks for repeated points.
5. Accept relevant examples from Kenya and other countries.

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Award 1 mark for each correct answer.

Question	Answer	Question	Answer
1	B	16	D
2	C	17	B
3	A	18	C
4	D	19	A
5	B	20	D
6	C	21	B
7	A	22	C
8	D	23	A
9	B	24	D
10	C	25	B
11	A	26	C
12	D	27	A
13	B	28	D
14	C	29	B
15	A	30	C

SECTION B: STRUCTURED QUESTIONS (50 MARKS)

QUESTION 1: INTRODUCTION AND TYPES OF TOURISM (8 MARKS)

a) Define the term tourism. (2 marks)

Tourism refers to the temporary movement of people from their usual places of residence to other destinations for leisure, recreation, business, education, religious activities or other purposes.

Mark allocation:

- Temporary movement of people from their usual environment – 1 mark.
- For leisure, business, recreation, education or other purposes – 1 mark.

b) Differentiate between domestic tourism and international tourism. (2 marks)

- Domestic tourism: Involves travelling within one's own country without crossing an international boundary. (1 mark)
- International tourism: Involves travelling from one country to another across international boundaries. (1 mark)

c) State four types of tourism practised in the world. (4 marks)

Award 1 mark for each correct response.

1. Domestic tourism.
2. International tourism.
3. Inbound tourism.
4. Outbound tourism.
5. Wildlife tourism.
6. Cultural tourism.
7. Historical tourism.
8. Adventure tourism.
9. Sports tourism.
10. Educational tourism.
11. Religious tourism.
12. Medical tourism.
13. Ecotourism.
14. Business tourism.
15. Rural tourism.
16. Agro-tourism.
17. Beach tourism.
18. Urban tourism.
19. Space tourism.
20. Gastronomic tourism.

Total: 8 marks

QUESTION 2: FACTORS INFLUENCING TOURISM IN KENYA AND FRANCE (8 MARKS)

a) Explain four physical factors that influence tourism development in Kenya. (4 marks)

Award 1 mark for each well-explained factor.

1. Favourable climate: Warm coastal conditions and mild highland climates encourage outdoor recreational activities and attract tourists.

2. Abundant wildlife: The presence of elephants, lions, giraffes, zebras and other wildlife attracts tourists interested in game viewing and photography.

3. Beautiful physical features: Mountains, valleys, lakes, rivers and waterfalls attract tourists interested in sightseeing, hiking and adventure activities.

4. Attractive coastline: Sandy beaches, coral reefs and marine parks encourage swimming, diving, sailing and other water sports.

5. Rich biodiversity: Different ecosystems support diverse plants and animals, attracting nature lovers and researchers.

6. Scenic landscapes: Beautiful landscapes in areas such as the Great Rift Valley and Amboseli attract photographers and sightseeing tourists.

7. Attractive forests: Indigenous forests provide opportunities for bird watching, nature walks and ecotourism.

8. Presence of lakes and rivers: Lakes and rivers support boating, fishing, bird watching and other recreational activities.

Any four well-explained points × 1 mark = 4 marks.

b) State four human factors that influence tourism development in France. (4 marks)

Award 1 mark for each correct factor.

1. Availability of well-developed transport infrastructure.
2. Rich historical heritage and monuments.
3. Availability of modern accommodation facilities.
4. Government support and promotion of tourism.
5. Political stability and security.
6. Availability of skilled hospitality personnel.
7. Development of shopping and entertainment facilities.
8. Advanced communication technology.
9. Rich cultural heritage, including art, fashion and cuisine.
10. Availability of international airports.
11. International conferences and sporting events.
12. Effective tourism marketing and advertising.

Any four correct responses × 1 mark = 4 marks.

Total: 8 marks

QUESTION 3: SIGNIFICANCE OF TOURISM IN KENYA (9 MARKS)

a) Explain five economic benefits of tourism to Kenya. (5 marks)

Award 1 mark for each well-explained point.

1. Earns foreign exchange: International tourists spend money on accommodation, transport, food and recreational activities, bringing foreign currency into Kenya.

2. Creates employment: Tourism provides jobs for tour guides, hotel workers, drivers, chefs, park wardens and other service providers.

3. Generates government revenue: The government earns revenue through taxes, licence fees, park entrance fees and other tourism-related charges.

4. Promotes infrastructure development: Tourism encourages the construction and improvement of roads, airports, communication networks and other facilities.

5. Encourages investment: Local and foreign investors establish hotels, resorts, restaurants and other tourism-related businesses.

6. Promotes entrepreneurship: People establish businesses such as tour companies, curio shops, restaurants and car hire services.

7. Creates markets for local products: Hotels and restaurants purchase agricultural products, while tourists purchase locally made crafts and souvenirs.

8. Promotes regional development: Tourism encourages investment and business activities in areas such as Narok, Kwale and Samburu counties.

9. Diversifies the economy: Tourism provides an additional source of national income alongside agriculture, manufacturing and other sectors.

10. Improves the balance of payments: Foreign earnings from international tourists contribute to Kenya's service exports.

Any five well-explained points × 1 mark = 5 marks.

b) Describe four ways in which tourism promotes cultural and social development in Kenya. (4 marks)

Award 1 mark for each well-described point.

1. Promotes national unity: Domestic tourism brings people from different communities together, encouraging friendship and peaceful coexistence.

2. Preserves cultural heritage: Tourism encourages communities to maintain traditional dances, songs, artefacts, clothing and cultural practices.

3. Promotes cultural exchange: Visitors and host communities share ideas, traditions, languages and experiences.

4. Promotes education: Educational trips enable learners to acquire practical knowledge about geography, history, wildlife and culture.

5. Improves living standards: Tourism creates income-generating opportunities that help families improve their welfare.

6. Encourages social interaction: People from different regions and countries interact and develop mutual understanding.

7. Promotes recreational activities: Tourism provides opportunities for leisure, relaxation and entertainment.

8. Promotes respect for cultural diversity: Visitors learn to appreciate different traditions, beliefs and lifestyles.

Any four well-described points × 1 mark = 4 marks.

Total: 9 marks

QUESTION 4: PROBLEMS FACING TOURISM IN KENYA (9 MARKS)

a) Explain five problems facing the tourism industry in Kenya. (5 marks)

Award 1 mark for each well-explained problem.

1. Insecurity and terrorism: Criminal activities and terrorist attacks discourage tourists from visiting affected areas, leading to cancellations and financial losses.

2. Political instability: Political unrest and demonstrations disrupt tourism activities and discourage potential visitors.

3. Poor transport infrastructure: Poorly maintained roads make some tourist destinations difficult to access, increasing travel time and costs.

4. Environmental degradation: Pollution, deforestation and destruction of natural habitats reduce the attractiveness of tourist destinations.

5. Poaching: Illegal hunting reduces wildlife populations, threatening wildlife conservation and reducing the attractiveness of national parks.

6. Human-wildlife conflict: Wild animals destroy crops, attack livestock and sometimes injure people, creating hostility towards wildlife conservation.

7. Seasonal fluctuations: Tourist numbers may decline during certain seasons, reducing income for tourism businesses.

8. High cost of tourism services: Expensive accommodation, transport and park charges discourage some tourists.

9. International competition: Other tourist destinations may attract visitors through competitive prices, marketing and facilities.

10. Disease outbreaks: Health emergencies and travel restrictions may discourage international visitors.

11. Climate change: Droughts, floods, coastal erosion and coral bleaching damage tourist attractions.

12. Inadequate marketing: Limited promotion reduces awareness of some tourist destinations.

13. Shortage of skilled personnel: Poor service delivery and lack of professional guides may reduce tourist satisfaction.

14. Poor waste management: Littering and pollution reduce the attractiveness of tourist sites.

15. Land-use conflicts: Human settlement and farming may interfere with wildlife habitats and migration routes.

Any five well-explained points × 1 mark = 5 marks.

b) Suggest four measures that can be undertaken to address problems facing tourism in Kenya. (4 marks)

Award 1 mark for each relevant solution.

1. Strengthen security surveillance and police patrols in tourist destinations.
2. Promote political stability and peaceful coexistence.
3. Improve roads and other transport infrastructure.
4. Enforce environmental conservation laws.
5. Strengthen anti-poaching programmes.
6. Establish wildlife corridors and barriers to reduce human-wildlife conflict.
7. Promote domestic tourism throughout the year.
8. Develop affordable tourism packages.
9. Improve tourism marketing locally and internationally.

10. Train tourism and hospitality personnel.
11. Strengthen public health and emergency response systems.
12. Promote climate adaptation and environmental restoration.
13. Improve waste collection and recycling.
14. Encourage community participation in tourism management.
15. Encourage investment in new tourism products.

Any four correct responses × 1 mark = 4 marks.

Total: 9 marks

QUESTION 5: SUSTAINABLE TOURISM AND LOCAL COMMUNITY PROMOTION (8 MARKS)

a) Define sustainable tourism. (2 marks)

Sustainable tourism refers to tourism development that meets the needs of present tourists and host communities while protecting environmental, cultural and economic resources for future generations.

Mark allocation:

- Meets present tourism and community needs while considering economic, social and environmental impacts – 1 mark.
- Protects resources and ensures their availability for future generations – 1 mark.

b) State three strategies that a local community can use to promote tourism. (3 marks)

Award 1 mark for each correct strategy.

1. Establishing cultural centres to display traditional artefacts and organise cultural performances.
2. Advertising local tourist attractions through social media, websites and brochures.
3. Training local residents as professional tourist guides.
4. Improving access roads and other tourism infrastructure.
5. Organising cultural festivals and traditional dance performances.
6. Conserving forests, rivers, historical sites and other attractions.
7. Developing accommodation and hospitality facilities.
8. Establishing community-based tourism enterprises.
9. Developing nature trails and camping sites.
10. Partnering with tour operators and tourism organisations.

Any three correct responses × 1 mark = 3 marks.

c) Explain three ways through which a school cultural centre can contribute to tourism development. (3 marks)

Award 1 mark for each well-explained point.

1. Preservation of cultural heritage: A cultural centre displays traditional tools, clothing, musical instruments and artefacts, helping preserve community traditions.

2. Attracting visitors: Cultural exhibitions, traditional dances and performances attract visitors, increasing tourism activities.

3. Promoting cultural education: Visitors learn about the traditions, beliefs, lifestyles and history of different communities.

4. Generating income: The centre can sell traditional crafts, souvenirs and other locally produced products.

5. Promoting national cohesion: Learners and visitors appreciate the cultural diversity of different Kenyan communities.

6. Creating employment: The centre can provide opportunities for cultural performers, guides, craft makers and other workers.

Any three well-explained points × 1 mark = 3 marks.

Total: 8 marks

QUESTION 6: TOURISM AND NATIONAL COHESION (8 MARKS)

a) Explain four ways in which tourism promotes national cohesion in Kenya. (4 marks)

Award 1 mark for each well-explained point.

1. Encourages interaction among communities: Domestic tourism brings people from different parts of Kenya together, promoting friendship and understanding.

2. Promotes appreciation of cultural diversity: Tourists learn about different traditions, languages, dances and lifestyles, encouraging respect for other communities.

3. Reduces ethnic stereotypes: Interaction enables people to understand other communities and overcome negative assumptions and prejudice.

4. Promotes a shared national identity: Visiting national parks, museums and historical sites encourages citizens to appreciate their common Kenyan heritage.

5. Encourages peaceful coexistence: Tourism creates opportunities for dialogue, cooperation and peaceful interaction among people.

6. Promotes inter-community cooperation: Different communities work together in tourism businesses, conservancies and cultural centres.

7. Creates shared economic opportunities: Tourism provides employment and business opportunities to people from different ethnic and social backgrounds.

8. Promotes cultural exchange: Tourists and host communities share traditions, ideas, knowledge and experiences.

9. Encourages cooperation in conservation: Communities work together to protect wildlife and natural resources.

10. Promotes national celebrations: Cultural festivals and tourism events bring people together to celebrate their shared national identity.

Any four well-explained points × 1 mark = 4 marks.

b) Discuss four strategies that can be used to improve the future of tourism in Kenya. (4 marks)

Award 1 mark for each well-explained strategy.

1. Improving security: Strengthening security in tourist destinations encourages visitors and investors.

2. Improving infrastructure: Constructing and maintaining roads, airports and communication networks makes tourist destinations more accessible.

3. Promoting sustainable tourism: Protecting wildlife, forests, beaches and other attractions ensures tourism resources remain available for future generations.

4. Strengthening marketing: Advertising Kenya's attractions through digital platforms and international tourism exhibitions attracts more visitors.

5. Promoting domestic tourism: Affordable holiday packages encourage Kenyans to visit local destinations.

6. Diversifying tourism products: Developing cultural, sports, medical, agro-tourism and adventure tourism reduces overdependence on wildlife tourism.

7. Training tourism personnel: Professional training improves customer service and the quality of tourism experiences.

8. Encouraging investment: Supporting local and foreign investors promotes development of hotels, resorts and recreational facilities.

9. Embracing technology: Using online booking, digital payment systems and modern marketing improves tourism services.

10. Promoting community participation: Involving local people in tourism planning and management ensures that communities benefit from tourism.

Any four well-explained points × 1 mark = 4 marks.

SUMMARY OF MARKS

Question	Topic	Marks
1	Introduction and types of tourism	8
2	Factors influencing tourism in Kenya and France	8
3	Significance of tourism in Kenya	9
4	Problems facing tourism in Kenya	9
5	Sustainable tourism and local community promotion	8
6	Tourism and national cohesion	8
	SECTION B TOTAL	50

17.0 LEARNER'S PERFORMANCE RECORD

Marks obtained	Performance level
72–80	EE1
60–71	EE2
47–59	ME1
33–46	ME2
25–32	AE1
17–24	AE2
9–16	BE1
1–8	BE2
0	No score

STRAND 3.0: HUMAN AND ECONOMIC ACTIVITIES

SUB-STRAND 3.4: TRANSPORT AND COMMUNICATION

1.0 INTRODUCTION TO TRANSPORT AND COMMUNICATION

Transport and communication are important human and economic activities that facilitate the movement of people, goods, services and information from one place to another.

They connect individuals, communities, countries and continents, thereby promoting trade, tourism, industrialisation, education, cultural exchange and economic development.

In Africa, transport and communication play a significant role in connecting rural and urban areas, linking landlocked countries to seaports, facilitating regional integration and promoting international trade.

Kenya has continued to develop its transport and communication infrastructure through the construction of modern highways, railways, airports, seaports and expansion of digital communication networks.

1.1 Meaning of Transport

Transport refers to the physical movement of people, animals, goods and services from one geographical location to another using different means and facilities.

Examples:

A passenger travelling from Nairobi to Mombasa by train.

Farmers transporting maize from Trans Nzoia to Nairobi.

Tourists travelling from Nairobi to Maasai Mara by road.

Imported goods being transported from the Port of Mombasa to Uganda.

Livestock being moved from pastoral areas to markets.

1.2 Meaning of Communication

Communication refers to the process of sending, receiving and exchanging information, ideas, messages and knowledge between individuals or groups using different channels and technologies.

Examples:

Making telephone calls using mobile phones.

Sending messages through WhatsApp.

Watching news on television.

Sending electronic mail (email).

Listening to radio broadcasts.

Attending online classes through digital platforms.

1.3 Meaning of Transport and Communication Networks

A **transport network** is a system of interconnected routes, terminals and facilities through which people and goods move between different places.

Examples include:

Road networks.

Railway networks.

Air transport routes.

Water transport routes.

Pipeline networks.

A **communication network** is a system of interconnected devices, transmission facilities and technologies that enable the exchange of information over short or long distances.

Examples include:

Mobile telephone networks.

Fibre-optic networks.

Radio broadcasting networks.

Television transmission networks.

Internet networks.

Satellite communication networks.

1.4 Difference Between Transport and Communication

Transport	Communication
Involves the physical movement of people and goods.	Involves the exchange of information and ideas.
Uses vehicles, ships, aircraft and pipelines.	Uses telephones, computers, radio and television.
Requires transport routes and terminals.	Requires communication channels and networks.
Examples include roads and railways.	Examples include the internet and mobile networks.
Facilitates the movement of goods and people.	Facilitates the transmission of information.

1.5 Importance of Studying Transport and Communication in Geography

The study of transport and communication enables learners to:

Understand how different geographical regions are connected.

Explain the relationship between transport and economic development.

Identify the distribution of transport infrastructure.

Understand how geographical factors influence transport development.

Appreciate the role of modern communication technologies.

Examine transport and communication challenges in Africa.

Develop awareness of road safety and responsible use of transport facilities.

Understand regional and international trade connections.

Appreciate the importance of sustainable transport systems.

Develop skills in map interpretation, research, problem-solving and decision-making.

2.0 TYPES OF TRANSPORT IN THE WORLD

Transport is classified according to the medium or route used in moving people and goods.

The major types of transport in the world include:

Road transport.

Railway transport.

Water transport.

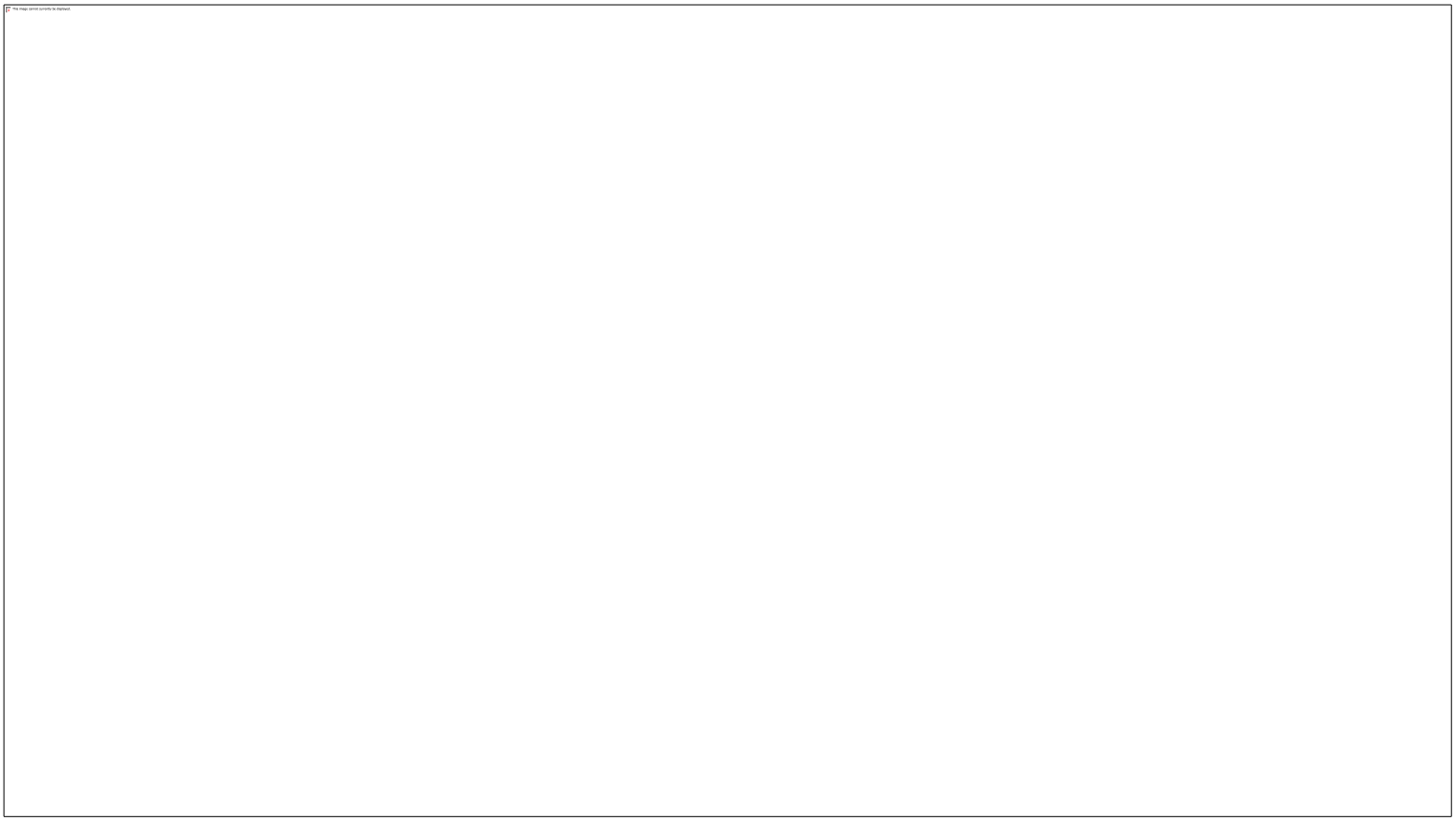
Air transport.

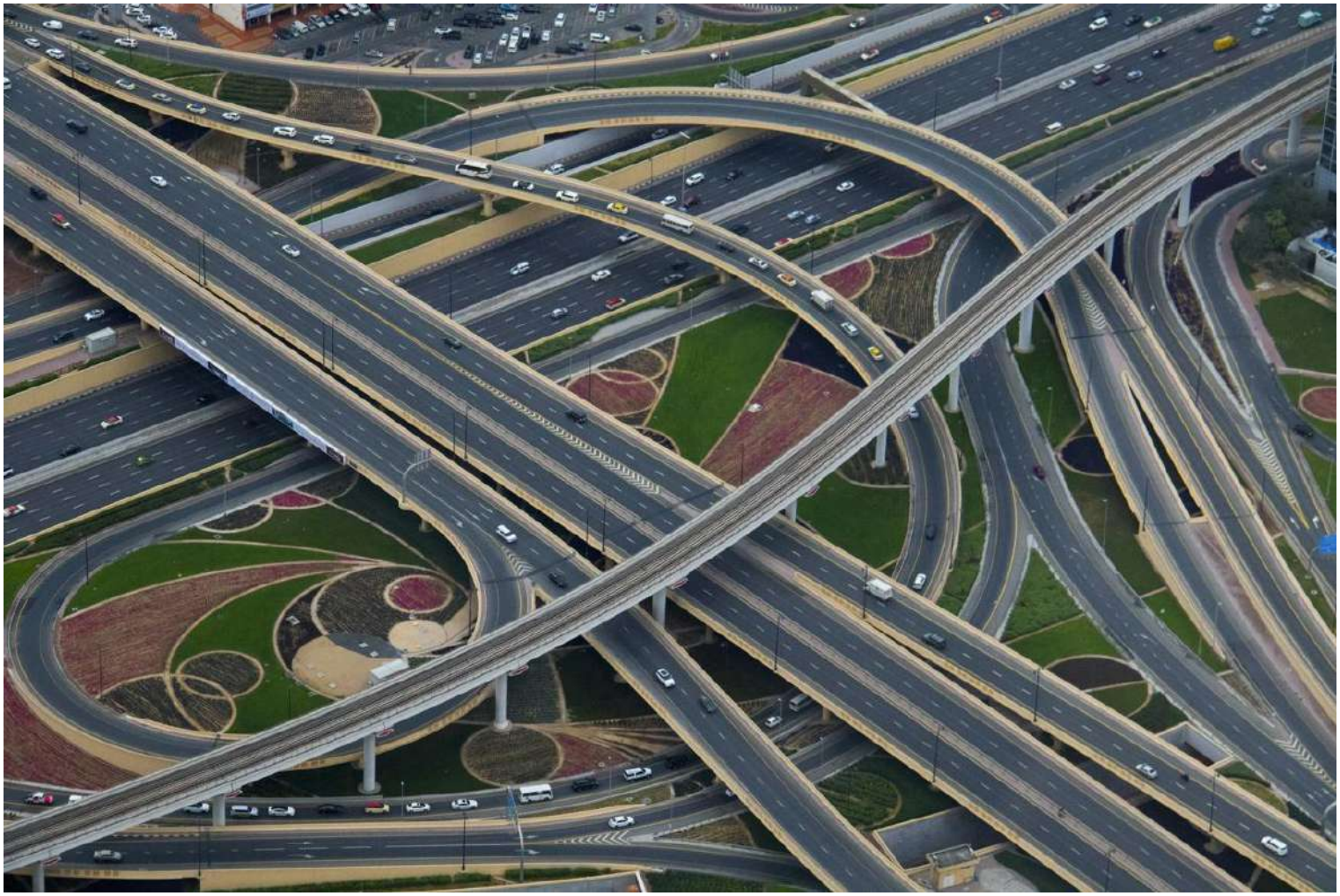
Pipeline transport.

Cable and ropeway transport.

2.1 Road Transport







Road transport is the movement of people and goods from one place to another using vehicles travelling on constructed or improved road surfaces.

It is one of the most widely used forms of transport in the world.

Examples of road transport vehicles

Cars.

Buses.

Matatus.

Lorries and trucks.

Motorcycles.

Bicycles.

Tractors.

Three-wheeled vehicles (tuk-tuks).

Pick-up trucks.

Specialised vehicles such as ambulances and fire engines.

Types of Roads

Roads are classified according to their construction, purpose, location and level of development.

A. According to construction and surface material

1. **Earth roads**

These are roads formed by clearing and levelling the natural ground.

They may become muddy and difficult to use during rainy seasons.

They are common in remote rural areas.

Example: Some rural access roads in parts of Narok and Turkana counties.

2. **Gravel roads**

These are roads covered with compacted gravel or small stones.

They are generally more durable than earth roads.

They require regular grading and maintenance.

They are commonly used to connect rural settlements and agricultural areas.

3. **Murram roads**

These are roads constructed using compacted lateritic soil or other suitable locally available materials.

They are common in many parts of Kenya.

Their condition may deteriorate due to heavy rainfall and poor drainage.

4. **Bitumen or tarmac roads**

These are roads surfaced with bitumen or asphalt.

They provide smoother surfaces for motor vehicles.

They are suitable for relatively high-speed traffic when properly designed and maintained.

Examples include the Nairobi–Nakuru Highway and Nairobi–Mombasa Highway.

5. **Concrete roads**

These are roads surfaced with reinforced or unreinforced concrete.

They are strong and can withstand heavy traffic.

They are often expensive to construct.

They are suitable for areas experiencing heavy vehicle loads.

B. According to purpose and function

1. **International highways**

These are major roads that connect two or more countries.

They facilitate international trade and movement of people.

Example: The Northern Corridor linking the Port of Mombasa to Uganda and other landlocked countries.

2. **National trunk roads**

These are major roads connecting important towns, cities, economic centres and regions within a country.

They facilitate long-distance transportation.

Example: Nairobi–Mombasa Highway.

3. **Regional roads**

These connect towns, counties and important economic centres within a region.

They promote regional trade and movement.

4. **Urban roads**

These are roads constructed within towns and cities.

They facilitate movement between residential, commercial, industrial and administrative areas.

Examples include roads within Nairobi, Nakuru, Kisumu and Mombasa.

5. **Rural feeder roads**

These connect villages, farms and rural settlements to major roads and markets.

They facilitate the transportation of agricultural produce.

They improve access to schools, health facilities and other social services.

6. **Expressways**

These are high-capacity roads designed to facilitate relatively fast movement of vehicles.

They generally have controlled access and limited direct entry or exit points.

They may have interchanges, bridges and grade-separated junctions.

Example: Nairobi Expressway.

Roles and Importance of Road Transport

1. **Movement of people:** Road transport enables people to travel between homes, workplaces, schools, hospitals and recreational facilities.

2. **Transportation of agricultural products:** Farmers use roads to transport crops and livestock to markets, processing industries and storage facilities.

3. **Promotion of trade:** Roads connect producers, wholesalers, retailers and consumers, thereby facilitating domestic and international trade.

4. **Industrial development:** Industries depend on roads to receive raw materials and distribute finished products.

5. **Tourism development:** Roads enable tourists to access national parks, game reserves, beaches, hotels and cultural attractions.

6. **Employment creation:** Road transport creates employment opportunities for drivers, mechanics, conductors, engineers, road construction workers and traffic officers.

7. **Rural development:** Feeder roads connect isolated rural communities to towns and essential services.

8. **National integration:** Roads connect different communities and regions, promoting social interaction and national unity.

9. **Emergency services:** Roads enable ambulances, fire engines, police vehicles and disaster response teams to reach affected areas.

10. **Access to education:** Learners and teachers use roads to access educational institutions and learning resources.

Limitations of Road Transport

Traffic congestion in urban centres.

Road accidents and loss of human life.

High fuel and vehicle maintenance costs.

Environmental pollution from vehicle emissions.

Destruction of roads by floods and heavy rainfall.

Traffic delays caused by poor road conditions.

Limited carrying capacity compared with some railway and water transport systems.

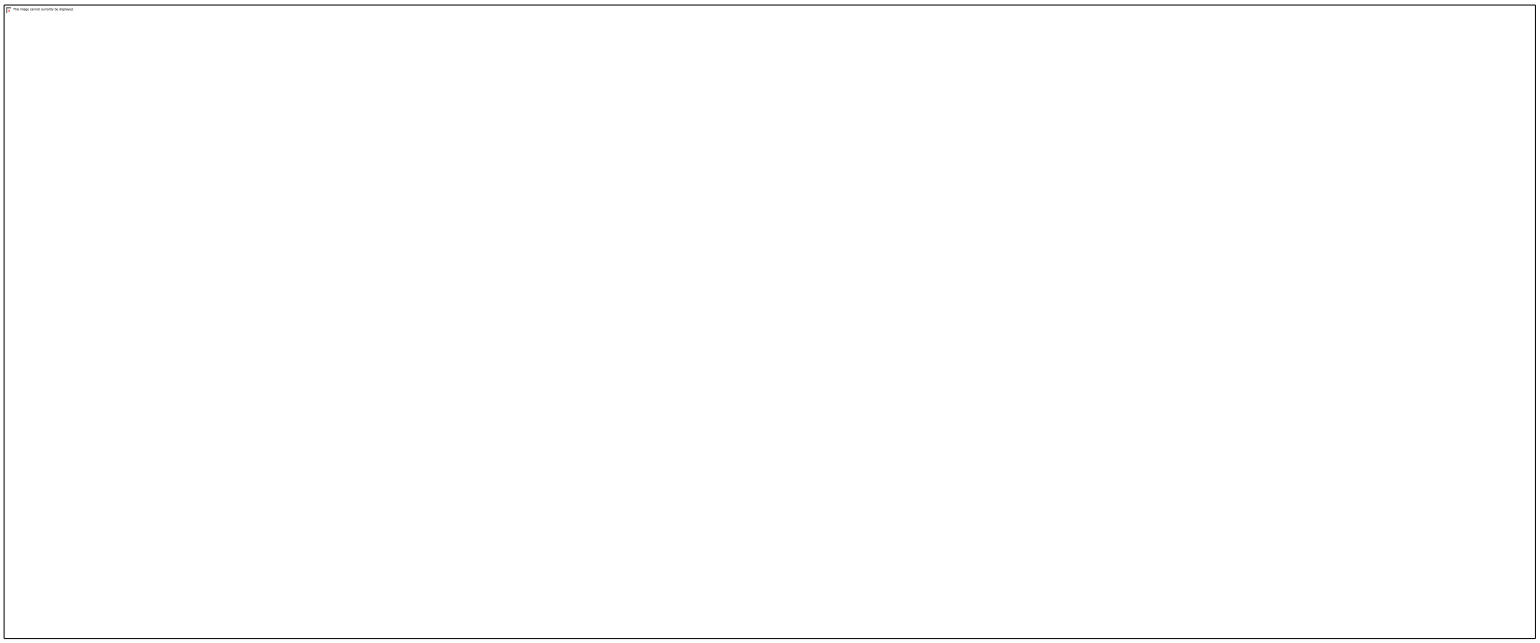
High construction and maintenance costs for modern highways.

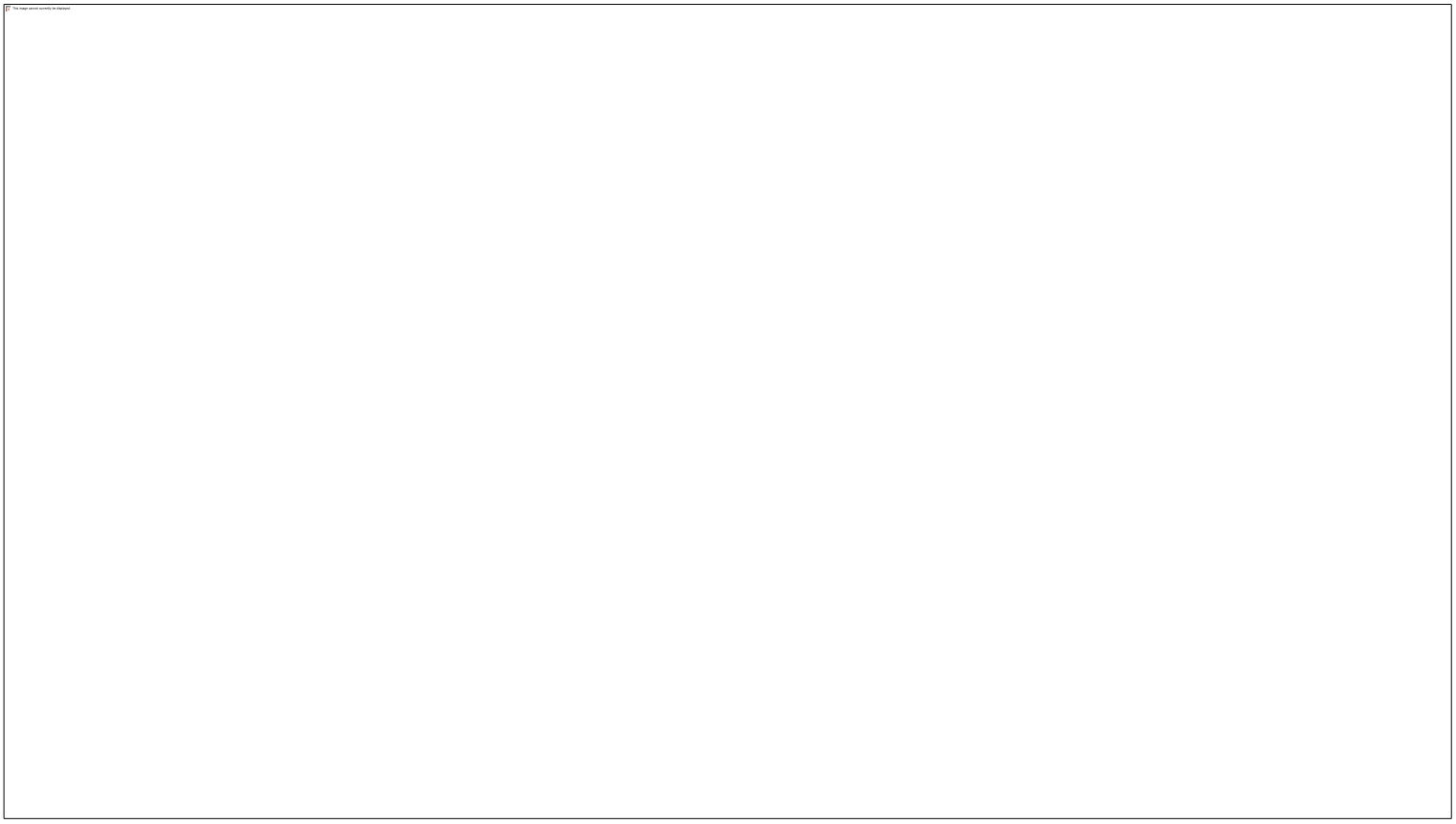
Inaccessibility of remote areas due to poor road networks.

Road damage caused by overloaded vehicles.

2.2 Railway Transport







Railway transport refers to the movement of passengers and goods using trains that travel along fixed railway tracks.

It is suitable for transporting large quantities of goods and many passengers over long distances.

Types of Railway Transport

1. **Conventional railway transport**

Uses traditional railway tracks and locomotives.

It may be powered by diesel or electricity.

It is commonly used for passenger and freight services.

2. **Standard Gauge Railway (SGR)**

Uses railway tracks with a standard distance of 1,435 millimetres between the inner faces of the rails.

It is designed to support modern passenger and freight services.

Kenya's Mombasa–Nairobi SGR is an example.

3. **Metre-gauge railway**

Uses tracks with a gauge of one metre.

It is found in several African countries, including Kenya.

It has historically played an important role in connecting towns and agricultural areas.

4. **High-speed railway**

Uses specially designed trains and railway infrastructure to transport passengers at very high speeds.

It is common in countries such as China, Japan and France.

5. **Urban commuter railway**

Transports people within cities and their surrounding metropolitan areas.

It helps reduce road congestion.

6. **Underground railway (metro)**

Uses trains operating mainly through underground tunnels.

It is common in densely populated cities.

Importance of Railway Transport

Transports bulky goods such as minerals, cement, fuel and agricultural produce.

Moves large numbers of passengers over long distances.

Reduces pressure on roads by shifting some passenger and freight traffic to rail.

Promotes industrial development by transporting raw materials.

Facilitates international trade when railway lines connect neighbouring countries.

Promotes tourism by providing passenger transport services.

Creates employment for railway engineers, drivers, technicians and station workers.

Can reduce the cost of transporting heavy goods over long distances.

Supports urban development by connecting residential and commercial areas.

Can reduce road accidents when freight and passenger movement is shifted from roads to rail.

Limitations of Railway Transport

High initial construction costs.

Expensive maintenance of railway tracks and locomotives.

Limited flexibility because trains follow fixed routes.

Railway lines may not reach remote settlements.

Delays caused by mechanical breakdowns and infrastructure damage.

Competition from road and air transport.

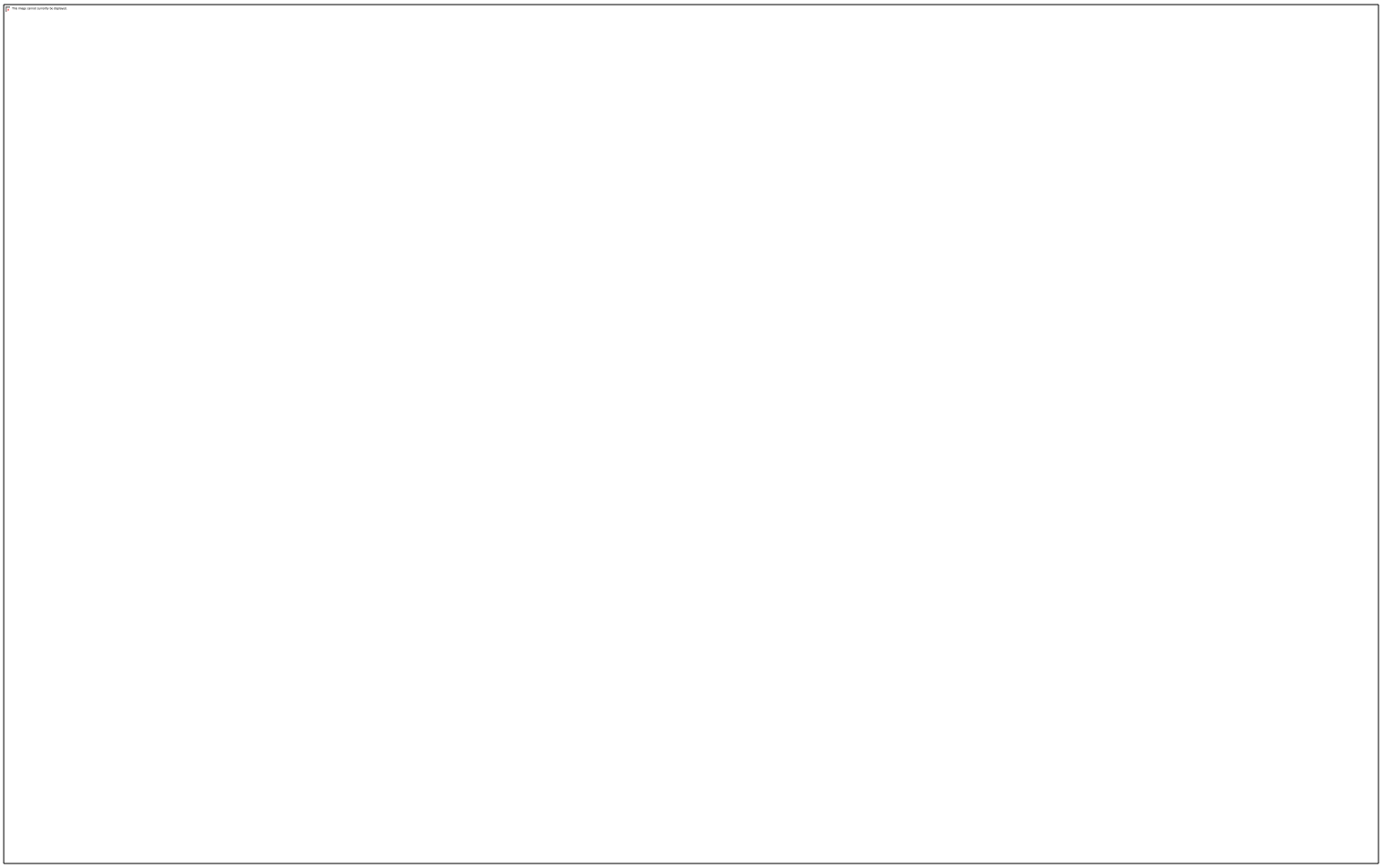
Construction may require tunnels, bridges and extensive land acquisition.

Some railway systems have low passenger or freight demand, making them expensive to operate.

2.3 Water Transport







Water transport refers to the movement of people and goods using vessels travelling through oceans, seas, lakes, rivers and canals.

It is particularly important in international trade because ships can carry large quantities of cargo over long distances.

Types of Water Transport

A. Ocean and sea transport

Involves movement of vessels across oceans and seas.

It is important in international trade.

It connects countries and continents.

Example: Ships transporting goods between Mombasa and ports in Asia and Europe.

B. Inland water transport

Involves the movement of vessels along rivers, lakes and navigable canals.

It is used for passenger and freight transportation.

Examples include transport on Lake Victoria and the Nile River.

C. Coastal transport

Involves the movement of vessels between ports located along the same coastline or within nearby coastal regions.

It facilitates domestic and regional trade.

Types of Water Vessels

Cargo ships.

Container ships.

Oil tankers.

Passenger ships.

Ferries.

Fishing vessels.

Cruise ships.

Barges.

Tugboats.

Canoes and small motorboats.

Importance of Water Transport

Facilitates international trade by transporting imports and exports.

Carries bulky goods such as petroleum, machinery, iron ore and agricultural produce.

Promotes tourism through cruises, ferries and recreational boating.

Creates employment in shipping, port operations, fishing and marine engineering.

Connects coastal countries and islands.

Provides access to international markets.

Supports fishing and other maritime economic activities.

Facilitates the transportation of heavy industrial equipment.

Can be relatively economical for transporting large quantities of goods over long distances.

Promotes regional integration through shared waterways.

Limitations of Water Transport

It is generally slower than air transport.

It depends on the availability of navigable waterways and suitable ports.

Some ports require expensive dredging and maintenance.

Ships may be affected by storms, rough seas and strong winds.

Accidents may result in loss of cargo and human life.

Piracy and maritime insecurity may affect shipping routes.

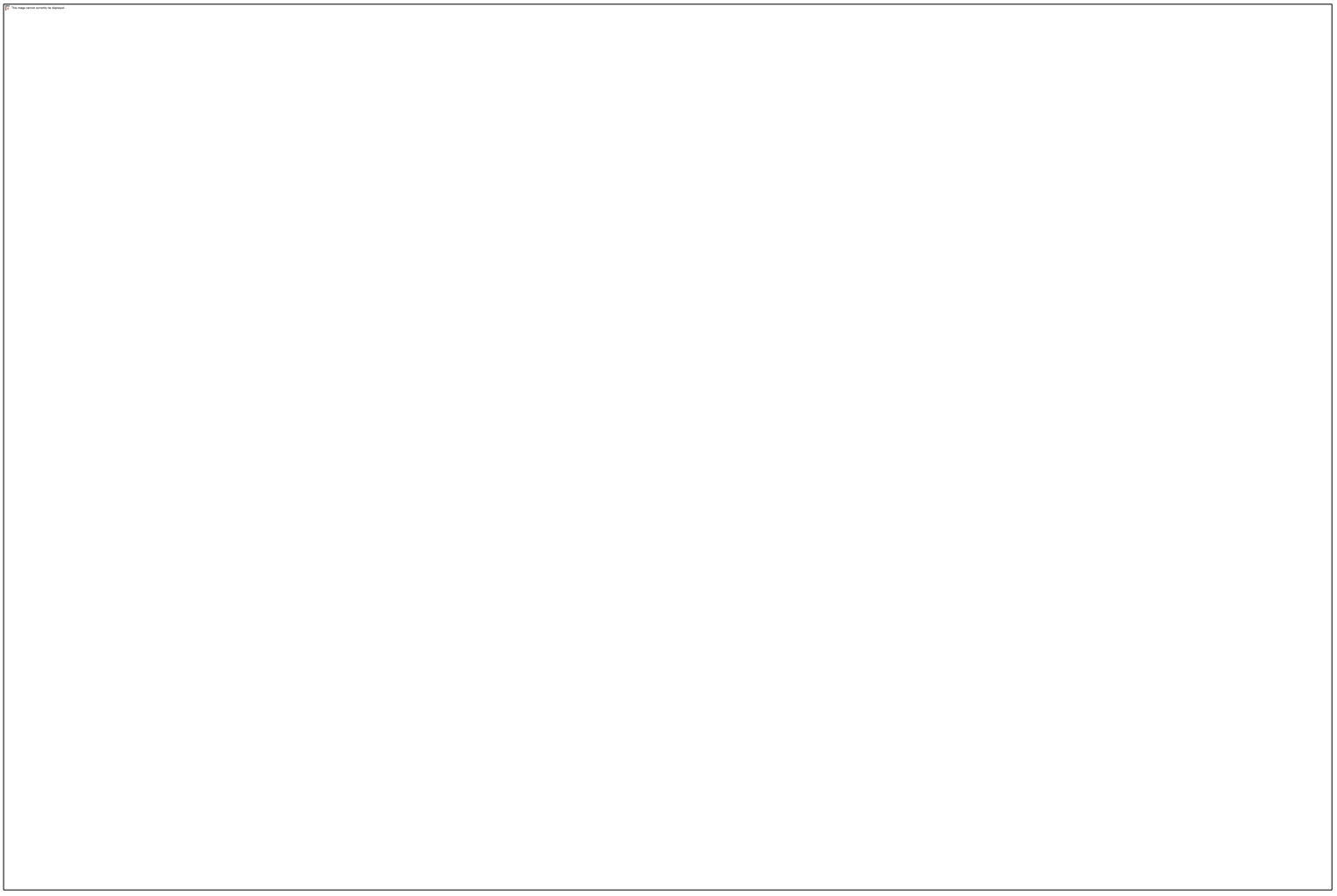
Some rivers have rapids, waterfalls and shallow sections.

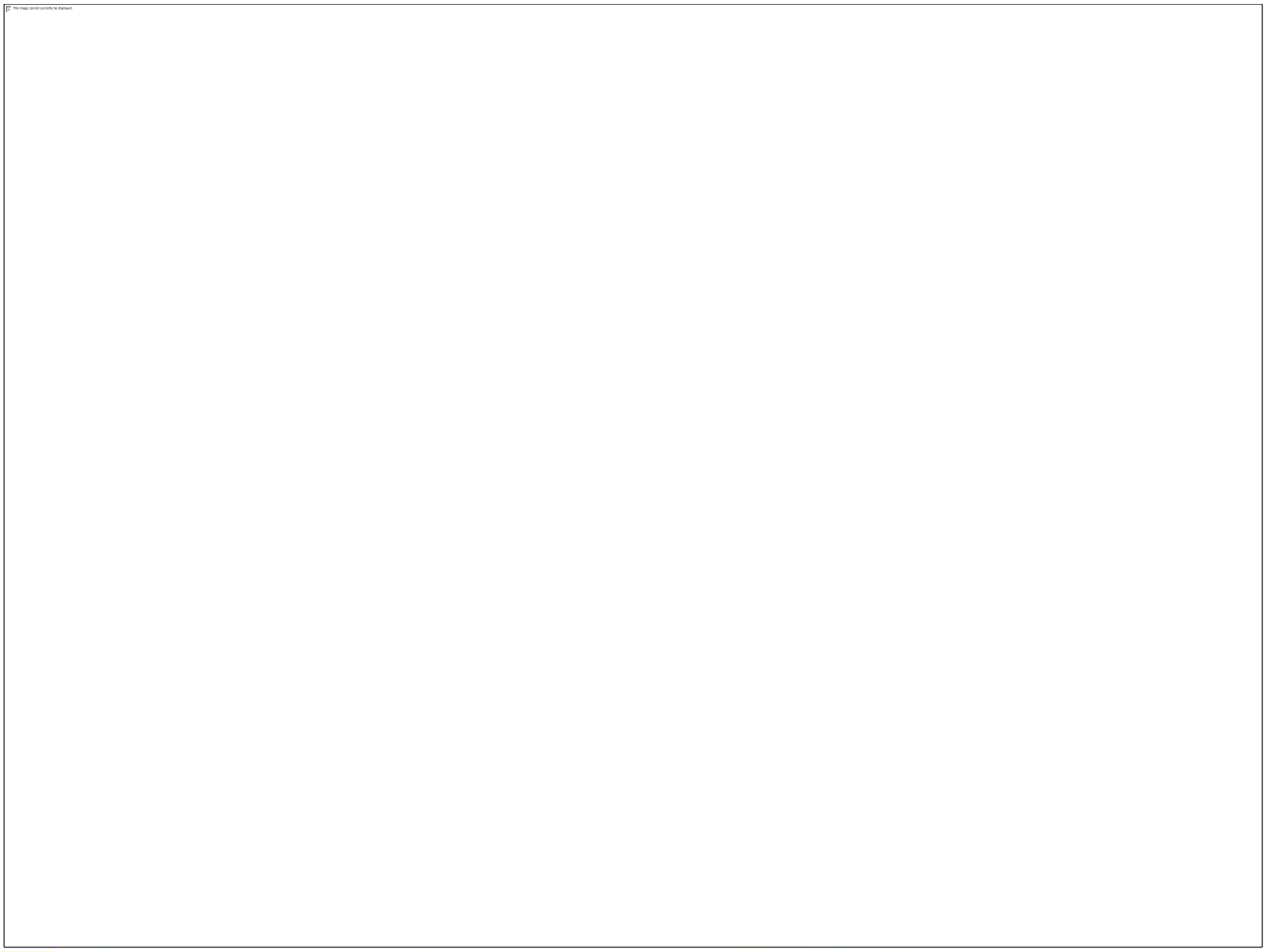
Port congestion may delay the handling of goods.

Some landlocked countries lack direct access to seaports.

Oil spills and waste disposal may cause marine pollution.

2.4 Air Transport







Air transport refers to the movement of people and goods from one place to another using aircraft travelling through the atmosphere.

It is the fastest major form of transport and is particularly important for long-distance passenger travel and the movement of valuable or perishable goods.

Types of Air Transport

1. **Domestic air transport**

Involves flights between destinations within the same country.

Example: Flights between Nairobi and Kisumu.

2. **International air transport**

Involves flights between different countries.

Example: Flights between Nairobi and London.

3. **Passenger air transport**

Involves aircraft used to transport people.

It includes scheduled commercial flights and charter services.

4. **Air cargo transport**

Involves the transportation of goods using aircraft.

It is suitable for high-value, urgent and perishable products.

5. **Charter air transport**

Involves hiring an aircraft for a particular journey or purpose.

It is used by tourists, businesses and specialised operations.

6. **Helicopter transport**

Uses helicopters for passenger movement, medical emergencies, rescue operations and specialised services.

Importance of Air Transport

1. **Fast movement of people:** It enables people to travel across countries and continents within relatively short periods.

2. **International trade:** It facilitates the export of high-value goods and perishable products.

3. **Tourism development:** It connects tourists to national parks, beaches and other tourist destinations.

4. **Emergency medical services:** Aircraft can transport patients, medical supplies and health workers to remote areas.

5. **Employment creation:** It provides jobs for pilots, cabin crew, air traffic controllers, engineers and airport workers.

6. **National security:** It supports surveillance, emergency response and defence operations.

7. **International relations:** It facilitates diplomatic visits and international cooperation.

8. **Movement of perishable products:** It supports the transportation of flowers, fresh vegetables, fruits and seafood.

9. **Disaster response:** Aircraft are used to deliver food, medicine and rescue personnel to disaster-affected areas.

10. **Promotion of globalisation:** It connects businesses and individuals across continents.

Limitations of Air Transport

High cost of tickets and freight charges.

Expensive construction and maintenance of airports.

Aircraft require specialised maintenance and highly trained personnel.

Flights may be delayed or cancelled due to adverse weather conditions.

Aircraft accidents may result in significant loss of life.

It has limited capacity compared with some large cargo ships and freight trains.

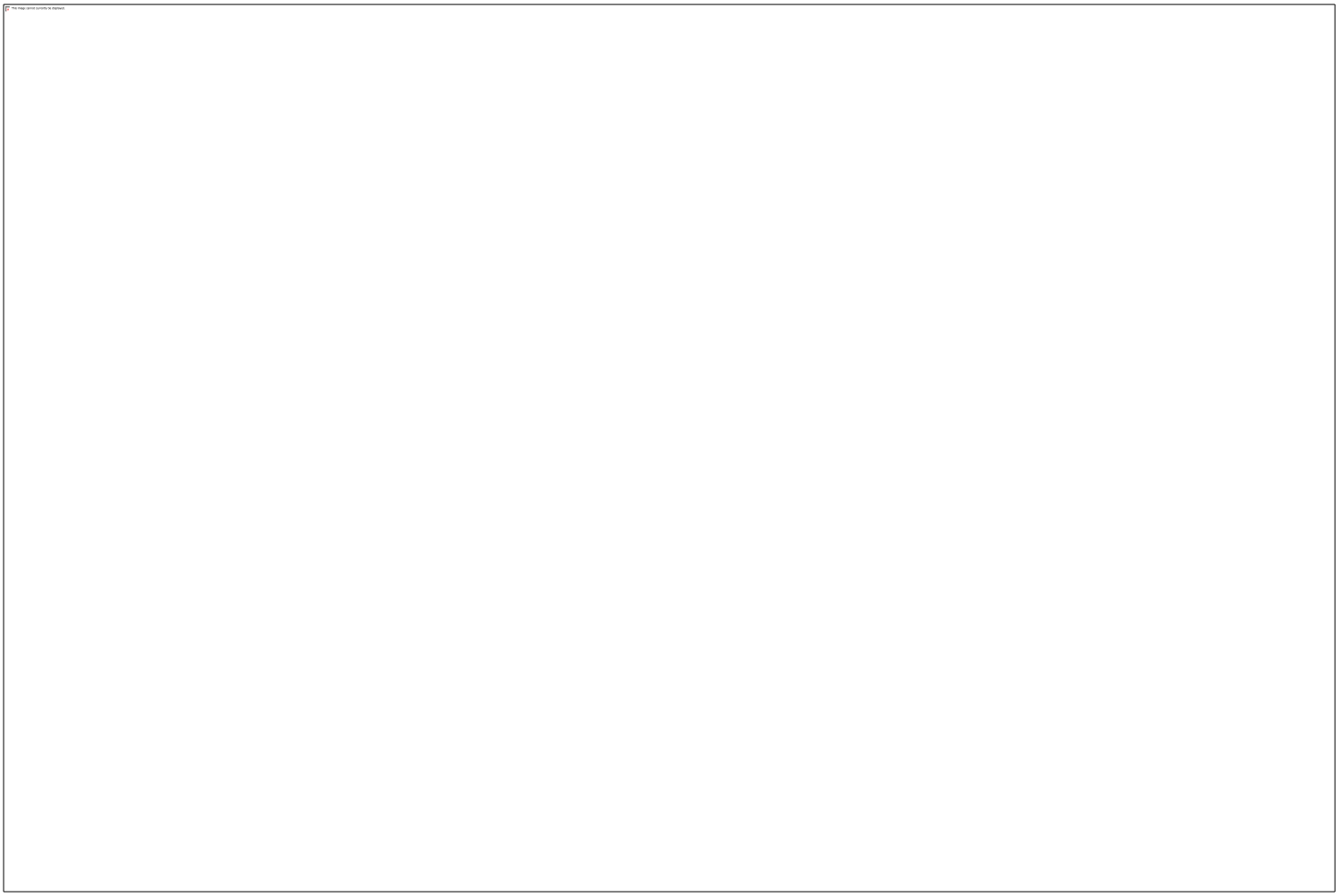
Airports require large areas of land.

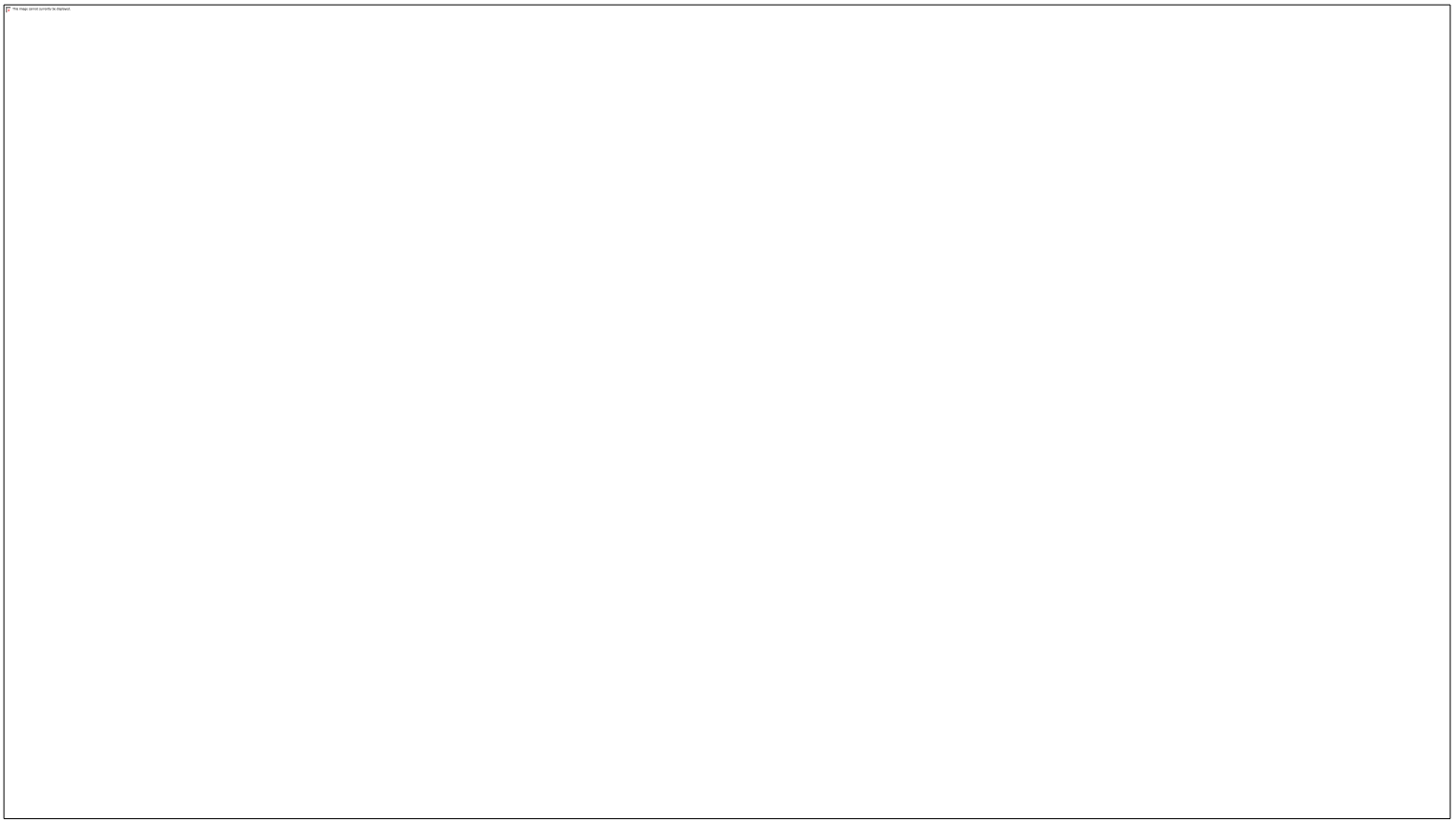
Aircraft emissions contribute to environmental pollution.

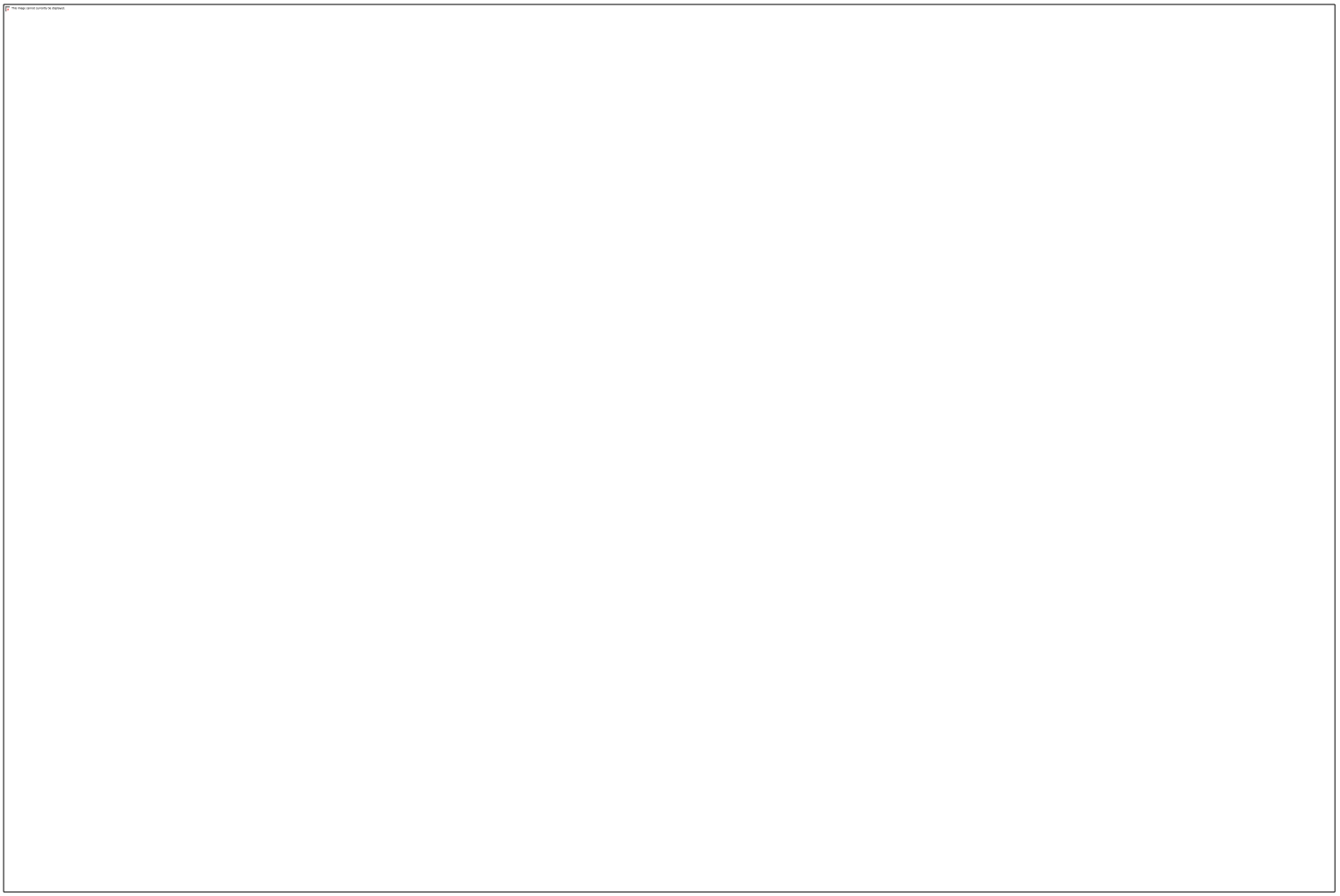
It may be inaccessible to low-income populations.

Security procedures may increase travel time.

2.5 Pipeline Transport







Pipeline transport refers to the movement of liquids, gases and some materials in slurry form through specially constructed pipes from one location to another.

It is mainly used to transport petroleum products, natural gas, water and industrial liquids.

Materials transported through pipelines

Crude oil.

Refined petroleum products.

Natural gas.

Water.

Industrial chemicals.

Slurry containing minerals mixed with water.

Examples in Kenya

The petroleum pipeline system operated by the Kenya Pipeline Company (KPC).

Water transmission pipelines supplying urban centres and industries.

Industrial pipelines used in specialised production processes.

Importance of Pipeline Transport

Transports large volumes of liquids and gases continuously.

Reduces the need for road tankers transporting petroleum products.

Minimises traffic congestion caused by fuel transportation vehicles.

Can be economical over long distances when transporting large volumes.

Reduces some risks associated with transporting petroleum by road.

Provides a relatively reliable supply of essential products.

Supports industrial development by supplying fuel and water.

Reduces the need for frequent loading and unloading of transported materials.

Limitations of Pipeline Transport

High initial construction costs.

Leakage may cause environmental pollution.

Pipelines can be damaged by corrosion or human activities.

They are limited to materials that can flow through pipes.

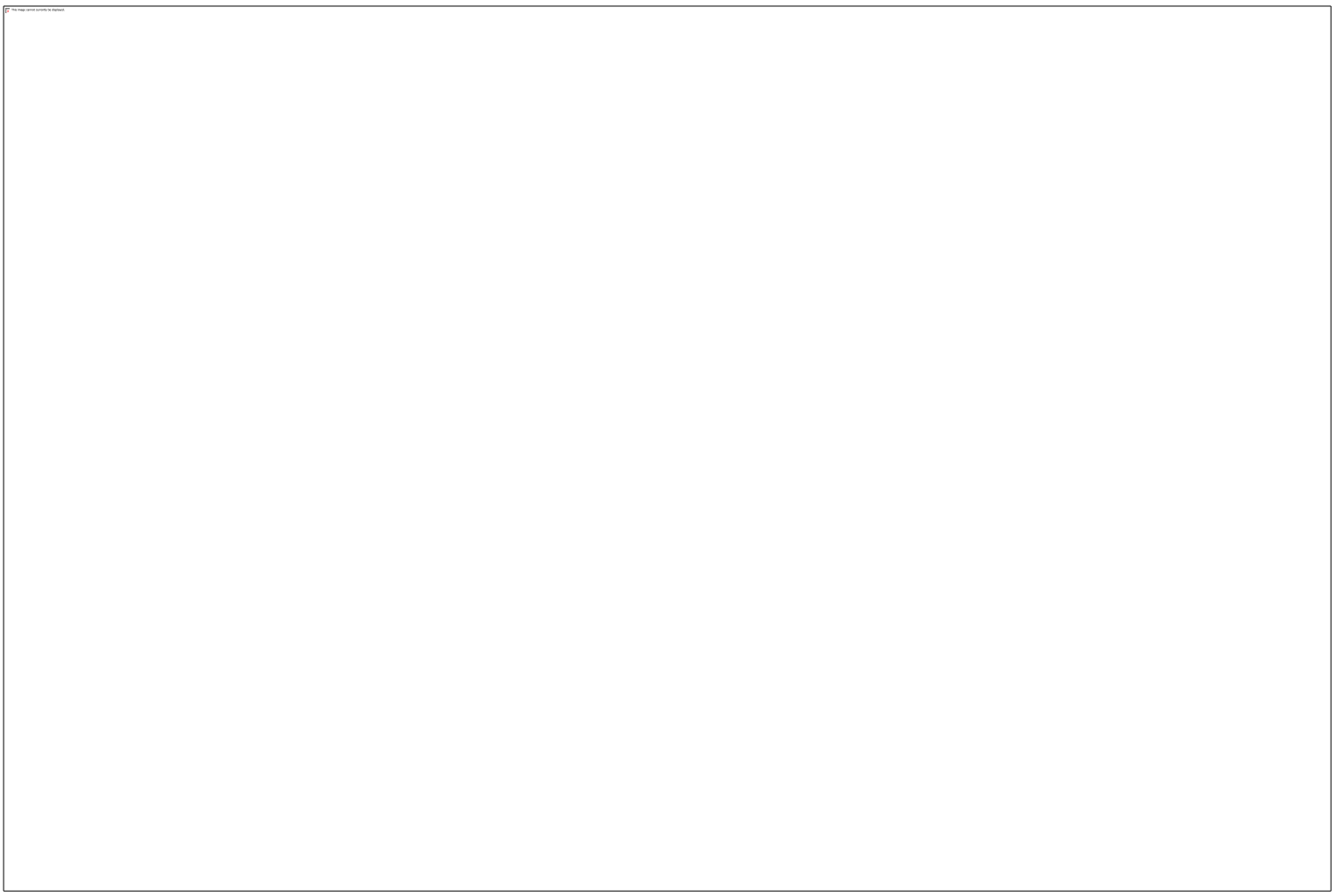
Construction may interfere with settlements, agricultural land and ecosystems.

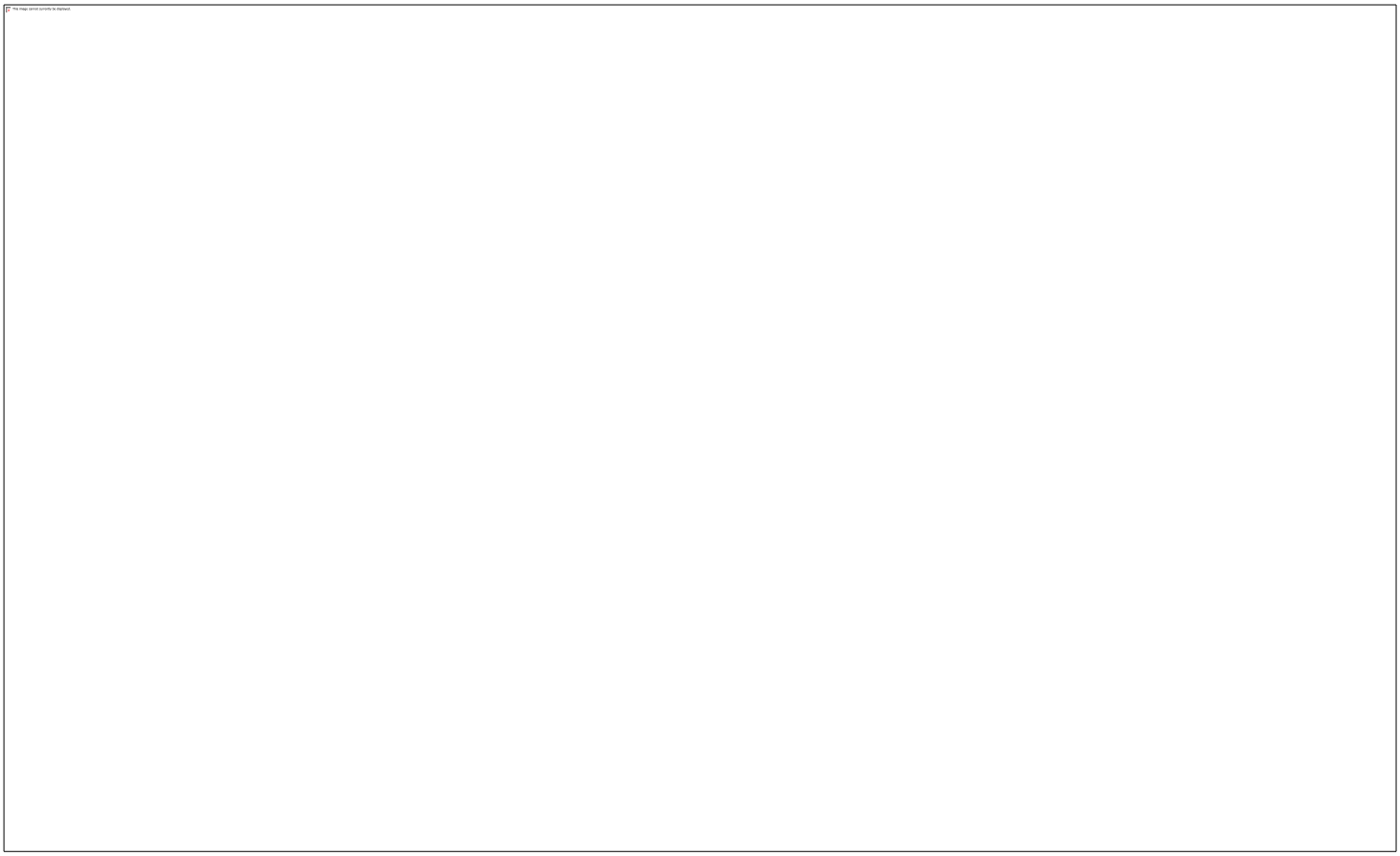
Pipeline vandalism and illegal connections may cause accidents.

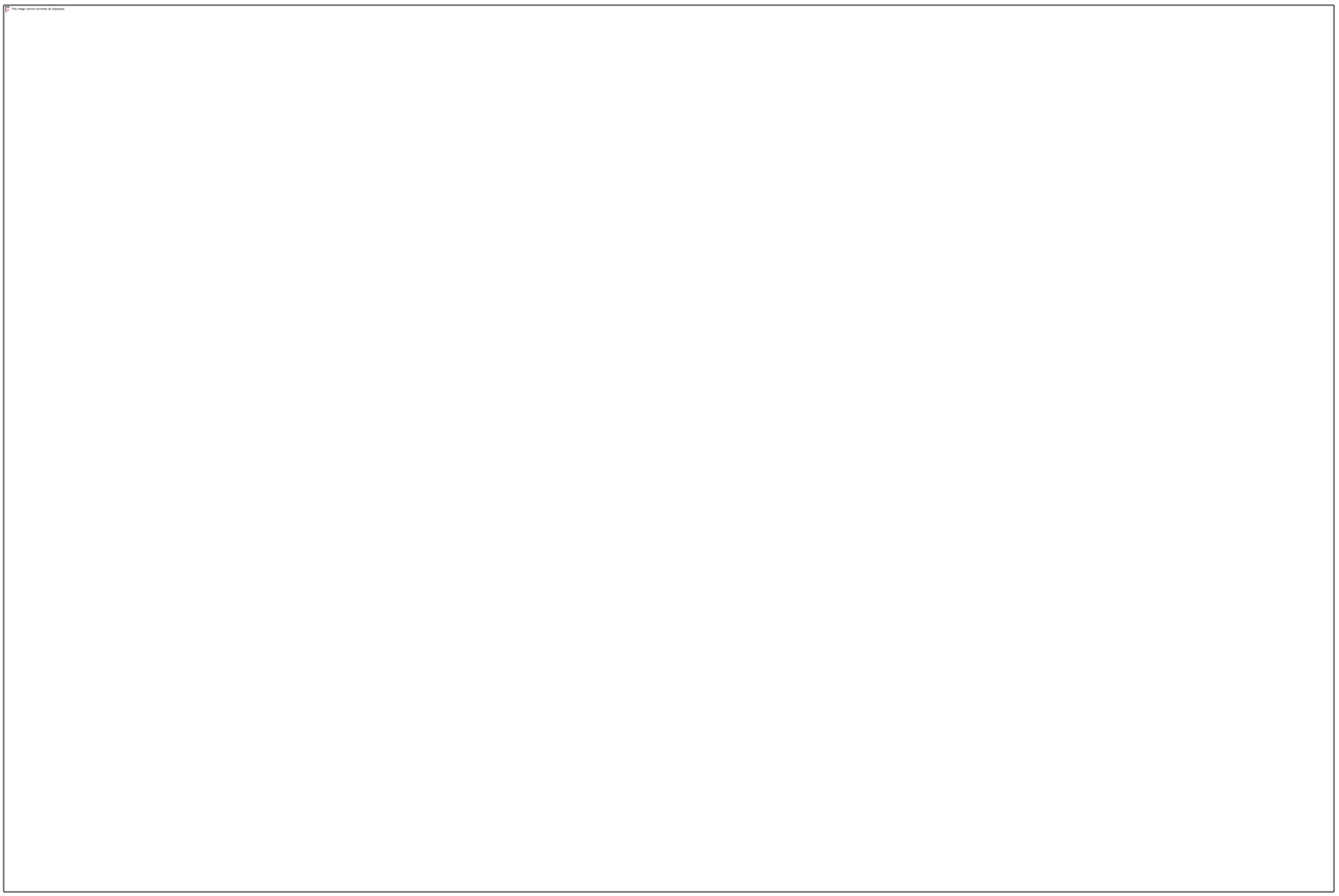
Difficulties may arise when pipelines cross rugged terrain.

Maintenance requires specialised equipment and technical personnel.

2.6 Cable and Ropeway Transport







Cable transport is a system of moving people or goods using cabins, baskets or other carriers suspended from or pulled by strong cables.

It is commonly used in mountainous areas, tourist destinations and locations where conventional roads are difficult or expensive to construct.

Types of Cable Transport

Cable cars.

Gondolas.

Chairlifts.

Aerial ropeways.

Material cableways.

Importance of Cable Transport

Provides transport in mountainous and steep areas.

Reduces the need for extensive road construction.

Promotes tourism and recreation.

Can reduce road congestion in suitable urban settings.

Facilitates the movement of goods in difficult terrain.

Provides access to areas that are difficult to reach by conventional vehicles.

Limitations

High installation and maintenance costs.

May be disrupted by strong winds and storms.

Has limited carrying capacity.

Requires specialised technical skills.

Mechanical failure may create serious safety risks.

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3.0 DEVELOPMENTS IN TRANSPORT IN KENYA

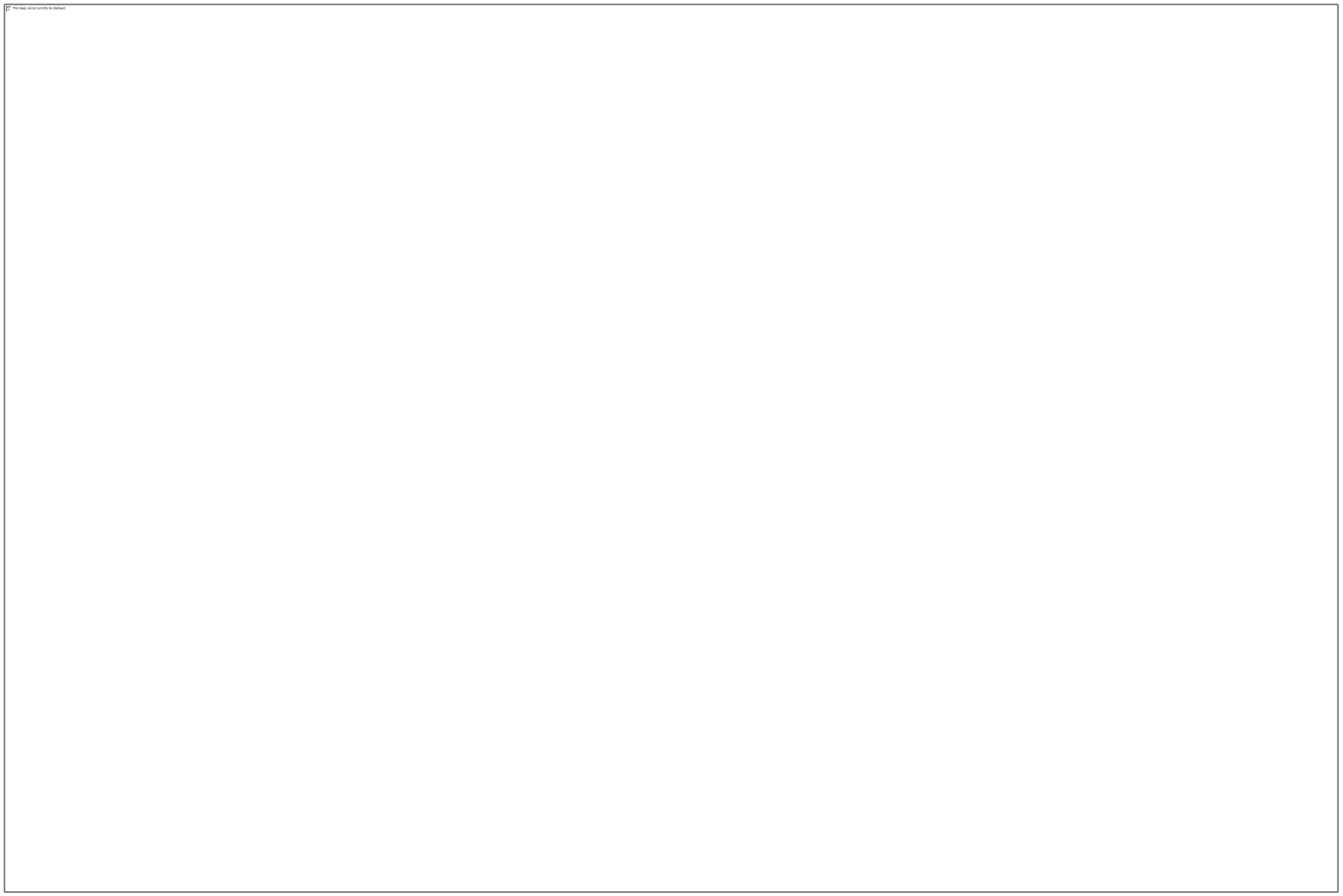
Kenya has experienced significant developments in transport over the years. These developments have been influenced by population growth, urbanisation, industrialisation, agricultural expansion, international trade and technological advancement.

The government and private sector have invested in modern transport infrastructure to improve connectivity, reduce transportation costs and promote economic development.

The major developments have occurred in road, railway, water, air and pipeline transport.

3.1 Development of Road Transport in Kenya





Road transport is the most widely used means of transport in Kenya. It connects major towns, cities, agricultural regions, industrial centres, tourist destinations and neighbouring countries.

Historical Development of Road Transport in Kenya

1. **Pre-colonial period**

Transport mainly involved footpaths and animal trails.

People used donkeys, camels and other pack animals to carry goods.

Local communities travelled on foot to markets and neighbouring settlements.

Roads were generally narrow and unpaved.

2. **Colonial period**

The colonial government constructed roads to facilitate administration, military operations and transportation of agricultural products.

Roads connected agricultural areas to railway stations, ports and administrative centres.

The road network expanded around Nairobi, Mombasa and other important settlements.

3. **Post-independence period**

The Kenyan government expanded and improved the road network.

Major highways were constructed or upgraded.

Roads were extended to rural areas to improve agricultural production and access to social services.

Road construction became an important part of national development planning.

4. **Modern period**

Kenya has invested in dual carriageways, expressways, bypasses, interchanges and bridges.

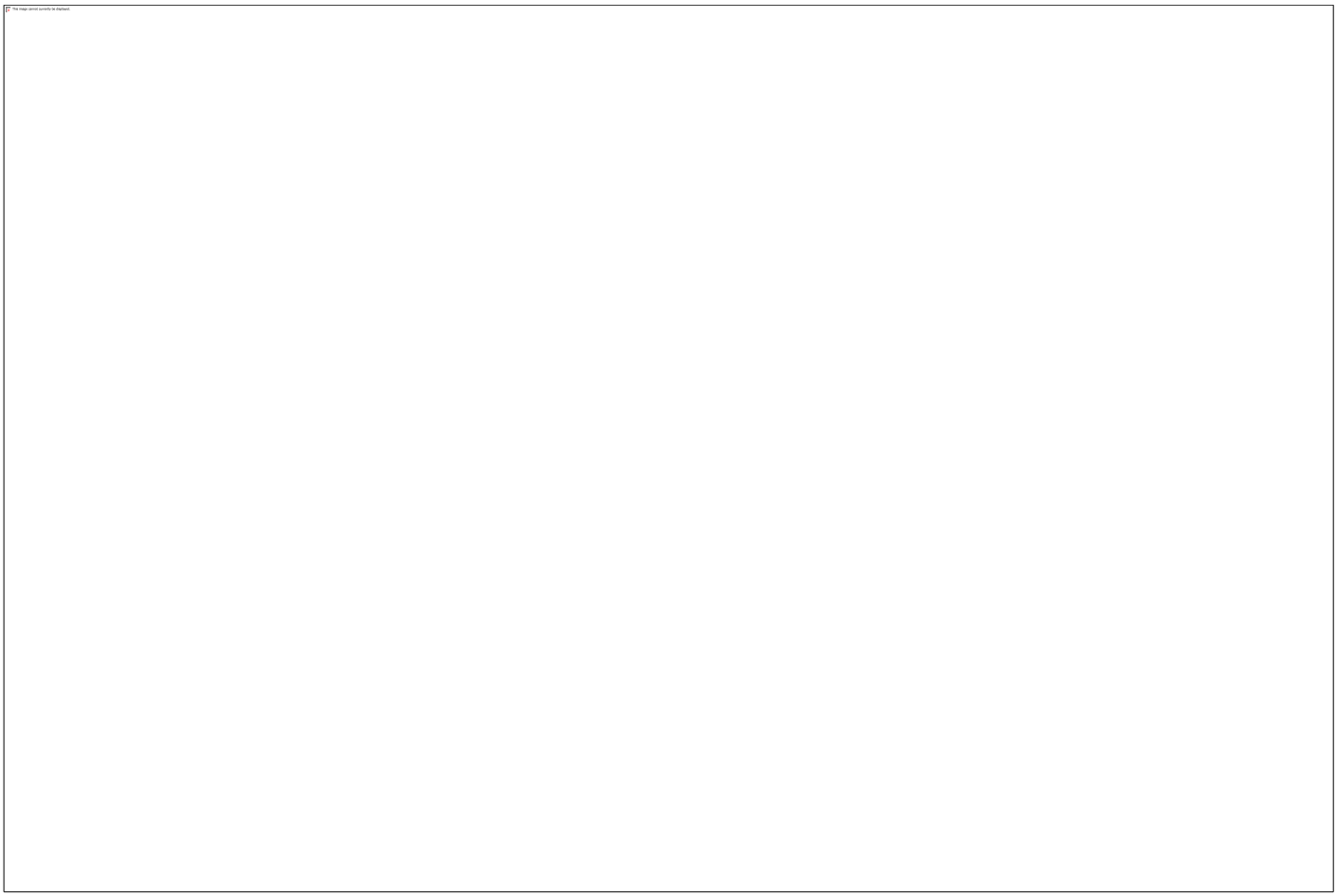
Modern road construction technologies have improved road quality.

Public-private partnerships have supported the development of major infrastructure projects.

Road maintenance and rehabilitation programmes have improved connectivity.

Major Road Transport Developments in Kenya

A. Thika Superhighway



The Thika Superhighway is a major dual-carriageway road connecting Nairobi to Thika.

Its development involved the expansion and improvement of the former Nairobi–Thika road.

Importance of Thika Superhighway:

Reduces travel time between Nairobi and Thika.

Improves transportation of agricultural produce from surrounding areas.

Promotes industrial and commercial activities along the highway.

Reduces traffic congestion at several junctions.

Improves access to educational institutions and residential areas.

Encourages investment in businesses and real estate.

Facilitates movement towards central and eastern Kenya.

B. Nairobi Expressway



The Nairobi Expressway is a modern elevated toll road running from the Mlolongo area through the city centre towards Westlands.

It was developed through a public-private partnership involving the Kenyan government and a private concessionaire.

Importance of Nairobi Expressway:

Reduces travel time along the Nairobi–Mombasa Road and Nairobi city corridor.

Provides an alternative route for motorists travelling through Nairobi.

Reduces congestion on some sections of the existing road network.

Improves access to Jomo Kenyatta International Airport.

Promotes business activities and investment.

Creates employment opportunities during construction and operation.

Demonstrates the application of modern engineering technology in Kenya.

Limitations associated with expressway development:

Toll charges may be expensive for some road users.

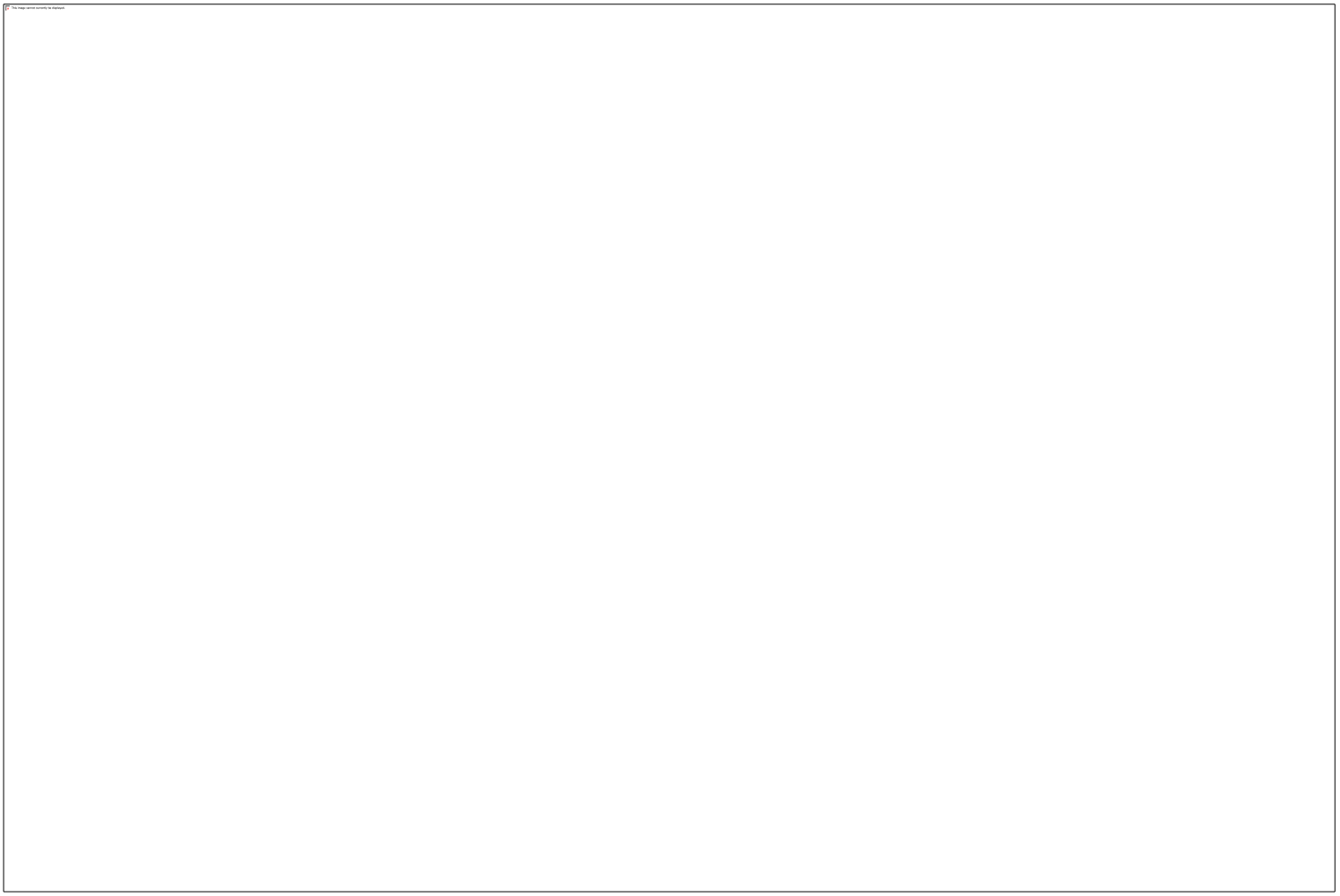
Construction requires substantial financial investment.

Traffic congestion may remain on connecting roads.

Construction activities may disrupt businesses and movement.

Maintenance and operational costs are high.

C. Construction of Bypasses and Ring Roads



Bypasses and ring roads are designed to allow vehicles to move around busy urban centres rather than passing through congested central business districts.

Examples include:

Nairobi Southern Bypass.

Nairobi Eastern Bypass.

Nairobi Northern Bypass.

Nairobi Western Bypass.

Importance:

Reduces through-traffic in central business districts.

Reduces traffic congestion in towns and cities.

Saves time and fuel for long-distance travellers.

Reduces vehicle emissions associated with prolonged traffic delays.

Improves connections between highways.

Promotes the development of new residential and commercial areas.

D. Development of Rural Feeder Roads

Rural feeder roads connect villages, farms and small trading centres to major roads.

Their development has helped to improve access to markets, schools and health facilities.

Importance:

Enables farmers to transport agricultural produce to markets.

Reduces post-harvest losses caused by delayed transportation.

Improves access to hospitals and schools.

Promotes rural trade and investment.

Connects remote communities to urban centres.

Supports the distribution of agricultural inputs such as fertilisers and seeds.

Major Classes of Roads in Kenya

Kenyan roads are classified according to their administrative responsibility and function.

Road classification	General function
Class S	International trunk roads linking Kenya with neighbouring countries.
Class A	International trunk roads connecting major international gateways.
Class B	National trunk roads connecting important centres.
Class C	Primary roads connecting county and other important centres.
Class D	Secondary roads connecting smaller centres.
Class E	Minor roads providing local access.

The classification and management of roads involve different national and county road authorities.

Road Safety and Risky Road Behaviours in Kenya

Road safety refers to the measures and practices adopted to prevent road accidents, injuries and loss of life.

Examples of risky road behaviours:

Over-speeding.

Driving under the influence of alcohol or drugs.

Overtaking carelessly.

Using mobile phones while driving.

Driving without valid licences.

Carrying excess passengers.

Failure to wear seat belts.

Failure to wear protective helmets when riding motorcycles.

Ignoring traffic signs and signals.

Driving unroadworthy vehicles.

Walking on roads without observing traffic.

Crossing roads at dangerous points.

Ways of promoting road safety:

Observing speed limits.

Wearing seat belts.

Wearing helmets when riding motorcycles.

Avoiding alcohol and drug consumption before driving.

Maintaining vehicles regularly.

Obeying traffic lights and road signs.

Using designated pedestrian crossings.

Providing road safety education.

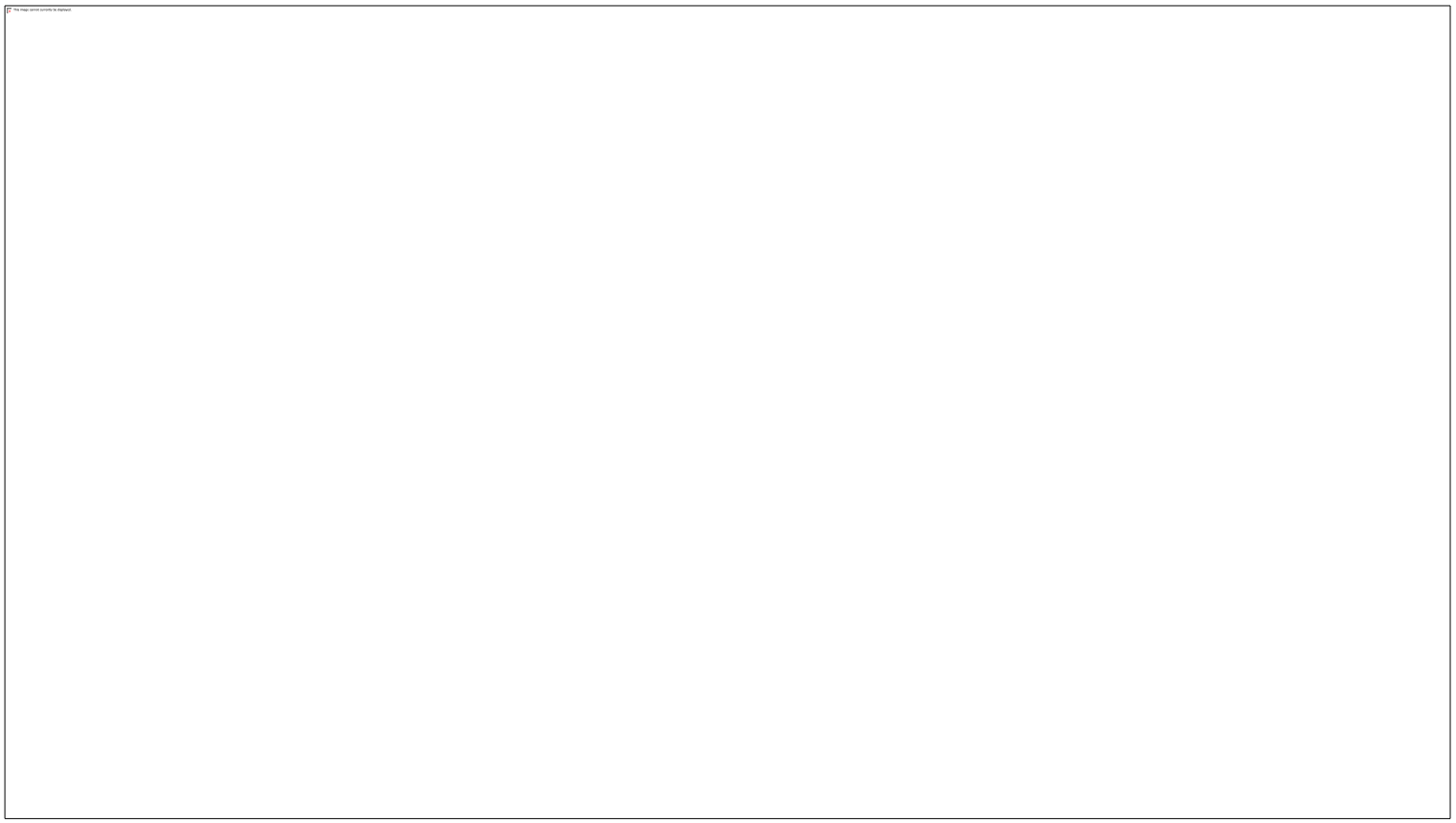
Enforcing traffic regulations.

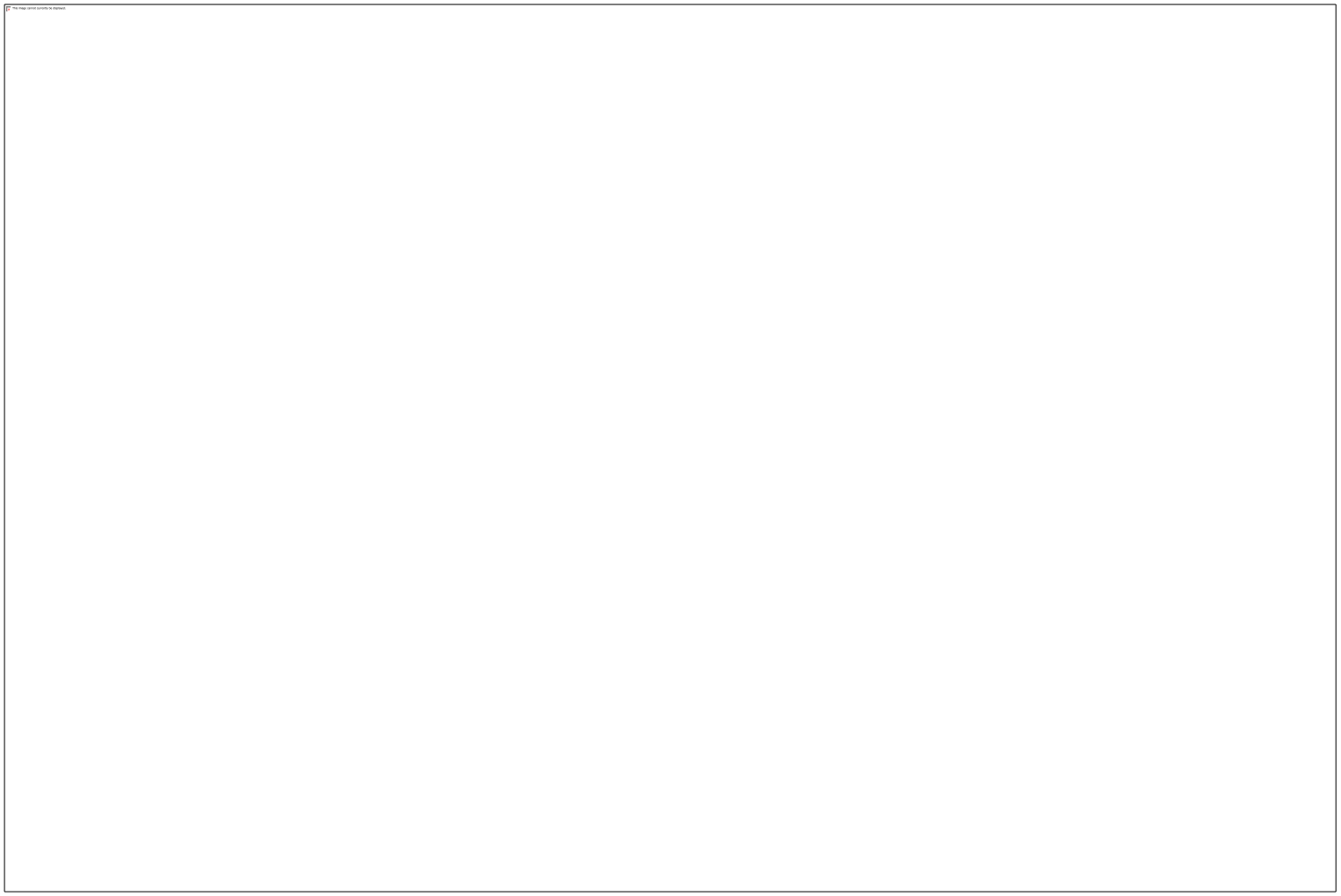
Avoiding distractions when driving.

Providing pedestrian walkways and footbridges.

Ensuring that drivers receive proper training.

3.2 Development of Railway Transport in Kenya





Railway transport has played an important role in the economic and historical development of Kenya.

It has facilitated the movement of people and goods between the Port of Mombasa, Nairobi and other inland destinations.

Historical Development of Railway Transport in Kenya

1. **Construction of the Uganda Railway**

Construction began in 1896 during British colonial rule.

The railway was built to connect the coastal port of Mombasa with the interior of East Africa.

It reached Kisumu on the shores of Lake Victoria in 1901.

It facilitated colonial administration, settlement and commercial activities.

2. **Expansion of the railway network**

Railway lines were extended to important agricultural and administrative centres.

The railway facilitated transportation of agricultural produce, minerals and other goods.

It encouraged the growth of towns along railway routes.

3. **Post-independence railway development**

Kenya continued operating and maintaining the railway network after independence in 1963.

Railway transport supported passenger and freight services.

The railway became an important component of the country's transport system.

4. **Development of the Standard Gauge Railway**

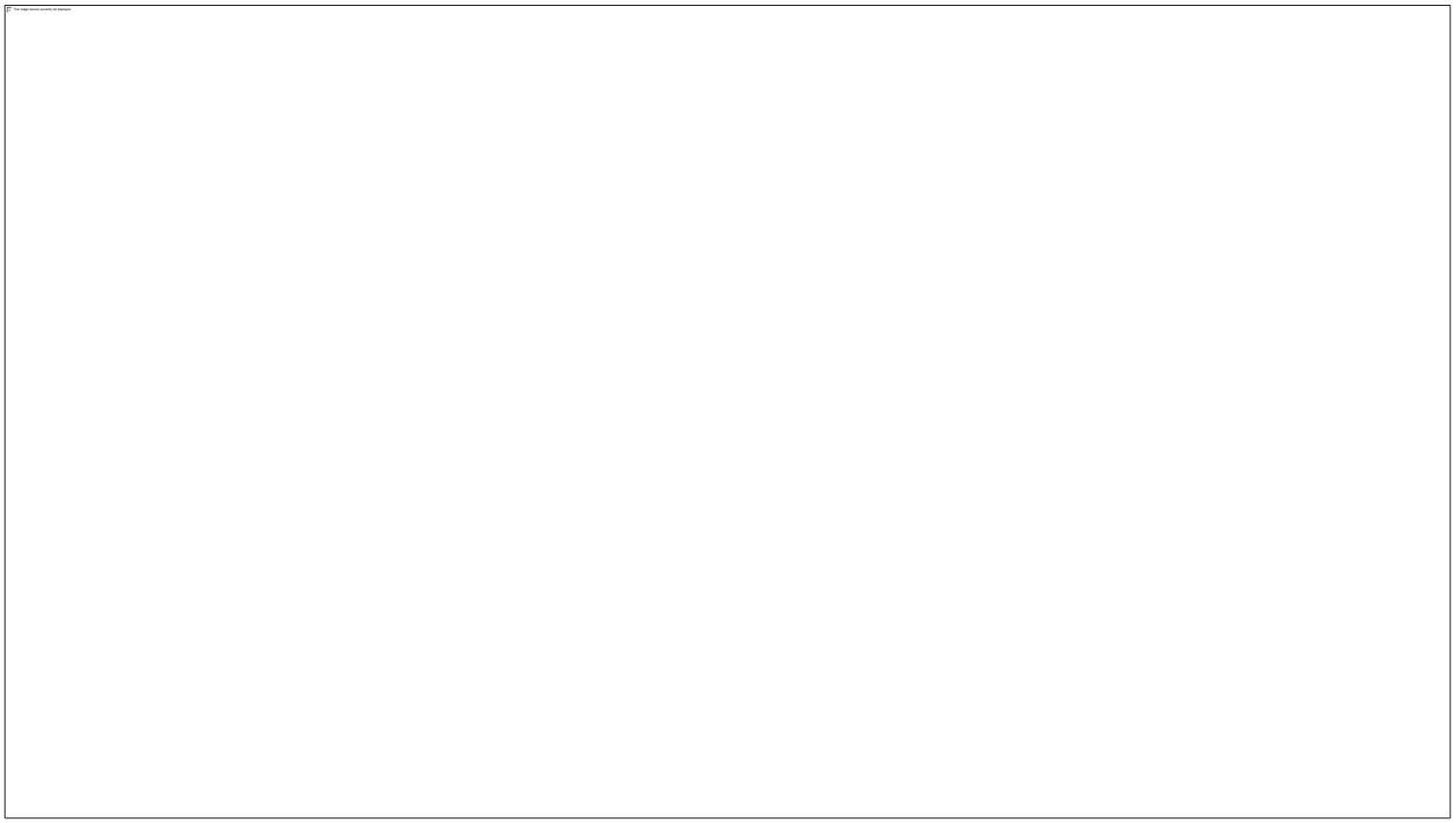
Kenya began constructing a modern Standard Gauge Railway in the 21st century.

The Mombasa–Nairobi section was officially opened for passenger services in 2017.

Freight services were subsequently introduced.

The railway was designed to improve the efficiency of passenger and cargo transportation.

The Standard Gauge Railway (SGR)



The Standard Gauge Railway is a modern railway system using tracks with a width of 1,435 millimetres between the inner rail faces.

The Mombasa–Nairobi SGR is one of Kenya's major modern infrastructure projects.

Main characteristics of the Kenyan SGR:

Uses modern railway technology.

Has dedicated passenger and freight services.

Connects Mombasa and Nairobi.

Includes railway stations and freight terminals.

Uses bridges, tunnels and embankments to cross difficult terrain.

Provides an alternative to road transport for passengers and cargo.

Supports regional transport and trade.

Importance of SGR in Kenya:

Reduces the time required to travel between Mombasa and Nairobi.

Improves transportation of containers and other cargo from the Port of Mombasa.

Reduces pressure on the Nairobi–Mombasa Highway.

Promotes tourism by facilitating passenger travel.

Creates employment opportunities.

Encourages the growth of towns and commercial centres near railway stations.

Promotes industrial development.

Facilitates trade with neighbouring countries through the port and inland logistics connections.

Improves the efficiency of freight movement.

Promotes modern technology and technical skills.

Challenges associated with SGR development:

High construction and financing costs.

High maintenance expenses.

Competition from road transport.

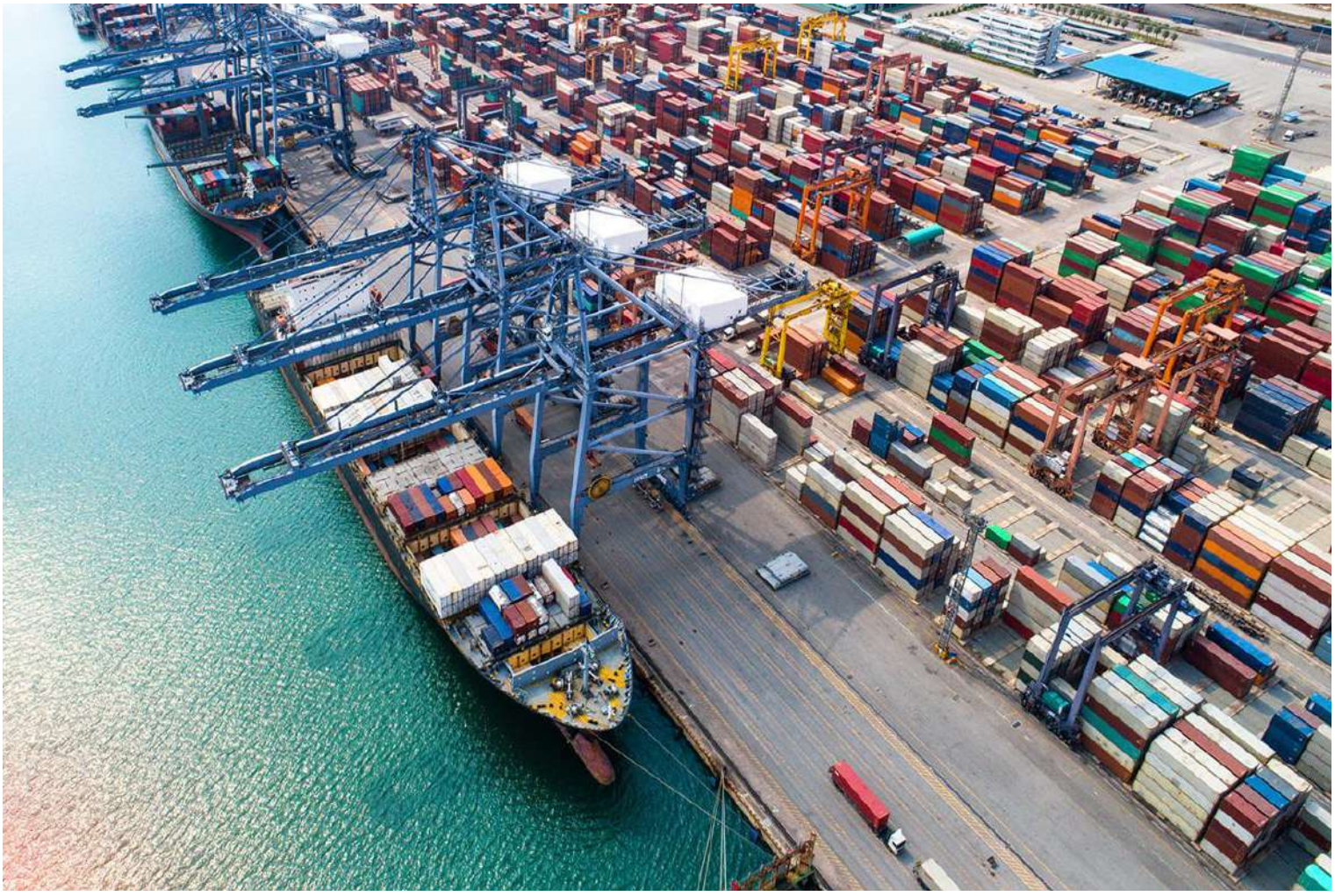
Environmental disturbance during construction.

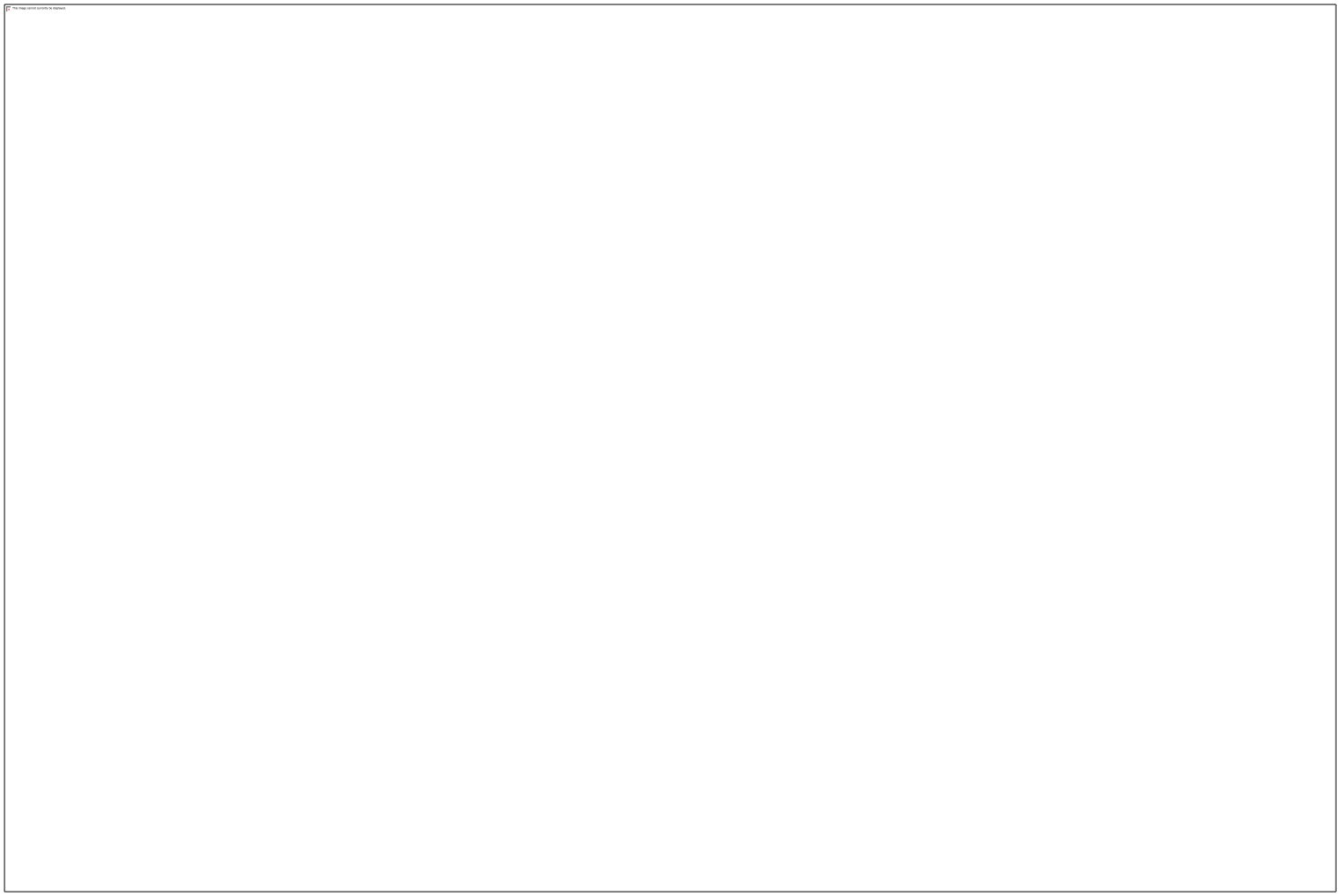
Land acquisition challenges.

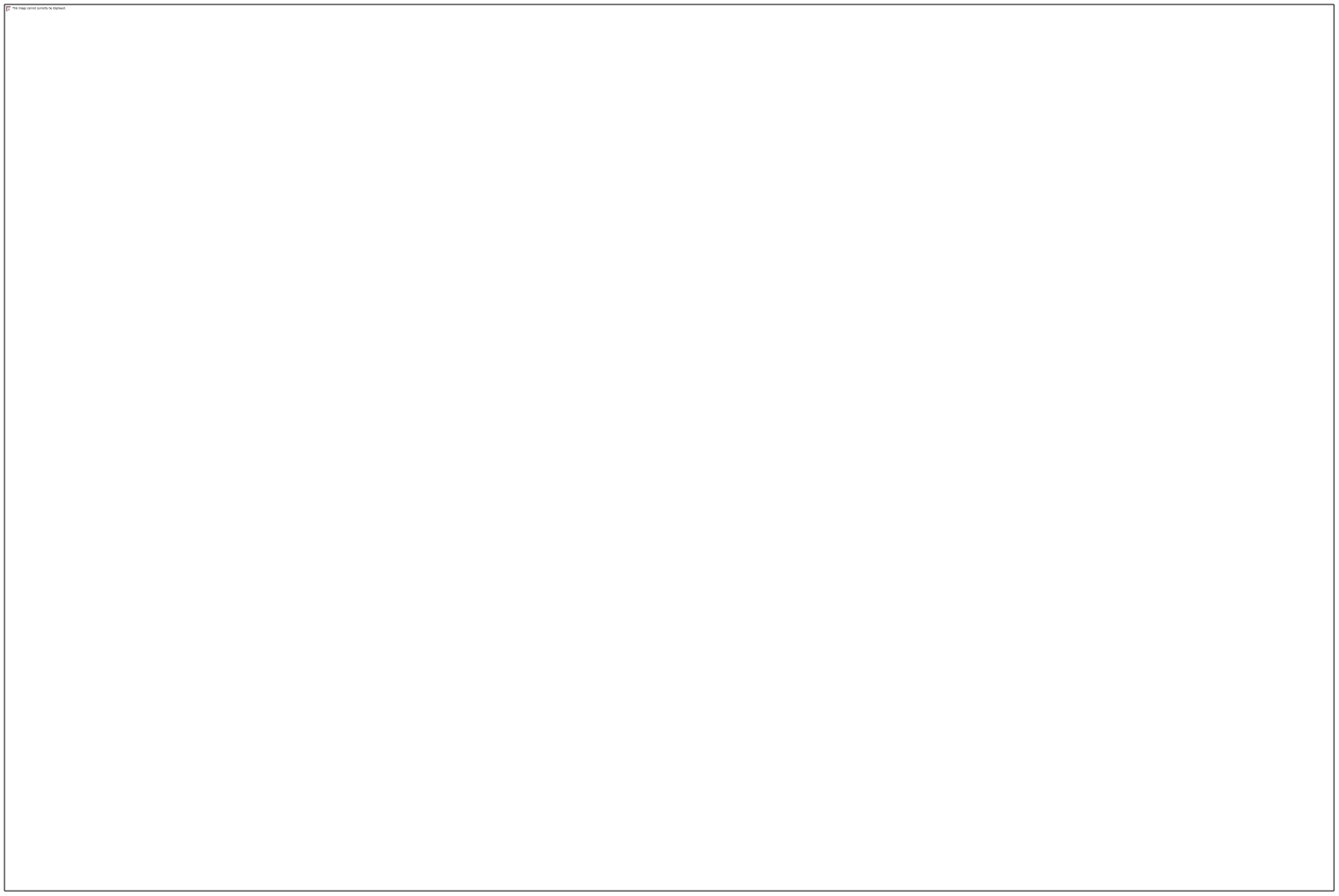
Need for sufficient passenger and freight demand.

High costs of specialised railway equipment and technology.

3.3 Development of Water Transport in Kenya



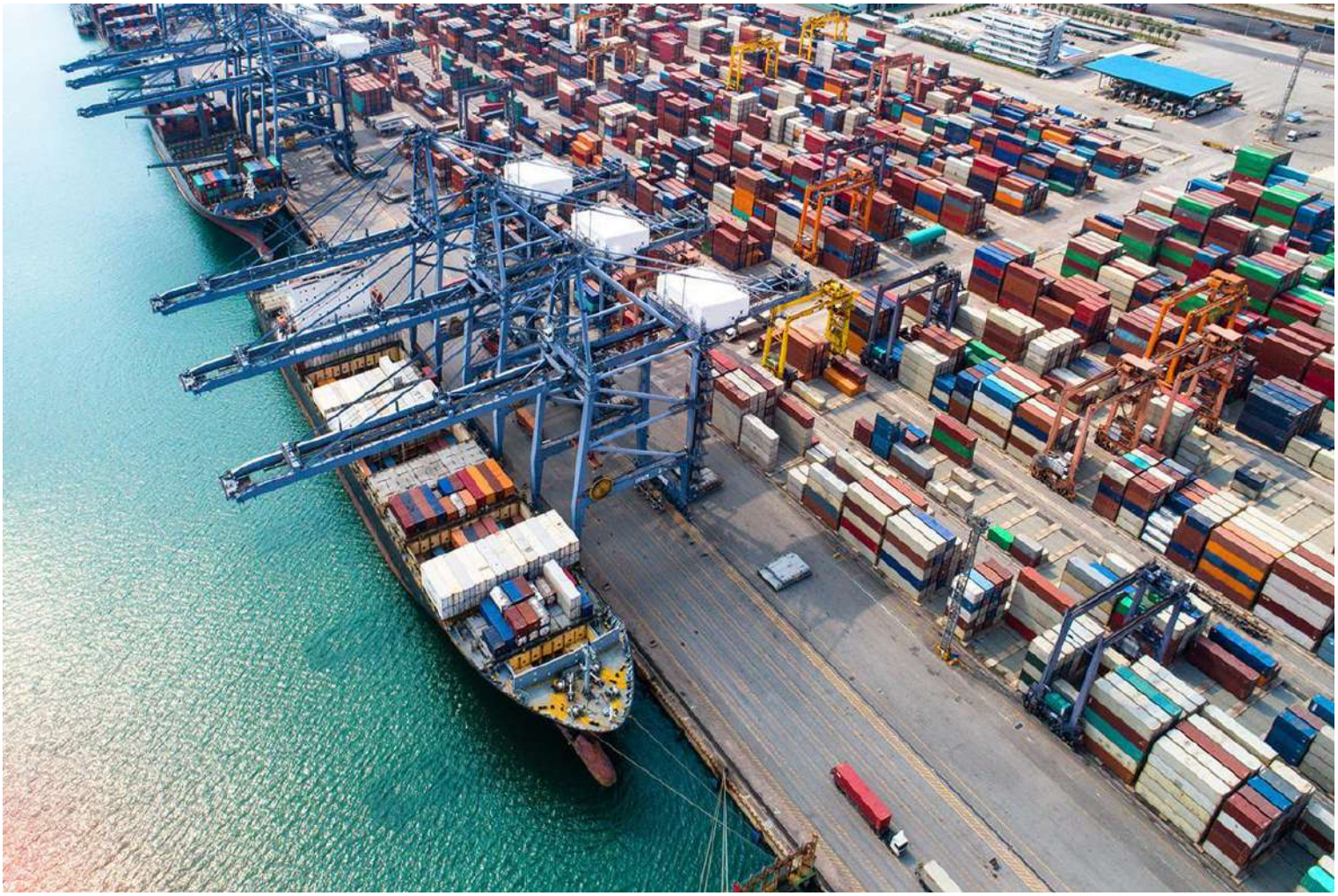




Water transport is important in Kenya because of its Indian Ocean coastline and inland water bodies, particularly Lake Victoria.

Major Developments in Water Transport

A. Modernisation of the Port of Mombasa



The Port of Mombasa is Kenya's principal seaport and an important gateway for international trade in East Africa.

Developments include:

Construction and expansion of container terminals.

Acquisition of modern cargo-handling equipment.

Improvement of port facilities.

Development of additional berths.

Modernisation of cargo management systems.

Improvement of access roads and railway connections.

Importance of the Port of Mombasa:

Facilitates imports and exports.

Serves neighbouring landlocked countries such as Uganda, Rwanda and South Sudan.

Generates government revenue through port-related activities.

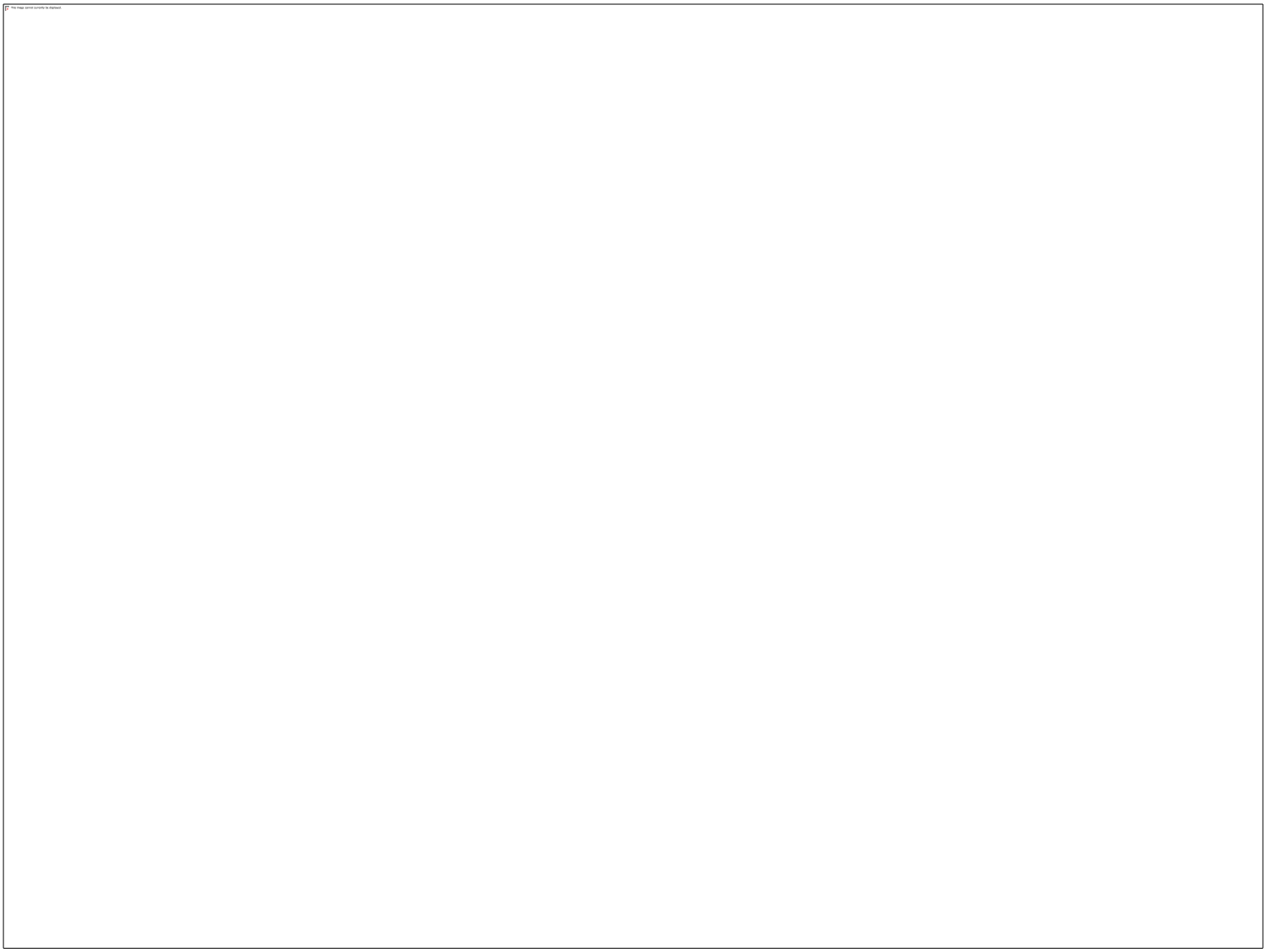
Creates employment in shipping, logistics and cargo handling.

Promotes industrial development.

Encourages international investment.

Facilitates the importation of machinery, fuel and industrial raw materials.

B. Development of the Port of Lamu



The Port of Lamu is a modern seaport developed as part of the Lamu Port-South Sudan-Ethiopia Transport (LAPSSET) Corridor project.

Importance:

Provides another maritime gateway for Kenya.

Supports regional trade with Ethiopia and South Sudan.

Encourages investment in northern Kenya.

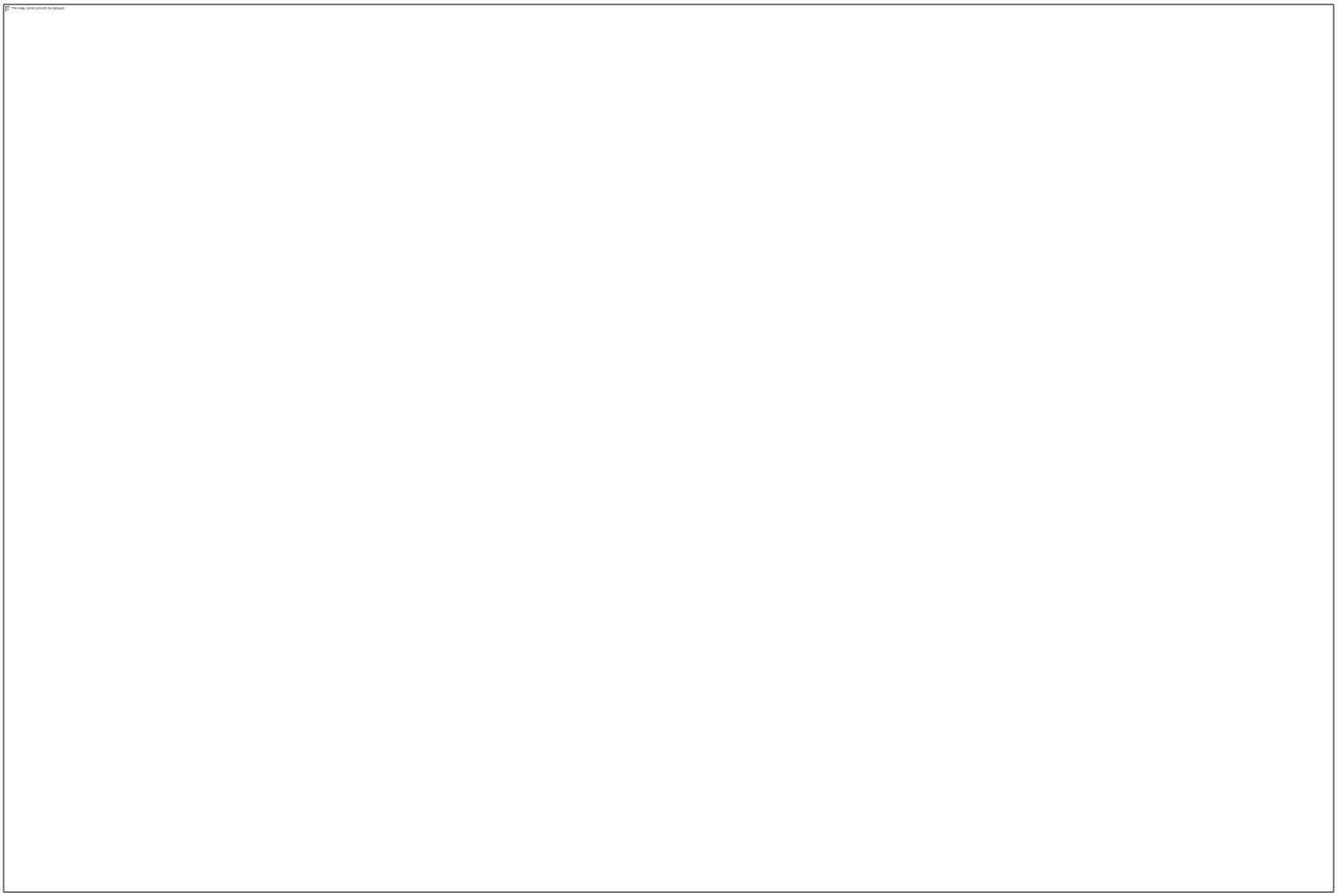
Creates employment opportunities.

Promotes tourism and commercial activities.

Supports regional integration.

Provides opportunities for development of industrial and logistics centres.

C. Development of Kisumu Port



Kisumu Port is located on the shores of Lake Victoria.

Its development and rehabilitation have improved opportunities for inland water transport in the Lake Victoria region.

Importance:

Facilitates trade between Kenya, Uganda and Tanzania.

Supports transportation of cargo across Lake Victoria.

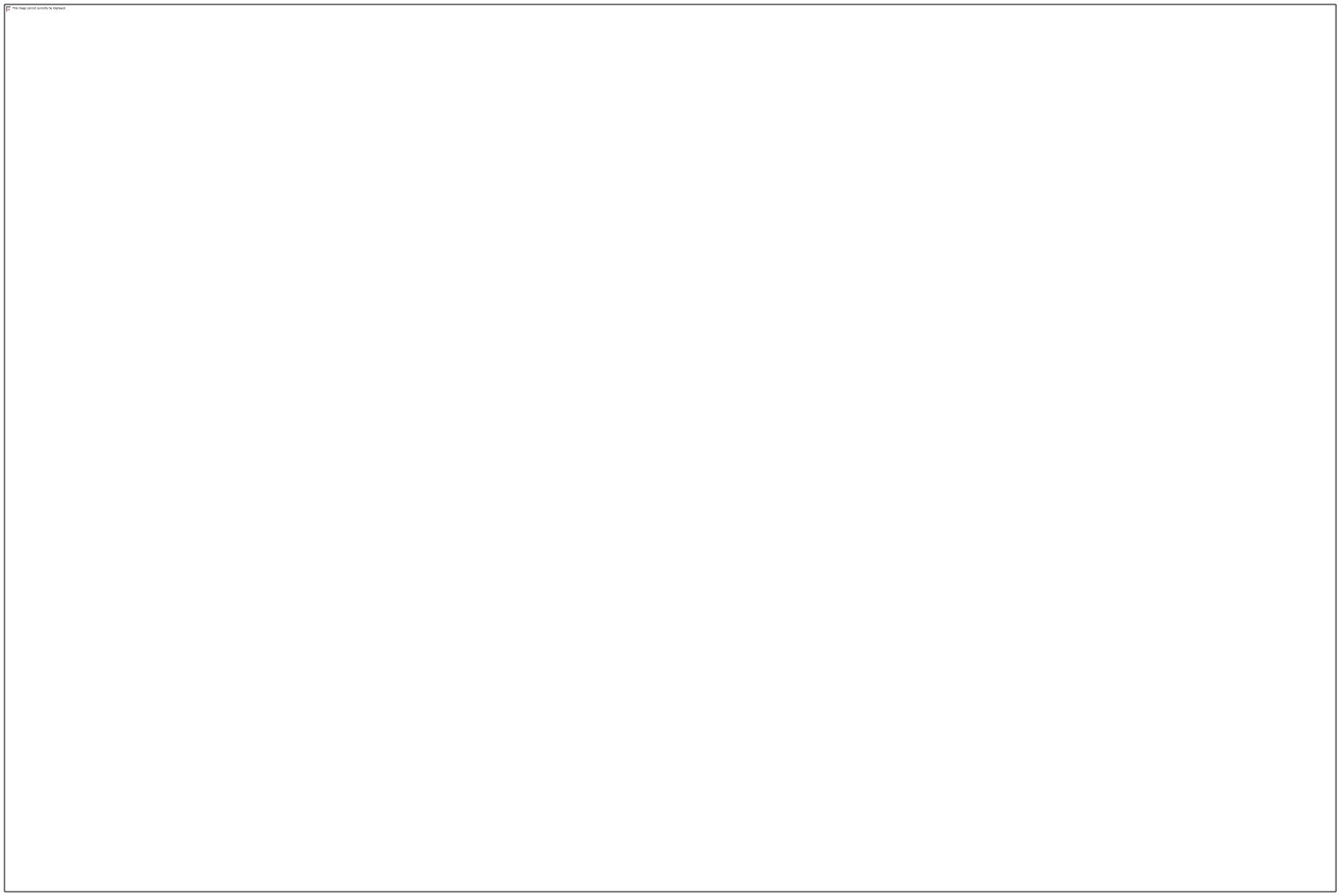
Promotes regional cooperation.

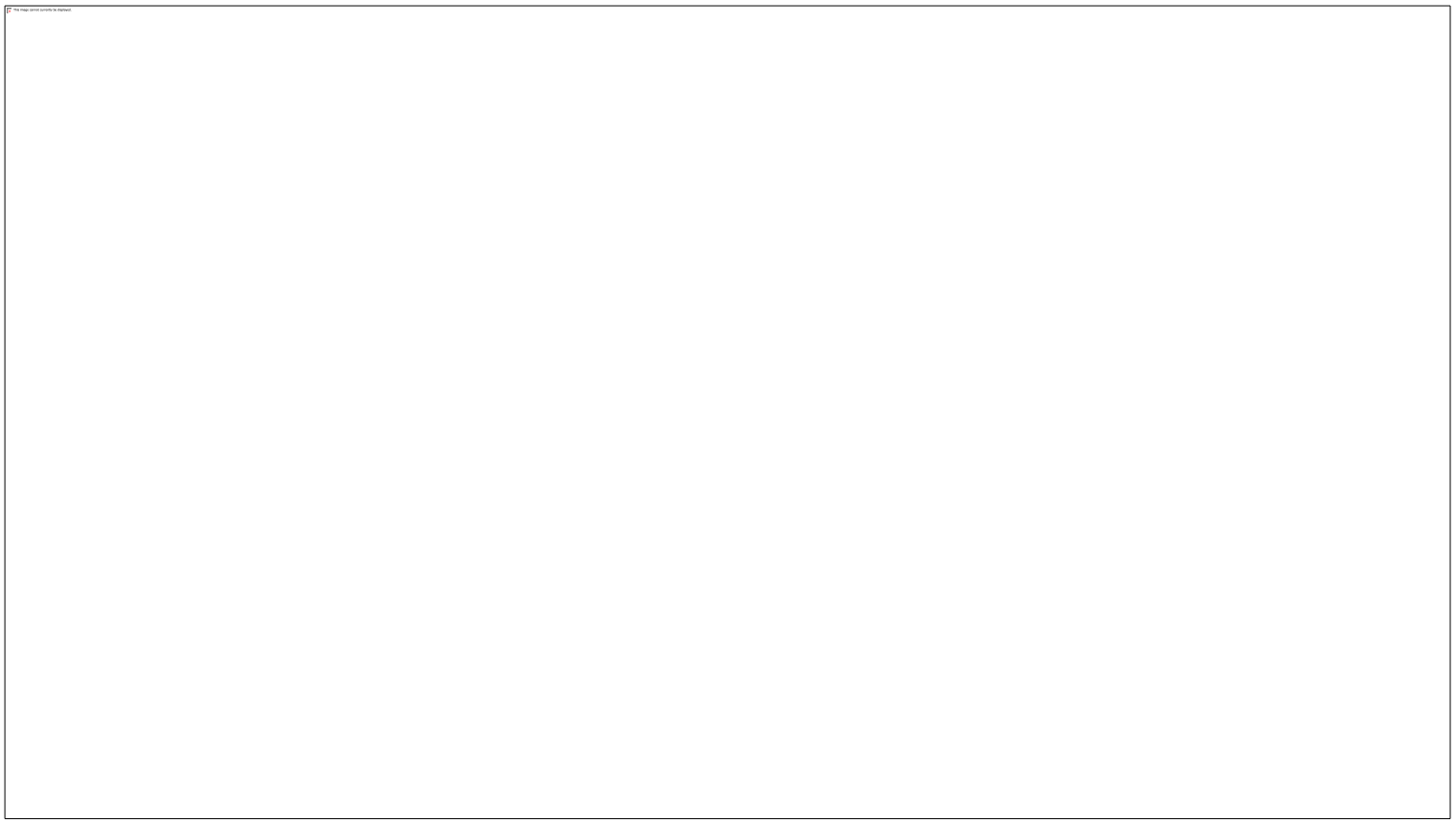
Creates employment opportunities.

Encourages tourism and fishing-related activities.

Provides an alternative to road transportation for suitable cargo.

3.4 Development of Air Transport in Kenya







Air transport in Kenya has developed through the construction, expansion and modernisation of airports, acquisition of modern aircraft and improvement of air navigation facilities.

Major Airports in Kenya

1. **Jomo Kenyatta International Airport (JKIA)**

Located in Nairobi.

It is Kenya's principal international airport.

Handles international and domestic passenger and cargo traffic.

Supports tourism, international business and trade.

2. **Moi International Airport**

Located in Mombasa.

Serves the coastal region.

Facilitates tourism and international travel.

3. **Kisumu International Airport**

Located in Kisumu.

Serves western Kenya and the Lake Victoria region.

Facilitates domestic and selected international air services.

4. **Eldoret International Airport**

Located in Eldoret.

Supports passenger and cargo transportation.

Serves the North Rift region and surrounding areas.

5. **Wilson Airport**

Located in Nairobi.

Handles domestic and regional flights.

Supports charter services, tourism and aviation training.

Developments in Air Transport

Expansion and modernisation of airport terminals.

Improvement of runways and taxiways.

Introduction of modern aircraft.

Improvement of air traffic control systems.

Expansion of domestic and international flight services.

Development of cargo-handling facilities.

Improvement of airport security systems.

Growth of aviation training institutions.

Increased use of digital passenger booking systems.

Expansion of aviation-related tourism services.

Importance of Air Transport Development in Kenya

Promotes international tourism.

Facilitates the export of flowers and fresh produce.

Connects Kenya with international markets.

Creates employment opportunities.

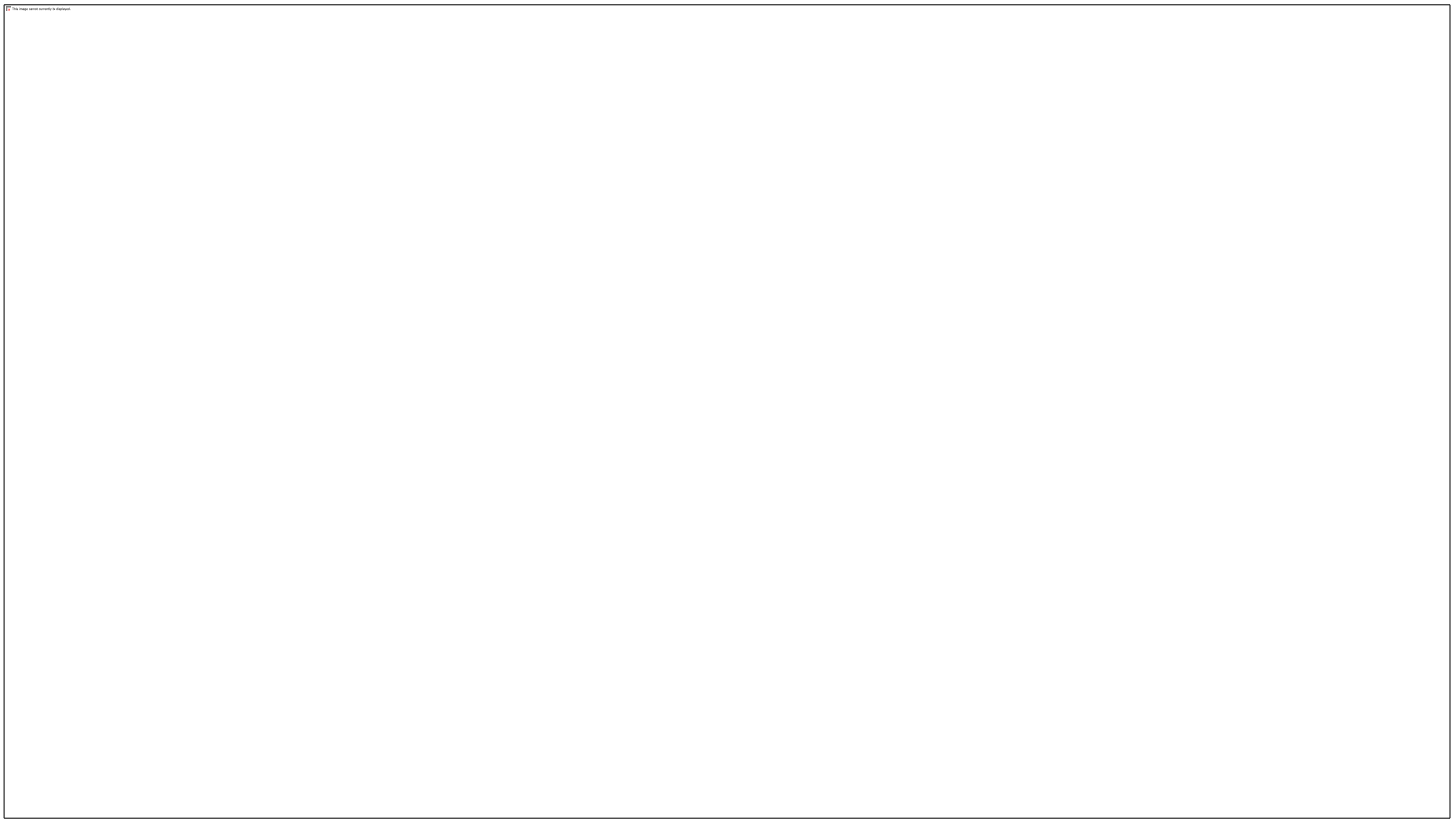
Encourages foreign investment.

Facilitates diplomatic relations.

Promotes medical evacuation and emergency response.

Supports international conferences and business activities.

3.5 Development of Pipeline Transport in Kenya



Pipeline transport has developed mainly to facilitate the movement of petroleum products from coastal storage and processing facilities towards inland distribution centres.

The Kenya Pipeline Company operates a major petroleum pipeline network.

Major Developments

Construction and extension of petroleum pipelines.

Development of pumping stations.

Installation of modern monitoring systems.

Construction of petroleum storage facilities.

Improvement of pipeline safety and maintenance systems.

Development of distribution connections to inland towns.

Introduction of modern leak detection and control technologies.

Importance

Facilitates the distribution of petroleum products.

Reduces dependence on road tankers.

Reduces traffic congestion caused by fuel transportation.

Improves the reliability of petroleum supply.

Supports industrial and commercial activities.

Promotes economic development.

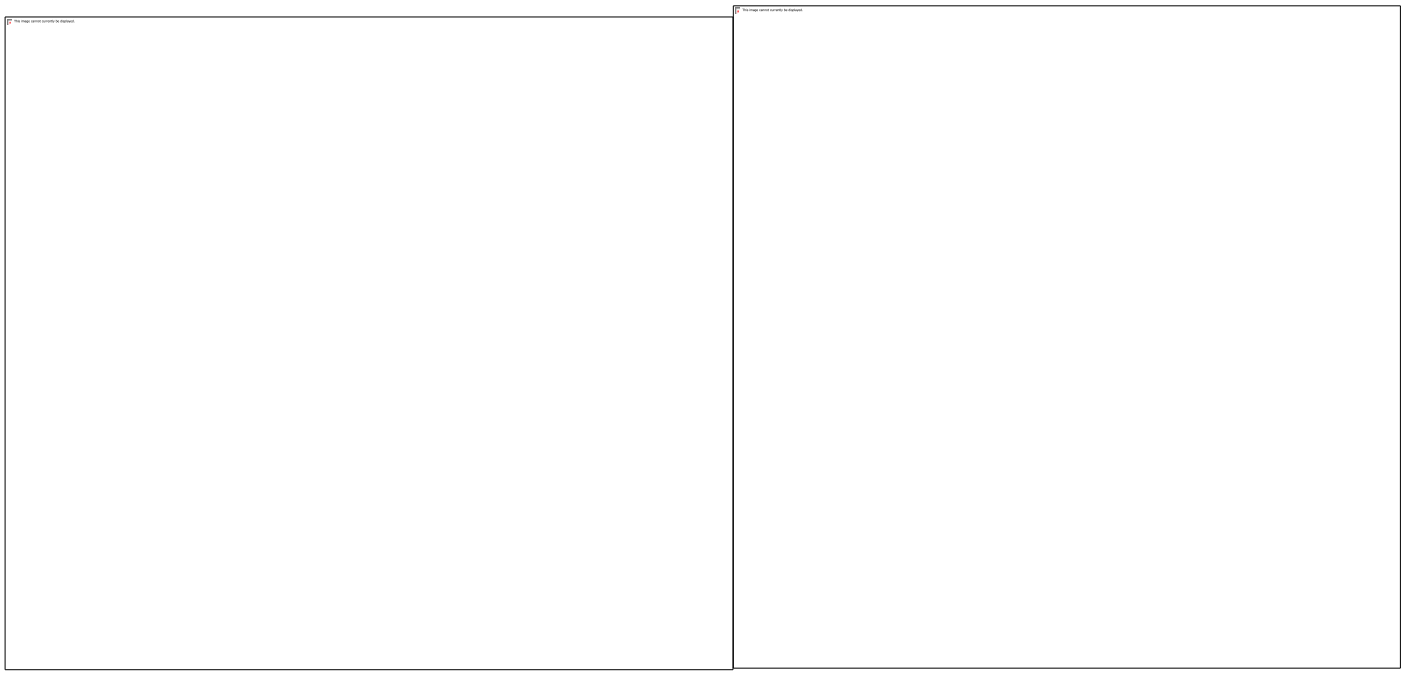
Enhances the efficiency of fuel distribution.

4.0 TYPES OF COMMUNICATION IN THE WORLD

Communication is an essential component of human and economic development. It allows individuals, organisations and governments to exchange information and coordinate activities.

Communication systems have developed from traditional methods such as drums and messengers to modern digital technologies such as smartphones, satellite systems and the internet.

4.1 Traditional Communication





Traditional communication refers to the exchange of information using indigenous methods and locally available materials before the widespread development of modern electronic communication technologies.

Examples of Traditional Communication

1. **Drum communication**

Drums were beaten in specific patterns to communicate messages.

Different rhythms could communicate warnings, announcements and ceremonial information.

They were particularly useful in communities where people lived far apart.

2. **Horn blowing**

Animal horns were used to produce sounds that communicated specific messages.

They were used to summon people or warn communities of danger.

3. **Smoke signals**

Smoke was produced in particular patterns to communicate messages across distances.

It was useful in areas with open landscapes.

4. **Town criers**

Individuals moved around villages announcing information to community members.

They communicated information about meetings, ceremonies, security and important events.

5. **Messengers**

Individuals physically carried messages from one person or community to another.

They were important before the development of modern postal and electronic systems.

6. **Storytelling**

Information, cultural values and historical knowledge were passed from one generation to another through oral narratives.

Importance of Traditional Communication

Preserves cultural heritage.

Promotes community unity.

Communicates warnings and emergencies.

Requires relatively simple materials.

Promotes the transmission of indigenous knowledge.

Can reach people who do not have access to modern technology.

Limitations

Messages may take a long time to reach distant communities.

Some methods have limited communication ranges.

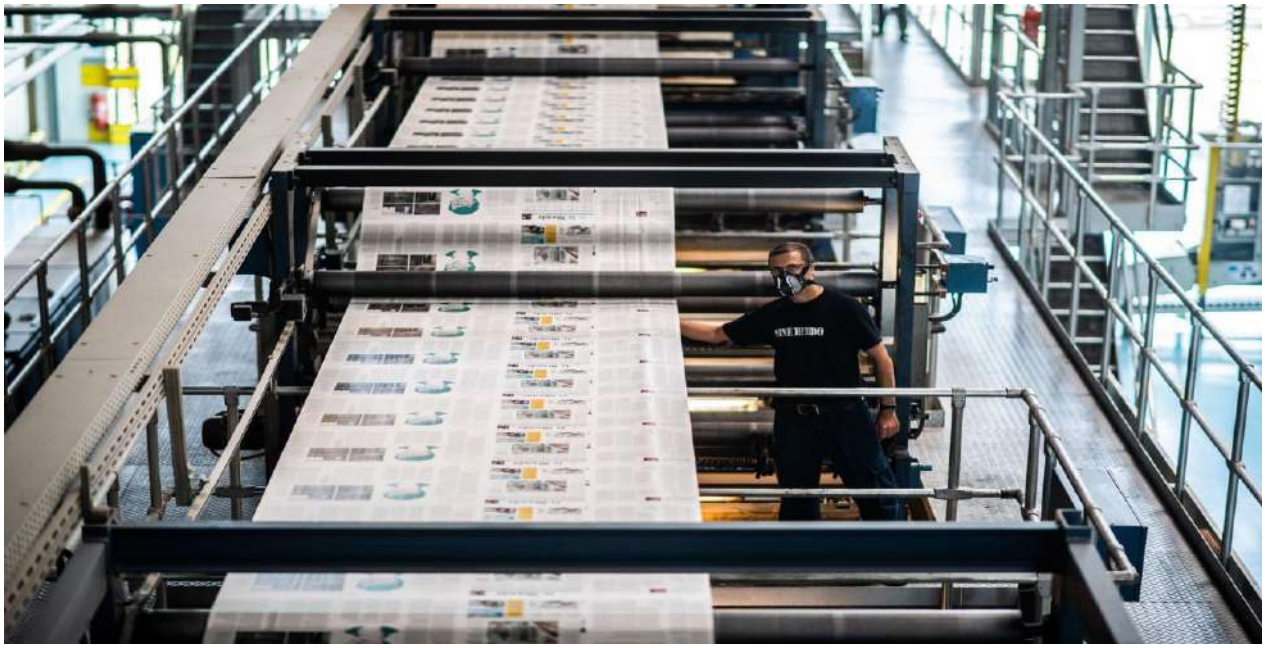
Information may be distorted during transmission.

Some methods cannot communicate complex information effectively.

They may be affected by weather conditions.

Messages may not be confidential.

4.2 Print Communication





Print communication refers to the transmission of information through printed materials that can be read by individuals or groups.

Examples

Newspapers.

Books.

Magazines.

Journals.

Posters.

Brochures.

Pamphlets.

Newsletters.

Maps.

Printed reports.

Importance of Print Communication

Provides educational information.

Preserves information for future reference.

Promotes literacy.

Facilitates the dissemination of government information.

Supports advertising and marketing.

Enables distribution of research findings.

Promotes public awareness of social and economic issues.

Limitations

Printing and distribution may be expensive.

Information may become outdated.

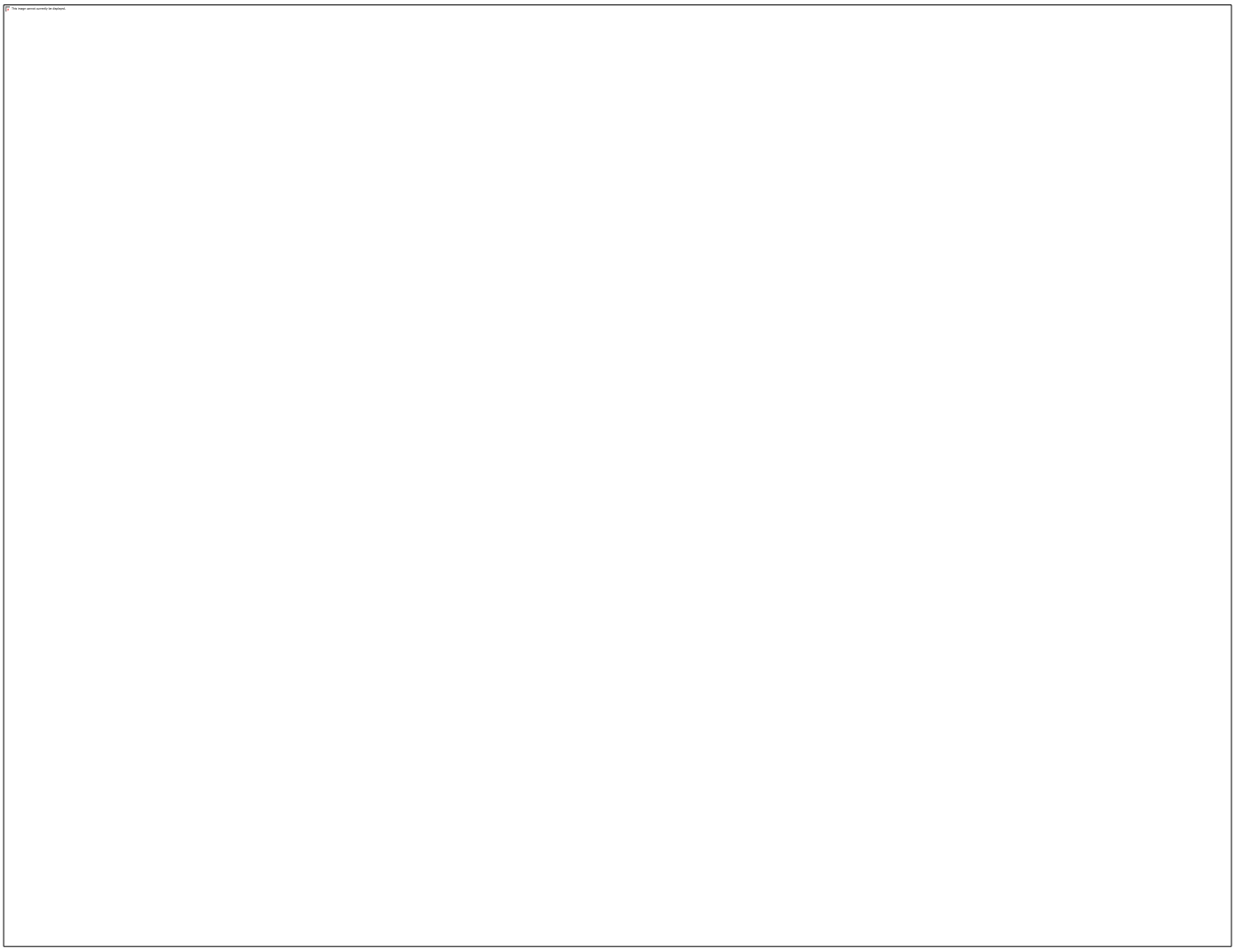
Printed materials require physical storage.

Distribution may be slow in remote areas.

Printing contributes to paper consumption.

Some people may be unable to read or interpret printed information.

4.3 Radio Communication



Radio communication refers to the transmission of information through electromagnetic radio waves without requiring a physical cable between the transmitter and receiver.

How Radio Communication Works

Information is converted into an electrical or digital signal.

The signal is processed by a transmitter.

The transmitter sends the signal using radio waves.

The waves travel through the atmosphere.

A radio receiver captures the signal.

The receiver converts the signal into sound that listeners can hear.

Importance of Radio Communication

Provides news and current affairs.

Educates the public on health and environmental issues.

Promotes agricultural knowledge among farmers.

Provides entertainment through music and programmes.

Communicates emergency warnings.

Promotes local languages and cultural identity.

Reaches people in remote areas.

Supports public education campaigns.

Provides weather and disaster information.

Facilitates public participation in national discussions.

Limitations

It is mainly an audio communication medium.

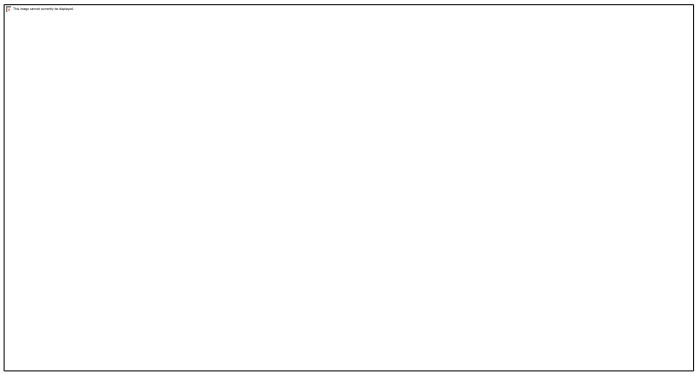
Radio signals may be affected by interference.

Some areas may have weak signal reception.

Listeners may miss information if they do not tune in at the right time.

Information may be inaccurate if broadcasting is not properly regulated.

4.4 Television Communication



Television communication refers to the transmission of information through audio-visual signals that enable viewers to see images and hear sound.

Importance

Provides news and current affairs.

Supports formal and informal education.

Promotes entertainment.

Provides agricultural and health information.

Promotes tourism through documentaries.

Facilitates public awareness campaigns.

Supports advertising and business promotion.

Communicates emergency information.

Promotes cultural exchange.

Provides visual demonstrations of scientific and technological developments.

Limitations

Television sets and subscriptions may be expensive.

Electricity is required to operate most television equipment.

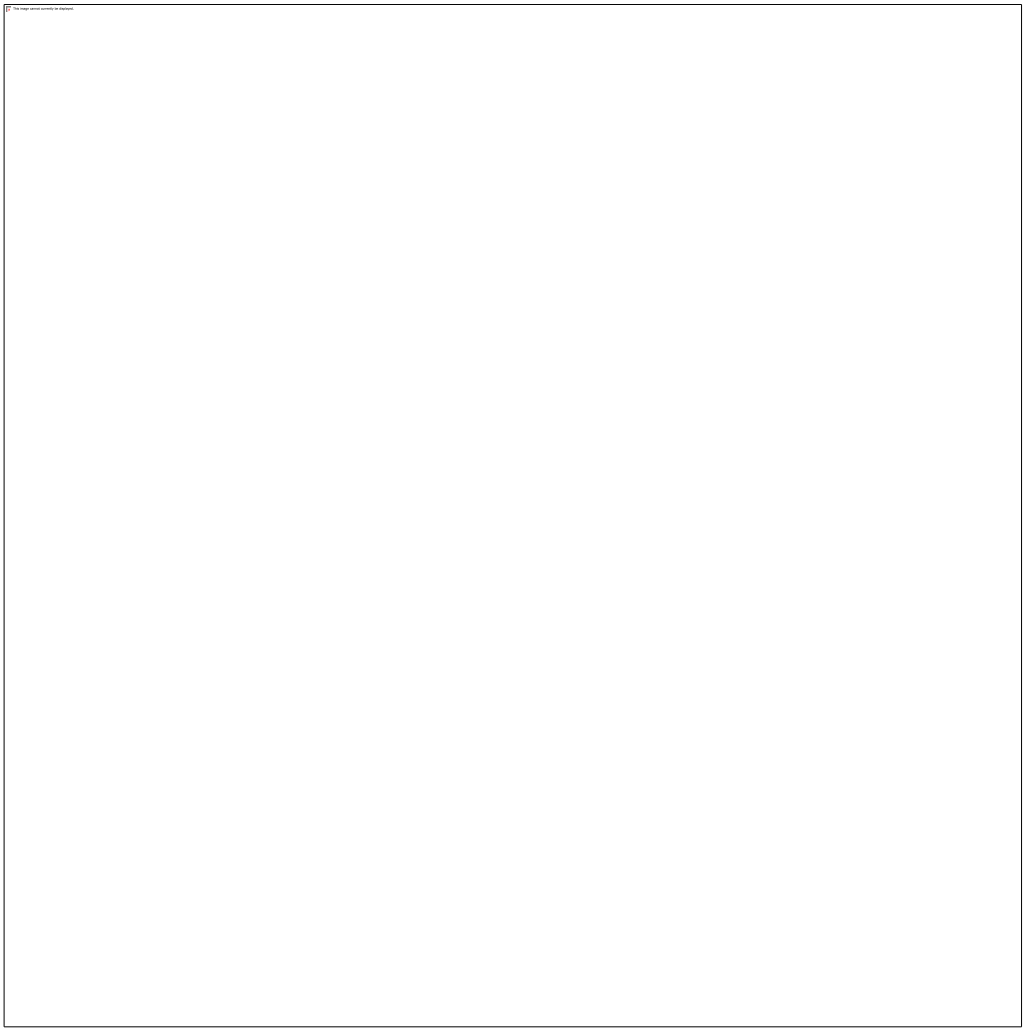
Some rural areas have limited signal coverage.

Programmes may encourage excessive screen time.

Some information may be misleading.

Broadcasting may require expensive equipment.

4.5 Telephone Communication





Telephone communication refers to the exchange of spoken information between individuals through electronic communication systems.

Types of Telephone Communication

A. Fixed-line telephone

Uses physical cables to connect telephone devices.

It is commonly installed in offices, institutions and some homes.

It traditionally relies on copper cables, although modern fixed systems may use fibre-optic technology.

B. Mobile telephone

Uses wireless cellular networks to connect users.

It allows communication while moving from one geographical location to another.

It is widely used in Kenya.

Importance of Telephone Communication

Facilitates immediate communication.

Supports business transactions.

Promotes family and social relationships.

Facilitates emergency communication.

Supports online learning and research.

Improves communication between farmers and markets.

Supports mobile banking and digital payments.

Promotes access to government services.

Facilitates communication between health workers and patients.

Promotes national and international connectivity.

Limitations

Requires network coverage.

Devices and communication services may be expensive.

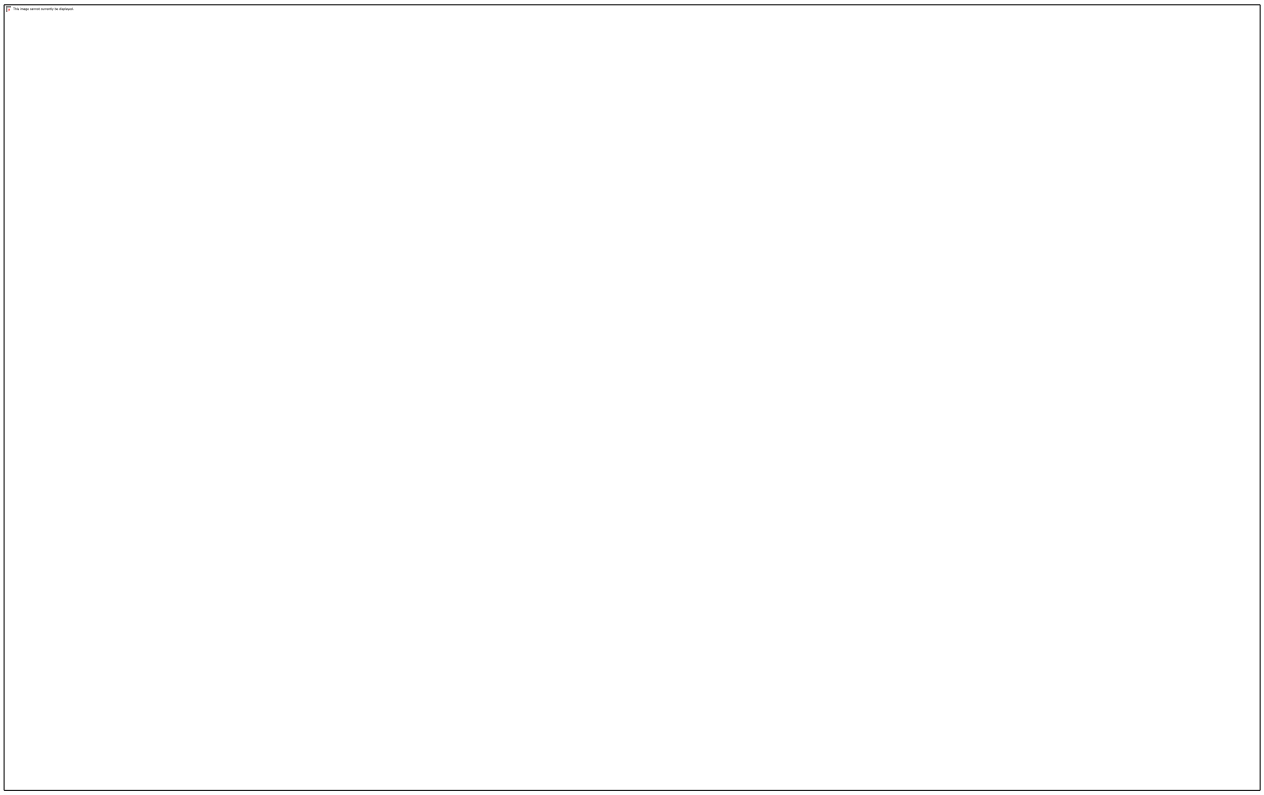
Mobile phones require charging.

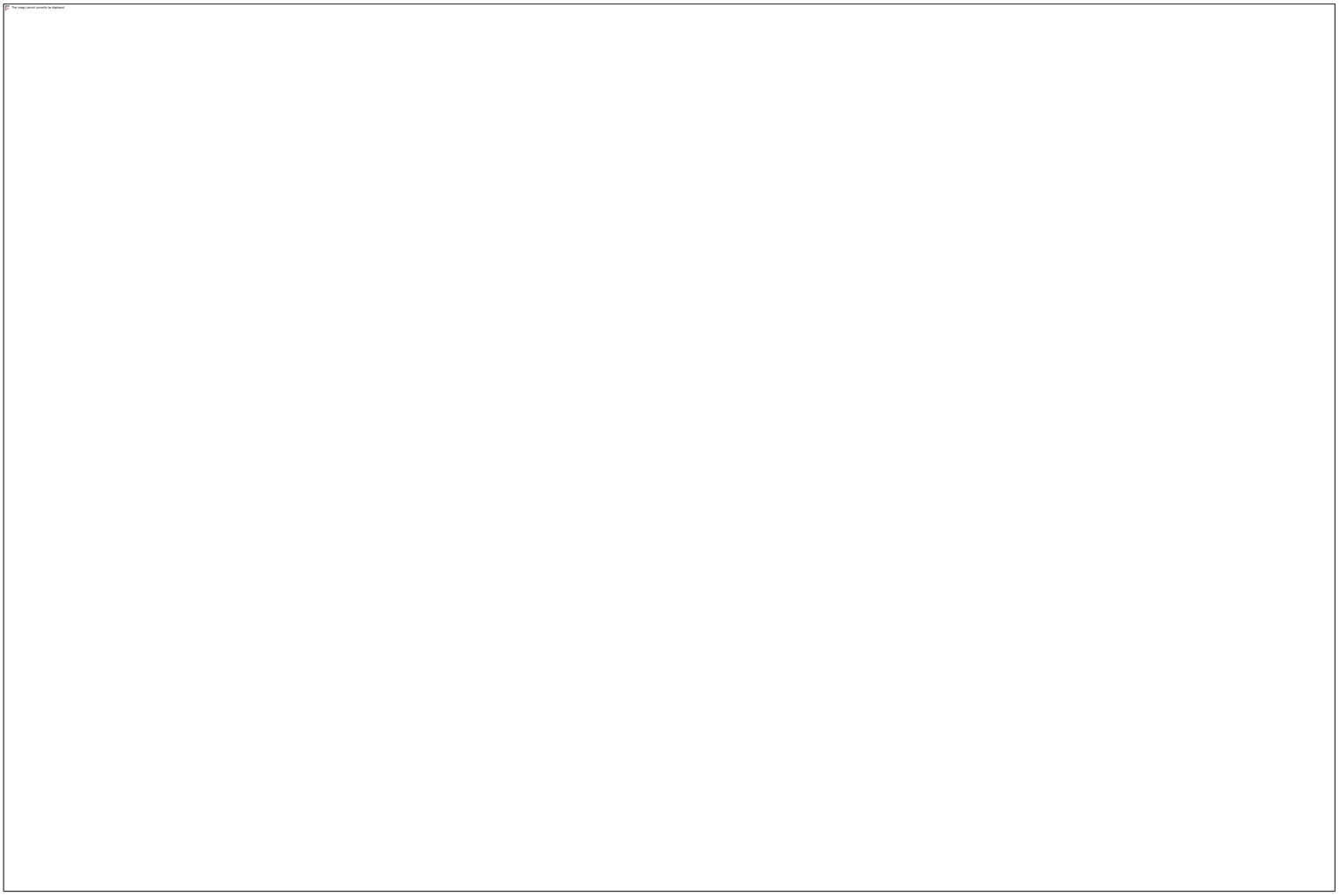
Cybercrime may threaten users.

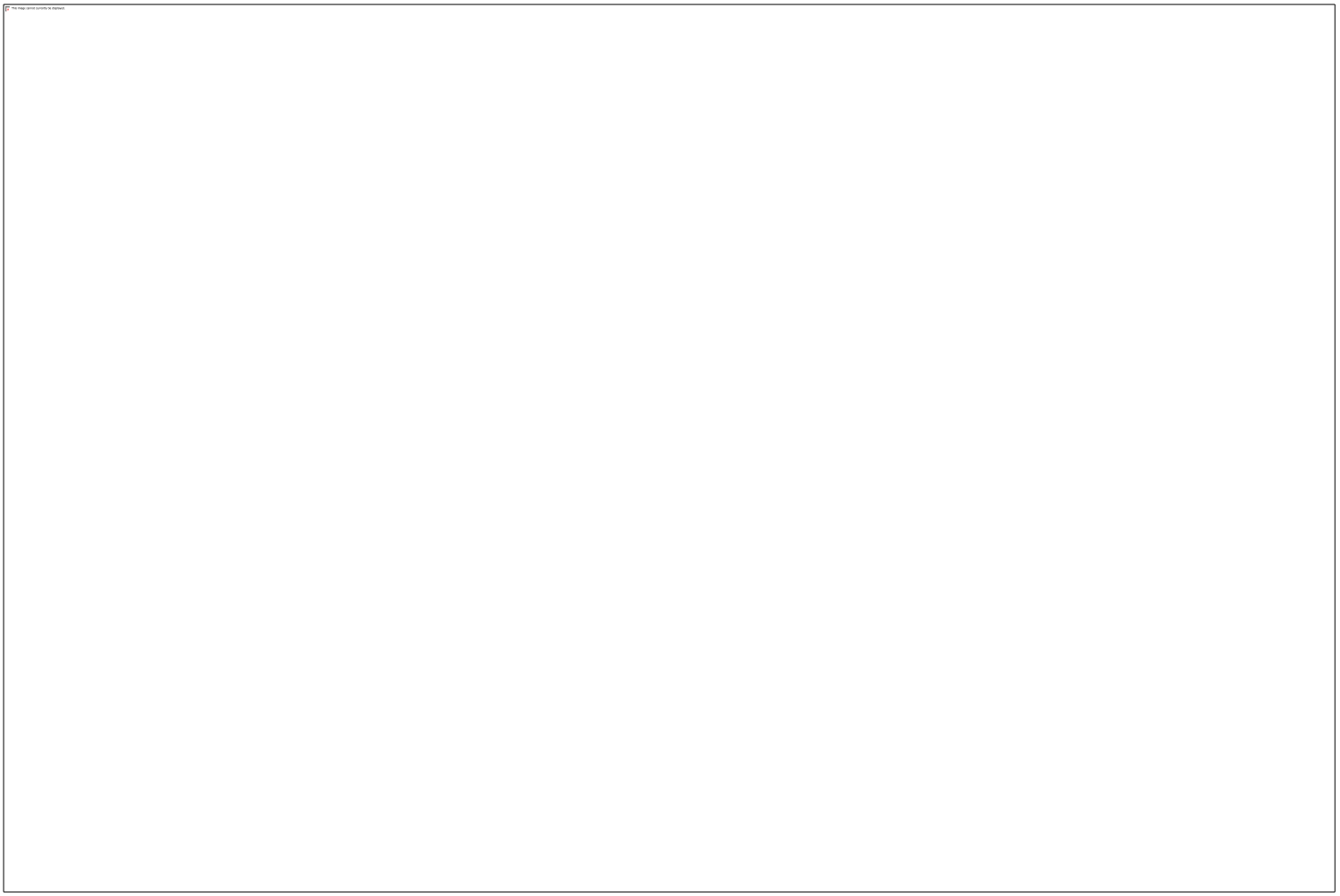
Network failure may interrupt communication.

Excessive use may affect productivity.

4.6 Internet and Digital Communication







Internet communication refers to the exchange of information through interconnected computer networks using internet-based technologies.

It allows users to send, receive, store and access information across geographical boundaries.

Examples of Internet Communication

Email.

Video conferencing.

Social media.

Instant messaging.

Online discussion forums.

Websites and blogs.

Online learning platforms.

Cloud-based communication services.

Importance of Internet Communication

Enables instant exchange of information.

Promotes online education.

Facilitates international business.

Supports e-commerce.

Promotes digital banking.

Facilitates research and innovation.

Enables remote working.

Promotes communication between governments and citizens.

Supports telemedicine and digital health services.

Promotes international cooperation.

Limitations

Cybercrime and online fraud.

Spread of misinformation.

High cost of internet access in some areas.

Digital inequality.

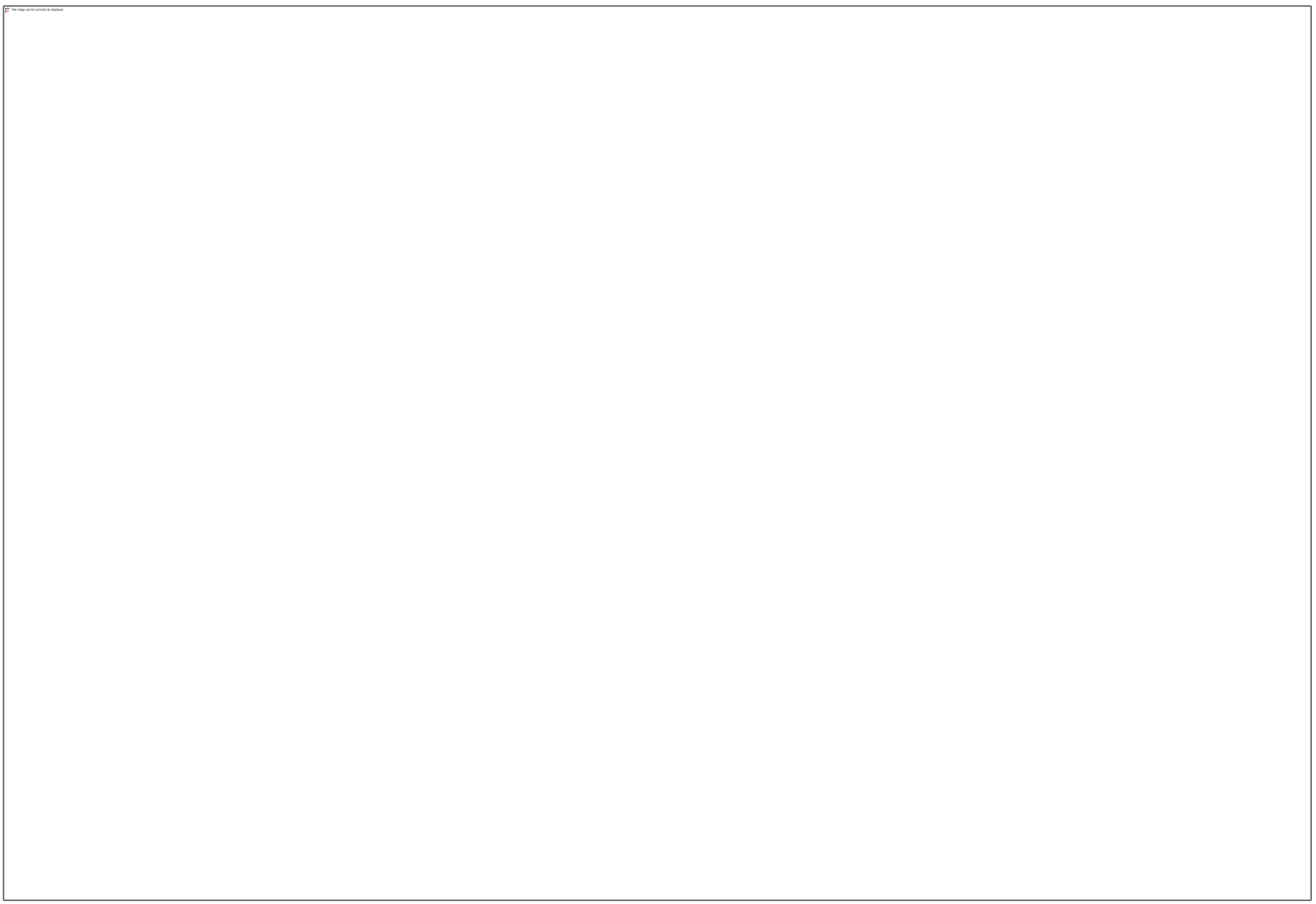
Internet addiction and misuse.

Loss of privacy.

Network outages.

Exposure to inappropriate online content.

4.7 Satellite Communication



Satellite communication refers to the transmission of information through artificial satellites positioned in space.

The satellites receive signals from ground stations and retransmit them to other stations or receivers.

Importance

Provides communication over very long distances.

Supports international television broadcasting.

Facilitates weather forecasting.

Supports navigation systems.

Provides communication in remote areas.

Supports disaster monitoring and management.

Facilitates military and security communication.

Supports international telephone and internet services.

Limitations

Satellite development and launch are expensive.

Signals may experience delays depending on satellite orbit and system design.

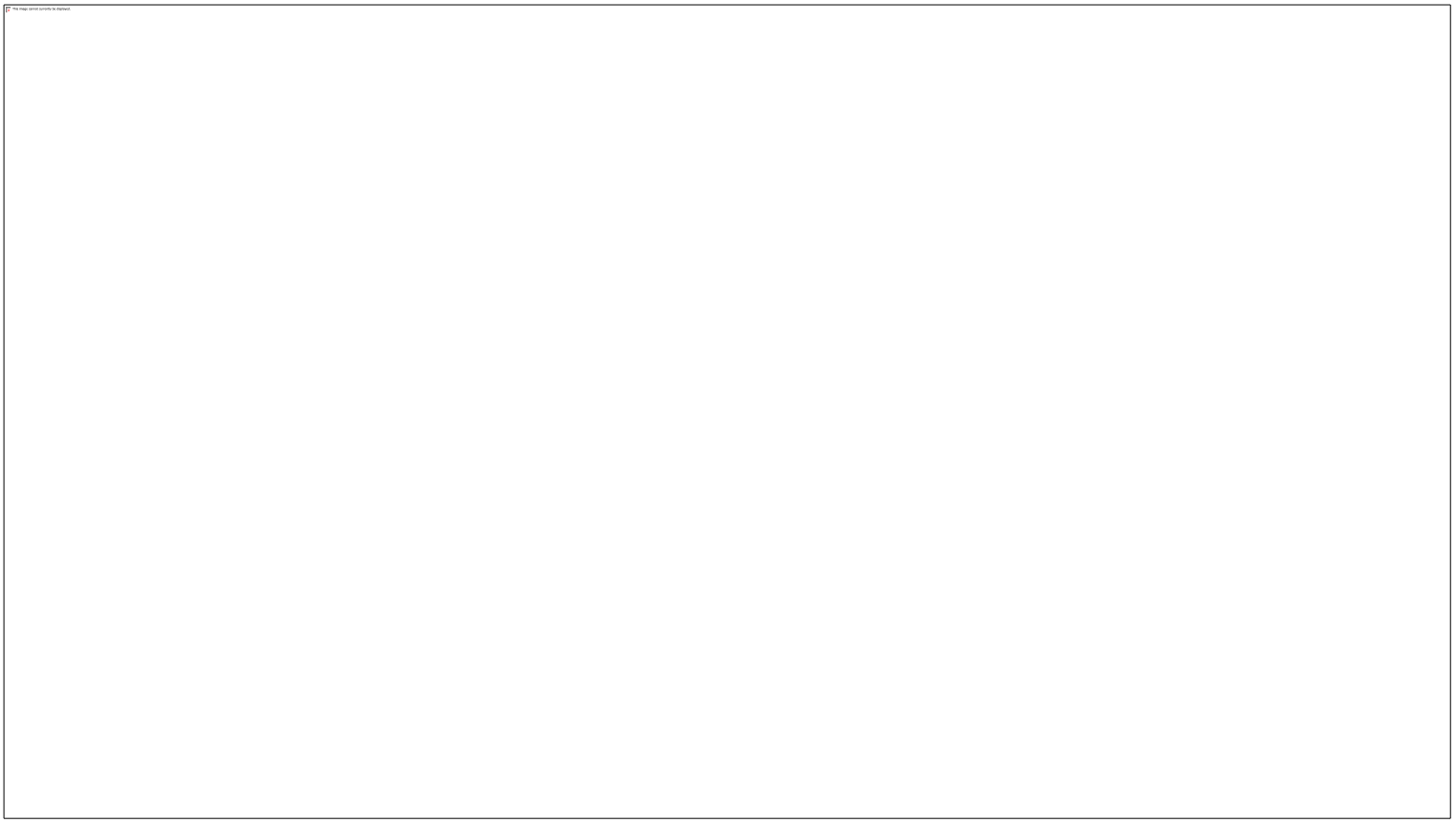
Some signals may be affected by atmospheric conditions.

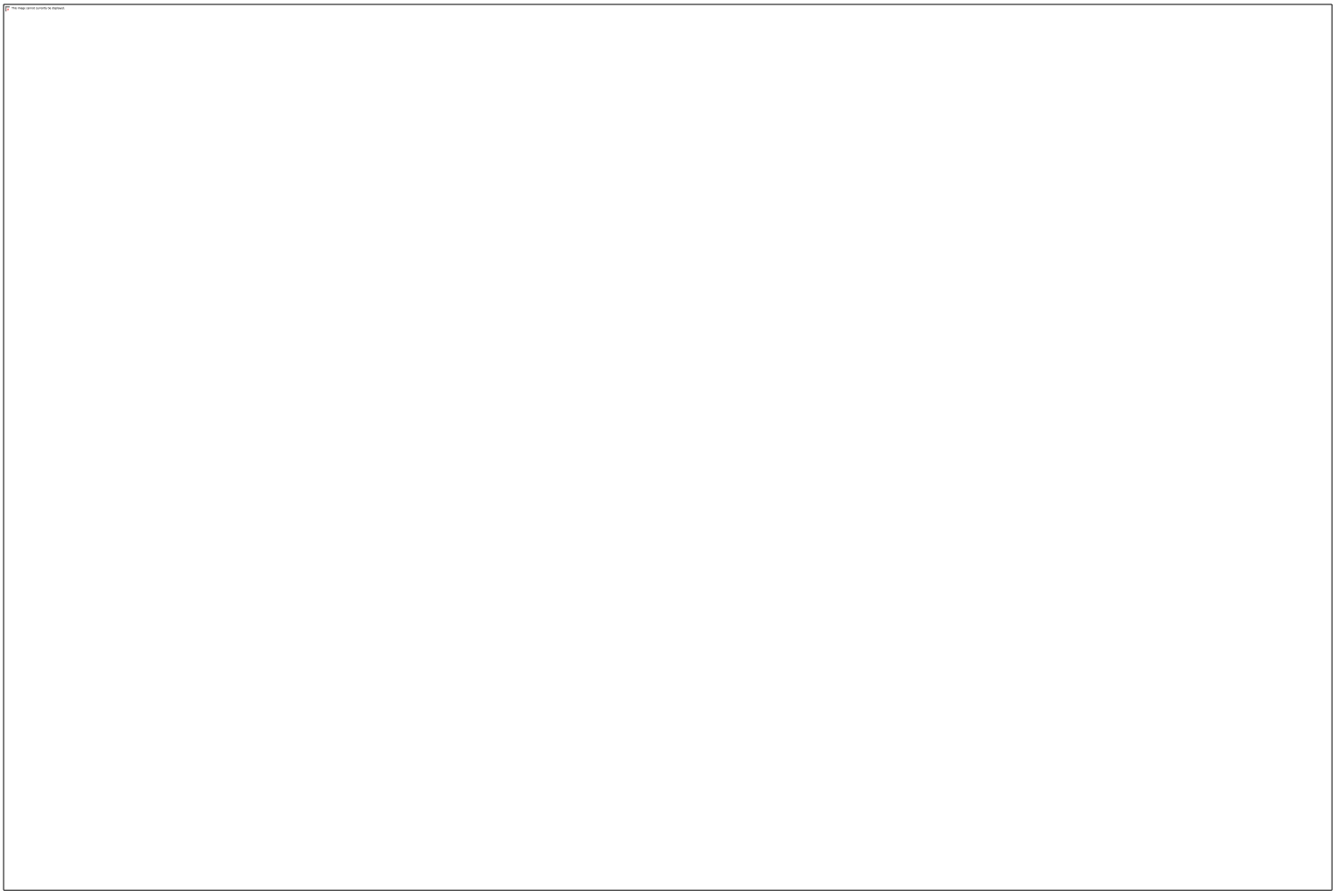
Satellite systems require specialised technical skills.

Space debris presents long-term operational risks.

5.0 DEVELOPMENT OF COMMUNICATION IN KENYA







Kenya has experienced major developments in communication, especially through the expansion of mobile telephone services, internet connectivity, broadcasting and digital technologies.

These developments have transformed education, trade, banking, agriculture, healthcare and public administration.

5.1 Development of Telecommunications

Telecommunications refers to the transmission of information over distances using electronic and digital technologies.

Major Developments in Kenya

Expansion of mobile telephone networks.

Introduction of digital telephone services.

Expansion of fibre-optic infrastructure.

Development of mobile money transfer services.

Growth of internet service providers.

Expansion of television and radio broadcasting.

Introduction of digital government services.

Development of data centres and cloud computing facilities.

Growth of online business platforms.

Expansion of mobile broadband services.

5.2 Growth of Mobile Telephone Services



Mobile telephone services have transformed communication in Kenya.

Several telecommunications operators provide mobile voice, messaging and internet services.

Examples include:

Safaricom.

Airtel Kenya.

Telkom Kenya.

Importance of Mobile Telephone Development

Enables people to communicate across long distances.

Promotes mobile banking.

Facilitates business transactions.

Supports communication in rural and urban areas.

Promotes access to educational resources.

Supports emergency response.

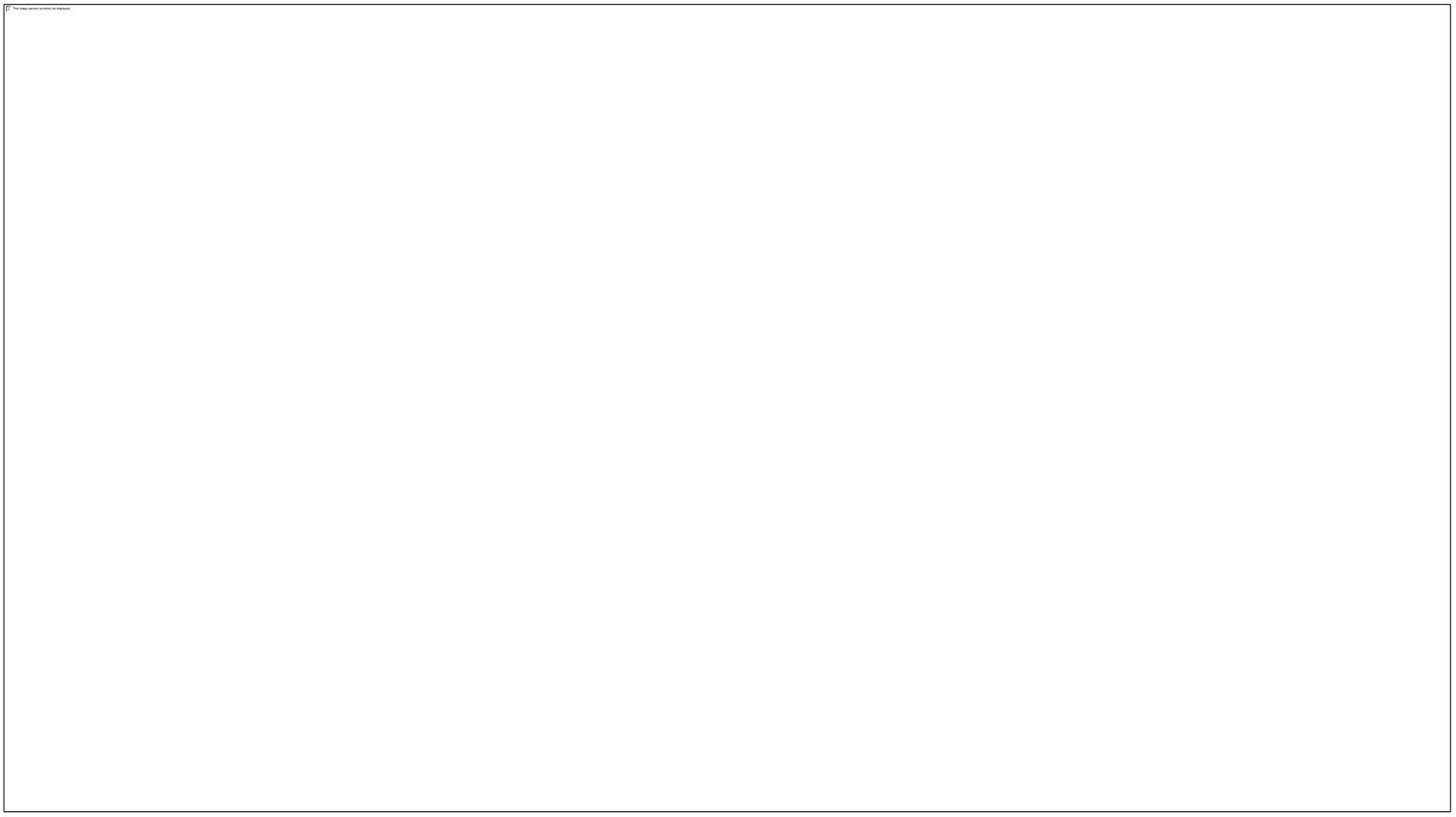
Improves communication between farmers and buyers.

Facilitates mobile money transfers.

Promotes social interaction.

Supports digital entrepreneurship.

5.3 Development of Mobile Money Transfer Services



Mobile money is a financial service that enables users to store, send and receive money using mobile devices and associated financial systems.

A major example in Kenya is M-PESA.

Importance of Mobile Money Services

Facilitates transfer of money between individuals.

Promotes financial inclusion.

Supports small businesses.

Facilitates payment of bills.

Promotes e-commerce.

Reduces the need to carry large amounts of physical cash.

Supports savings and other financial services.

Facilitates payment of school fees.

Promotes rural economic activities.

Supports government and private-sector digital payments.

5.4 Development of Fibre-Optic Communication



Fibre-optic communication involves the transmission of information using pulses of light through thin strands of glass or plastic.

Kenya has invested in terrestrial and submarine fibre-optic infrastructure to improve internet connectivity.

Importance

Provides high-speed internet connectivity.

Supports online learning.

Facilitates international communication.

Promotes e-commerce.

Supports digital government services.

Improves access to cloud computing.

Supports banking and financial transactions.

Facilitates video conferencing.

Supports research and technological innovation.

Improves communication between institutions.

5.5 Development of Broadcasting Services

Broadcasting involves the distribution of audio or audio-visual information to large audiences through radio and television systems.

Developments in Kenya

Growth of private radio stations.

Expansion of television broadcasting.

Introduction of digital television broadcasting.

Growth of community radio stations.

Expansion of vernacular-language broadcasting.

Introduction of online radio and television services.

Improvement of broadcasting transmission equipment.

Importance

Promotes education and public awareness.

Provides entertainment.

Supports national discussions.

Promotes local languages.

Facilitates disaster communication.

Promotes cultural exchange.

5.6 Development of E-Government Services

E-government refers to the use of information and communication technologies by government institutions to deliver services and information to citizens.

Examples in Kenya include:

eCitizen services.

Online government payment systems.

Digital business registration services.

Online application services.

Digital tax administration services.

Importance

Improves access to government services.

Reduces unnecessary physical visits to offices.

Saves time.

Promotes transparency.

Improves record management.

Facilitates payment of government charges.

Supports efficient public administration.

6.0 MAJOR TRANSPORT NETWORKS IN AFRICA

Africa has an extensive but unevenly distributed transport network. The network consists of roads, railways, seaports, airports, inland waterways and pipelines.

Transport networks connect countries, facilitate regional trade, promote tourism and support the movement of people and goods across the continent.

However, the distribution and quality of transport infrastructure vary considerably among African countries because of differences in economic development, relief, climate, population distribution and investment.

6.1 Meaning of a Transport Network

A **transport network** refers to an interconnected system of roads, railway lines, waterways, air routes and other transport facilities that enable the movement of people and goods between different geographical locations.

A well-developed transport network enables countries to:

Exchange goods and services.

Access international markets.

Transport agricultural and industrial products.

Promote regional economic integration.

Facilitate tourism.

Improve access to social services.

Promote international cooperation.

6.2 Major Road Transport Networks in Africa


Trans-African Highways
North Atlantic Ocean
South Atlantic Ocean
Indian Ocean
Algiers
Rades
Tripoli
Alexandria
Cairo
Porto Grande
Praia
Dakar
Nouakchott
Bamako
Niamey
Ouagadougou
Ndjamena
Khartoum
Asmara
Djibouti
Addis Ababa
Abuja
Lagos
Yamoussoukro
Monrovia
Conakry
Freetown
Bissau
Malabo
Yaounde
Bangui
Libreville
Sao Tome
Kampala
Nairobi
Kigali
Bujumbura
Mombasa
Victoria
Mogadishu
Dodoma
Brazzaville
Kinshasa
Luanda
Lobito
Moroni
Lilongwe
Lusaka
Harare
Beira
Toamasina
Antananarivo
Port Louis
Windhoek
Gaborone
Pretoria
Mbabane
Maputo
Richards Bay
Maseru
Cape Town
Major Port
National Capital
TAH 01: Cairo - Dakar
TAH 02: Algiers - Lagos
TAH 03: Tripoli - Windhoek - Cape Town
TAH 04: Cairo - Gaborone - Cape Town
TAH 05: Dakar - N'djamena
TAH 06: N'djamena - Djibouti
TAH 07: Dakar - Lagos
TAH 08: Lagos - Mombassa
TAH 09: Beira - Lobito
TAH-10: Libreville - Djibouti
Kilometers
0
500
1,000



Road transport is one of the most important forms of transport in Africa. It connects countries, major cities, agricultural regions, industrial centres and seaports.

Some African roads are part of international transport corridors designed to facilitate trade between countries.

A. Trans-African Highway Network

The Trans-African Highway Network is a system of major road routes intended to connect different regions of Africa and improve continental trade and movement.

The network comprises nine principal highway routes.

The nine major Trans-African Highways

1. **Cairo–Dakar Highway**

Connects Cairo in Egypt to Dakar in Senegal.

Passes through parts of North and West Africa.

Promotes trade and movement between the two regions.

2. **Algiers–Lagos Highway**

Also known as the Trans-Saharan Highway.

Connects Algiers in Algeria to Lagos in Nigeria.

Passes through the Sahara Desert and Sahelian region.

Facilitates trade between North and West Africa.

3. **Tripoli–Windhoek–Cape Town Highway**

Connects North Africa with southern Africa.

Links Tripoli in Libya with Windhoek in Namibia and Cape Town in South Africa.

Promotes long-distance trade and regional connectivity.

4. **Cairo–Gaborone–Cape Town Highway**

Connects Egypt with southern Africa.

Passes through eastern and southern African countries.

Facilitates movement between North, East and Southern Africa.

5. **Dakar–N'Djamena Highway**

Connects Senegal in West Africa with Chad in Central Africa.

Facilitates trade and movement across the Sahelian region.

6. **N'Djamena–Djibouti Highway**

Connects Chad with Djibouti in the Horn of Africa.

Provides an important link between Central and Eastern Africa.

7. **Dakar–Lagos Highway**

Connects Senegal with Nigeria.

Passes through several West African coastal countries.

Promotes regional trade and movement within West Africa.

8. **Lagos–Mombasa Highway**

Connects Lagos in Nigeria with Mombasa in Kenya.

Links West Africa, Central Africa and East Africa.

Supports long-distance continental trade.

9. **Beira–Lobito Highway**

Connects Beira in Mozambique with Lobito in Angola.

Provides an important east-west connection across southern and central parts of Africa.

Supports trade and access to ports.

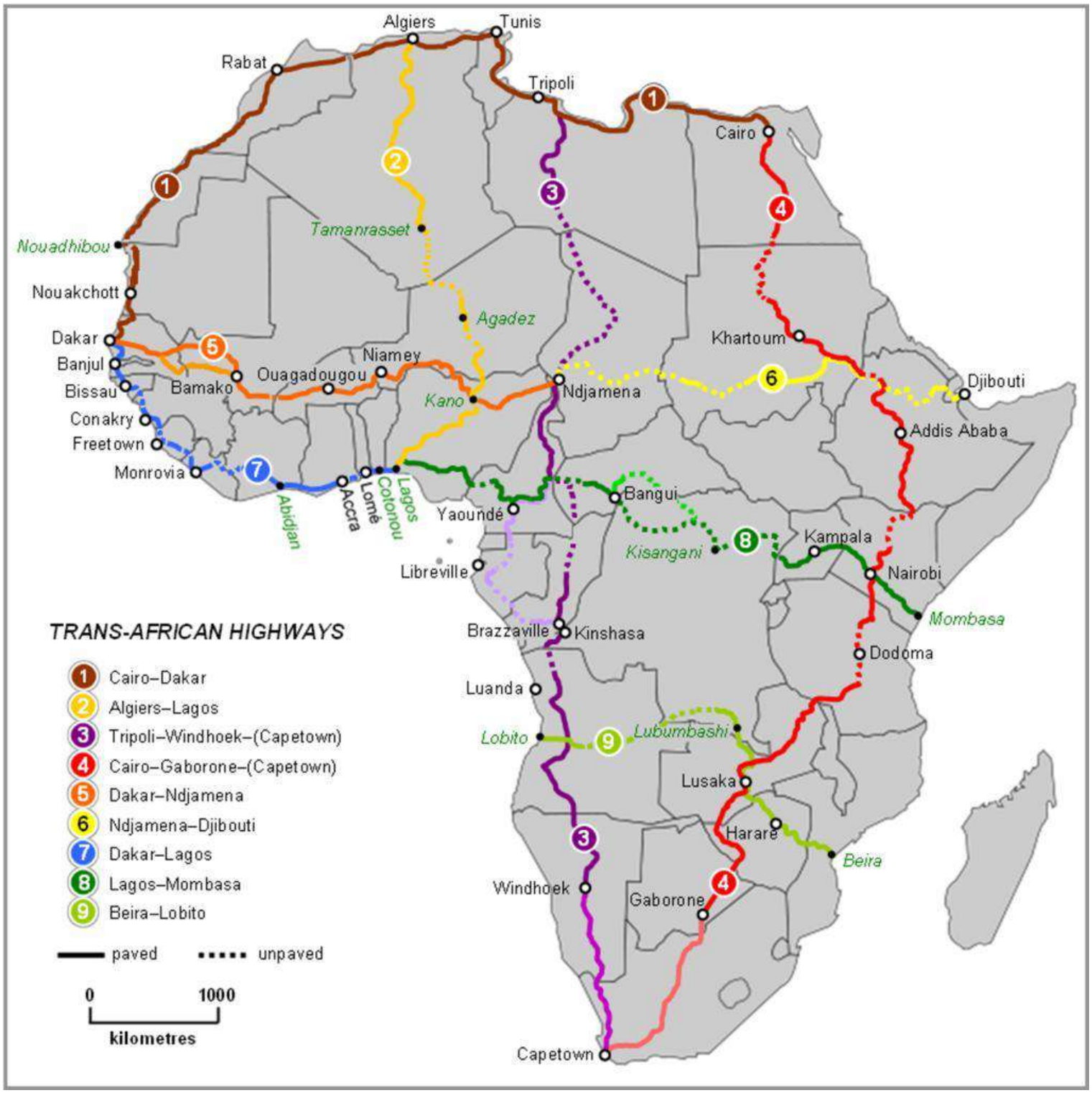


Figure 6.1: The Trans-African Highway Network. Learners should use an atlas to identify and trace the nine routes.

Importance of the Trans-African Highway Network

1. **Promotes continental trade:** The highways connect different countries, enabling the movement of agricultural products, manufactured goods and minerals.

2. **Promotes regional integration:** They encourage cooperation among African countries by improving physical connections.

3. **Facilitates international transportation:** The roads enable vehicles to transport goods across national boundaries.

4. **Promotes tourism:** Tourists can travel between countries to visit national parks, historical sites and cultural attractions.

5. **Creates employment:** Road construction, transport businesses, vehicle repair and logistics provide employment opportunities.

6. **Promotes industrial development:** Industries can obtain raw materials and distribute finished products more efficiently.

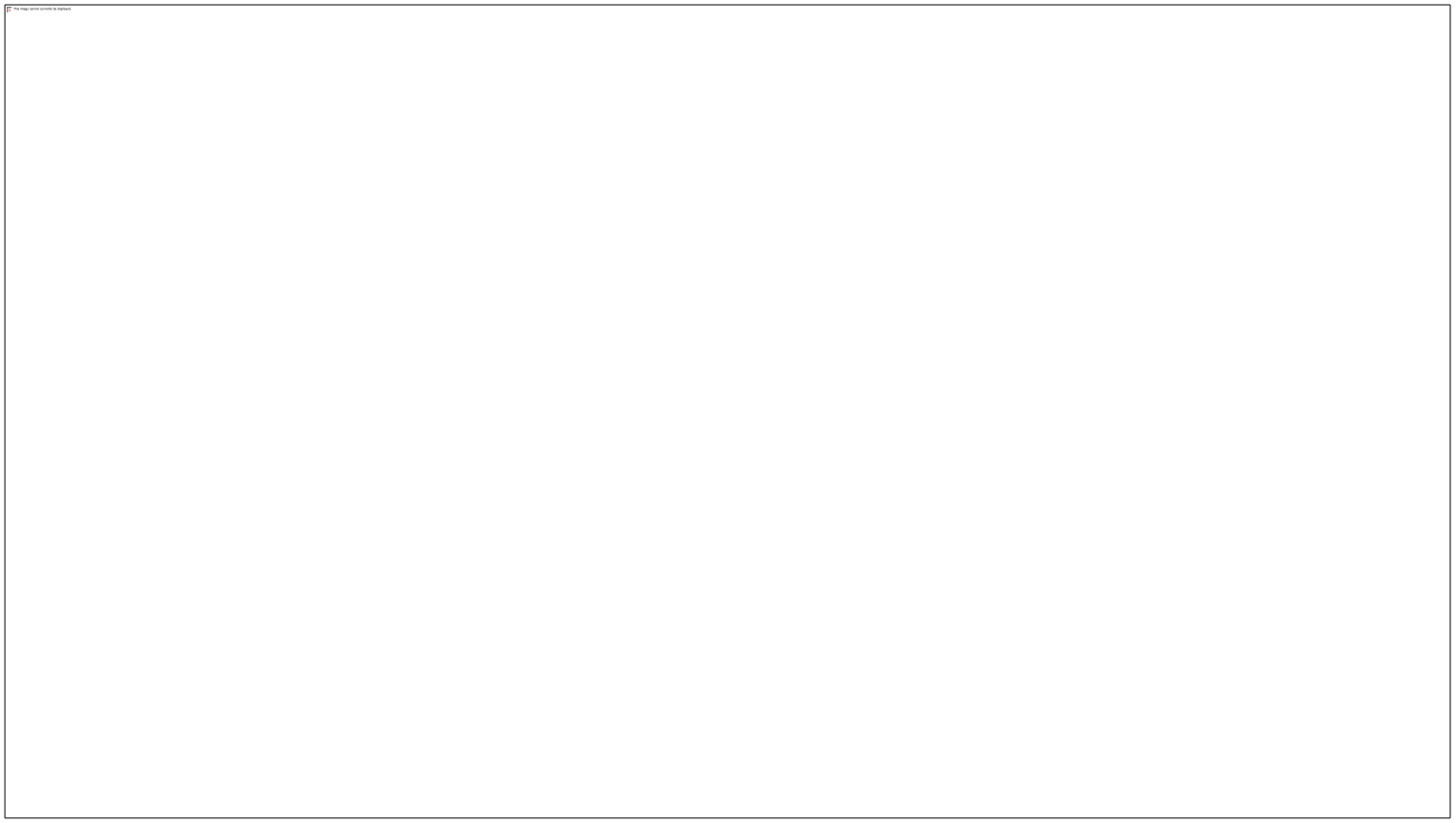
7. **Improves access to markets:** Farmers and traders can transport products to wider markets.

8. **Promotes investment:** Improved accessibility encourages investors to establish businesses along transport corridors.

9. **Facilitates cultural exchange:** People from different countries interact through travel and trade.

10. **Supports economic development:** Efficient road networks reduce transport barriers and promote economic activities.

B. The Northern Corridor



The Northern Corridor is a major regional transport and trade route linking the Port of Mombasa in Kenya to landlocked countries in East and Central Africa.

It is one of the most important transport corridors serving the East African region.

Major destinations and connections include:

Mombasa.

Nairobi.

Nakuru.

Eldoret.

Malaba.

Kampala.

Kigali through regional connections.

Bujumbura through regional connections.

Eastern Democratic Republic of Congo through regional connections.

South Sudan through regional connections.

Importance of the Northern Corridor

Connects landlocked countries to the Indian Ocean through the Port of Mombasa.

Facilitates the importation of fuel, machinery and manufactured goods.

Promotes the export of agricultural and industrial products.

Supports trade between Kenya and neighbouring countries.

Creates employment in transport and logistics.

Promotes regional economic integration.

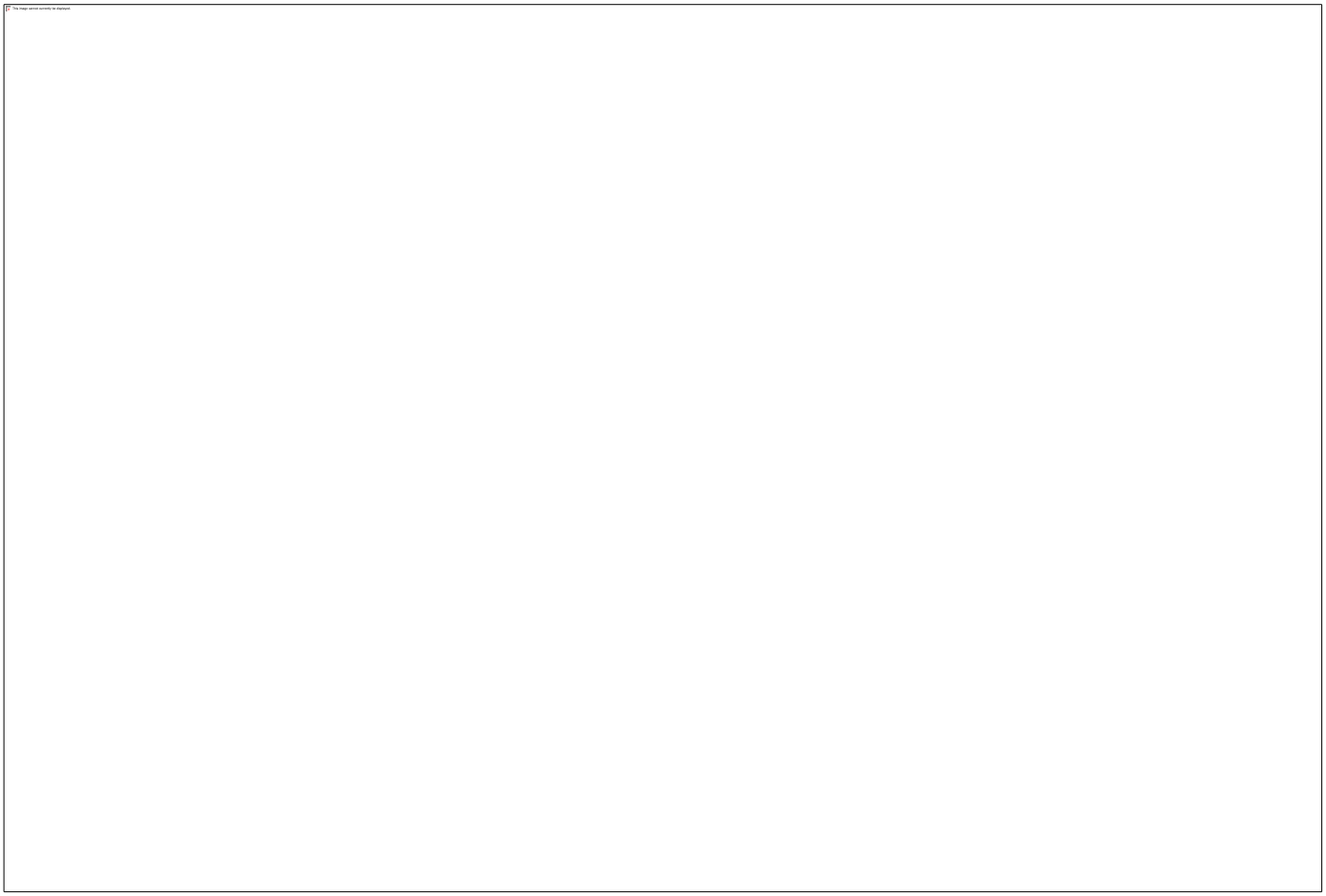
Encourages the development of towns along the corridor.

Facilitates the movement of containers from Mombasa to inland destinations.

Supports industrial development.

Improves access to international markets.

C. The Central Corridor



The Central Corridor is an important regional transport route linking the Port of Dar es Salaam in Tanzania with landlocked countries in East and Central Africa.

It serves countries such as:

Tanzania.

Rwanda.

Burundi.

Uganda through regional connections.

Democratic Republic of Congo.

Importance:

Provides access to the Indian Ocean through Dar es Salaam.

Facilitates the importation of goods into landlocked countries.

Supports the export of minerals and agricultural products.

Promotes trade between East and Central Africa.

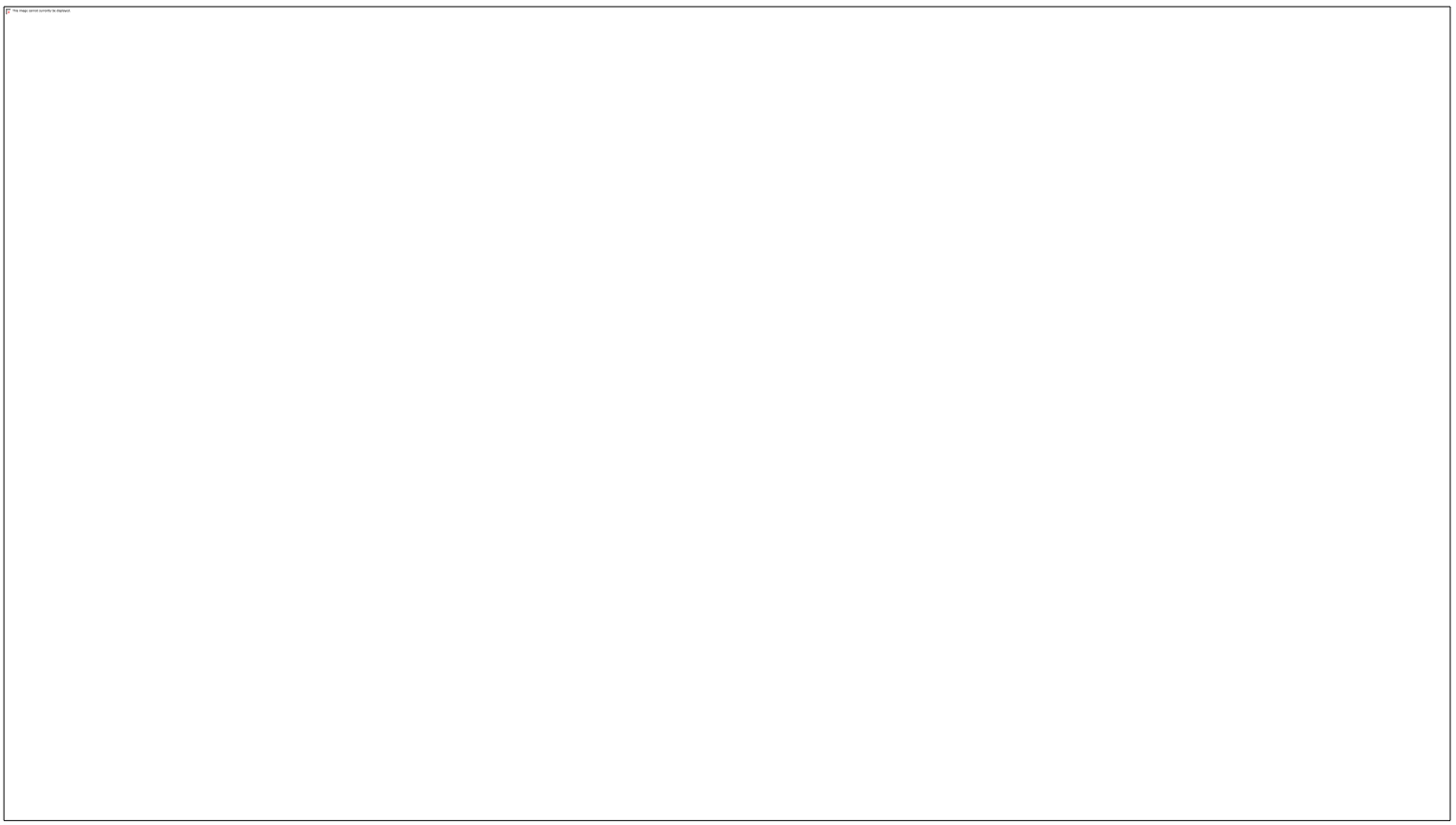
Encourages infrastructure development.

Promotes regional cooperation.

Reduces dependence on a single maritime gateway.

Creates employment opportunities.

D. West African Coastal Road Network



The West African coastal road network connects important cities and economic centres along the Atlantic Ocean.

It links countries such as:

Nigeria.

Benin.

Togo.

Ghana.

Côte d'Ivoire.

Liberia.

Sierra Leone.

Guinea.

Importance:

Promotes trade among West African countries.

Connects major coastal ports.

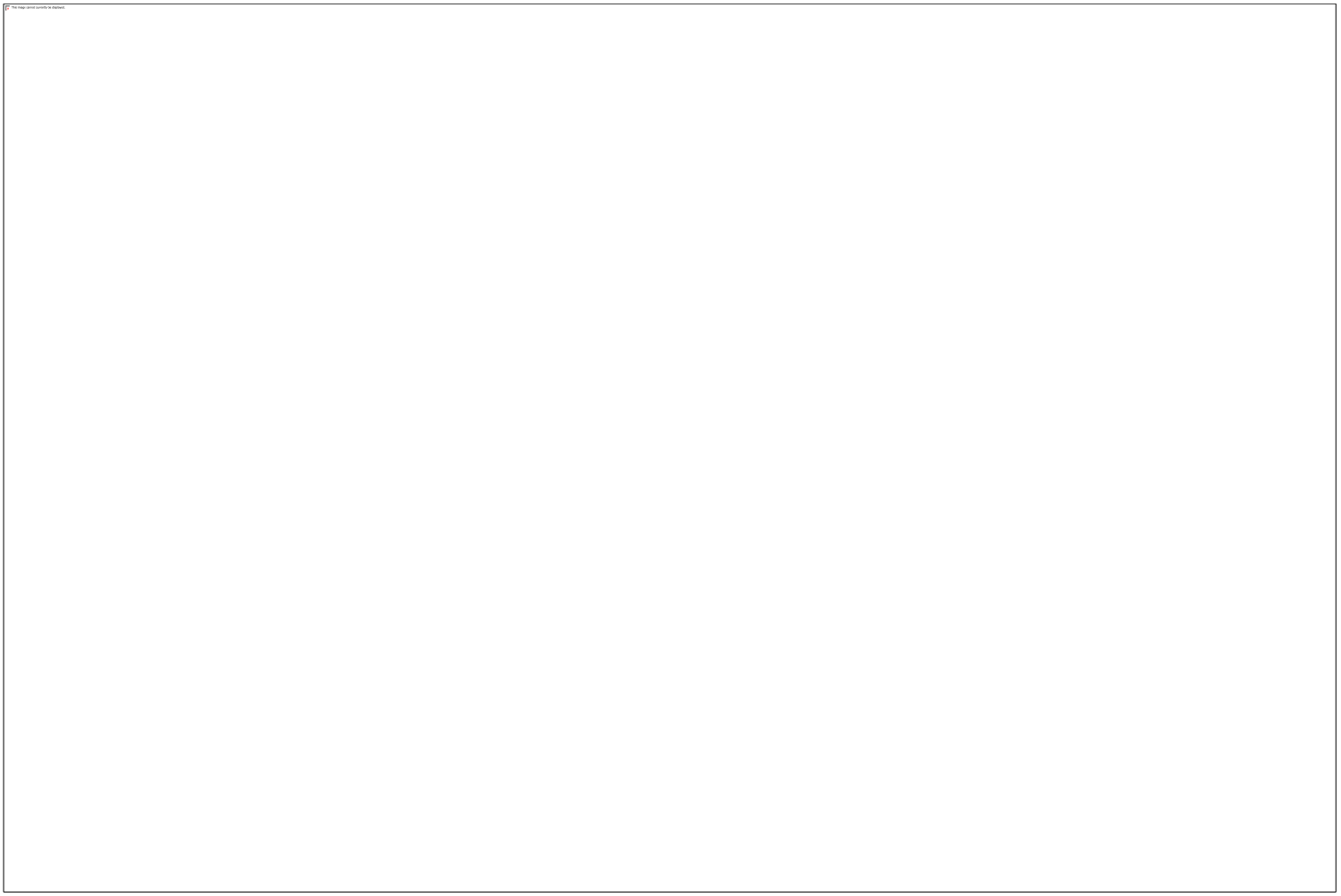
Facilitates tourism.

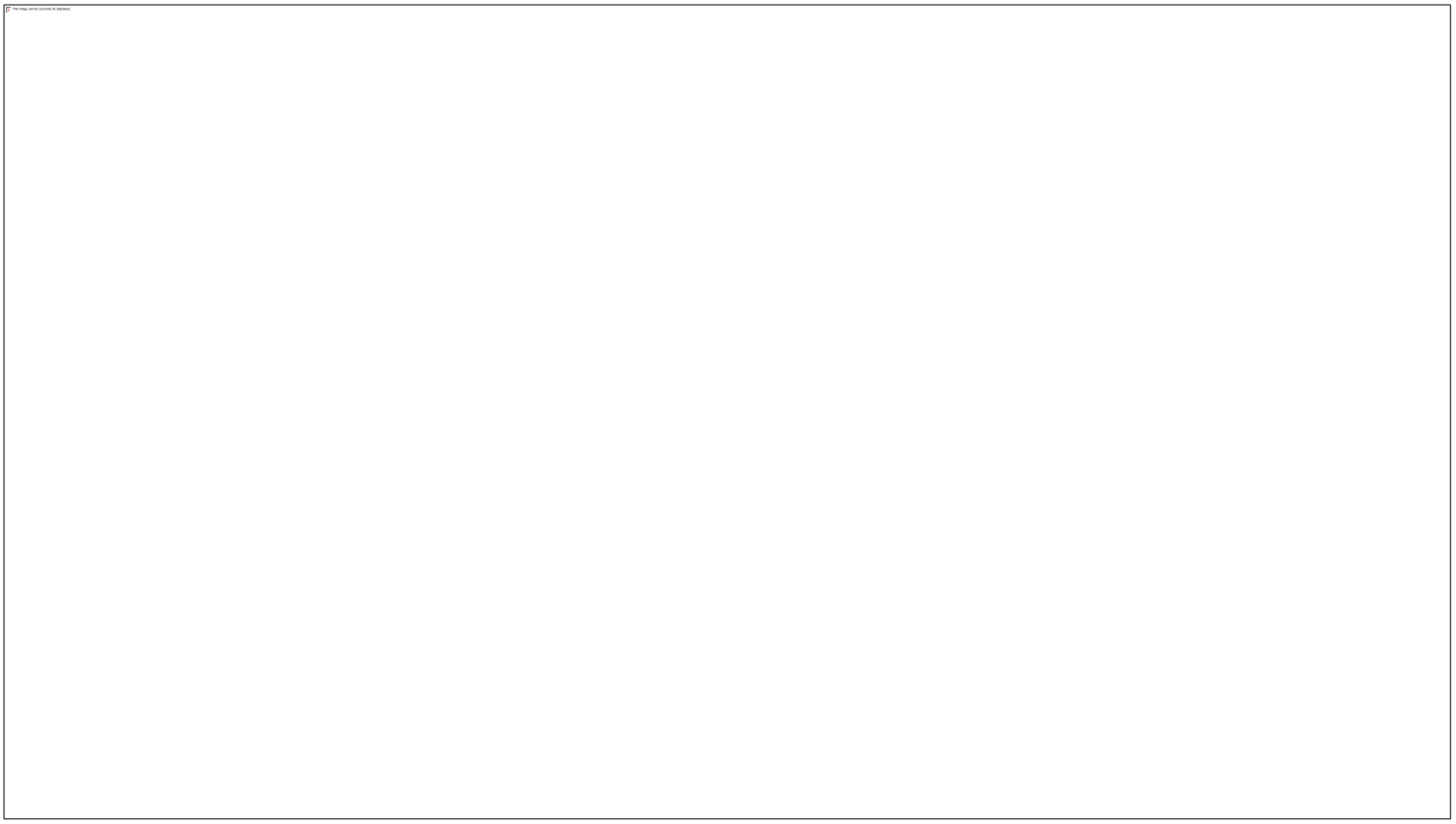
Supports movement of agricultural products.

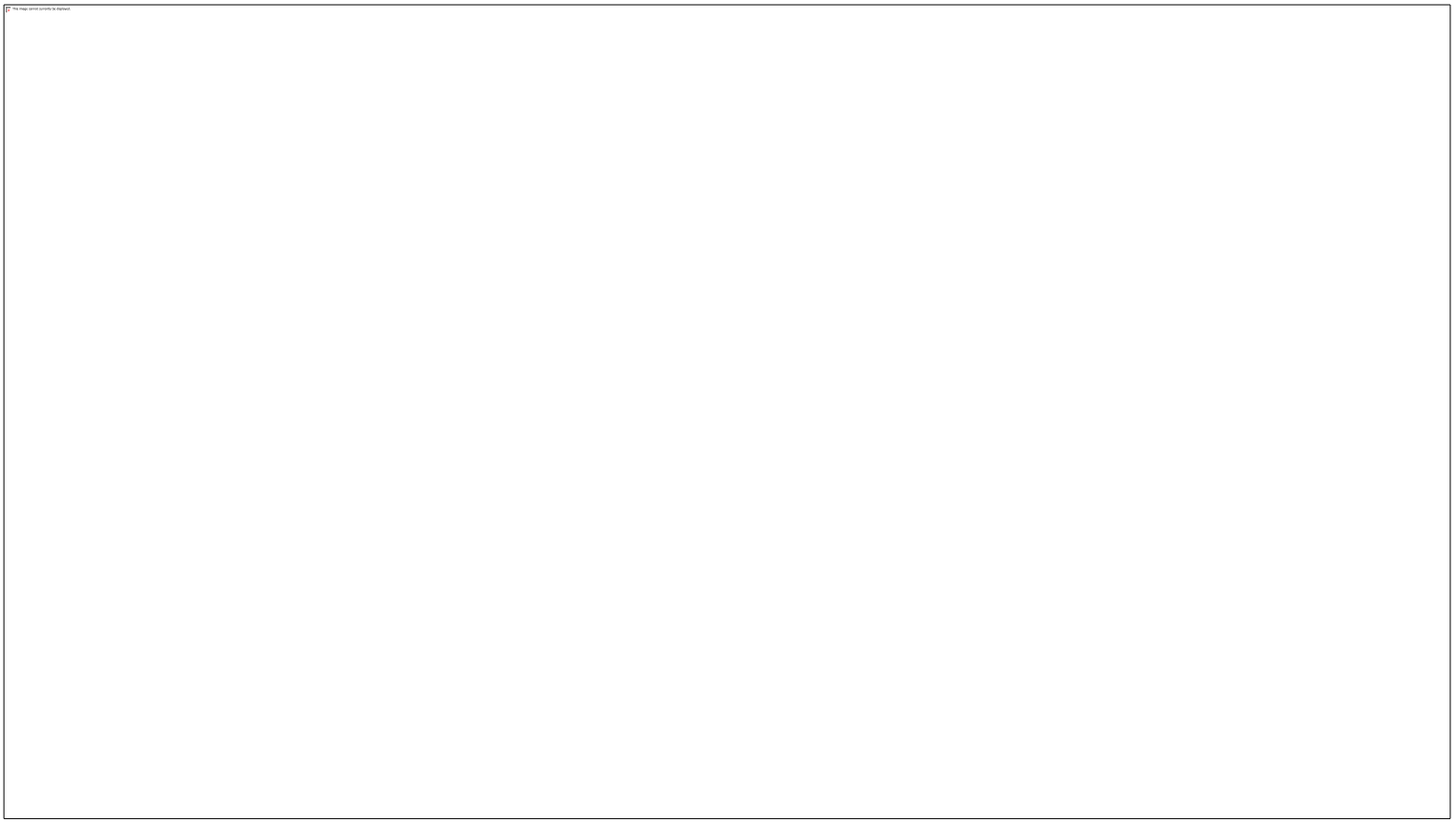
Promotes regional integration.

Improves access to industrial and commercial centres.

6.3 Major Railway Networks in Africa







Railway transport is important in Africa because it facilitates the movement of bulky goods, minerals, agricultural products and passengers.

However, railway networks are unevenly distributed. Countries such as South Africa, Egypt and Morocco have relatively extensive railway systems, while several other countries have limited railway coverage.

Major Railway Networks and Routes in Africa

A. Kenya–Uganda Railway

Historically developed as part of the Uganda Railway.

Connects Mombasa with inland areas of Kenya and historically extended to Kampala in Uganda.

Facilitates transportation of passengers and goods.

Has played a significant role in the economic development of East Africa.

B. Tanzania Central Railway Line

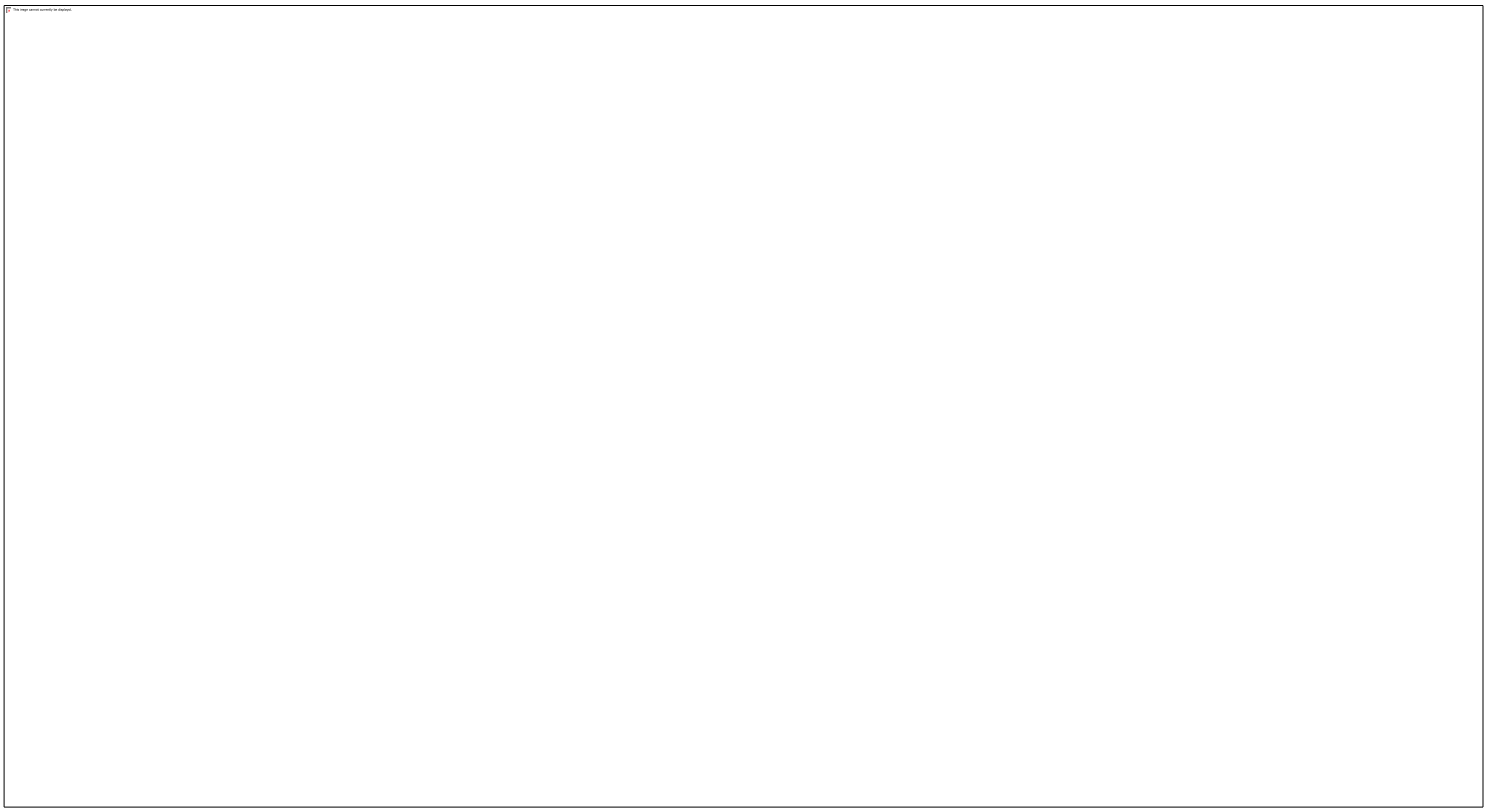
Connects Dar es Salaam with inland parts of Tanzania.

Provides access to important agricultural and commercial regions.

Supports transportation of goods and passengers.

Has connections and links with regional transport systems.

C. Ethiopia–Djibouti Railway



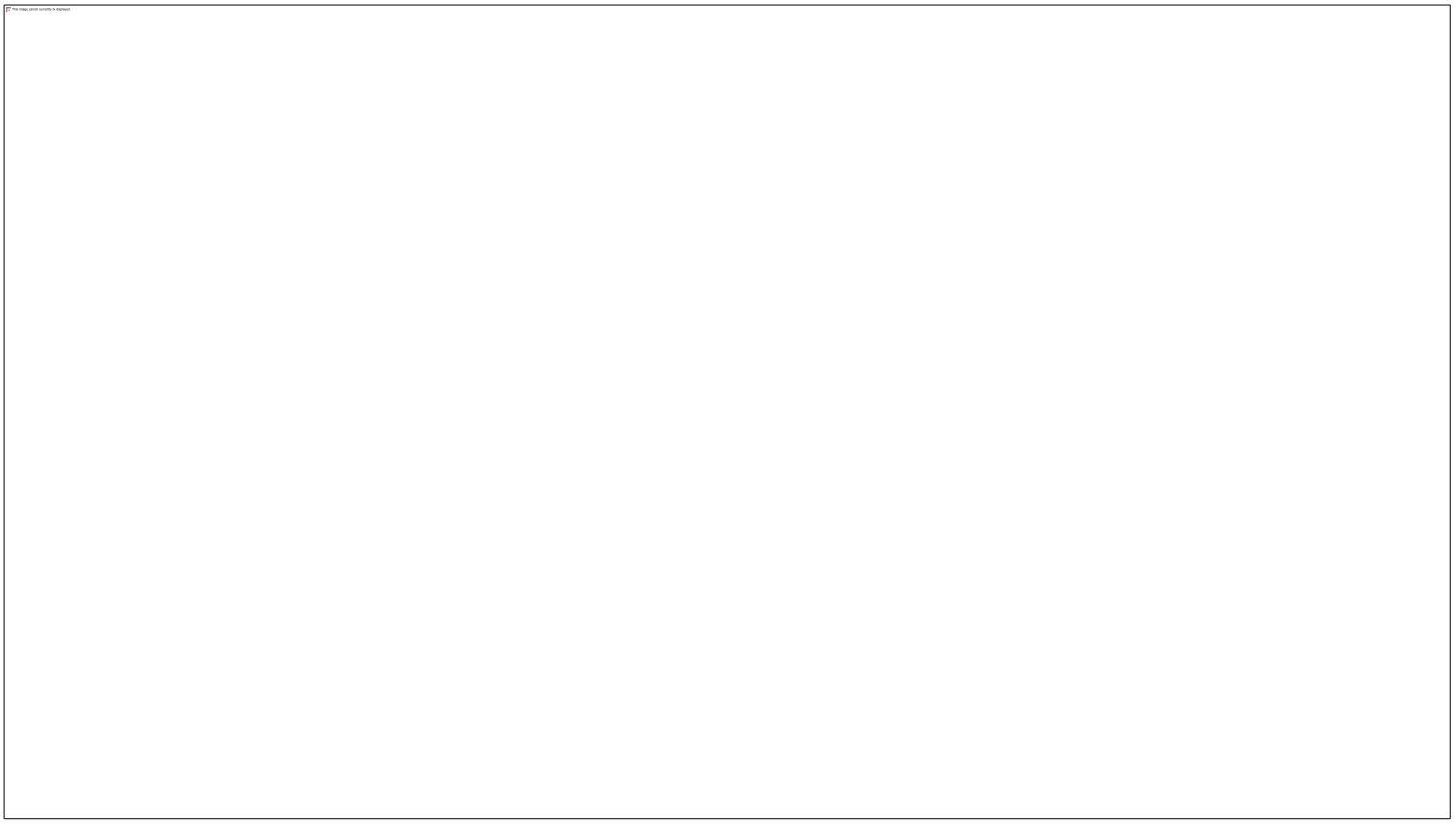
Connects Addis Ababa in Ethiopia with the Port of Djibouti.

Provides landlocked Ethiopia with access to a major seaport.

Facilitates the transportation of passengers and cargo.

Promotes international trade.

D. South African Railway Network



South Africa has one of the most extensive railway networks in Africa.

The network connects mining regions, industrial centres, ports and major cities.

It is important for transporting coal, iron ore, manganese and other minerals.

It supports passenger and freight transportation.

E. North African Railway Network

Countries such as Egypt, Morocco, Algeria and Tunisia have important railway systems.

The networks connect major cities and industrial centres.

They facilitate passenger and freight movement.

Morocco has developed modern high-speed passenger railway services.

Importance of Railway Networks in Africa

Facilitate transportation of minerals.

Connect landlocked countries to seaports.

Promote international trade.

Reduce pressure on road networks.

Support industrial development.

Create employment.

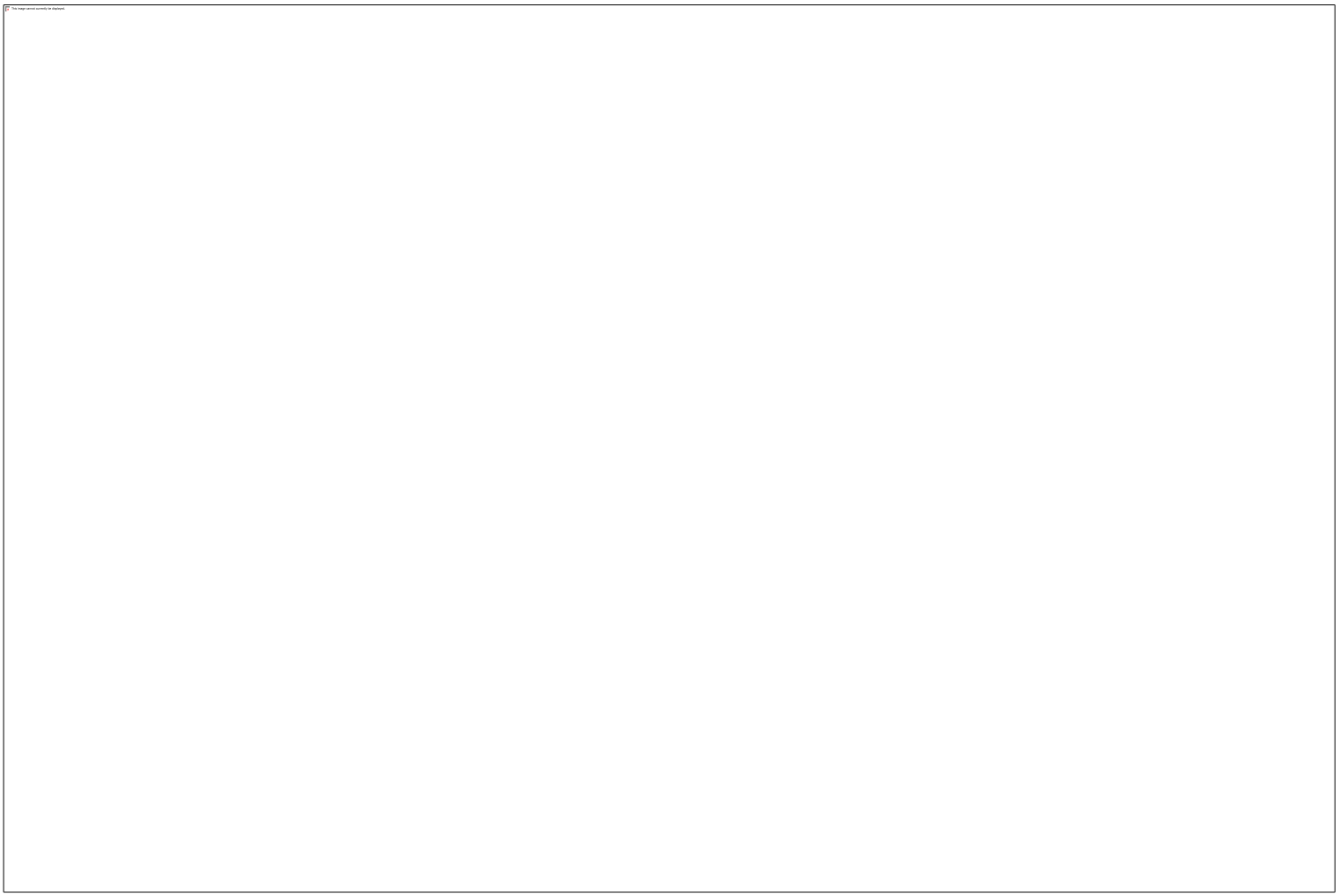
Promote tourism.

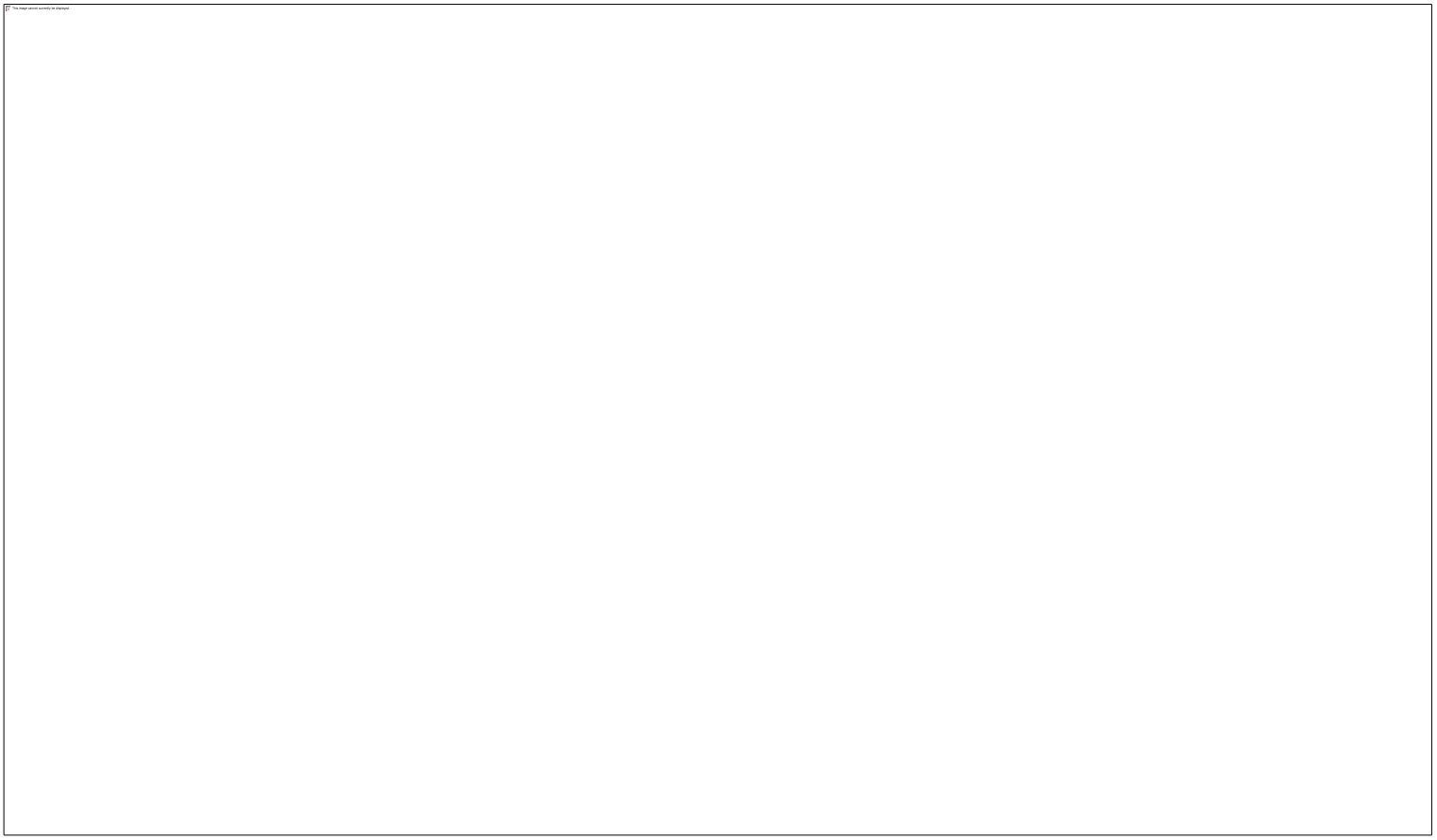
Facilitate regional integration.

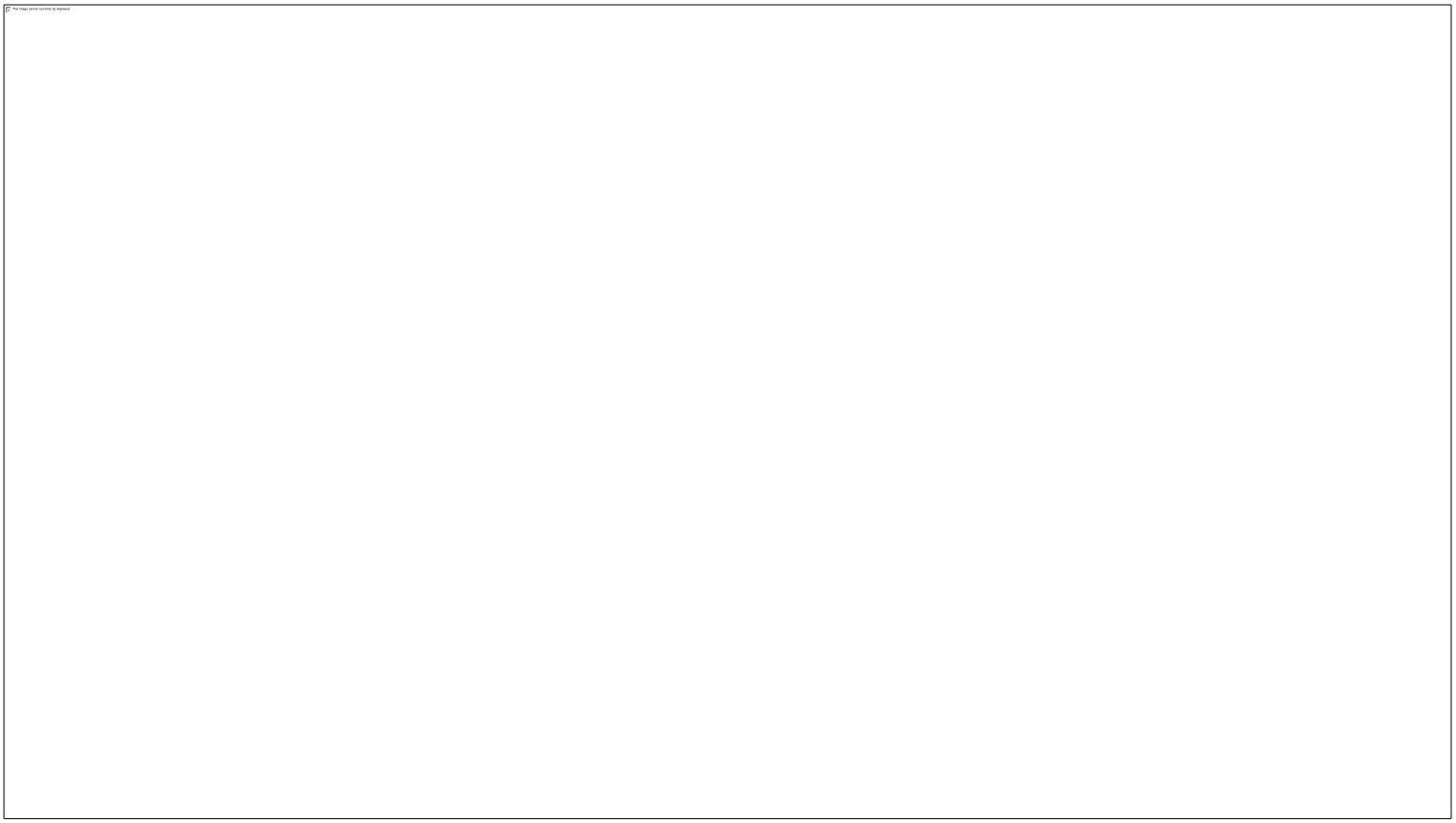
Reduce the cost of transporting bulky goods over suitable long distances.

Encourage development of towns and commercial centres.

6.4 Major Water Transport Networks in Africa







Africa is surrounded by the Atlantic Ocean, Indian Ocean and Mediterranean Sea. It also has important inland water bodies, including Lake Victoria, Lake Tanganyika and Lake Malawi.

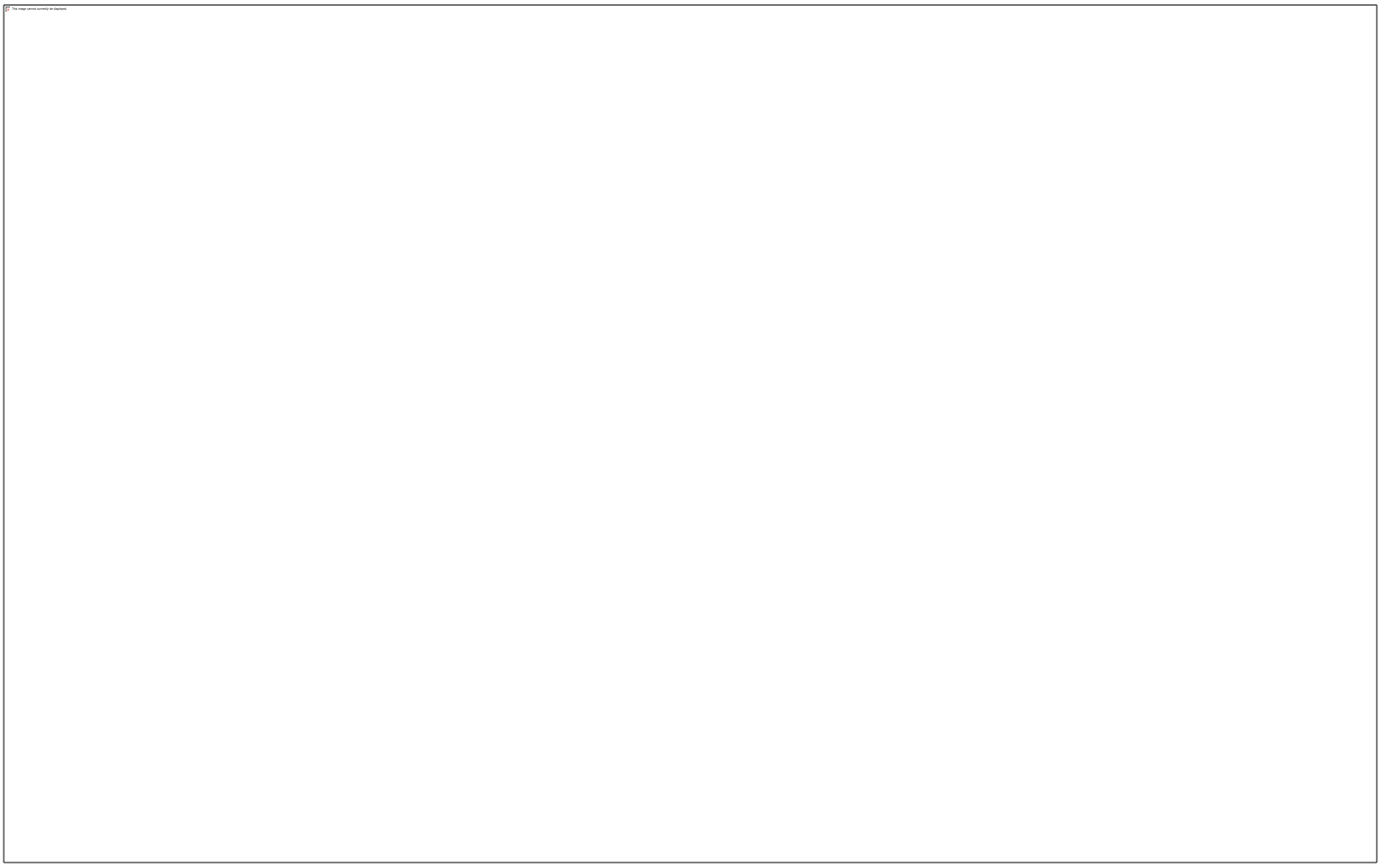
Water transport is therefore important in facilitating international and inland trade.

Major Seaports in Africa

Port	Country	Importance
Mombasa	Kenya	Major gateway to East Africa.
Dar es Salaam	Tanzania	Serves Tanzania and neighbouring landlocked countries.
Durban	South Africa	Important commercial and industrial port.
Cape Town	South Africa	Supports international trade and shipping.
Lagos/Apapa	Nigeria	Serves Nigeria's commercial and industrial activities.
Tema	Ghana	Important West African trade gateway.
Abidjan	Côte d'Ivoire	Facilitates regional and international trade.
Dakar	Senegal	Important port in West Africa.
Djibouti	Djibouti	Serves Ethiopia and regional trade.
Port Said	Egypt	Located near the Mediterranean entrance to the Suez Canal.
Alexandria	Egypt	Important Mediterranean seaport.
Casablanca	Morocco	Supports international trade in North Africa.
Port Sudan	Sudan	Important Red Sea port.
Lobito	Angola	Supports trade and mineral transportation.

Major Inland Water Transport Routes

A. Lake Victoria



Lake Victoria is shared by Kenya, Uganda and Tanzania.

It supports:

Passenger transportation.

Fishing activities.

Cargo transportation.

Tourism.

Trade among lakeside communities.

B. River Nile

The Nile River flows through several countries in northeastern Africa.

It supports:

Inland transportation in navigable sections.

Fishing.

Agriculture.

Tourism.

Economic activities along river settlements.

C. Congo River

The Congo River and its tributaries form an important inland water transport system in Central Africa.

They facilitate transportation in areas where road and railway networks are poorly developed.

D. Niger River

The Niger River is important in West Africa, especially in Mali, Niger and Nigeria.

It supports:

Inland water transportation.

Fishing.

Agricultural activities.

Trade between river settlements.

Tourism.

6.5 Major Air Transport Networks in Africa





Air transport connects African countries with one another and with other continents.

It is particularly important because of the long distances separating some African countries and the challenges of developing road and railway infrastructure in certain regions.

Major International Airports in Africa

Airport	Country	City
Jomo Kenyatta International Airport	Kenya	Nairobi

Addis Ababa Bole International Airport	Ethiopia	Addis Ababa
OR Tambo International Airport	South Africa	Johannesburg
Cairo International Airport	Egypt	Cairo
Murtala Muhammed International Airport	Nigeria	Lagos
Kotoka International Airport	Ghana	Accra
Mohammed V International Airport	Morocco	Casablanca
Houari Boumediene Airport	Algeria	Algiers
Entebbe International Airport	Uganda	Entebbe
Julius Nyerere International Airport	Tanzania	Dar es Salaam

Importance of Air Transport Networks in Africa

Connect major African cities.

Facilitate international tourism.

Promote international trade.

Transport high-value and perishable goods.

Facilitate medical evacuation.

Support diplomatic relations.

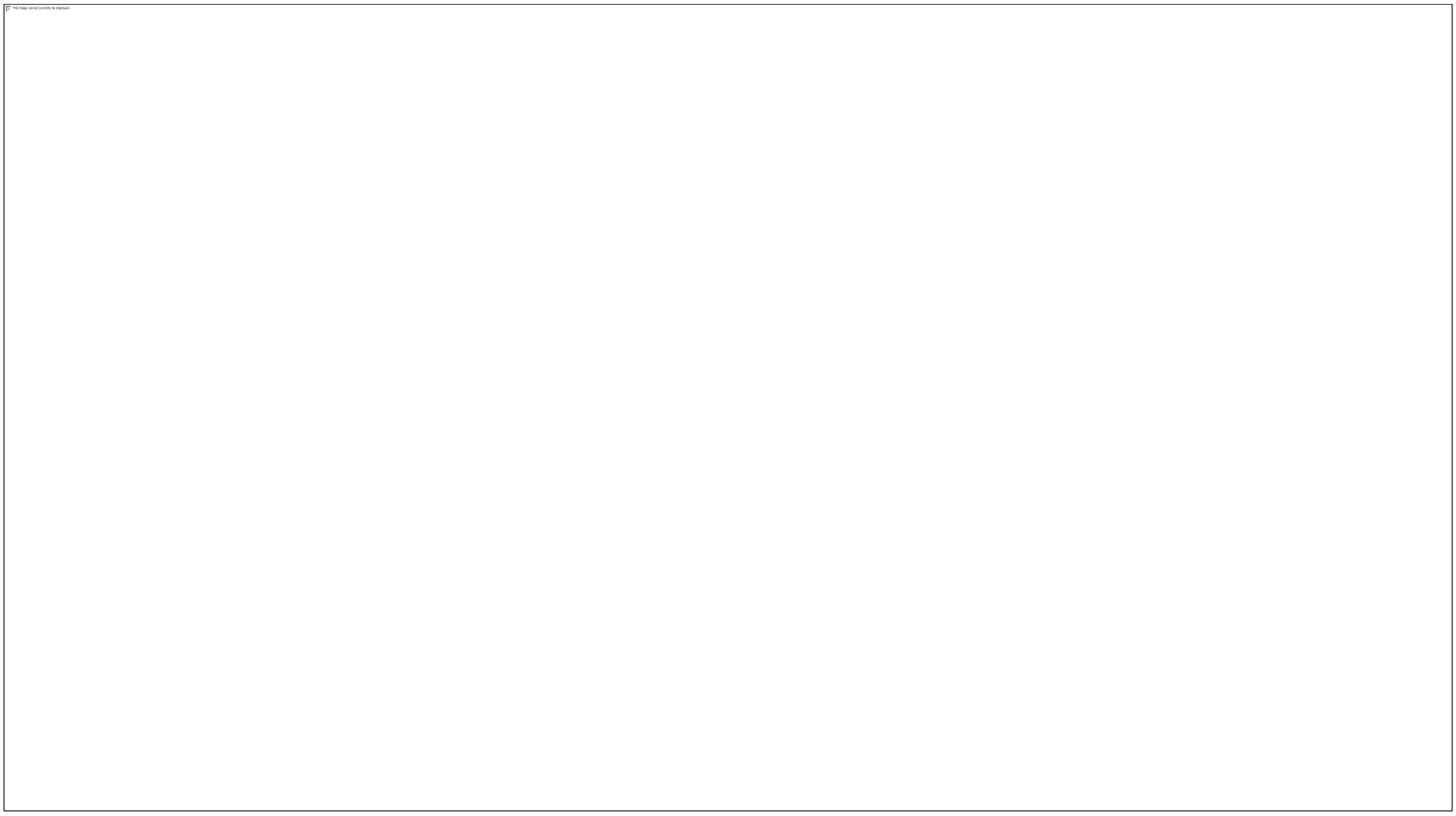
Create employment opportunities.

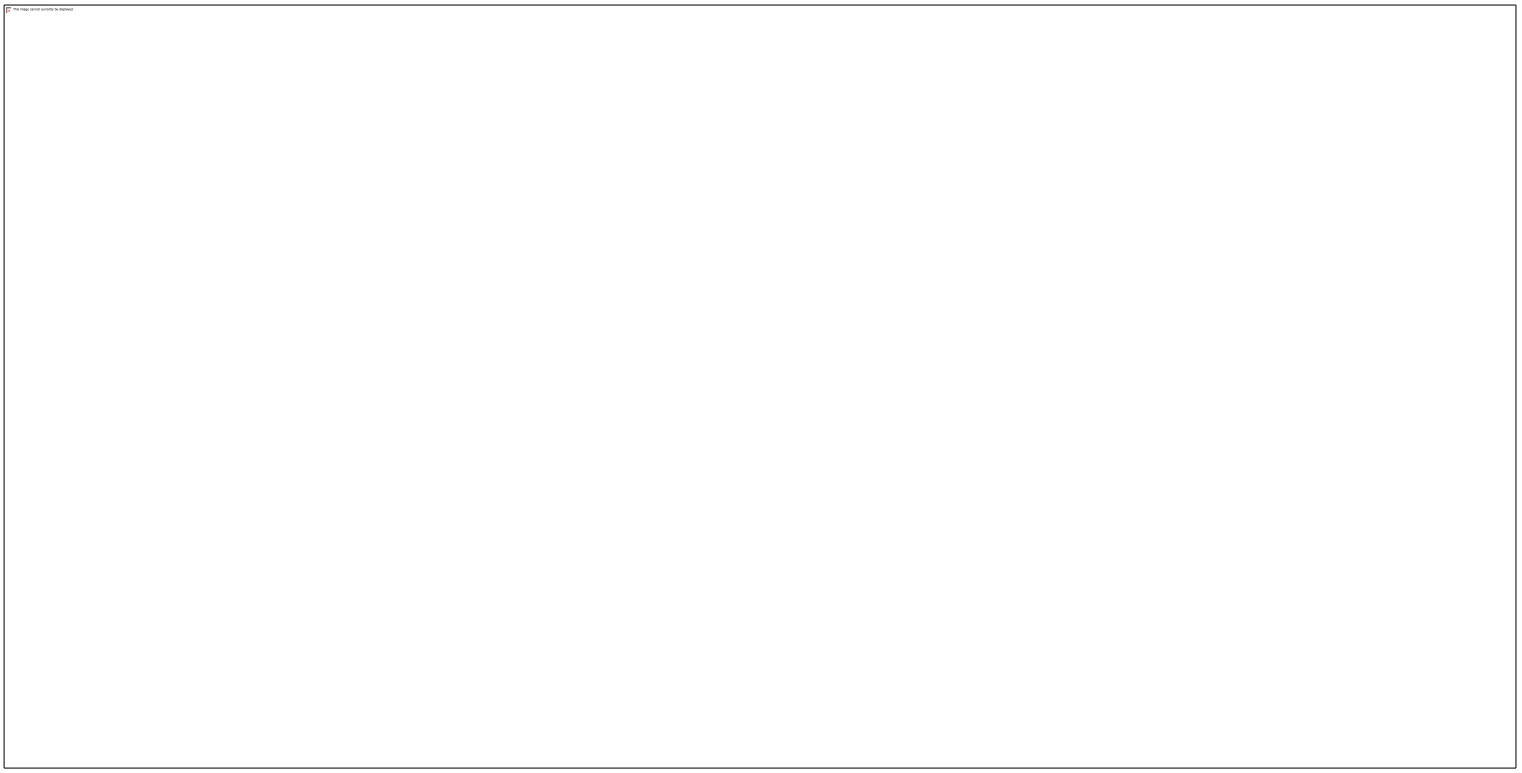
Promote investment.

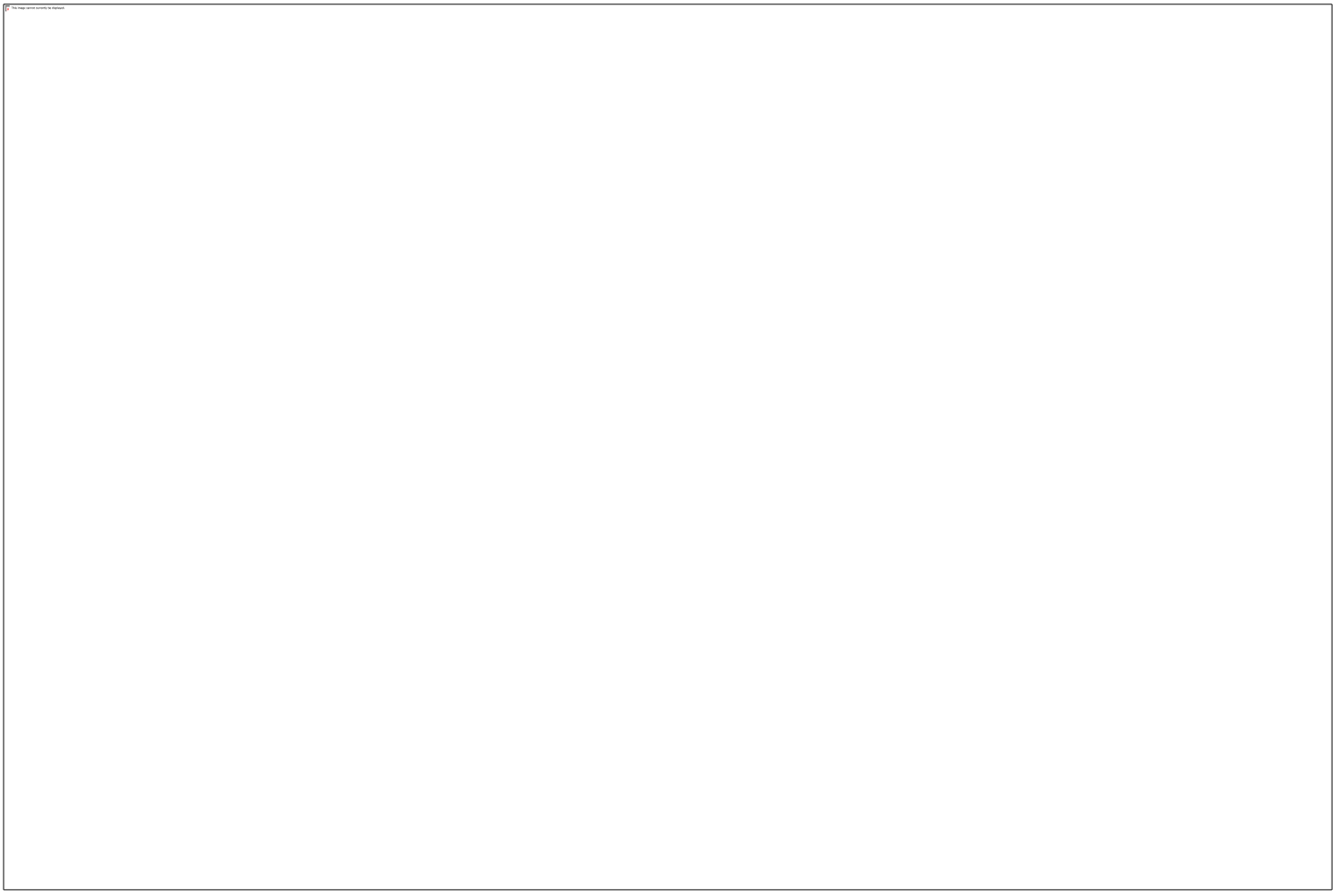
Facilitate disaster relief operations.

Promote continental integration.

6.6 Major Pipeline Networks in Africa







Pipeline transport is used in Africa mainly to move crude oil, refined petroleum products, natural gas and water.

Examples of Pipeline Systems in Africa

1. **Kenya petroleum pipeline network**

Transports petroleum products from coastal facilities towards inland distribution centres.

Supports fuel supply in Kenya and regional markets.

2. **West African Gas Pipeline**

Transports natural gas from Nigeria towards Benin, Togo and Ghana.

Supports energy supply and industrial development.

3. **Chad–Cameroon Petroleum Pipeline**

Transports crude oil from oil-producing areas in Chad to the Atlantic coast of Cameroon.

Facilitates petroleum exports.

4. **Arab Gas Pipeline**

A regional natural gas pipeline system serving parts of the Middle East and North Africa.

Supports regional energy transportation.

5. **East African Crude Oil Pipeline project**

Designed to transport crude oil from Uganda's oil-producing region towards the export terminal at Tanga in Tanzania.

It is an important regional energy infrastructure project.

Importance of Pipeline Networks

Facilitate petroleum transportation.

Promote regional energy cooperation.

Support industrial development.

Reduce reliance on road tankers for suitable petroleum transportation.

Facilitate international energy trade.

Create employment.

Promote investment in energy infrastructure.

7.0 MAJOR TRANSPORT CORRIDORS IN AFRICA

A **transport corridor** is a geographical route consisting of interconnected transport infrastructure and supporting facilities that facilitate the movement of people and goods between economic centres, ports and countries.

Transport corridors may include roads, railways, pipelines, border facilities, ports and logistics centres.

7.1 Major Transport Corridors

A. Northern Corridor

Starts at the Port of Mombasa in Kenya.

Connects Kenya with Uganda and other neighbouring countries.

Supports international and regional trade.

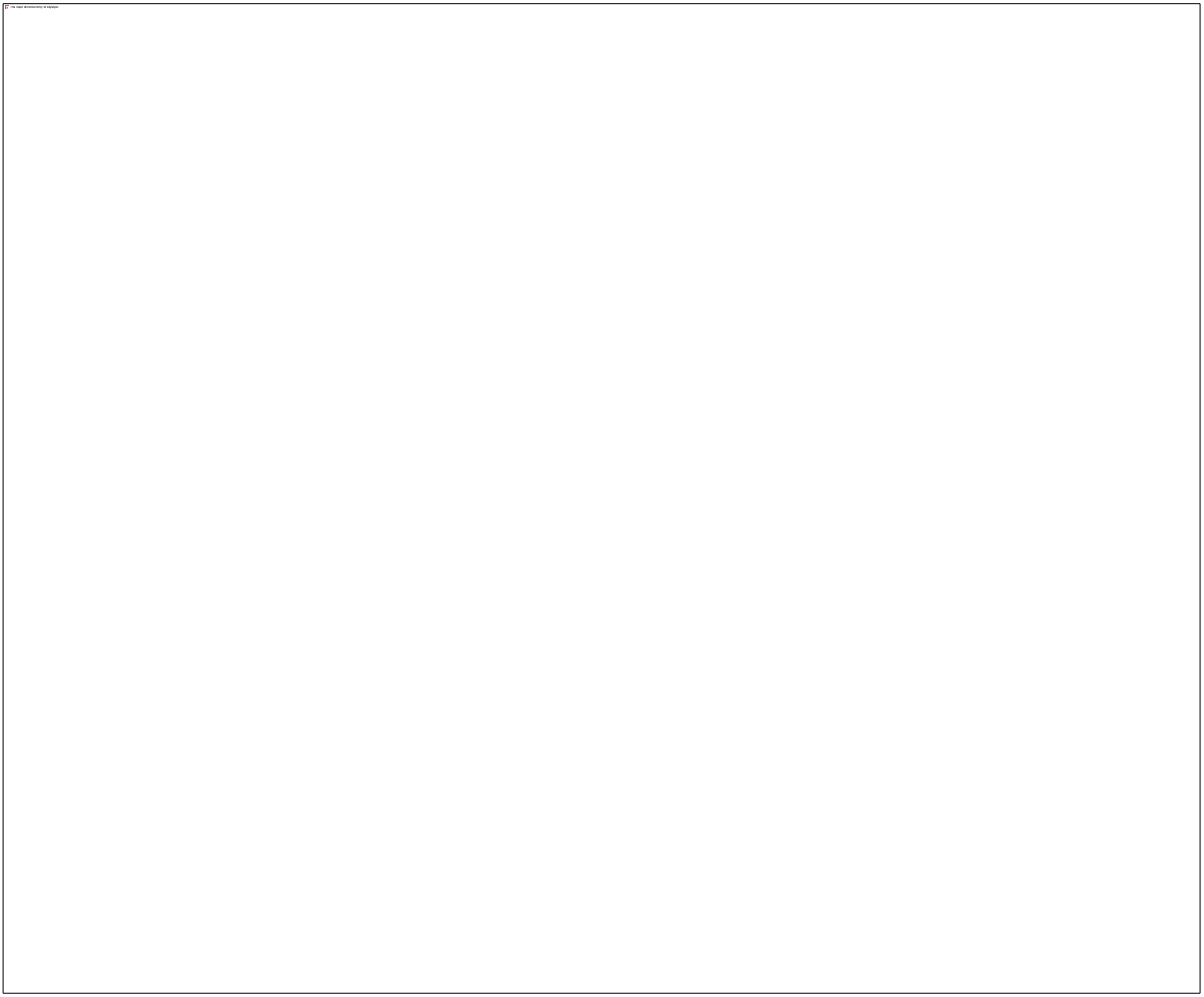
B. Central Corridor

Starts at the Port of Dar es Salaam in Tanzania.

Connects Tanzania with Rwanda, Burundi and the Democratic Republic of Congo through regional transport links.

Promotes trade and access to the Indian Ocean.

C. LAPSSET Corridor



LAPSSET stands for Lamu Port–South Sudan–Ethiopia Transport Corridor.

It is a major regional infrastructure programme designed to connect Kenya, Ethiopia and South Sudan.

Main components include:

Lamu Port.

Highways.

Railway infrastructure.

Oil pipeline infrastructure as planned.

Airports.

Resort cities.

Supporting logistics facilities.

Importance of LAPSSET:

Opens up northern Kenya for economic development.

Provides access to the Indian Ocean for regional countries.

Promotes trade with Ethiopia and South Sudan.

Creates employment opportunities.

Promotes tourism.

Encourages infrastructure investment.

Promotes regional integration.

Supports development of transport and logistics services.

D. Maputo Development Corridor



The Maputo Development Corridor connects the industrial region of Gauteng in South Africa with the Port of Maputo in Mozambique.

Importance:

Facilitates exportation of minerals and manufactured goods.

Improves access to the Port of Maputo.

Promotes regional trade.

Encourages industrial investment.

Creates employment opportunities.

Promotes cooperation between South Africa and Mozambique.

E. Abidjan–Lagos Corridor

The Abidjan–Lagos Corridor connects important coastal cities in West Africa.

It links Côte d'Ivoire, Ghana, Togo, Benin and Nigeria.

Importance:

Promotes trade among West African countries.

Improves movement of people.

Facilitates access to major seaports.

Promotes tourism.

Supports regional economic integration.

Encourages investment along the corridor.

8.0 MAJOR COMMUNICATION NETWORKS IN AFRICA

Communication networks are essential in connecting people, institutions and countries across Africa.

The development of telecommunications, mobile phones, fibre-optic cables, broadcasting and satellite systems has improved information exchange.

8.1 Mobile Telephone Networks



Mobile telephone networks use cellular technology to provide voice, messaging and internet services.

Examples of mobile network operators in Africa include:

Safaricom.

Airtel.

MTN.

Orange.

Vodacom.

Ethio Telecom.

Importance:

Enables communication across national borders.

Supports mobile money services.

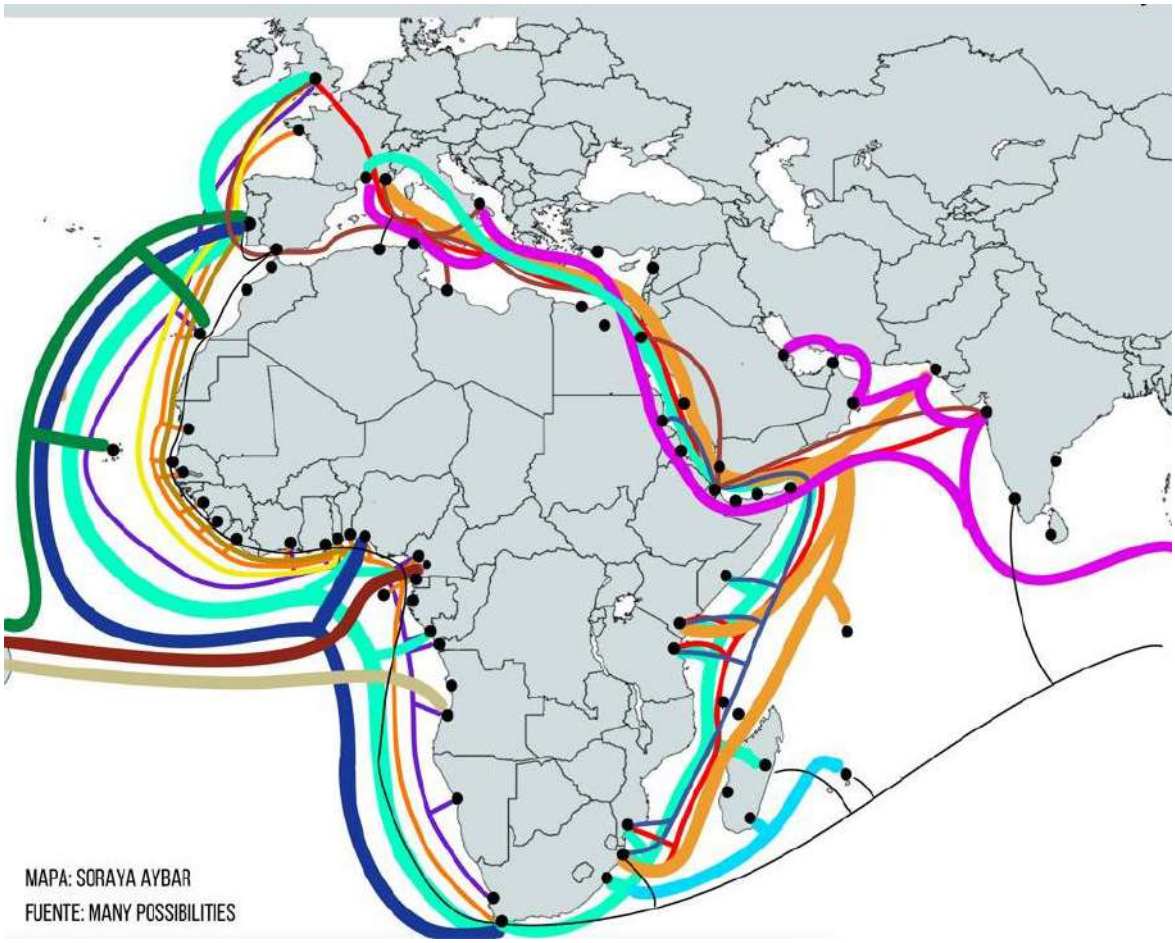
Promotes business development.

Supports emergency response.

Facilitates access to digital education.

Promotes social interaction.

8.2 Fibre-Optic Communication Networks



Fibre-optic networks transmit information using light signals through optical fibres.

Africa is connected to the global internet through several submarine fibre-optic cable systems and terrestrial networks.

Examples include:

SEACOM.

EASSy (Eastern Africa Submarine Cable System).

TEAMS (The East African Marine System).

2Africa.

WACS (West Africa Cable System).

ACE (Africa Coast to Europe).

Importance:

Provides high-speed internet.

Improves international communication.

Supports online business.

Promotes e-learning.

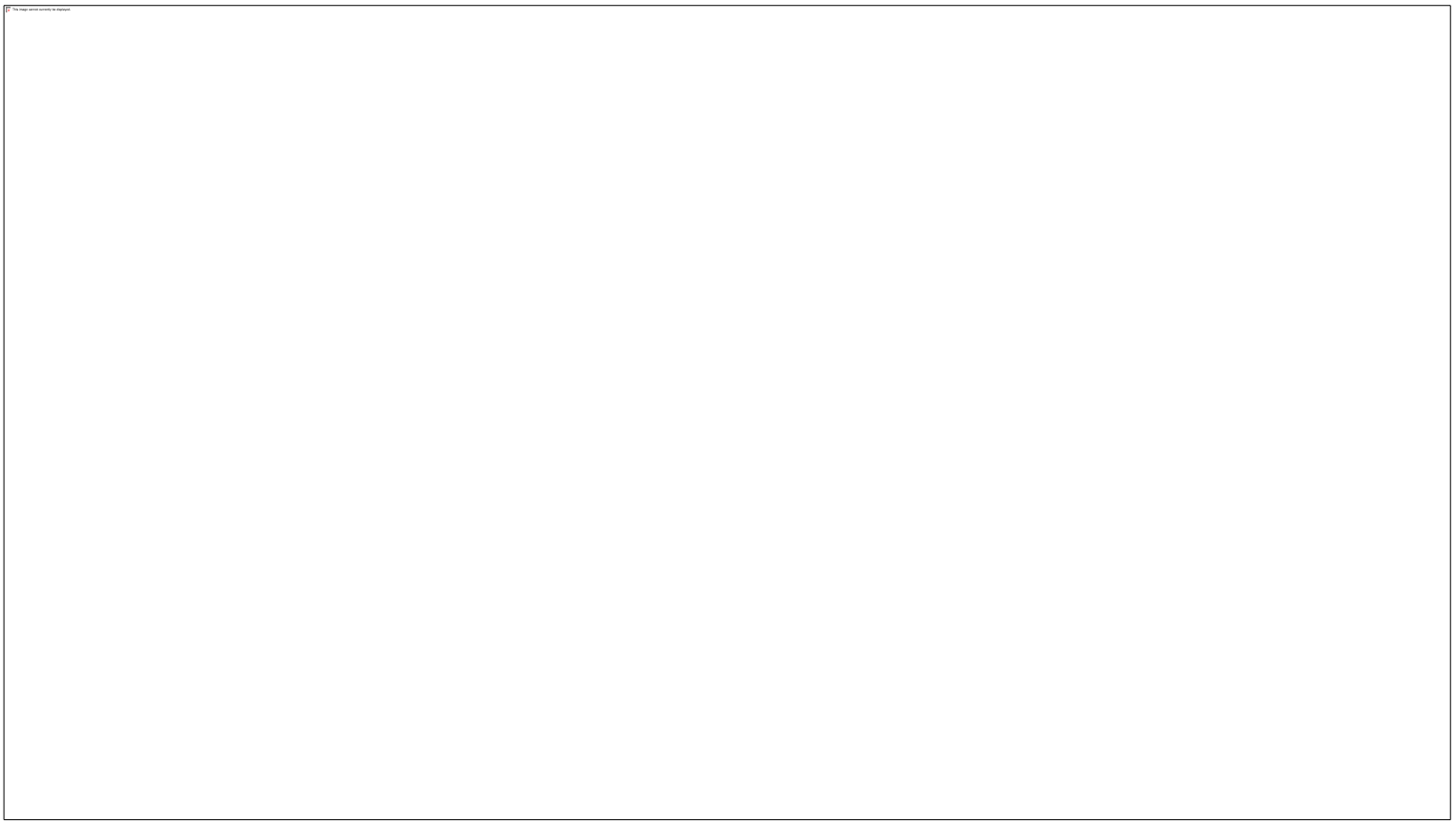
Supports digital banking.

Facilitates research and innovation.

Improves access to international information.

Supports international data exchange.

8.3 Radio and Television Broadcasting Networks



Radio and television networks transmit information to large populations across different geographical areas.

Examples include:

Kenya Broadcasting Corporation.

South African Broadcasting Corporation.

Ghana Broadcasting Corporation.

Nigerian Television Authority.

Ethiopian Broadcasting Corporation.

Importance:

Educates the public.

Provides news and entertainment.

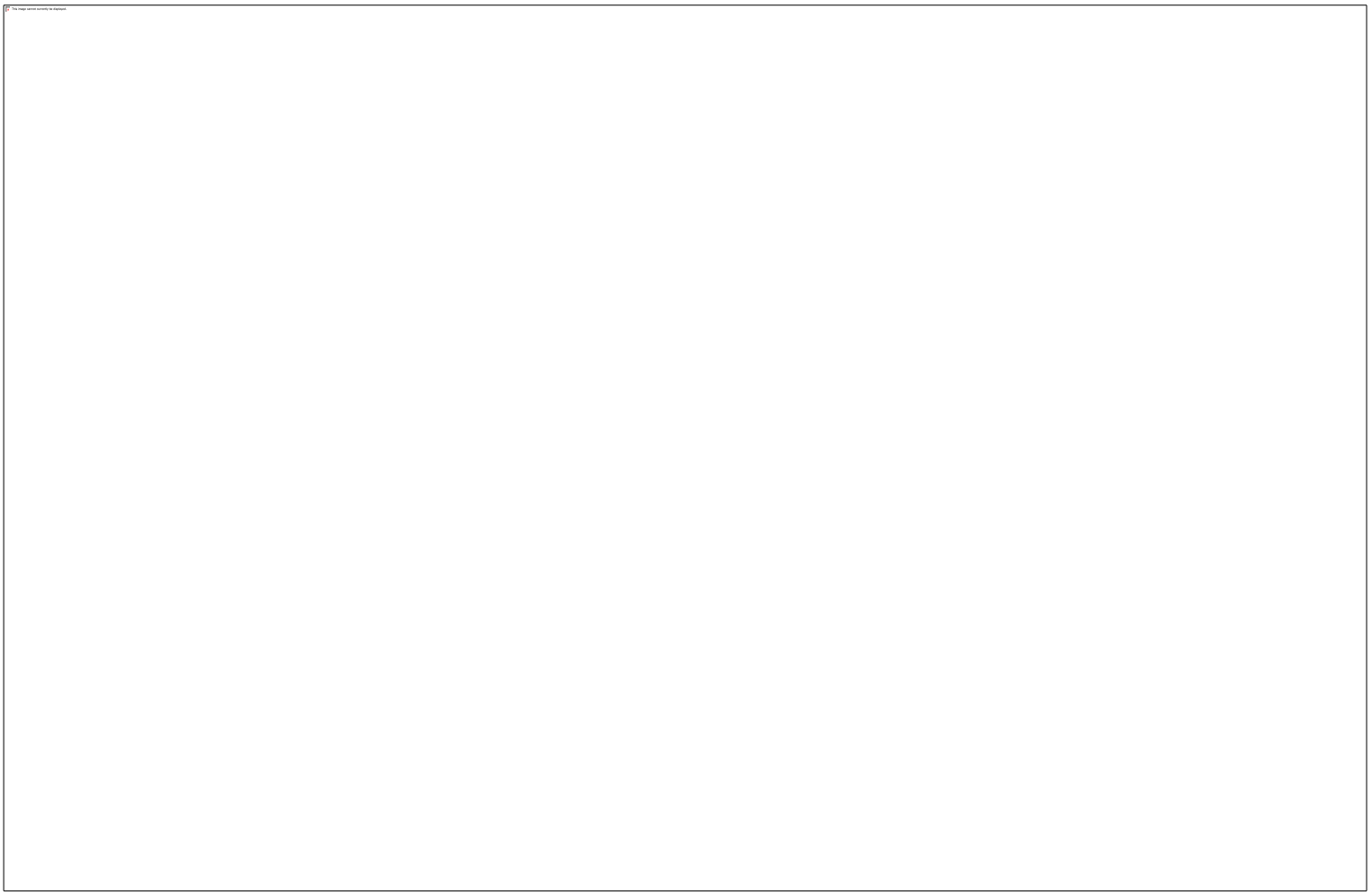
Promotes cultural exchange.

Supports public awareness campaigns.

Communicates emergency warnings.

Promotes national unity.

8.4 Satellite Communication Networks



Satellite communication enables information to be transmitted over large geographical distances through artificial satellites.

Importance:

Provides communication in remote areas.

Supports television broadcasting.

Facilitates weather monitoring.

Supports navigation systems.

Promotes international communication.

Supports disaster management.

9.0 FACTORS INFLUENCING THE DEVELOPMENT OF TRANSPORT AND COMMUNICATION IN AFRICA

Transport and communication infrastructure is not evenly distributed across Africa. Several physical, economic, political and social factors influence its development.

9.1 Physical Factors

1. Relief

Relief refers to the variation in the height and shape of the land surface.

Flat and gently sloping areas favour the construction of roads and railways.

Mountainous areas increase construction costs because tunnels and bridges may be required.

Steep slopes may make road construction difficult.

Example: The East African highlands present challenges to some transport infrastructure projects.

2. Climate

Climate refers to the average weather conditions of a place over a long period.

Heavy rainfall may damage roads and railway lines.

Flooding may destroy bridges and transport facilities.

Desert conditions may cause sand accumulation on roads and railway lines.

Extremely high temperatures may affect infrastructure and vehicle operations.

Example: Heavy rainfall in parts of East Africa may disrupt road transport.

3. Drainage and water bodies

Wide rivers may require bridges or ferries.

Swamps and wetlands make road construction difficult.

Navigable rivers and lakes encourage inland water transport.

Flood-prone areas may require expensive drainage systems.

4. Vegetation

Dense forests may require clearing before roads can be constructed.

Thick vegetation may increase construction costs.

Forest conservation requirements may restrict infrastructure development.

5. Soil and geological conditions

Stable soils provide suitable foundations for roads and railway tracks.

Swampy and loose soils require expensive engineering measures.

Rocky terrain may increase excavation costs.

Areas prone to landslides may require additional protection.

9.2 Economic Factors

1. Availability of capital

Construction of modern transport facilities requires large financial investments.

Countries with limited financial resources may struggle to develop extensive networks.

External loans and private investment may support infrastructure development.

2. Level of economic development

Economically developed countries can invest more in infrastructure.

Industrialised countries have greater demand for efficient transport.

Poor economic performance may reduce government investment.

3. Availability of technology

Modern technology improves road construction, railway systems and digital communication.

Lack of advanced technology may delay infrastructure development.

Some countries depend on imported equipment and technical expertise.

4. Availability of skilled labour

Engineers, surveyors, technicians and communication specialists are required.

Shortages of skilled personnel may delay projects.

Training institutions support infrastructure development.

5. Demand for transport and communication

Areas with large populations and high economic activity attract more investment.

Industrial and agricultural centres require efficient transport systems.

Low population and economic activity may reduce the demand for infrastructure.

9.3 Political and Institutional Factors

Political stability encourages investment.

Civil wars and insecurity discourage infrastructure development.

Good governance promotes proper use of infrastructure funds.

Corruption increases construction costs and delays projects.

Supportive government policies encourage private investment.

Regional cooperation promotes cross-border transport networks.

Poor planning may lead to incomplete or unsuitable projects.

9.4 Social Factors

Population distribution influences where transport infrastructure is developed.

Population growth increases demand for transport and communication.

Urbanisation increases the need for roads and public transport.

Literacy levels influence the adoption of modern communication technologies.

Cultural practices may influence transport patterns.

Income levels affect people's ability to use modern transport and communication services.

10.0 CHALLENGES FACING TRANSPORT AND COMMUNICATION IN AFRICA

Despite improvements in transport and communication infrastructure, many African countries continue to experience challenges that limit the efficiency, accessibility and reliability of these services.

These challenges affect trade, industrialisation, tourism, agriculture, education and general economic development.

10.1 Challenges Facing Transport in Africa

1. Inadequate Financial Resources

Construction of modern roads, railways, airports and seaports requires substantial capital.

Many African countries have limited financial resources to finance large infrastructure projects.

Some countries depend heavily on foreign loans and development partners.

Limited funds may result in incomplete projects and poor maintenance.

Example: Some rural areas have remained poorly connected because of inadequate infrastructure investment.

2. Poor Road Conditions



Some roads are unpaved, narrow or poorly maintained.

Potholes and damaged bridges make transportation difficult.

Heavy rainfall may wash away road surfaces.

Poor road conditions increase vehicle maintenance costs.

They also cause delays and road accidents.

Agricultural products may spoil before reaching markets.

3. Difficult Physical Conditions

Mountainous areas increase the cost of constructing roads and railway lines.

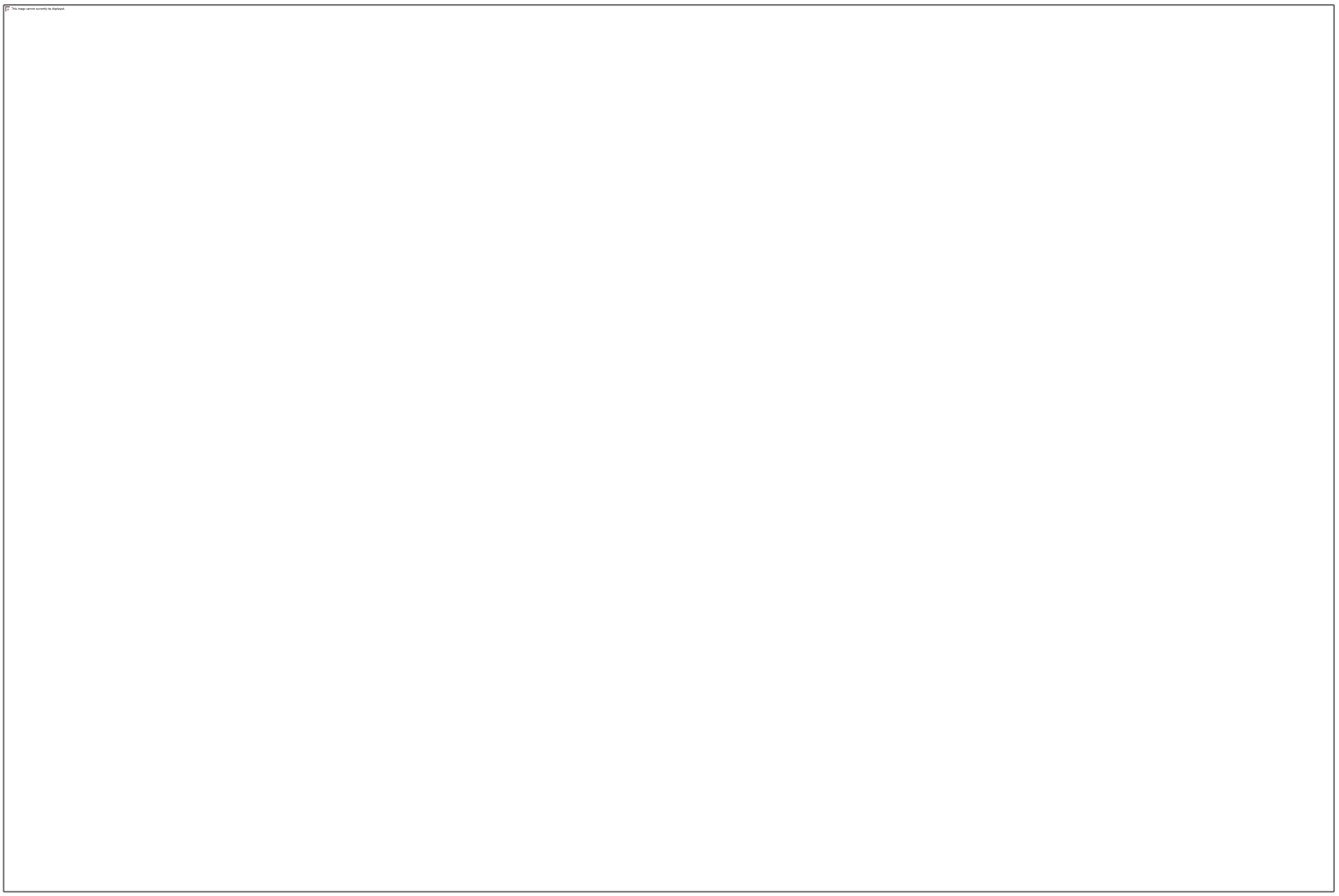
Deserts create difficulties because of shifting sand and extreme temperatures.

Swamps and wetlands make construction expensive.

Dense forests may require extensive clearing.

Rivers and deep valleys require bridges and other expensive structures.

4. Traffic Congestion



Rapid urbanisation increases the number of vehicles on roads.

Poor urban planning may lead to overcrowded roads.

Inadequate public transport encourages excessive use of private vehicles.

Traffic congestion causes delays and increases fuel consumption.

It contributes to air pollution and economic losses.

5. Road Accidents

Over-speeding increases the likelihood of serious accidents.

Driving under the influence of alcohol and drugs endangers road users.

Poor road conditions contribute to accidents.

Overloading vehicles may affect their stability and braking ability.

Failure to obey traffic regulations causes collisions.

Inadequate pedestrian facilities expose pedestrians to danger.

6. Political Instability and Insecurity

Armed conflicts may destroy roads, bridges, airports and railway infrastructure.

Insecurity discourages investment in transport infrastructure.

Some transport routes become unsafe for passengers and cargo.

Political instability may interrupt regional trade.

Infrastructure projects may be abandoned during periods of conflict.

7. Uneven Distribution of Transport Infrastructure

Major cities and commercial centres often have better transport facilities than rural areas.

Remote communities may lack all-weather roads.

Some landlocked countries have limited access to seaports.

Unequal infrastructure development increases regional economic inequalities.

8. High Maintenance Costs

Roads, railway lines, airports and ports require regular maintenance.

Poor maintenance causes infrastructure to deteriorate.

Imported machinery and spare parts may be expensive.

Inadequate maintenance funds may shorten the lifespan of transport facilities.

9. Border Delays and Customs Procedures

Lengthy customs procedures delay the movement of goods.

Poor coordination between neighbouring countries increases transportation time.

Excessive documentation may increase business costs.

Border congestion affects international trade.

10. Inadequate Railway Infrastructure

Some railway networks are outdated.

Railway systems in different countries may have incompatible technical standards.

Some railway lines do not extend to important agricultural and industrial centres.

Inadequate investment limits the expansion of railway services.

Competition from road transport may reduce railway profitability.

11. Limited Access to Seaports

Landlocked countries depend on neighbouring countries for access to international maritime trade.

Port congestion may delay the movement of cargo.

Poor road and railway connections to ports increase transportation costs.

Political disagreements may interfere with the use of transit routes.

12. Environmental Pollution

Motor vehicles release harmful gases into the atmosphere.

Oil spills from ships and pipelines pollute water bodies.

Noise pollution affects communities near highways and airports.

Construction of roads may lead to deforestation and habitat destruction.

Transport infrastructure may disrupt wildlife migration routes.

13. Shortage of Skilled Personnel

Some countries have inadequate numbers of qualified transport engineers and technicians.

Lack of specialised personnel affects infrastructure maintenance.

Some countries depend on foreign technical experts.

Inadequate technical training slows technological development.

14. Corruption and Poor Management

Misappropriation of infrastructure funds increases project costs.

Poor supervision may result in substandard construction.

Delays may arise from weak project management.

Corruption discourages investors and development partners.

15. Transport Accidents and Natural Disasters

Floods may destroy bridges and roads.

Landslides may block highways and railway lines.

Droughts may affect navigability of some rivers.

Storms may disrupt air and water transport.

Earthquakes may damage infrastructure.

10.2 Challenges Facing Communication in Africa





1. Inadequate Communication Infrastructure

Some rural areas lack mobile telephone towers.

Fibre-optic networks are concentrated around major urban centres in some countries.

Remote communities may have limited access to internet services.

Poor infrastructure reduces the reliability of communication.

2. High Cost of Communication Services

Internet subscriptions may be expensive for low-income households.

Smartphones and computers may be unaffordable to some people.

High data costs discourage regular internet use.

Small businesses may struggle to adopt digital communication technologies.

3. Digital Divide

The digital divide refers to the gap between individuals or communities that have access to modern information and communication technologies and those that do not.

Urban communities may have better internet connectivity than rural communities.

Wealthier households may afford modern digital devices.

Some schools lack computers and reliable internet.

This inequality limits access to digital education and information.

4. Unreliable Electricity Supply

Communication equipment requires electricity.

Power outages may interrupt telephone and internet services.

Rural communication towers may lack reliable electricity.

Some institutions cannot operate digital equipment effectively.

5. Inadequate Technical Skills

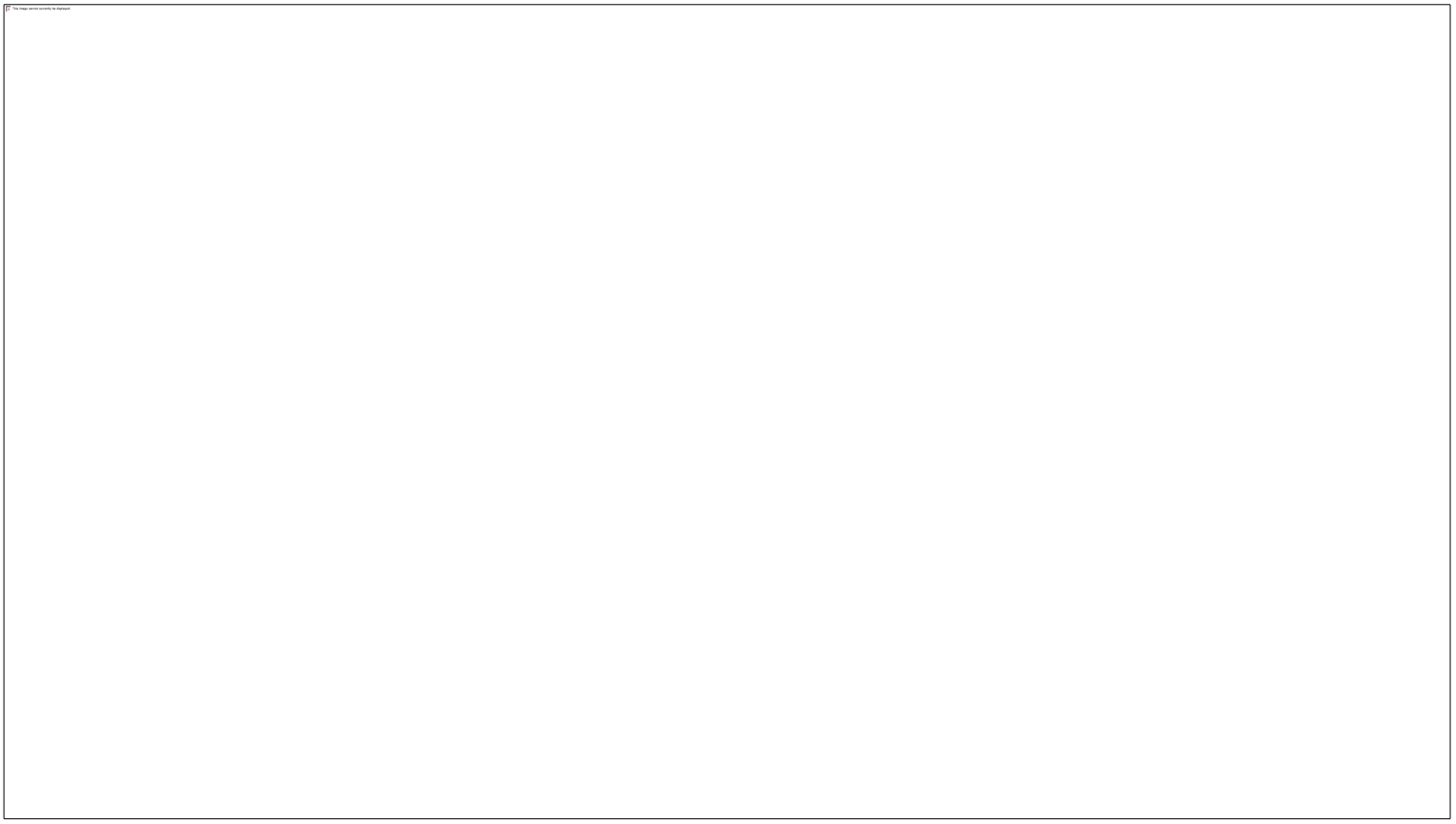
Some people lack digital literacy skills.

Shortage of trained technicians affects maintenance of communication equipment.

Some organisations lack specialised ICT personnel.

Limited training reduces effective use of digital technologies.

6. Cybercrime



Cybercrime refers to illegal activities carried out using computers, digital devices or communication networks.

Examples include:

Online fraud.

Identity theft.

Hacking.

Phishing.

Cyberbullying.

Unauthorised access to private information.

Cybercrime threatens the security and reliability of digital communication.

7. Misinformation and Fake News

False information spreads rapidly through social media.

Misleading information may create social conflict.

Fake news may interfere with public decision-making.

Unverified information may cause panic during emergencies.

8. Poor Network Coverage

Some mountainous and remote areas have weak network signals.

Mobile communication may be interrupted by technical failures.

Network congestion may reduce internet speed.

Satellite and telecommunications infrastructure may be expensive to install.

9. Language Barriers

Africa has many languages and dialects.

Some digital platforms do not support local languages.

Language differences may limit access to information.

Translation services may not be available in all communities.

10. Technological Dependence

Some African countries depend on imported communication equipment.

Dependence on foreign technology may increase operating costs.

Limited local research and development slows innovation.

Equipment replacement may be expensive.

11. Inadequate Regulatory Frameworks

Weak cybercrime laws may encourage online criminal activities.

Poor enforcement of communication regulations may affect service quality.

Inadequate data protection may expose users to privacy violations.

Unclear policies may discourage investment.

12. Destruction of Communication Infrastructure

Vandalism may damage communication towers and cables.

Theft of cables interrupts network services.

Natural disasters may destroy communication equipment.

Armed conflicts may damage communication facilities.

11.0 SOLUTIONS TO CHALLENGES FACING TRANSPORT AND COMMUNICATION IN AFRICA

African governments, regional organisations, private investors and international development partners have important roles to play in improving transport and communication infrastructure.

11.1 Solutions to Transport Challenges

1. Increased Government Investment

Governments should allocate adequate funds to transport infrastructure.

More roads, bridges, railways, airports and ports should be constructed.

Rural and remote areas should receive attention.

Long-term infrastructure development plans should be implemented.

2. Public-Private Partnerships

Governments should encourage private companies to invest in transport infrastructure.

Private investors can support construction and maintenance of highways, ports and airports.

Public-private partnerships can reduce pressure on government budgets.

Example: The Nairobi Expressway was developed through a public-private partnership.

3. Regular Maintenance of Transport Infrastructure

Roads should be inspected and repaired regularly.

Damaged bridges should be reconstructed.

Railway tracks should be maintained.

Drainage systems should be improved.

Port equipment should be serviced regularly.

4. Improvement of Road Safety

Traffic regulations should be strictly enforced.

Drivers should receive proper training.

Speed limits should be observed.

Road safety education should be strengthened.

Pedestrian walkways and footbridges should be constructed.

Overloading and reckless driving should be discouraged.

5. Expansion of Railway Networks

Existing railway systems should be modernised.

New railway lines should connect important economic centres.

Regional railway connections should be improved.

Freight services should be made more efficient.

Investment in railway technology should be encouraged.

6. Promotion of Regional Cooperation

African countries should cooperate in developing cross-border infrastructure.

Customs procedures should be harmonised.

Border clearance systems should be modernised.

Regional transport agreements should be strengthened.

International transport corridors should be improved.

7. Use of Appropriate Technology

Modern road construction machinery should be adopted.

Intelligent transport systems should be introduced.

Digital traffic management should be strengthened.

Modern railway signalling systems should be installed.

Advanced cargo-handling equipment should be used in ports.

8. Improvement of Urban Public Transport

Governments should develop reliable public transport systems.

Bus rapid transit systems should be expanded where appropriate.

Urban railway services should be improved.

Pedestrian and cycling infrastructure should be developed.

Urban transport planning should be strengthened.

9. Environmental Conservation

Environmental impact assessments should be conducted before construction.

Wildlife corridors should be protected.

Sustainable construction materials should be used.

Tree planting should be encouraged.

Pollution from transport activities should be controlled.

10. Promotion of Political Stability

Governments should promote peace and security.

Infrastructure should be protected from destruction.

Conflicts should be resolved through dialogue.

Investors should be provided with a stable operating environment.

11. Development of Rural Transport

Rural feeder roads should be improved.

Bridges should be constructed across rivers.

Remote communities should be connected to markets.

Affordable transport services should be encouraged.

Rural transport should be included in national development plans.

12. Training of Skilled Personnel

Engineering institutions should be strengthened.

Technical and vocational training should be promoted.

Transport workers should receive regular professional development.

Local expertise should be developed.

11.2 Solutions to Communication Challenges

1. Expansion of Communication Infrastructure

More telecommunications towers should be constructed.

Fibre-optic networks should be extended to rural areas.

Satellite communication should be used where appropriate.

Internet connectivity should be improved in schools and hospitals.

2. Reduction of Communication Costs

Governments should encourage competition among service providers.

Affordable internet packages should be introduced.

Taxes and charges on essential digital equipment should be reviewed.

Public institutions should provide accessible digital services.

3. Improvement of Electricity Supply

Electricity networks should be expanded.

Solar energy should be used to power remote communication facilities.

Reliable backup power systems should be installed.

Renewable energy should be encouraged.

4. Promotion of Digital Literacy

ICT education should be strengthened in schools.

Communities should receive digital skills training.

Adults should be encouraged to participate in digital literacy programmes.

Vocational institutions should offer ICT courses.

5. Strengthening Cybersecurity

Cybercrime laws should be strengthened and enforced.

Organisations should install appropriate security systems.

Users should be educated on online safety.

Strong passwords and secure authentication should be encouraged.

Personal information should be protected.

6. Promotion of Local Innovation

Governments should support technological research.

Local companies should be encouraged to manufacture communication equipment.

Universities should develop innovative digital solutions.

Technology start-ups should receive support.

7. Improvement of Network Reliability

Communication equipment should be maintained regularly.

Multiple network connections should be developed.

Service providers should improve network coverage.

Alternative communication systems should be available during emergencies.

8. Regulation of Communication Services

Communication authorities should monitor service providers.

Data protection laws should be enforced.

Misleading information should be addressed through appropriate legal and educational measures.

Fair competition should be encouraged.

9. Development of Local Language Content

Digital platforms should support African languages.

Educational materials should be translated into appropriate local languages.

Community radio stations should be strengthened.

Local content creators should be encouraged.

10. Protection of Communication Infrastructure

Communication towers and cables should be secured.

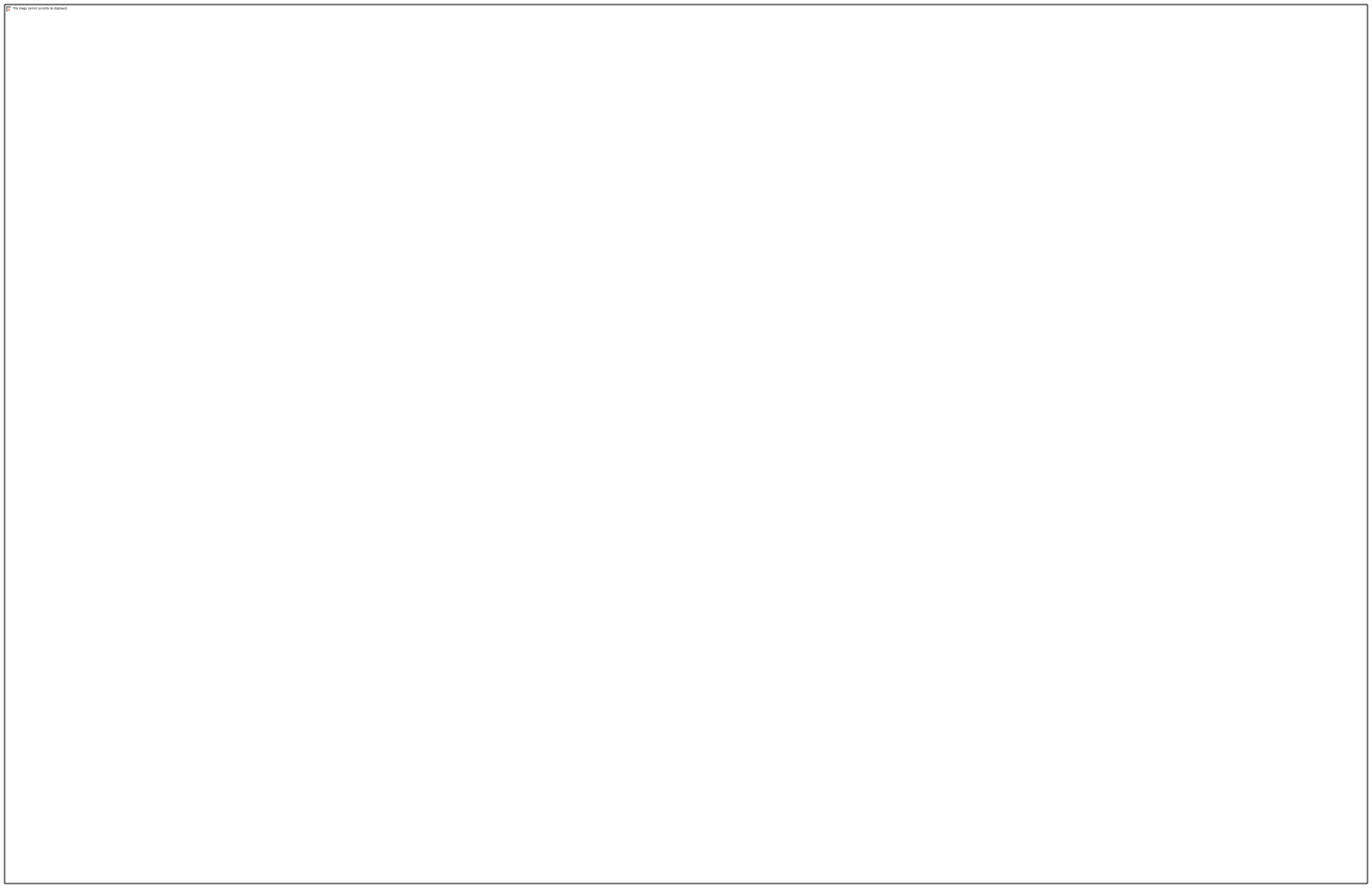
Vandalism should be discouraged through law enforcement.

Communities should be sensitised on the importance of communication facilities.

Disaster-resistant infrastructure should be developed.

12.0 ROLE OF TRANSPORT AND COMMUNICATION IN THE ECONOMIC DEVELOPMENT OF AFRICA





Transport and communication are fundamental to economic development because they facilitate the movement of resources, people, products, services and information.

Economic development refers to the sustained improvement in the economic and social well-being of a population.

12.1 Promotion of International Trade

Transport enables countries to export agricultural products, minerals and manufactured goods.

Seaports and airports connect African countries to international markets.

Communication facilitates negotiations between buyers and sellers.

Digital platforms enable businesses to identify international markets.

Efficient transport reduces the cost of delivering goods.

12.2 Promotion of Agricultural Development

Roads connect farmers to markets.

Transport facilities enable farmers to obtain fertilisers, seeds and machinery.

Refrigerated transport helps preserve perishable agricultural products.

Mobile communication enables farmers to access market prices.

Weather information helps farmers plan agricultural activities.

Example: Farmers in the Rift Valley can transport maize and potatoes to markets in Nairobi and other urban centres.

12.3 Promotion of Industrialisation

Transport facilitates the movement of raw materials to industries.

Finished products are transported to consumers.

Communication enables industries to coordinate production activities.

Reliable communication supports automation and modern manufacturing.

Efficient logistics attract industrial investment.

12.4 Development of Tourism

Roads connect tourist attractions to airports and towns.

Air transport brings international tourists into Africa.

Communication platforms promote tourist destinations.

Online booking systems facilitate hotel and travel reservations.

Transport enables tourists to access national parks, beaches and historical sites.

Examples in Kenya:

Maasai Mara National Reserve.

Amboseli National Park.

Tsavo National Parks.

Lake Nakuru National Park.

Lamu Old Town.

12.5 Employment Creation

Transport and communication create direct and indirect employment opportunities.

Examples include:

Drivers.

Pilots.

Railway engineers.

Mechanics.

Ship operators.

Port workers.

Communication technicians.

Software developers.

Internet service providers.

Logistics managers.

Tour operators.

12.6 Promotion of Regional Integration

Transport connects neighbouring countries.

Communication enables governments to share information.

Regional trade agreements become easier to implement.

Cross-border movement promotes cooperation.

Transport corridors encourage economic interdependence.

12.7 Development of Urban Centres

Transport networks encourage the growth of towns and cities.

Industries and businesses develop near major transport routes.

Communication facilitates urban management.

Improved accessibility attracts investors.

Transport infrastructure promotes the growth of residential areas.

12.8 Promotion of Education

Transport enables learners and teachers to access educational institutions.

Internet connectivity facilitates online learning.

Digital communication enables sharing of educational materials.

Video conferencing supports distance learning.

Educational research becomes easier through digital platforms.

12.9 Improvement of Healthcare Services

Roads enable ambulances to reach patients.

Air transport facilitates medical evacuation.

Communication enables health workers to consult specialists.

Digital health systems improve management of patient records.

Transport facilitates the distribution of medicines and vaccines.

12.10 Promotion of Financial Services

Mobile money enables individuals to transfer money.

Digital banking facilitates financial transactions.

Communication improves access to financial information.

Transport enables the physical distribution of cash and financial services.

E-commerce promotes digital payments.

12.11 Promotion of National Security

Transport facilitates the movement of security personnel.

Communication enables coordination of security operations.

Emergency response teams can reach affected areas.

Surveillance technologies support security management.

Regional communication promotes cooperation against cross-border crime.

12.12 Promotion of Cultural Exchange

Transport enables people to visit different communities.

Communication promotes the sharing of languages and cultural practices.

Tourism encourages interaction between people.

Radio, television and digital platforms promote cultural awareness.

International events promote understanding among communities.

12.13 Promotion of Disaster Management

Roads and airports enable emergency teams to reach disaster areas.

Communication networks facilitate early warning systems.

Radio and mobile phones disseminate emergency messages.

Transport facilitates the delivery of food, water and medicine.

Satellite systems support weather monitoring and disaster assessment.

12.14 Attraction of Foreign Investment

Good transport infrastructure reduces the cost of doing business.

Reliable communication attracts technology companies.

Efficient logistics improve the competitiveness of industries.

Investors can access information about business opportunities.

Modern infrastructure encourages the establishment of international businesses.

13.0 ROAD EMERGENCY RESPONSE AND DISASTER MANAGEMENT

Transport systems may experience accidents, breakdowns, fires, floods and other emergencies. Proper preparation and response help to minimise injuries, deaths, property damage and disruption of services.

13.1 Meaning of a Road Emergency

A **road emergency** refers to an unexpected incident occurring on or near a road that threatens the safety of road users or disrupts the movement of traffic.

Examples include:

Vehicle collisions.

Vehicle fires.

Fuel spillages.

Vehicle breakdowns in dangerous locations.

Road collapses.

Flooding.

Landslides.

Dangerous cargo accidents.

13.2 Procedures for Responding to Road Emergencies



1. Ensure personal safety

Do not rush into a dangerous accident scene.

Observe approaching traffic.

Avoid touching exposed electrical wires or leaking fuel.

Wear protective equipment where available.

2. Secure the accident scene

Warn approaching motorists.

Use warning triangles where safe and appropriate.

Keep unnecessary people away from the accident scene.

Avoid blocking emergency access routes.

3. Contact emergency services

Call the appropriate emergency service.

Provide the location of the incident.

Explain the nature of the accident.

Give the approximate number of casualties.

Report any fire, fuel leakage or hazardous materials.

4. Provide basic first aid

Assist injured people only within your level of training.

Check whether casualties are responsive and breathing.

Control serious external bleeding using appropriate first-aid techniques.

Avoid unnecessary movement of injured persons, especially where spinal injuries are suspected.

Follow instructions from emergency responders.

5. Avoid further accidents

Do not crowd around the scene.

Do not move vehicles unless necessary for safety or instructed by authorities.

Keep the road clear for emergency vehicles.

Avoid taking photographs that interfere with rescue activities.

6. Cooperate with emergency personnel

Provide accurate information.

Assist police and medical personnel when requested.

Help identify witnesses.

Follow official traffic instructions.

13.3 Strategies for Disaster Preparedness in Transport

Regular inspection of roads and bridges.

Installation of road signs and warning signals.

Training drivers on emergency procedures.

Establishment of emergency response teams.

Availability of ambulances and rescue equipment.

Development of alternative transport routes.

Improvement of drainage systems.

Monitoring of flood-prone roads.

Provision of emergency communication systems.

Public education on disaster preparedness.

Regular maintenance of transport infrastructure.

Development of emergency evacuation plans.

13.4 Disaster Preparedness in Communication Systems

Establish backup communication networks.

Install backup power supplies.

Protect communication towers from disasters.

Develop emergency broadcasting systems.

Provide public warning messages through mobile networks.

Maintain alternative communication equipment.

Train communication personnel on emergency response.

Establish coordination systems between emergency agencies.

Back up important digital records.

Conduct regular disaster preparedness exercises.

14.0 SUSTAINABLE TRANSPORT AND COMMUNICATION

Sustainable transport and communication refer to systems that meet present needs while minimising environmental damage, social inequality and unnecessary use of resources.

14.1 Characteristics of Sustainable Transport

Affordable and accessible to different groups of people.

Safe and reliable.

Energy-efficient.

Environmentally friendly.

Economically viable.

Well maintained.

Accessible to people with disabilities.

Designed to reduce traffic congestion.

Supports public transport.

Minimises pollution.

14.2 Ways of Promoting Sustainable Transport in Africa

Encouraging the use of public transport.

Promoting walking and cycling where safe.

Developing electric transport systems.

Maintaining roads to reduce vehicle fuel wastage.

Promoting railway transportation for suitable freight.

Developing efficient urban transport systems.

Protecting forests and wildlife corridors.

Promoting cleaner fuels.

Encouraging car sharing.

Conducting environmental impact assessments.

14.3 Sustainable Communication Practices

Promoting responsible internet use.

Recycling electronic waste.

Using energy-efficient communication equipment.

Protecting personal information.

Promoting digital literacy.

Encouraging responsible sharing of information.

Developing accessible communication technologies.

Using renewable energy to power communication facilities.

15.0 COMPETENCE-BASED LEARNING ACTIVITIES

The following activities enable learners to develop practical skills, critical thinking, creativity, collaboration and problem-solving abilities.

Activity 1: Investigating Types of Transport

Instructions:

Work in groups.

Identify different types of transport used in Kenya and other parts of the world.

Collect pictures showing road, railway, water, air and pipeline transport.

Classify the pictures according to the type of transport.

Explain the advantages and limitations of each type.

Present your findings to the class.

Expected competencies:

Communication and collaboration.

Critical thinking and problem-solving.

Learning to learn.

Digital literacy.

Activity 2: Investigating Transport Developments in Kenya

Watch video clips showing the Thika Superhighway, Nairobi Expressway and Standard Gauge Railway.

Identify the geographical locations of these developments.

Explain the reasons for their construction.

Discuss their contribution to Kenya's economy.

Identify challenges associated with their development.

Write a report and present it to the class.

Activity 3: Mapping Major Transport Networks in Africa

Obtain an outline map of Africa.

Locate the following:

Cairo.

Dakar.

Lagos.

Mombasa.

Nairobi.

Addis Ababa.

Dar es Salaam.

Johannesburg.

Cape Town.

Tripoli.

Trace selected Trans-African Highway routes.

Mark major seaports and international airports.

Identify the Northern and Central Corridors.

Display your completed map.

Activity 4: Road Safety Awareness

Discuss common road accidents in your community.

Identify behaviours that cause road accidents.

Suggest ways of preventing accidents.

Develop road safety messages.

Design posters promoting responsible road use.

Present the posters to the school community.

Activity 5: Investigating Communication Technology

Identify different communication devices used in your community.

Research the development of mobile communication in Kenya.

Explain how mobile money has transformed business activities.

Investigate challenges facing internet users.

Suggest ways of promoting responsible digital communication.

Present your findings.

Activity 6: Emergency Preparedness

Discuss possible emergencies involving transport systems.

Identify appropriate emergency response agencies.

Develop a road emergency response procedure.

Demonstrate how to communicate an emergency location.

Discuss basic first-aid precautions.

Develop a disaster preparedness poster.

REVISION EXERCISES

SUB-STRAND 3.4 **Transport and Communication**

SECTION A: MULTIPLE-CHOICE QUESTIONS (30 MARKS)

Choose the correct answer from the alternatives provided.

1. Which of the following best describes transport?

A. Exchange of information between individuals.

B. Physical movement of people and goods from one place to another.

C. Storage of information using computers.

D. Production of goods in industries.

2. Which one of the following is an example of pipeline transport?

A. Transportation of passengers by train.

B. Movement of petroleum products through pipes.

C. Transportation of goods by ship.

D. Movement of people by aeroplane.

3. Which of the following is a major advantage of railway transport?

A. It can reach every village.

B. It transports bulky goods over long distances.

C. It is unaffected by mechanical breakdowns.

D. It requires no construction costs.

4. The Nairobi Expressway is an example of:

A. Pipeline transport.

B. Water transport.

C. Modern road transport infrastructure.

D. Railway transport.

5. Which of the following ports is Kenya's principal seaport?

A. Kisumu Port.

B. Lamu Port.

C. Mombasa Port.

D. Malindi Port.

6. The Standard Gauge Railway uses a track gauge of:

A. 1,000 mm.

B. 1,435 mm.

C. 1,500 mm.

D. 1,600 mm.

7. Which of the following is an example of inland water transport?

A. Transportation on Lake Victoria.

B. Transportation across the Atlantic Ocean.

C. Transportation between Mombasa and Dubai.

D. Transportation through an oil pipeline.

8. The fastest major means of transport is:

A. Road transport.

B. Railway transport.

C. Water transport.

D. Air transport.

9. Which of the following is a major disadvantage of air transport?

A. It is unsuitable for passenger movement.

B. It is generally expensive.

C. It cannot connect different countries.

D. It cannot transport perishable goods.

10. Which of the following is an example of traditional communication?

A. Email.

B. Mobile telephone.

C. Drum beating.

D. Video conferencing.

11. The transmission of information through light signals in thin glass fibres is known as:

A. Radio communication.

B. Fibre-optic communication.

C. Print communication.

D. Traditional communication.

12. Which of the following is an example of satellite communication?

A. Sending messages using smoke signals.

B. Communicating through artificial satellites.

C. Printing information in newspapers.

D. Communicating through town criers.

13. Which Kenyan communication service is widely associated with mobile money transfers?

A. M-PESA. B. Railway Express.

C. KPA. D. KAA.

14. Which of the following is the main purpose of a transport corridor?

A. To prevent international trade.

B. To connect economic centres and facilitate movement.

C. To restrict movement between countries.

D. To replace all forms of communication.

15. The Northern Corridor begins at:

A. Port of Durban.

B. Port of Mombasa.

C. Port of Lagos.

D. Port of Alexandria.

16. Which of the following routes connects Dakar and Lagos?

A. Trans-African Highway 1.

B. Trans-African Highway 2.

C. Trans-African Highway 7.

D. Trans-African Highway 9.

17. Which of the following countries is served by the Ethiopia–Djibouti Railway?

A. Ethiopia.

B. Kenya.

C. Ghana.

D. Nigeria.

18. Which of the following is a major international airport in Kenya?

A. Wilson Airport only.

B. Jomo Kenyatta International Airport.

C. Kisumu Domestic Airstrip only.

D. Malindi Airstrip.

19. The West African Gas Pipeline transports natural gas mainly from:

A. Kenya.

B. South Africa.

C. Nigeria.

D. Egypt.

20. Which of the following physical factors may increase the cost of road construction?

A. Flat terrain.

B. Mountainous relief.

C. Gentle slopes.

D. Stable ground.

21. Which of the following is a major challenge facing road transport in Africa?

A. Excessive availability of good roads.

B. Inadequate road maintenance.

C. Absence of vehicles.

D. Excessive railway development.

22. The term digital divide refers to:

A. Differences in geographical altitude.

B. The gap between people with and without access to digital technologies.

C. Differences between road and railway networks.

D. The separation of countries by oceans.

23. Which of the following contributes to traffic congestion in African cities?

A. Effective urban planning.

B. Improved traffic management.

C. Rapid urbanisation and increasing vehicle numbers.

D. Increased use of pedestrian walkways.

24. Which of the following is an effective solution to communication challenges in rural areas?

A. Closing mobile telephone networks.

B. Expanding telecommunications infrastructure.

C. Restricting internet access.

D. Reducing digital literacy programmes.

25. Which of the following is a major benefit of transport to agriculture?

A. Increasing the distance to markets.

B. Preventing farmers from accessing inputs.

C. Facilitating transportation of farm produce to markets.

D. Increasing post-harvest losses.

26. The Maputo Development Corridor connects South Africa with:

A. Mozambique.

B. Nigeria.

C. Egypt.

D. Ethiopia.

27. Which of the following is a risky road behaviour?

A. Observing speed limits.

B. Wearing seat belts.

C. Driving under the influence of alcohol.

D. Using designated pedestrian crossings.

28. Which of the following is an effective way of protecting communication networks?

A. Encouraging vandalism.

B. Strengthening cybersecurity measures.

C. Destroying communication towers.

D. Discouraging digital literacy.

29. Which of the following best demonstrates the role of communication in economic development?

A. Preventing the exchange of information.

B. Facilitating business transactions and market information.

C. Increasing isolation among communities.

D. Restricting access to education.

30. Which of the following practices promotes sustainable transport?

A. Excessive use of private vehicles.

B. Destruction of public transport infrastructure.

C. Encouraging efficient public transport.

D. Constructing roads without environmental assessment.

SECTION B: STRUCTURED QUESTIONS (50 MARKS)

Answer all questions.

1. Types of Transport (8 Marks)

a) Define the term transport. (2 marks)

b) Identify four major types of transport used in the world. (4 marks)

c) State two advantages of railway transport. (2 marks)

2. Development of Transport and Communication in Kenya (8 Marks)

a) Name two modern road infrastructure developments in Kenya. (2 marks)

b) Explain three ways in which the Standard Gauge Railway has contributed to Kenya's economic development. (3 marks)

c) State three developments in communication technology in Kenya. (3 marks)

3. Transport Networks in Africa (8 Marks)

a) What is meant by a transport network? (2 marks)

b) Name three major transport corridors in Africa. (3 marks)

c) Explain three ways in which the Northern Corridor promotes economic development in East Africa. (3 marks)

4. Communication in Africa (8 Marks)

a) Define communication. (2 marks)

b) Identify three modern forms of communication used in Africa. (3 marks)

c) Explain three advantages of fibre-optic communication networks. (3 marks)

5. Challenges and Solutions (9 Marks)

a) State three challenges facing transport development in Africa. (3 marks)

b) Explain three measures that African governments can adopt to overcome challenges facing transport. (3 marks)

c) Identify three challenges facing communication development in Africa. (3 marks)

6. Economic Development and Road Safety (9 Marks)

a) Explain four ways in which transport and communication promote economic development in Africa. (4 marks)

b) State three risky road behaviours that contribute to road accidents. (3 marks)

c) Identify two measures that can be taken to improve emergency response during road accidents. (2 marks)

TEACHER'S ANSWER GUIDE

Section A: Multiple-Choice Answers

Question	Answer	Question	Answer
1	B	16	C
2	B	17	A
3	B	18	B
4	C	19	C
5	C	20	B
6	B	21	B
7	A	22	B
8	D	23	C
9	B	24	B
10	C	25	C
11	B	26	A
12	B	27	C
13	A	28	B
14	B	29	B
15	B	30	C

Section B: Suggested Marking Scheme

1. Types of Transport (8 marks)

a) Transport is the physical movement of people, animals and goods from one geographical location to another using different means and facilities. (2)

b)

Road transport. (1)

Railway transport. (1)

Water transport. (1)

Air transport. (1)

c)

Transports bulky goods over long distances. (1)

Can transport large numbers of passengers. (1)

2. Development of Transport and Communication in Kenya (8 marks)

a)

Thika Superhighway. (1)

Nairobi Expressway. (1)

b)

Reduces travel time between Mombasa and Nairobi. (1)

Facilitates transportation of cargo. (1)

Reduces pressure on roads and supports trade. (1)

c) Any three:

Expansion of mobile telephone networks.

Development of fibre-optic infrastructure.

Introduction and expansion of mobile money services.

Growth of digital television broadcasting.

Expansion of internet connectivity.

Development of e-government services.

(1 mark each)

3. Transport Networks in Africa (8 marks)

a) A transport network is an interconnected system of routes and facilities used to move people and goods between geographical locations. (2)

b) Any three:

Northern Corridor. (1)

Central Corridor. (1)

LAPSSET Corridor. (1)

Maputo Development Corridor.

Abidjan–Lagos Corridor.

c) Any three:

Connects Mombasa Port with landlocked countries. (1)

Facilitates international trade. (1)

Promotes transportation of agricultural and industrial products. (1)

Creates employment opportunities.

Promotes regional integration.

Encourages investment.

4. Communication in Africa (8 marks)

a) Communication is the process of sending, receiving and exchanging information, ideas and messages between individuals or groups. (2)

b) Any three:

Mobile telephone communication. (1)

Internet communication. (1)

Satellite communication. (1)

Radio broadcasting.

Television broadcasting.

Fibre-optic communication.

c) Any three:

Provides high-speed internet connectivity. (1)

Facilitates international communication. (1)

Supports online learning. (1)

Promotes e-commerce.

Supports digital banking.

Facilitates research and innovation.

5. Challenges and Solutions (9 marks)

a) Any three:

Inadequate financial resources. (1)

Poor road conditions. (1)

Difficult physical conditions. (1)

Political instability.

Traffic congestion.

High maintenance costs.

Inadequate railway infrastructure.

b) Any three:

Increasing government investment. (1)

Encouraging public-private partnerships. (1)

Maintaining existing infrastructure. (1)

Improving road safety.

Expanding railway networks.

Promoting regional cooperation.

c) Any three:

High communication costs. (1)

Poor network coverage. (1)

Cybercrime. (1)

Digital divide.

Inadequate electricity.

Shortage of technical skills.

Destruction of communication infrastructure.

6. Economic Development and Road Safety (9 marks)

a) Any four:

Promotes international trade. (1)

Facilitates agricultural development. (1)

Promotes industrialisation. (1)

Encourages tourism. (1)

Creates employment.

Promotes regional integration.

Improves access to education and healthcare.

Attracts foreign investment.

b) Any three:

Over-speeding. (1)

Driving under the influence of alcohol. (1)

Careless overtaking. (1)

Using mobile phones while driving.

Overloading vehicles.

Ignoring traffic signs.

Driving unroadworthy vehicles.

c) Any two:

Establishing emergency response teams and ambulance services. (1)

Providing first-aid training. (1)

Establishing emergency communication systems.

Providing warning signs and emergency equipment.

Educating the public on emergency procedures.

SENIOR SCHOOL CURRICULUM