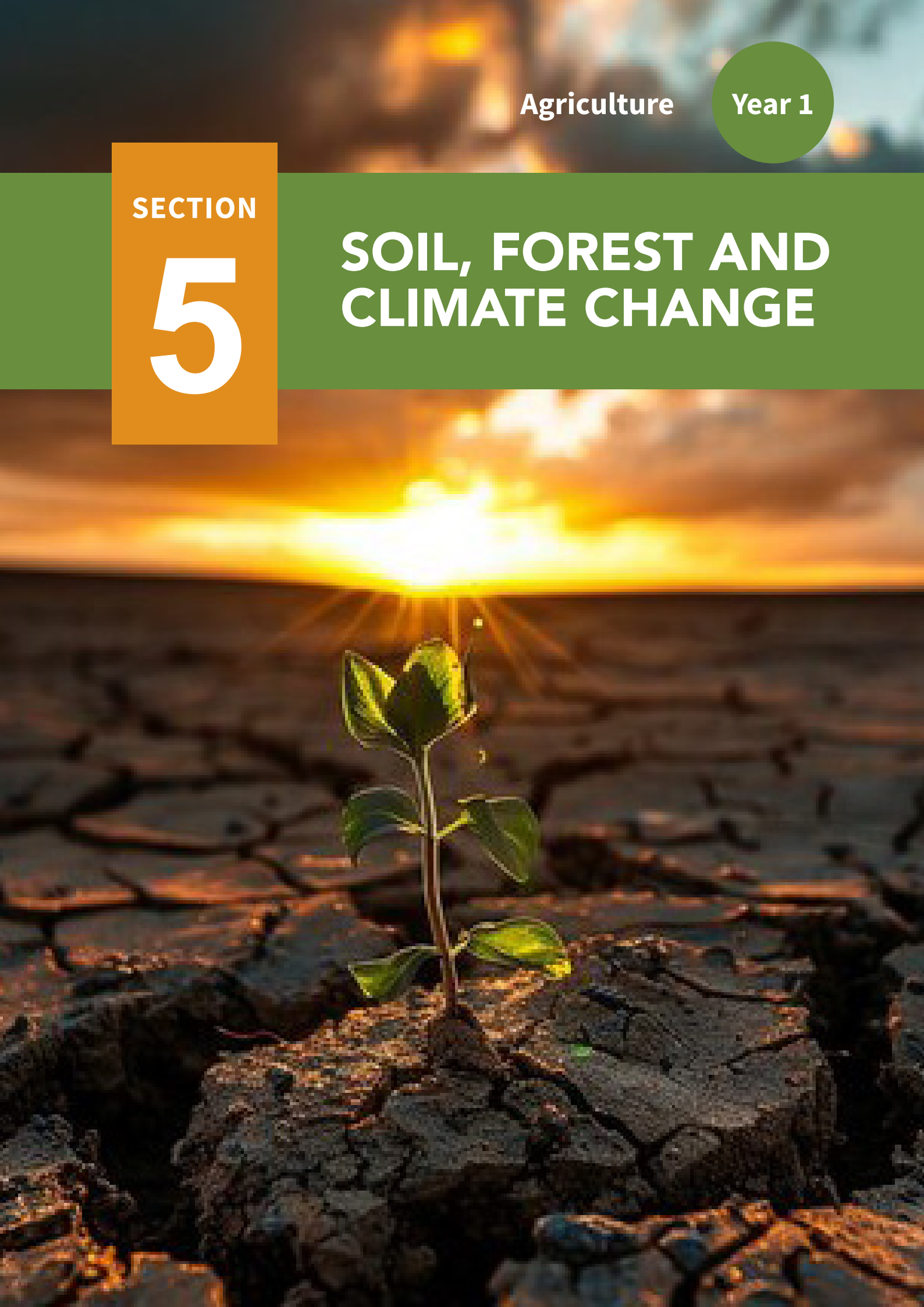
Agriculture Year 1

SECTION 5

SOIL, FOREST AND CLIMATE CHANGE



Food Production and Natural Resource Conservation

Principles of Natural Resource Conservation in Agriculture

INTRODUCTION

Welcome to Section 5. In this section, you will be learning about the forest, the soil, and climate change and its effects on agricultural production. With the forest, you will learn the importance and principles of forestry and forest management, and agroforestry systems. The composition and properties of soil and soil profile will be learnt about soil. On climate change, you will learn the effect of climate change on food production and strategies to mitigate against them. All these will be achieved through well-crafted activities. The section is important as it has links with the study of natural resources management.

At the end of this section, you will be able to:

- Explain the meaning, importance and principles of forestry and forest management.
- Discuss the concepts and the importance of the interrelations between forestry and Agriculture.
- Discuss agroforestry practices and systems in forest management.
- Explain the meaning, importance and nature of soil.
- Describe the physical and chemical properties of soils and their importance.
- Discuss the composition of soil
- Explain the meaning and effects of climate change on food production.
- Discuss the effects of climate change on food production and the mitigating strategies

Key Ideas

- Forest management involves making informed decisions about the use, protection and restoration of forests to optimise their productivity.
- The interrelations between forestry and Agriculture refer to the close and diverse relationships that exist between forestry and Agriculture in terms of land use.
- Agroforestry involves carefully planting and managing trees alongside farming to increase productivity and make the environment stronger.
- Examples of agroforestry are Agri silviculture, silvopasture, taungya system, fodder and

protein banks, shelterwood, woodland grazing, apiculture, and multipurpose woodlots.

- A typical soil profile consists of six (6) horizons that is O Horizon (Organic Layer), A Horizon (Topsoil), E Horizon (Eluviation Layer), B Horizon (Subsoil), C Horizon (Parent Material) and R Horizon (Bedrock).
- The physical properties of soil are; soil texture, soil structure, porosity, bulk density and water-holding capacity.
- Soil pH, Cation Exchange Capacity (CEC), Organic Matter Content, Nutrient Content and Cation Ratios are some chemical properties of soil.
- Mineral particles, organic matter, water, air, living organisms and inorganic substances are the main compositions of the soil.
- It is primarily caused by human activities, specifically the release of greenhouse gases (GHGs) into the atmosphere, which trap heat and lead to global warming.
- Some ways of mitigating the impact of climate change on food security include Implementing sustainable soil management practices.

MEANING AND IMPORTANCE OF FORESTRY AND FOREST MANAGEMENT

Forestry

Forestry is the art, and practice of managing forests and woodlands to achieve objectives such as protection of the forest, proper timber production, biodiversity protection and the supply of ecosystem services.

Forest Management

Forest management is the process of planning and applying forest practices to realise specific objectives in forested areas. It involves making informed decisions about the use, protection and restoration of forests to optimise their productivity.

Importance of Forestry and Forest Management

The following are some importance of forestry and forest management;

1. **Environmental protection:** Forests play a vital role in maintaining biodiversity, supporting various plant and animal species, and providing habitat for wildlife. Forest management helps protect these ecosystems and preserves important biodiversity.
2. **Carbon sequestration and climate change moderation:** Forests act as significant carbon sinks, absorbing carbon dioxide from the atmosphere and minimizing climate change. Proper forest management can enhance carbon sequestration and contribute to global climate change mitigation efforts.

3. **Sustainable timber production:** Forest management ensures that timber is harvested in the proper way, balancing the demand for wood products with the need to maintain forest health and productivity.
4. **Water regulation:** Forests regulate water flow, improve water quality and reduce the risk of floods and droughts. Well-managed forests help maintain a stable water supply for both human use and ecosystems.
5. **Recreation and tourism:** Forests provide entertainment opportunities such as hiking, camping and wildlife observation, contributing to the well-being of communities and supporting tourism industries.
6. **Cultural and traditional values:** Forests hold cultural significance for many communities, and forest management can help preserve cultural heritage and traditional practices.
7. **Economic development:** Forestry supports local economies by providing jobs, income from timber sales, and other forest-based products and services.
8. **Erosion control and soil protection:** Forests help prevent soil erosion and protect watersheds, ensuring the long-term sustainability of agricultural lands and maintaining soil fertility.

Principles of Forestry and Forest Management in Agriculture

The principles of forestry and forest management in Agriculture involves the forest practices that balance environmental, social and economic aspects to ensure the long-term health and productivity of forest ecosystems.

Here are some key principles of forest management;

1. **Sustainable forest management:** Making sure we use forest resources today in a way that doesn't prevent future generations from using them too. It involves keeping forests healthy and productive by using them wisely, planting new trees and protecting them.
2. **Biodiversity conservation:** Protecting the variety of plants and animals in forests to keep nature in balance and ensure forests continue to provide important benefits.
3. **Ecosystem approach:** Managing forests by treating them as interconnected systems, where plants, animals, the environment, and human activities work together to keep the forest healthy and sustainable.
4. **Community engagement and participation:** Involving local communities and stakeholders in forest management decisions, accepting their traditional knowledge and ensuring their livelihoods are considered in planning and operation of the forest.
5. **Adaptive management:** Regularly checking and evaluating forest conditions and management practices, and making changes as needed based on new information and changing conditions.

6. **Conservation of forest soils:** Taking care of forest soils to prevent damage and erosion by using good management practices, which are important for keeping water clean and supporting plants grow
7. **Fire management:** Taking steps to prevent and manage wildfires, and sometimes using planned burns to help keep forests healthy.
8. **Timber harvesting and regeneration:** Cutting trees in a way that helps the forest recover naturally and causes less damage to the ecosystem
9. **Forest certification:** Getting a third party to check and certify that forest management practices follow accepted sustainability rules and standards.

Activity 5.1

1. What comes to mind when you hear the term forestry and forest management.
2. Write your ideas on a piece of paper and share with your peer for input.

Activity 5.2

1. Visit a nearby forest in your community with a peer or watch a video/picture of a forest (Click here).
2. With your experience at the forest, write down the importance of forest and its management in Agriculture.
3. Make a presentation of your experience at the forest and the importance of the forest to your class.

Activity 5.3

1. Using the following guiding questions, discuss the principles of forestry and forest management in Agriculture in pairs;
   a. What are the main ideas for sustainable forestry and why are they important for agriculture?
   b. How does forest management contribute to soil conservation and water quality in agricultural areas?
   c. What role does biodiversity play in effective forest management, and how does it benefit agriculture?
   d. How do controlled burns and fire prevention support the health of forests and surrounding agricultural lands?

e. Why is it important to consider both living and non-living components in forest management?

2. Present your thoughts to the class.

CONCEPTS AND IMPORTANCE OF THE INTERRELATIONS BETWEEN FORESTRY AND AGRICULTURE

The interrelations between forestry and Agriculture refer to the close and diverse relationships that exist between forestry and Agriculture in terms of land use. Forestry and Agriculture often share the same space and benefit from each other. Understanding these links is essential for planning land use in a sustainable way, managing resources well and achieving broader environmental and socio-economic goals.

Here are some key concepts of their interrelations:

1. **Land use and landscape integration:** Agricultural and forested areas are often integrated into landscapes. Having farms close to forests can boost biodiversity, improve local climate, and protect soil in farming areas. Also, the forests benefit from being near farms through pollinator movement and better soil nutrients.
2. **Agroforestry:** Agroforestry is an example of the interdependence of Agriculture and forestry, which involves integrating trees with crops and/or livestock on the same piece of land. Agroforestry systems can enhance agricultural productivity through improved soil fertility and climate control by the trees. At the same time, the crops and livestock contribute to the livelihoods and income of farmers.
3. **Water resource management:** Forests play a important role in regulating water flow and quality in watersheds. Well-managed forests act as natural sponges, storing and gradually releasing water which benefits Agriculture by ensuring a stable water supply for irrigation and other uses.
4. **Biodiversity and ecosystem services:** Forests are vital reservoirs of biodiversity and provide various ecosystem services that support Agriculture such as pollination, pest regulation and soil protection. Maintaining or restoring forest ecosystems can enhance these services and benefit agricultural productivity.
5. **Climate change mitigation and adaptation:** Forests absorbs carbon dioxide from the atmosphere, helping to reduce climate change effects. Integrating trees into agricultural landscapes or practicing agroforestry practices can contribute to carbon absorption and climate change adaptation.
6. **Livestock grazing in forests:** In some regions, livestock grazing is practised in forested areas. Sustainable grazing management can promote biodiversity conservation, soil protection, and enhance livestock productivity.

7. **Forest fuelwood and agro-residue use:** Forests can provide a source of fuelwood for cooking and heating, reducing pressure on agricultural resources. Agro-residues from crop production can also be used as biomass for energy generation.
8. **Economic and social benefits:** Both Agriculture and forestry contribute significantly to local and national economies, generating employment, income and economic development. Many rural communities rely on both sectors for their livelihoods and social well-being.

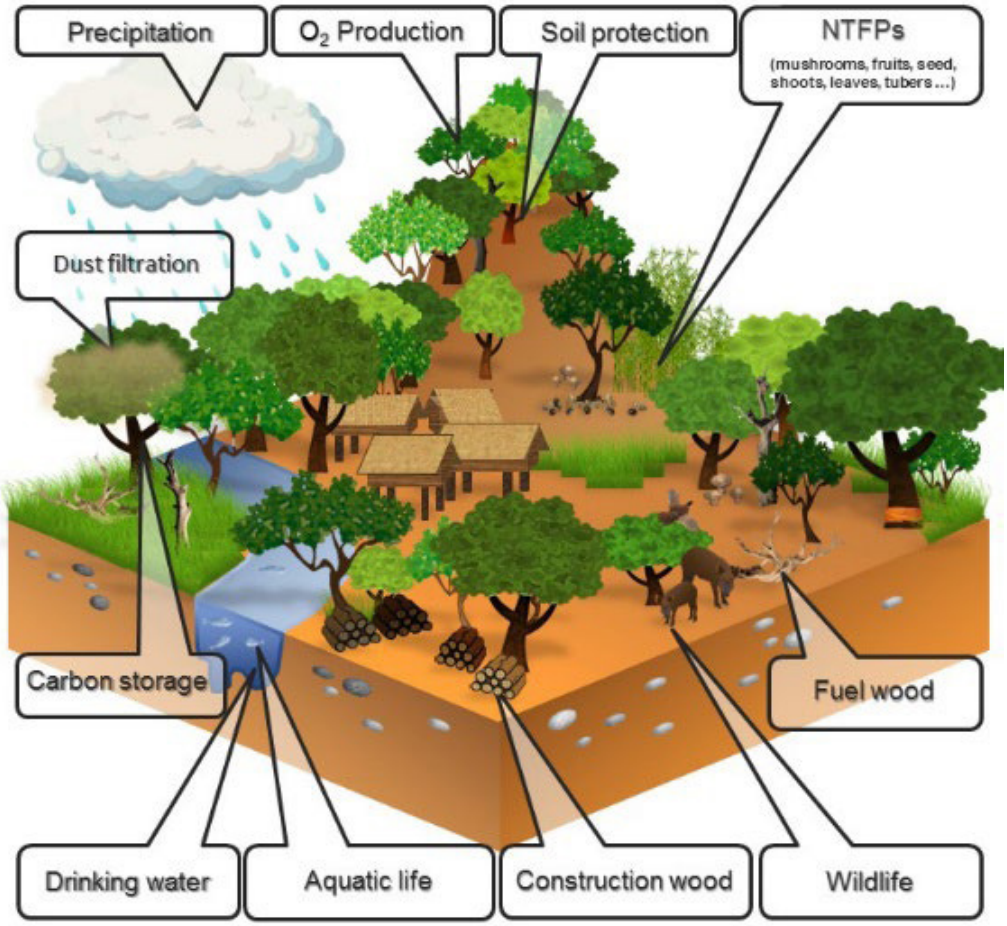


Fig. 5.1: Picture showing the interrelationship between agriculture and forestry

Activity 5.4

With the help of the internet and other resources describe how agriculture depend on forestry and how forestry also depends on Agriculture.

Share your thoughts with your peer for feedback.

Activity 5.5

Prepare a chart of the interrelationship between Agriculture and forestry

Present your chart to the whole class.

AGROFORESTRY PRACTICES AND SYSTEMS IN FOREST MANAGEMENT

Agroforestry is a way of using land where trees are grown together with crops or livestock on the same land. It involves carefully planting and managing trees alongside farming to increase productivity and make the environment stronger.

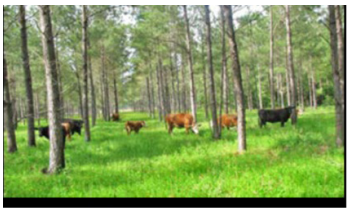
Agroforestry Practices and Systems In Forest Management

Here are some common agroforestry practices and systems in forest management:

1. **Alley Cropping (Agri silviculture):** Alley cropping involves the planting of trees or shrubs at regular intervals in rows within an agricultural field. Crops are then grown in the spaces between the tree rows. This system provides shade, reduces wind erosion, improves soil fertility through nutrient cycling, and provides timber or other tree products.
2. **Silvopasture:** It is the combination of tree planting with livestock grazing. Trees are spaced to allow for grazing underneath, providing shade and forage for livestock. This improves livestock productivity, soil quality, and carbon absorption.
3. **Windbreaks:** Windbreaks are trees or shrubs planted along the edges of fields or farms to reduce wind speed and protect crops and livestock. They act as physical barriers, preventing wind erosion and reducing stress on plants and animals.
4. **Agroforestry Gardens:** This is agroforestry systems found around households. They include fruit trees, timber trees, vegetables, and medicinal plants. Home gardens provide diverse food sources, support biodiversity, and contribute to household nutrition and income.
5. **Taungya System:** This is the temporal association of crops with tree planting. Farmers cultivate annual crops between newly planted tree seedlings to make productive use of land during the early establishment of the trees. Once the trees mature, the agricultural component is gradually phased out.
6. **Forest Gardens (Food Forests):** Forest gardens mimic natural forests by combining food-producing trees, shrubs, and herbs. These systems are designed

to be self-sustaining, providing food, fuel, and other resources while supporting biodiversity.

7. **Community Forest Management:** Community forest management involves joint efforts by local communities to manage and utilise forest resources sustainably. Agroforestry practices such as fruit tree plantations, can be integrated into community-managed forests to vary income sources and enhance ecosystem services.
8. **Forest Farming:** Forest farming refers to the cultivation of non-timber forest products (NTFPs) under the canopy of existing forests or agroforestry systems. Examples include cultivating mushrooms, medicinal herbs, or fruits in the undergrowth of a forest.
9. **Fodder and Protein Banks:** Planting trees that provide fodder and protein-rich leaves for livestock grazing, enhancing animal nutrition.
10. **Shelterwoods and Woodland Grazing:** Using forests or woodlands for livestock grazing while maintaining the forest canopy for shade and ecosystem benefits.
11. **Woody Hedgerows:** Planting rows of trees or shrubs along agricultural fields as living fences or windbreaks to protect crops and provide additional resources.
12. **Apiculture:** Introducing beekeeping in agroforestry systems to enhance pollination and honey production.
13. **Multipurpose Woodlots:** Establishing small woodlots with multiple tree species for various purposes such as fuelwood, timber, fruit, and fodder.

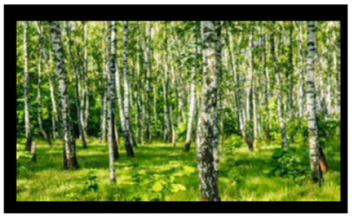


Silvopasture

Agosilvoculture

Tungya System

Apiculture



Woodlots

Woody hedgerows

Fig.5.2: Some agroforestry practices

Activity 5.6

Visit an agro-forestry site in your community/watch a video/picture recording on agro-forestry systems(click here)

Write a 2-page report on your visit or the video/picture watched and present the report to the class for feedback. In writing your report be guided by the following;

a. The type of agroforestry system being practised at the site.
b. The types of trees, crops, and/or livestock at the agroforestry site.
c. How are the trees, crops, and/or livestock integrated into the land?
d. The environmental benefits such as soil conservation, biodiversity, or climate regulation produced by agroforestry.
e. The benefit of the agroforestry site to the local community in terms of food production, income, or environmental protection.

MEANING, IMPORTANCE AND NATURE OF SOIL

Meaning of Soil

Soil is a natural body made up of minerals, organic matter, water and air, which serves as a medium for plant growth and supports the life of various organisms.

OR

It is the upper layer of the earth's crust, consisting of mineral particles, organic matter, water, air and living organisms.

Soil provides a medium for plant growth and serves as a reservoir for nutrients and water essential for supporting crops. The quality and health of the soil directly impact agricultural productivity and sustainable food production

Importance of Soil in Agricultural Production

The following are some importance of soil;

1. **Nutrient Supply:** Soil is the primary source of important nutrients for plant growth. It stores and releases nutrients such as nitrogen, phosphorus, potassium, and micronutrients which are vital for the development of healthy crops.
2. **Water Retention:** Soil acts as a reservoir, holding water for plant roots to access during dry periods. Proper water retention ensures continuous plant growth and helps withstand drought conditions.

3. **Root Anchorage:** Soil provides a stable medium for plant roots to anchor and support plants. Strong root systems enhance plant stability and allow efficient nutrient uptake.
4. **Aeration and Gas Exchange:** Soil pores allow air to reach plant roots, facilitating oxygen uptake and carbon dioxide release during respiration. Adequate aeration is essential for root health and overall plant growth.
5. **Soil Buffering:** Soil acts as a buffer against extreme pH changes, helping maintain a stable and suitable environment for plant roots and microorganisms.
6. **Biological Support:** Soil is teeming with diverse microorganisms such as bacteria, fungi and earthworms that play crucial roles in nutrient cycling, organic matter decomposition and promoting soil health.
7. **Organic Matter Decomposition:** Soil facilitates the breakdown of organic matter such as plant residues and animal waste, into simpler nutrients that can be absorbed by plants.
8. **Habitat for Beneficial Organisms:** Soil provides habitat and refuge for beneficial organisms such as pollinators and predators that support plant growth and protect against pests.
9. **Carbon Storage:** Soil is a significant carbon sink, isolating carbon dioxide from the atmosphere. Healthy soils with high organic matter content contribute to climate change mitigation.
10. **Filtration and Purification:** Soil acts as a natural filter, removing pollutants and impurities from water as it drains or seep through the soil profile.
11. **Seedbed for Germination:** Soil provides a suitable seedbed for germination, offering the necessary conditions of moisture, temperature, and nutrients for seeds to sprout and develop into seedlings.

Fig. 5.4: Some importance of soil in Agriculture

Meaning of Soil Profile

A soil profile is a vertical cross-section of soil that shows its layers or horizons, each with distinct characteristics and properties.

A typical soil profile consists of several layers or horizons, each denoted by a letter symbol:

1. **O Horizon (Organic Layer):** This topmost layer consists of decayed organic matter (humus) like leaves, branches, roots and plant residues. It is the layer where humus is concentrated and plays a crucial role in nutrient cycling. It is usually dark brown or black in colour.
2. **A Horizon (Topsoil):** The A horizon is formed from the O horizon through decomposition and mixture of mineral particles, organic matter, and microorganisms. It is the primary layer for plant growth and contains most of the soil's nutrient content. They are typically dark brown or grayish-brown.
3. **E Horizon (Eluviation Layer):** This horizon is characterised by the leaching (seepage) or removal of clay, iron, and other minerals from the A horizon to lower layers. It is typically found below the A horizon and above the B horizon.
4. **B Horizon (Subsoil):** The B horizon is often referred to as the subsoil and it is formed from the A horizon through weathering and leaching. It may have different characteristics from the topsoil, lower in organic matter and nutrients than A horizon.
5. **C Horizon (Parent Material):** The C horizon is the layer where weathered parent material, sediments or glacial deposits(a slowly moving mass of ice). May contain fragments of rocks or minerals. It forms the basis for the development of upper horizons.
6. **R Horizon (Bedrock):** The R horizon is the unweathered bedrock or consolidated rock that lies beneath the soil horizons. There is no soil formation or alteration and it acts as a barrier to root growth and water movement.

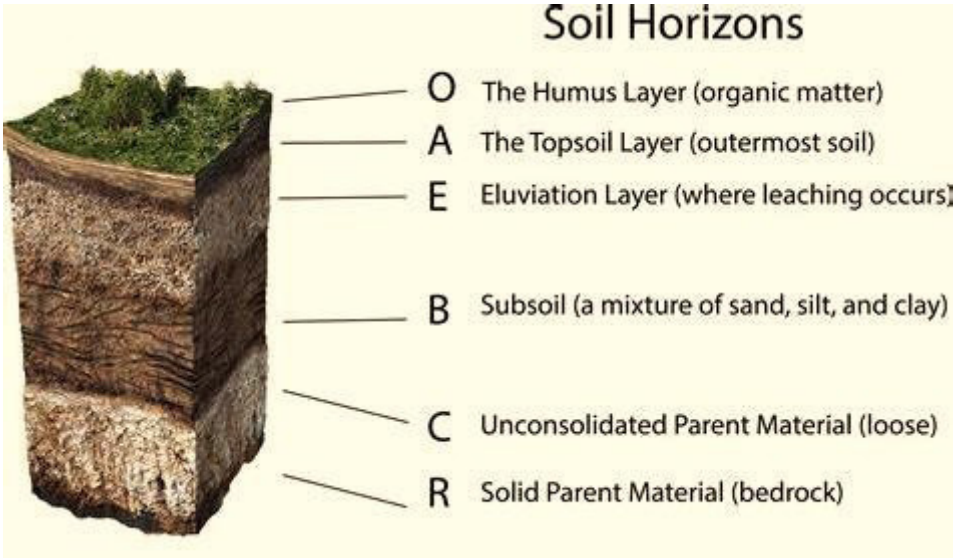


Fig. 5.5: Soil profile showing the various layers/horizons

Importance of Soil Profile in Agriculture Production

The following are some importance of soil profile in agricultural production;

1. **Help in assessing soil fertility:** Studying and getting knowledge on soil profile assist farmers and soil scientists to assess the fertility and nutrients status of the soil. It also guides farmers to know the fertilisers to apply in their right proportion to increase crop productivity.
2. **Drainage and water management:** knowledge about the soil profile help identify soil layers with different drainage characteristics which enable farmers to adopt appropriate irrigation and water management practices.
3. **Help in nutrient management:** it provides insight into nutrient availability, pH and microbial activity that impact nutrient absorption. It allows farmers to tailor nutrient management practices accordingly.
4. **Aids in crop suitability and selection:** The knowledge gain in soil profile influence farmers to select crops that are suitable and can adapt for specific areas in the farm.
5. **Soil erosion control:** Understanding the soil profile helps in determining the soil's susceptibility to erosion. Proper management of the soil layers, especially the topsoil, is crucial for sustainable agriculture and long-term productivity.
6. **Root development:** The soil profile influences the depth to which roots can grow. A deep, healthy profile allows for better root penetration, leading to stronger plants that can access more nutrients and water. It also help farmers to grow deep rooted or shallow rooted crops.
7. **Soil health assessment:** studying and understanding soil profile can contribute to assessing soil health, including factors such as soil structure, organic matter content, and biological activity that aids in plant growth and development.
8. **Soil classification and land use planning:** Soil profiles aid in classifying soils and formulating land use plans, matching land use practices with soil capabilities. The land can be used for construction purposes, agriculture purposes and other recreational purposes.

Activity 5.7

1. What comes to mind when you hear the term soil?
2. Share your thoughts with your peer for feedback and input
3. Using the internet and other resources (click here) come up with the importance of soil in agricultural production.
4. Share your findings with your colleagues for feedback and input.

Activity 5.8

1. In groups of 4 and under the guidance of your teacher/ field technician, dig a pit of 1 m2. visit at the school farm.
2. Examine the and document the horizons (soil profile) of a pit dug on the farm. In your examination consider the following;
   a. The differences in the colour and texture of the soil as you dig deeper into the pit.
   b. The distinct layers (horizons) forming the soil profile
   c. The characteristics of each layer in terms of colour, texture, structure, and presence of decayed organic matter.
   d. The presence of plant roots.
3. Draw the soil profile observed in the pit at the school farm showing the various horizons and present it to the whole class.

Caution: The activity should only be done in the presence of a technician or a supervisor. All the safety precautions must be observed during the activity.

DESCRIPTION OF THE PHYSICAL AND CHEMICAL PROPERTIES OF SOIL AND THEIR IMPORTANCE

Physical Properties of Soil

Physical properties of soil are the physical characteristics which can be observed and measured. The physical properties of soil are essential for understanding its behaviour and how it interacts with plants and other beneficial microorganisms.

These properties include:

1. **Soil texture:** It refers to the relative proportions of sand, silt, and clay particles in the soil. Soil texture affects water retention, drainage, aeration, and nutrient availability. Sandy soil has coarse particles that create large pore spaces, promoting drainage but reducing water-holding capacity. Silt has fine particles that feel smooth and hold more water than sand but have better drainage than clay. Clay has very fine particles that can hold a lot of water, but poorly drain, leading to compaction and reduced aeration.
2. **Soil structure:** The arrangement of soil particles into aggregates or clumps, such as granular, blocky, or platy structures. Well-structured soils allow for better

water movement, root growth, and microbial activity, while poorly structured soils may impede plant development.

3. **Soil porosity:** Porosity is the percentage of pore spaces or voids in the soil. It influences water infiltration and storage, as well as air circulation in the soil. High porosity allows water and air movement, benefiting root health.
4. **Soil density:** Bulk Density refers to the mass of soil per unit volume, including the pore spaces. Higher bulk density indicates compacted soil, which can restrict root growth and water movement.
5. **Soil aeration:** Soil aeration refers to the amount of air space within the soil. It's a crucial factor for plant growth, microbial activity, and overall soil health.
6. **Water-Holding Capacity:** This refers to the soil's ability to retain water after excess water has drained away. Soils with a high water-holding capacity can sustain plants during dry spells.
7. **Soil consistence:** This refers to the soil's ability to resist deformation or change in shape, particularly when wet or dry. Consistence impacts soil management practices such as tillage and planting.

Chemical Properties of Soil

Chemical properties of soil refer to its chemical characteristics which affect soil fertility, plant growth and environmental quality. These include:

1. **Soil pH :** It is the measure of acidity and alkalinity of the soil. The pH scale measure from 1 to 14. Values below 7 indicate acidic soil, while values above 7 indicate alkaline soil and 7 indicates neutral.
2. **Cation Exchange Capacity (CEC):** CEC is the soil's ability to retain and exchange cations (positively charged ions such as calcium, potassium, magnesium, and others). Soils with high CEC can retain more nutrients, making them more available to plants over time.
3. **Nutrient content:** The presence of key nutrients in the soil, including primary macronutrients like nitrogen (N), phosphorus (P), and potassium (K), along with secondary nutrients (calcium, magnesium, Sulphur) and micronutrients (such as iron, zinc, and copper).
4. **Organic matter content:** Organic matter consists of decomposed plant and animal residues, microorganisms, and humus (fully decomposed organic material). It also plays a critical role in providing a source of nutrients through mineralization and supports microbial life, which aids in nutrient cycling and soil health.
5. **Cation Ratios:** It refers to the relative proportions of different positively charged ions or cations, present in the soil. These cations include calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), sodium (Na^{+}), hydrogen (H^{+}), and others.

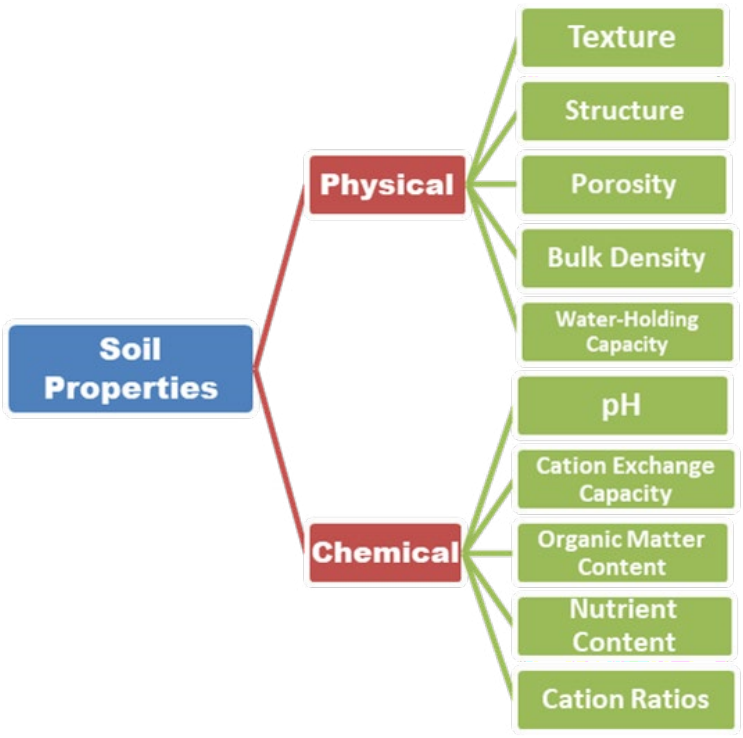


Fig.5.6: Physical and chemical properties of soil.

Importance of Physical and Chemical properties of Soil

The following are the importance of the physical and chemical properties of soil;

1. **Increased crop yield:** understanding the physical and chemical properties of soil helps farmers optimize conditions for plant growth, leading to higher crop yields.
2. **Nutrient availability and management:** soil properties affect the availability of essential nutrients like nitrogen, phosphorus and potassium to plants.
3. **Water retention and management:** properties like soil texture, porosity and structure impact water retention capacity and assist in efficient water management practices.
4. **Soil erosion prevention:** understanding soil properties helps in implementing erosion control measure to protect the soil and crops.
5. **Environmental impact:** understanding soil properties aids in sustainable farming practices, reducing environmental degradation and promoting ecosystem health.
6. **Land Use Planning:** Soil properties influence land use decisions, such as crop selection, irrigation requirements, and conservation practices
7. **Sustainable agriculture:** Understanding soil properties is essential for carrying out sustainable agricultural practices that protect soil health and promote long-term soil fertility.

Determination of Basic Soil Chemical and Physical Properties on the field

Assessing basic soil chemical and physical properties in the field is essential for assessing soil health and making informed choices in agriculture, land management, and environmental conservation. Laboratory and field base methods can be used in determining the physical and chemical properties of soil. Below are some common techniques used to determine some soil properties:

1. **Soil pH method:** The soil pH can be determined by using a litmus paper, soils that turn blue litmus paper red or maintain the red colour are acidic and soils that turn red litmus paper blue or maintain the blue colour are alkaline. A portable pH meter can also be used to determine the pH of soil.
2. **Organic matter content:** Soil samples are visually assessed for dark colouration indicating organic matter. Soils high in organic matter tend to be darker in colour and have a crumbly texture with a granular structure.
3. **Soil structure:** Soil structure can be assessed in the field by carefully digging a soil pit or using a soil auger (a drilling tool used to make holes in the ground) to extract a soil core. The soil profile is observed and described, noting the size and shape of aggregates, their distinctness and the presence of any layers or horizons. Common terms used to describe soil structure include granular, blocky, prismatic, platy, and columnar.
4. **Soil Texture:** In the field, wet soils can be felt between the fingers to determine the soil texture. Soils that feel gritty and have large, coarse particles are sandy, sticky soils with small, fine particles are clay and soils that feel smooth, soapy and/or powdery with medium-sized particles are silt. By observing these characteristics, farmers can estimate the relative proportions of sand, silt, and clay in their soil and use the soil textural triangle to determine the type of soil.
5. **Porosity:** The soil porosity can also be inferred based on the different soil textures. Sandy soils are highly porous, while silt is moderately porous with clay being less porous.
6. **Water-Holding Capacity:** Water-holding capacity of the soil can also be assessed based on the soil texture. Soils with higher clay and organic matter content tend to have greater water-holding capacity compared with sandy soils.
7. **Soil colour:** A freshly exposed soil sample is visually examined, and its colour is recorded. Soil colour gives clues about organic matter content, moisture, and mineral composition.

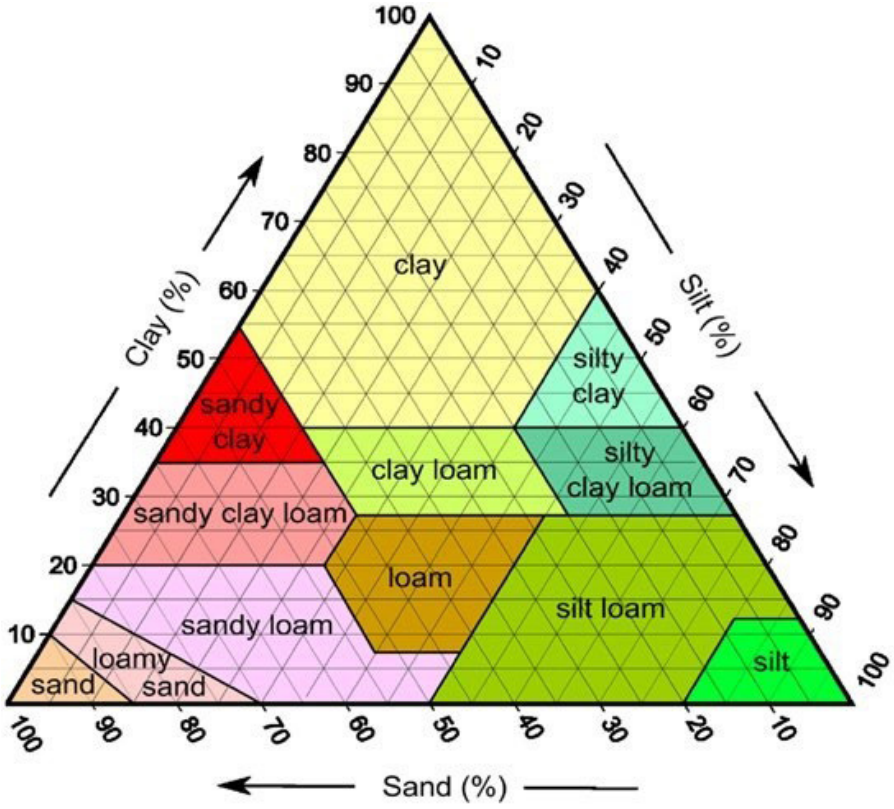


Fig. 5.7: Soil textural triangle

Organisations that Provide Soil Analysis Support for Farmers

When farmers find it difficult to determine the soil properties on their own, they rely on other organisations to seek professional services for accuracy. The following organisations can assist farmers with the process of determining the physical and chemical properties of soil in Ghana:

1. **Council for Scientific and Industrial Research (CSIR): CSIR - Soil Research Institute (SRI):** The SRI is situated in Kwadaso and Crop Research Institute in Fumesua, conducts soil testing and provides recommendations for soil fertility management to improve agricultural productivity across the country.
2. **Ministry of Food and Agriculture (MoFA):** Through its Agricultural Extension Services, MoFA collaborates with various partners to provide soil testing services for farmers, supporting informed fertiliser use and sustainable farming practices.
3. **University Agricultural Research Stations:** Several universities in Ghana have agricultural research stations and departments that conduct research on soil science and Agriculture.
4. **Cocoa Research Institute of Ghana (CRIG):** CRIG offers soil analysis services, particularly for cocoa farmers, to enhance soil fertility management and improve cocoa yields.

5. **Private Laboratories:** Private companies and laboratories such as Crop Doctor Ghana and Omnifert offer soil testing services to help farmers with tailored recommendations for fertilization and soil management.
6. **Non-Governmental Organisations (NGOs):** Non-Governmental Organisations (NGOs) involved in agriculture and rural development in Ghana often offer soil testing services and technical support to farmers as part of their agricultural extension initiatives.

Activity 5.9

Using the internet and other sources list the physical and chemical properties of soil. Present your findings in a table below

Physical properties	Chemical properties

Share and discuss your table with a peer for feedback and input.

Activity 5.10

1. In pairs, take samples of soil from different locations of the school field.
2. Perform the activities below to identify some properties of soil;

Task A

a. Moisten the soil and rub it between your fingers.

b. Based on how it feels between the fingers determine the texture of the soil as gritty (sand), smooth (silt), or sticky (clay).

Task B

a. Mix soil with distilled water and stir with stirring rod

b. Put in a stripe of litmus paper.

c Classify the soil as acidic, neutral, or alkaline based on the colour change of the litmus paper as red to blue (alkaline) blue to red (acidic) no colour change (neutral).

Task C

a. Weigh the soil collected using a scale
b. Separate the soil into clay, sand and silt
c. Weigh the different compositions (sand, clay, silt)
d. Compute the percentages of the compositions using the formula
e. Weight of composition (clay/sand/silt) / total weight of sand X 100.
f. Using the textual triangle determine the type of soil collected by locating the intersection of the percentages for the clay, silt and sand.

3. Share your report with the whole class for feedback.

EXAMINATION AND DISCUSSION ON THE COMPOSITION OF SOIL AND THEIR IMPORTANCE

Soil Components and Their Importance

1. **Mineral particles:** These are the inorganic components of soil, mainly derived from the weathering of rocks. The three primary mineral particle sizes are sand, silt, and clay, together referred to as soil texture.

   Importance: Soil texture influences water-holding capacity, aeration, and nutrient availability.

2. **Organic Matter:** Organic matter includes the remains of dead plants, animals, and microorganisms in various stages of decomposition. It is also called humus when fully decomposed.

   Importance: It enhances soil fertility and supports beneficial microbial activity contributing to climate change mitigation.

3. **Water:** Water is essential for soil life and plant growth. It occupies the pore spaces between soil particles and can be present in different forms, such as gravitational water, capillary water, and hygroscopic water.

   Importance: Water is the medium through which nutrients are transported to plant roots. It supports essential biochemical reactions in soil microorganisms. Adequate soil moisture is vital for seed germination, plant growth, and overall agricultural productivity.

4. **Air:** Air fills the pored spaces between soil particles, coexisting with water. **Importance:** Soil air is essential for root respiration and aerobic microbial activity. It facilitates nutrient uptake by plant roots and promotes the decomposition of organic matter.

5. **Living Organisms:** Soil is made up of diverse living organisms, including bacteria, fungi, nematodes, earthworms, insects and other microorganisms.

   Importance: They improve soil fertility, suppress plant diseases and enhance soil health through symbiotic relationships with plants.

6. **Inorganic Substances:** Inorganic substances in soil include various ions such as calcium (Ca), potassium (K), magnesium (Mg), phosphorus (P), and trace elements (e.g., iron, zinc).

   Importance: Inorganic substances are essential nutrients for plant growth and development. They are crucial for various metabolic processes, enzyme activities, and the synthesis of organic compounds.

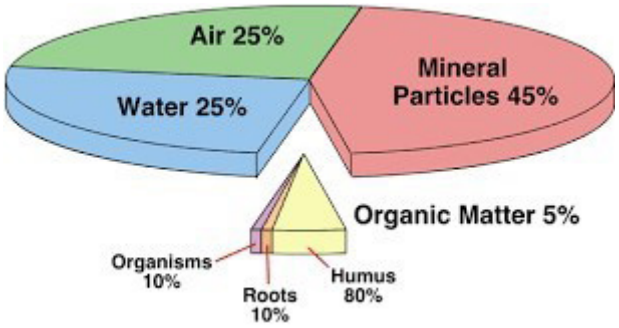


Fig. 5.8: Compositions of soil

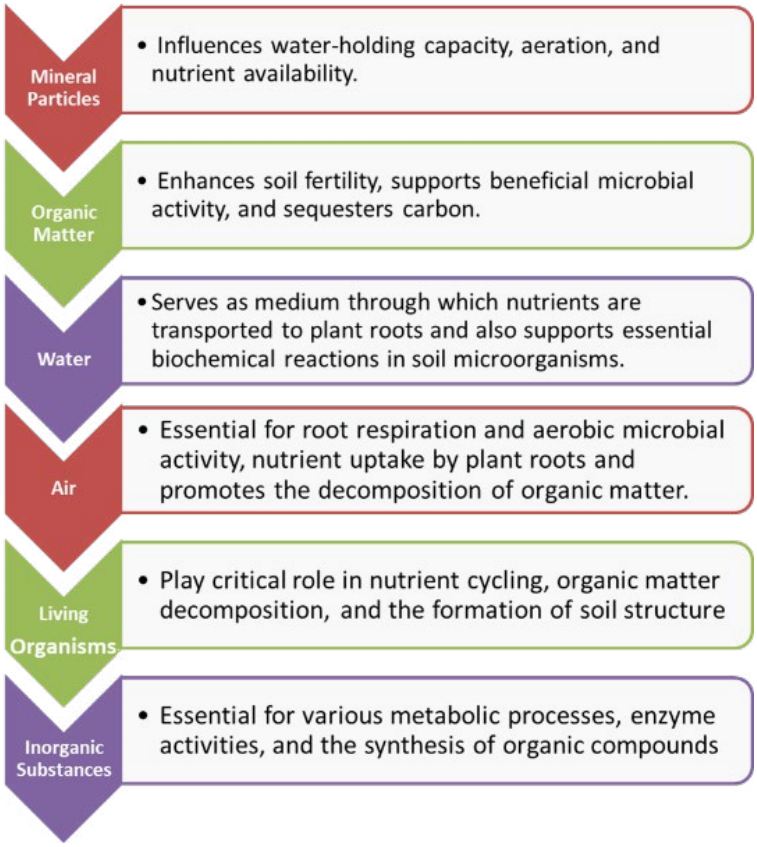


Fig. 5.9: Soil compositions and their importance

Activity 5.11

1. In pairs collect soil samples from different locations on the school farm
2. Conduct an experiment to identify the various compositions of the soil following the guidelines

Materials needed: Samples of different types of soil, measuring cylinders, water and stirring rod/stick

Steps for the experiment

   a. Put the soil sample into the measuring cylinders
   b. Pour the water gently into the measuring cylinders and observe what happens
   c. Stir the mixture with the rod/stick and allow to settle
   d. Examine the mixture and draw your conclusion

3. Write a report on the experiment and present your findings to the class. In writing the report focus on
   a. The observations during the experiment
   b. The identification of the various components of the soil.
   c. Precautions taken during the experiment.

Activity 5.12

1. With the help of the internet and other resources, discuss the effect of the various soil composition identified on the health of the soil.
2. Present your findings in the table below and share them with the class for feedback and input

Soil composition	Effect on soil health

MEANING AND EFFECTS OF CLIMATE CHANGE ON FOOD PRODUCTION AND THEIR MITIGATING STRATEGIES

Climate Change

Climate change refers to long-term shifts and changes in weather patterns and average conditions of temperature, rainfall, wind patterns, ecosystem disruptions and other aspects of the Earth's climate system. It is primarily caused by human activities, specifically the release of greenhouse gases (GHGs) into the atmosphere, which trap heat and lead to global warming. The release of GHGs, basically carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), from human activities such as burning fossil fuels, deforestation, industrial processes, and intensive agricultural practices has increased atmospheric concentrations of these gases. This increase in GHGs leads to the greenhouse effect, trapping heat in the Earth's atmosphere and causing global temperatures to rise.

Effects Of Climate Change On Food Production

1. **Crop yields:** Changes in temperature, rainfall patterns and extreme weather events can negatively affect crop yields. Heatwaves, droughts, floods, and storms can damage crops, reduce their productivity, and lead to crop failures. Also, rising temperatures can disrupt pollination processes and decrease crop quality.
2. **Shifts in growing seasons:** Climate change can alter the timing and duration of growing seasons. Changes in temperature and rainfall patterns may cause changes in planting and harvesting times, affecting crop development and productivity. Some regions may experience shorter growing seasons or reduced suitability for certain crops.
3. **Water availability:** Changes in rainfall patterns can result in water shortage or excess water in different regions, impacting irrigation practices and water availability for Agriculture. Droughts can lead to water stress for crops while increased rainfall can cause waterlogging and soil erosion.
4. **Pests and diseases:** Climate change can influence the presence of pests, weeds, and crop diseases. Warmer temperatures and changes in climatic conditions can create more favourable environments for pests and diseases leading to increased infestations and crop damage.
5. **Shifts in pest dynamics:** Climate change can change natural pest control mechanisms. For example, changes in temperature and rainfall patterns can affect the abundance and activity of beneficial insects, impacting their ability to regulate other pest populations.
6. **Livestock and fisheries:** Climate change also affects livestock and fisheries. Rising temperatures, reduced water availability, and changes in forage quality impact livestock production and health. In fisheries, changes in ocean

temperature and acidity can disrupt ecosystems and lead to shifts in fish populations, affecting fishing industries and food sources.

7. **Food price volatility:** Climate change-related disruptions to food production can contribute to increased price volatility in food markets. Reduced crop yields, supply chain disruptions, and increased demand for food can drive up prices, making food more expensive causing food insecurity.

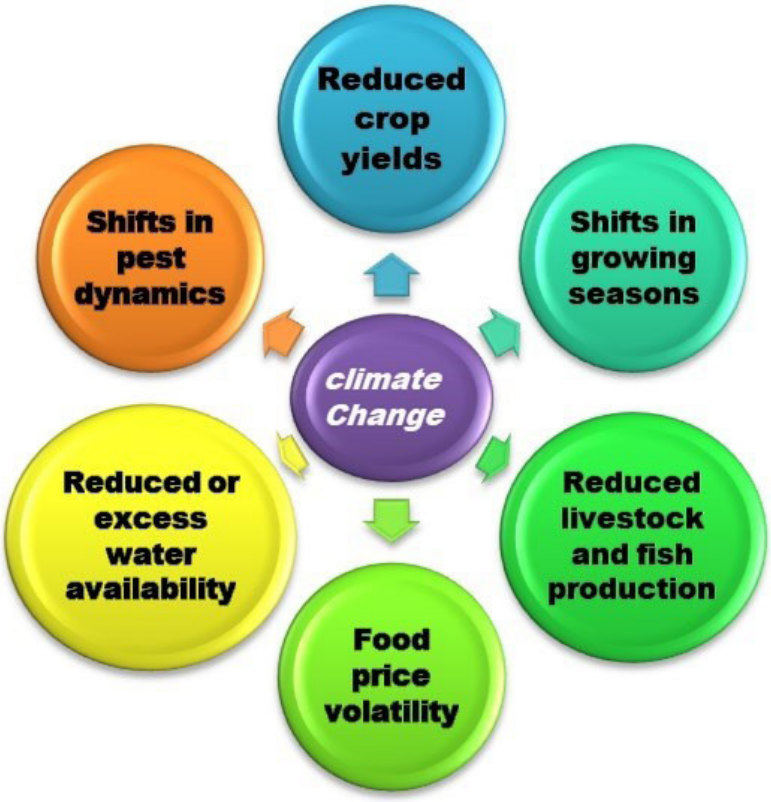


Fig. 5.10: Effects of climate change on food production

Mitigating strategies of climate change effects on food production

Climate change poses significant threats to food production (availability, accessibility and utilisation) for all individuals. The following are some strategies to reduce the effects of climate change;

1. Developing and promoting crop varieties which that can withstand temperature fluctuations, drought, and pests.
2. Implementing sustainable soil management practices such as conservation agriculture and agroforestry, to improve soil health, water retention, and nutrient availability.
3. Investing in agricultural research and technology to develop climate-smart farming techniques and precision agriculture methods.

4. Monitoring and early warning systems to detect and respond to pest and disease outbreaks promptly.
5. Promoting integrated pest management practices that reduce chemical pesticide use and rely on natural pest control methods.
6. Conducting research on pest and disease resistance in crops and developing resistant crop varieties.
7. Implementing efficient irrigation techniques such as drip irrigation and precision irrigation to reduce water wastage.
8. Developing and improving water storage and management systems, including rainwater harvesting systems and small-scale reservoirs.
9. Promoting water-use efficiency and conservation practices among farmers and encouraging the adoption of drought-tolerant crop varieties.
10. Enhancing livestock management practices, including improved animal housing, feeding, and health management to mitigate heat stress and disease risks.
11. Promoting sustainable and climate-resilient aquaculture practices.
12. Strengthening marine conservation and fisheries management to protect fish populations and preserve aquatic ecosystems. Combating the impacts of climate change on food security requires a multi-faceted approach involving policy interventions, technological advancements, and international collaboration.

Activity 5.13

1. Come up with the meaning of climate change in agriculture production by responding to these questions;
   a. What comes to mind when you hear the term climate change?
   b. Why do you think changes in weather patterns might affect farming and food production?
2. Share your thoughts and ideas with peers.
3. Create a chart to show the relationship between climate change and agriculture and discuss it with your peer.

Activity 5.14

1. In pairs, consider the following case studies;

Case study A

The Ashanti Region, a major agricultural producer in Ghana, is facing a severe drought. The drought has lasted for three years, with the past year being the driest on record. The water levels in reservoirs and rivers have dropped significantly, and the soil moisture is at an all-time low

Case study B

Heavy rainfall has caused severe flooding in the three northern regions of Ghana, a major agricultural region. The floodwaters have submerged fields, destroying crops and structures. The flooding has also contaminated water sources, making it difficult for farmers to irrigate their crops.

Case study C

A severe heat wave has struck the Afram Plains a major agricultural district in the Eastern Region of Ghana. Temperatures have soared above 38 degrees Celsius for several days, causing widespread damage to crops and livestock.

2. Discuss the impact of the above case studies on Agricultura production using the following guiding questions
   a. What are the immediate and long-term impacts of the climatic conditions in the affected areas?
   b. What are the potential economic consequences for farmers and the broader community in the affected areas?
   c. What strategies can be implemented to mitigate the effects of the climatic conditions in the affected area?
3. Share your findings with the class.

Activity 5.15

1. Using the internet and other resources write a 2-page essay on how to reduce the impact of climate change on food production. in your writing be guided by the following the activities that cause climate change
   a. What can farmers and community members do to reduce the impact of climate change on food production?
   b. What can the government do to reduce the impact of climate change on food production?
2. Share your ideas and thoughts with peers.

REVIEW QUESTIONS

1. Explain how forest management contributes to the preservation of biodiversity.
2. How can integrating trees into an agricultural system improve soil health?
3. What are the economic benefits of agroforestry to smallholder farmers
4. Your school want to embark on an agriculture venture by planting tomatoes, maize and cabbage for sale at the local market. As an agricultural scientist, give the soil conditions that will be favourable for the cultivation of the crops.
5. What is the impact of pH on nutrient availability and plant growth?
6. How can a farmer improve the physical properties of soil, such as its structure, texture and drainage?
7. What are the key components of soil that affect its water-holding capacity?
8. How does the composition of soil affect its fertility and plant growth?
9. What are the implications of soil composition for crop selection and management in a specific agricultural context?
10. What is the effect of a change in temperature on crop yields?
11. What are some potential consequences of more frequent flooding on agricultural land?
12. What role can technology play in helping farmers adapt to climate change?
13. How can consumers contribute to reducing the impact of climate change on food production?

ANSWERS TO REVIEW QUESTIONS

1. Forest management contributes to the preservation of biodiversity through practices that protect and enhance the variety of species, habitats, and ecosystems within a forest. Some ways that forest management supports biodiversity are;
    - **Maintaining habitat diversity:** Forest management practices, such as selective logging and creating buffer zones, help preserve different types of habitats within a forest, ensuring that various species have the environments they need to thrive.
    - **Protecting endangered species:** forest management plans often include measures to protect endangered or threatened species by conserving critical habitats and reducing human impacts.
    - **Promoting natural regeneration:** By allowing natural processes like seed dispersal and growth to occur, forest management supports the regeneration of diverse plant species, which in turn supports a wide range of animal life.
    - **Controlling invasive species:** Forest management helps prevent the spread of invasive species that can outcompete native plants and animals, maintaining the natural balance of the ecosystem.
    - **Restoring degraded areas:** Reforestation and afforestation efforts restore degraded lands, reintroducing native species and rebuilding ecosystems that have been damaged by human activity.
2.
    - **Nitrogen fixation:** Some trees, such as legumes, have the ability to fix atmospheric nitrogen into the soil, enriching it with nutrients.
    - **Organic matter:** Trees provide leaf litter, which decomposes and adds organic matter to the soil, improving its structure and fertility.
    - **Erosion control:** Tree roots help stabilize the soil, reducing erosion and preventing nutrient loss.
    - **Reducing soil temperature:** The shade provided by trees helps regulate soil temperature, keeping it cooler in hot weather. This reduces the rate of soil moisture evaporation and protect soil organisms that are sensitive to high temperatures,
    - **Supporting soil biodiversity:** Trees create a habitat for a variety of soil organisms, such as earthworms, insects, fungi, and bacteria. These organisms play a crucial role in decomposing organic matter, cycling nutrients, and maintaining soil structure.

3.

- **Diversified income:** Farmers can earn income from multiple sources, such as selling timber, fruits, nuts, and other tree products.
- **Reduced inputs:** Trees in agroforestry systems can reduce the need for chemical fertilizers and pesticides by improving soil health and providing habitat for beneficial insects.
- **Value-added products:** Farmers can increase profitability by processing tree products, such as making jams, oils, or crafts, to sell at a higher price.
- **Improved food security:** Agroforestry systems can enhance food security of farmers by providing a diverse range of food products, such as fruits, nuts, and leafy greens. This diversity helps farmers meet their families' nutritional needs and reduces the need to purchase food.
- **Increased crop yields:** Trees in agroforestry systems can improve soil fertility through nitrogen fixation, organic matter addition, and moisture retention, which can lead to higher crop yields. Improved yields translate to greater harvests and increased income from crop sales.

4. A well-balanced loamy soil with a good mixture of sand, silt, and clay is ideal. The soil should have a crumbly structure that allows for easy root penetration, water infiltration, and air circulation, all of which are essential for healthy crop growth. The soil should retain enough moisture to support crop growth but also drain excess water efficiently to prevent waterlogging, which is especially important for tomatoes and cabbage. For optimal growth, the soil pH should be slightly acidic to neutral. Tomatoes thrive best in pH 6.0 to 6.8, maize in pH 6.0 to 7.5, and cabbage in pH 6.5 to 7.5. The soil should be loose and well-aerated to promote oxygen availability for roots and microbial activity, enhancing plant growth and nutrient cycling. The soil should be rich in organic matter to enhance soil fertility, water retention, and nutrient availability.

5. Soil pH affects the solubility of nutrients, determining whether plants can absorb them efficiently. In acidic soils (low pH), important nutrients like phosphorus, calcium, and magnesium become less available to plants, while toxic elements like aluminium and manganese may become more soluble, potentially harming plants. In alkaline soils (high pH), micronutrients such as iron, zinc, copper, and manganese become less available, leading to nutrient deficiencies that can stunt growth. Different plants have specific pH preferences. If the soil pH is outside the optimal range for a particular plant species, it can hinder nutrient uptake, reduce growth, and lead to poor yields.

6. Farmers can improve the physical properties of soil, such as its structure, texture and drainage through the following;

- Adding organic materials like compost, manure, or cover crops to improve the soil aggregation, creating a more stable structure. Organic matter helps bind soil particles into larger aggregates, improving aeration and water infiltration.

- Reducing tillage to maintain soil structure by reducing the disruption of soil aggregates and preventing compaction.
- Rotating crops, especially with deep-rooted plants, helps break up compacted layers, promote better soil structure, and improve root channels for subsequent crops.
- Reducing the use of heavy equipment and managing grazing patterns can help prevent compaction, maintain better soil structure and porosity.
- Aerating compacted soils, especially on farmland and pastures to allow air, water, and nutrients to penetrate the root zone, encouraging better plant growth.
- Applying mulch to the soil surface protects it from erosion, conserves moisture, and adds organic matter as it decomposes.
- In sloped areas, ploughing along contours or building terraces helps slow water runoff and prevents soil erosion, maintaining better soil quality and structure.

7. Refer to the content for the answer.
8. The compositions of soil including the proportions of sand, silt and clay affect soil fertility by making nutrients available and providing correct pH and plant growth by promoting root development and ensuring nutrient uptake.
9. The importance of soil composition in agriculture production including its impact on crop selection aids in choosing crops adapted to soil type, and management practices such as irrigation, fertilisation and overall productivity.
10. A change in temperature can lead to drought stress, altered growing seasons and changed pest dynamics, finally reducing crop yields.
11. Potential flooding can lead to soil erosion, nutrient loss, and increased risk of waterborne diseases, ultimately affecting crop quality and quantity
12. Technology can help farmers adapt to climate change by embarking on precision agriculture, climate-smart agriculture and other technological innovations.
13. Consumers can contribute to reducing the impact of climate change on food production by sustaining consumption patterns, reducing food waste and supporting climate-resilient agriculture.

EXTENDED READING

- For more information on forest management, click here , click here and here
- For more information on Agroforestry, click here
- Exotic series, General Agriculture for SHS by Eric Amoah
- Brady, N.C., & Weil, R.R. (2008). The Nature and Properties of Soils.14th ed. Prentice Hall.
- Hillel, D. (2004). Introduction to Environmental Soil Physics. Elsevier.
- Agriculture and climate change: An introduction" by Robert Mendelsohn
- Climate change and food security" by Paoli Rossi

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7. General Agriculture Text Book for Senior Secondary Schools.
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9. General Agriculture Text Book for Senior Secondary Schools.

GLOSSARY

- **Forestry:** the art and practice of managing forests and woodlands to protect the forest and its biodiversity, ensure proper timber production and supply of ecosystem services.
- **Forest management:** the process of planning and applying forest practices to realise specific objectives in forested areas.
- **Agroforestry:** a way of using land where trees are grown together with crops or livestock on the same land.
- **Soil:** a natural body made up of minerals, organic matter, water and air, which serves as a medium for plant growth, a reservoir for nutrients and water, and supports the life of various soil organisms.
- **Soil profile:** a vertical cross-section of soil that shows its layers or horizons, each with distinct characteristics and properties.
- **Climate change:** refers to long-term shifts and changes in weather patterns and average conditions of temperature, rainfall, wind patterns, ecosystem disruptions and other aspects of the Earth's climate system.

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