MINISTRY OF EDUCATION

AGRICULTURAL SCIENCE

For Senior High Schools

TEACHER MANUAL

YEAR THREE

NATIONAL COUNCIL FOR CURRICULUM & ASSESSMENT OF MINISTRY OF EDUCATION

MINISTRY OF EDUCATION

REPUBLIC OF GHANA

AGRICULTURAL SCIENCE

For Senior High Schools

Teacher Manual

Year Three

NATIONAL COUNCIL FOR CURRICULUM & ASSESSMENT OF MINISTRY OF EDUCATION

AGRICULTURAL SCIENCE TEACHER MANUAL

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Contents

Introduction for the Year Three Teacher Manual

The National Council for Curriculum and Assessment (NaCCA) has developed the third and final set of curriculum materials to support the implementation of the new Senior High School curriculum.

This Year Three Teacher Manual for covers all aspects of the content, pedagogy, teaching and learning resources and assessment required to effectively support learners in their final year of Senior High School. All the necessary information for the Student Assessment Portal has been included in the Year Three Teacher Manual to simplify the development of weekly learning plans, meaning that teachers have a single reference document.

The Year Three Teacher Manual has two main objectives:

- To support learners to consolidate and deepen their understanding of the content, pedagogy, and assessment across all three years of the new Senior High School curriculum in preparation for the West Africa Senior Secondary Certificate Examination (WASSCE).
- To equip teachers with the tools and resources needed to deliver revision-focused, assessment-led lessons that build on the knowledge learners have acquired from Year One to Year Three.

In this third year, teachers will be supporting learners to prepare for the WASSCE. Each section of the Teacher Manual is therefore structured around the highest Depth of Knowledge (DoK) levels, allowing learners to build progressively on knowledge acquired from Year One to Year Three. For each week, learning tasks and pedagogy are built around the assessment, ensuring that classroom activities directly prepare learners for the demands of the examination. Two sets of sample examination papers are also provided; one administered by Week 12 as a first semester practice examination, and one by Week 20 as a mock examination, to gauge learners' competencies and identify areas requiring remediation.

To further support teachers in delivering Year Three, NaCCA, working with the Ghana Education Service, has developed a subject specific App for each subject.

The Year Three PLC sessions have been revised in response to findings from the 2025 annual evaluation survey. The survey confirmed that teachers have made strong progress in lesson planning, use of varied instructional methods, ICT integration and modes of assessment. To address the identified gap in explaining concepts clearly using examples familiar to learners, each PLC session now includes a dedicated Content Exploration segment. This ten-minute segment brings the subject group together to work through one challenging problem or concept from the week's Teacher Manual content, not to plan how to teach it, but to ensure that every teacher in the group fully understands it.

The PLC sessions in Year Three also place particular emphasis on connecting the week's content to equivalent topics taught in Years One and Two. Teachers are encouraged to note the recap weeks signposted throughout the Teacher Manual and to use the App to explore how content across all three years links together.

As in previous years, teachers are expected to integrate National Values, Gender Equality and Social Inclusion (GESI), Social and Emotional Learning (SEL), and 21st-century skills into their learning activities, assessment tasks, and rubrics and mark schemes. The subject-specific App will support teachers in doing this throughout the year.

Ghana Education Service acknowledges the dedication of the teachers who have implemented the new curriculum across Years One and Two and recognises that Year Three represents both the culmination of that effort and a critical moment for learners. The Year Three Teacher Manual and its accompanying resources have been developed to ensure that every learner, regardless of background, ability, or school context, is fully prepared to demonstrate what they know and can do in the WASSCE and to progress confidently to further studies, the world of work, and adult life.

Acknowledgements

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SECTION 1: BUDDING AND GRAFTING IN TREE FRUIT CROP PRODUCTION

STRAND: NEW DAWN IN AGRICULTURE

Sub-Strand: Emerging Technologies in Agriculture

Learning Outcome: *Identify emerging technologies in plantation and fruit tree enterprises*

Content Standard: *Demonstrate knowledge and understanding of emerging technologies and their benefits in plantation and fruit tree enterprises*

INTRODUCTION AND SECTION SUMMARY

Tree fruit crop production is a major agricultural activity in many parts of Ghana, including the Forest, Forest-Savanna Transition, and Savanna zones. Mango, citrus and avocado are the main fruit trees cultivated and all are grown from seeds or budded/grafted seedlings. Growing them from seeds, however, delays the pre-flowering phase, resulting in unnecessary establishment costs for growers. Grafting and budding require expertise that many growers lack. This section introduces learners to budding and grafting in tree fruit crops. It highlights the budding and grafting procedure, their role in the rapid production of seedlings, creation of new cultivars with unique characteristics such as resistance to diseases or pests, and reduction in maturity time. The section encourages practical activity to help learners develop their skills in budding and grafting, an art they can perfect as a business for income generation and cultivating tree fruit crops.

The weeks and the indicators covered by the section are:

- **Weeks 1 & 2:** Carry out budding and grafting in tree fruit crops.

Summary of Pedagogical Exemplars

This section suggests pedagogy – experiential learning – that involves practical activity where the teacher or technician guides the learners to acquire budding and grafting skills. While practising budding and grafting, learners will combine experiential learning with collaborative and digital learning. This will allow them to assess and share vital information on the learning indicator and focal area, and benefit from an effective learning experience and a deeper knowledge and skills in budding and grafting. Teachers are encouraged to consider the diverse needs of the learners and tailor the pedagogical strategies to meet their needs. All teachers and facilitators should always remember and apply these six core guiding principles in their activities and interactions with the learners, during every lesson.

Equality of Opportunity: The learners should have fair and equal access during all activities.

Recognition of Diversity: The teacher should ensure the learners acknowledge and respect the diverse, intersecting identities (e.g., race, disability, age, gender) that shape human experiences.

Participation and Empowerment: The teacher should encourage the marginalised and vulnerable groups to have a voice and an active role in every decision-making in class.

Proportional Inclusion: The teacher should ensure a fair representation of all three levels in all groupings.

Non-Discrimination: Eliminating biases, stereotypes, and prejudice based on identity.

Social Justice: Actively addressing the root causes of systemic inequalities.

ASSESSMENT SUMMARY

Diverse assessment strategies are suggested in this section to evaluate learners' performance. These include formative and summative assessment strategies to provide regular feedback to learners, helping them identify their strengths and areas for improvement. The assessment is based on DoK Level 3 strategic reasoning. It includes class exercises and tests, individual and group projects and demonstration of skills in hands-on activities. The responses will be either oral or written and presented by individuals or groups. Teachers are expected to give prompt feedback to learners on their performance and record their performance in the Assessment Portal.

Table 1.1: *Assessment summary for the indicator*

Indicator	DoK Level	Assessment Strategy and/or Mode
Carry out budding and grafting in tree fruit crops	3	Project Work

WEEKS 1 & 2

Learning Indicator: *Carry out budding and grafting in tree fruit crops*

Focal Area: Budding and grafting of tree fruit crops

1. Meaning and differences between budding and grafting

a. Budding is a horticultural technique used for vegetative or asexual plant propagation. In this technique, a bud (the scion) (Figure 1.1) from one plant is inserted into the bark of another plant (the rootstock). This allows the scion to grow and develop into a new shoot or plant, incorporating the desirable traits of the donor plant. This method allows the transfer of specific characteristics, such as flower colour, fruit quality, or disease resistance, into a different plant.

i. Purpose: Budding is commonly used for fruit trees and ornamental plants due to its efficiency and the ability to maintain specific traits. Its primary purpose is to produce new individuals without the need for sexual reproduction.

ii. Common examples of budded plants:

- Roses: Often budded to combine different varieties for better blooms and disease resistance.
- Citrus trees: Varieties like oranges and lemons are frequently propagated using budding techniques.
- Apple trees: Used to propagate specific cultivars and improve fruit quality.

b. Grafting is a technique in which tissues (scion) from one plant are joined to another plant (the rootstock) to grow together as a single plant. This method is commonly used to combine desirable traits from both plants, such as disease resistance, fruit quality, flower colour, or growth habits.

Figure 1.1: *An excised bud*

c. Differences between budding and grafting: While both techniques are used for plant propagation, budding focuses on a single bud insertion, whereas grafting involves joining larger plant sections. Each method has its applications, advantages and challenges (Table 1.2).

Table 1.2: *Differences between budding and grafting*

Feature	Budding	Grafting
Plant part	Involves only a single bud	Involves a larger piece eg stem
Application	Primarily used for certain fruit trees and ornamental plants	Widely used for a variety of plants, including fruit trees, vegetables, and ornamentals

Success rate	Often high due to the smaller size and fewer tissues involved	Can be low due to the complexity of joining larger tissues
Scion type	Uses only a bud	Uses a stem section containing multiple buds

2. Importance of budding and grafting in fruit trees

Budding and grafting have advantages that contribute to the health, productivity and longevity of the crop. Budding and grafting contribute to the sustainability of commercial and home orchards.

a. Importance of budding

i. Clonal reproduction: Budding produces clones of the parent tree, ensuring uniformity in fruit quality and tree characteristics. This consistency is important for commercial fruit production, where uniformity in size, taste, and appearance is desired.

ii. Propagation of desired varieties: Budding allows for the propagation of specific fruit tree varieties that exhibit desirable traits, such as improved fruit quality, disease resistance, or enhanced yield. By using a bud from a parent tree with these traits, growers can ensure that new trees will produce fruit with the same qualities.

iii. Early maturity: Trees grown from budding often reach fruit-bearing age more quickly than seeds.

iv. Disease resistance: Budding susceptible but high-yielding varieties onto resistant rootstocks can solve specific soil-borne disease or pest problems and improve the overall health and productivity of orchards.

b. Importance of grafting

i. Improved tree health and productivity: Grafting a scion from a desirable fruit variety onto a rootstock well-adapted to local soil and climate conditions enhances the tree's overall health, increases resistance to pests and diseases, and improves productivity.

ii. Variety development: Grafting allows growers to experiment with and develop new fruit varieties. By combining different scions and rootstocks, new cultivars with unique characteristics can be created, leading to a wider range of fruit options and potentially new market opportunities.

iii. Repair and maintenance: Grafting can repair damaged trees or rejuvenate older less productive trees, hence extending their productive life.

iv. Space efficiency: Grafting allows for the propagation of multiple varieties on a single rootstock, which is particularly useful for small spaces or specialty orchards, diversifying the types of fruit produced.

3. Procedure for budding and grafting

Budding

a. Selection of scion and rootstock

i. Rootstock: Select a vigorously growing and healthy rootstock to provide the growth base and root system.

ii. Scion: The part of the plant that will become the new shoot (usually a bud from a desirable variety). Choose the scion from a healthy desired plant/shoot.

b. Preparation

i. Scion preparation: Using a budding knife, carefully remove the bud from the shoot, typically with a small portion of wood (See Figure 1.2).

ii. Rootstock preparation: Cut the bark of the rootstock where the bud will be inserted in a T-shape, inverted T or a vertical slit.

c. Insertion: Lift to separate the bark from the rootstock and insert the bud into the cut, ensuring good contact with the cambium layer (the growth tissues).

d. Securing: The bud and the rootstock are wrapped with tape or another binding material to hold them in place and prevent moisture loss.

e. Healing: Over time, the tissues of the rootstock and bud will grow together and become one plant. Once the bud has successfully taken and is growing well, the binding material can be removed

f. Aftercare: The plant is monitored for growth and health. Any shoots growing from the rootstock below the bud should be pruned.

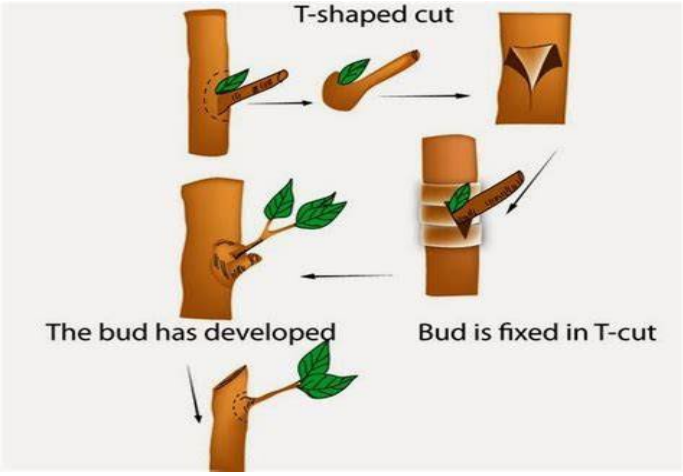


Figure 1.2: *The budding process*

Grafting

a. Types of grafting: There are various types of grafting, but there are four common forms: Cleft/ wedge grafting, Whip-and-tongue grafting, Side grafting and Veneer grafting.

i. Cleft grafting is used to join a scion to a rootstock. The process involves splitting the rootstock, inserting the scion, and securing them together to allow for fusion and growth. It's commonly used for top-working fruit trees, changing varieties, or propagating trees that are difficult to root from cuttings (Figure 1.3A).

ii. Whip-and-tongue grafting: a plant graft made by locking a small tongue and notch in the obliquely cut base of the scion with corresponding cuts in the stock (Figure 1.3B).

iii. Side grafting: A wedge-shaped cut is made into the rootstock, removing a section of wood and bark. The rootstock may be decapitated, depending on the specific side grafting technique. The scion is usually a wedge-shaped piece of wood, designed to fit into the cut on the rootstock. The main advantage of side grafting is that it can be used with scions of varying sizes and may offer too large a surface area for easy vascular fusion (Figure 1.3C).

iv. Veneer grafting: It is a type of side grafting, also called inlay grafting. A thin, almost superficial cut is made on the rootstock, creating a "veneer" of bark and wood. The rootstock is usually not decapitated, allowing shoot growth to continue above the graft. The scion is a wedge-shaped piece of branch, designed to fit into the veneer cut on the rootstock. Veneer grafting is used for stocks larger than 2.5 centimetres. The cut is made on the side of the stock and not on top. Its main advantage is that it is easier to perform than cleft grafting, and can be used with rootstocks of different sizes (Figure 1.3D).

b. Selection of scion and rootstock: Choose a compatible rootstock and scion; the scion should be the same girth as the rootstock at the grafting point.

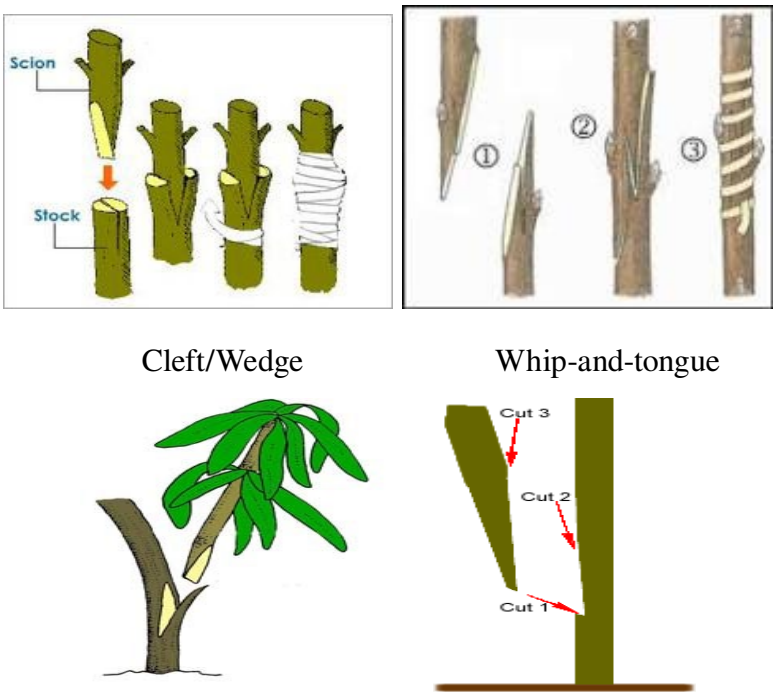
c. Preparation: Cut the rootstock and scion to fit together, according to the grafting technique.

d. Joining: The scion and rootstock are joined, ensuring the cambium layers (the growth tissues) are aligned. Proper alignment is crucial for successful grafting.

e. Securing: The joined parts are secured with grafting tape, rubber bands, or string. The graft union should be protected from infection, sometimes with wax or a grafting compound.

f. Healing: The graft union is covered with a grafting compound or wax to prevent desiccation and infection. Over time, the tissues of the scion and rootstock fuse.

g. Aftercare: The grafted plant is monitored for healthy growth. Any new shoots from the rootstock below the graft are removed. Over time, the tissues will unite and form a single plant.



Cleft/Wedge Whip-and-tongue

Veneer grafting Side grafting

Figure 1.3: *Grafting types*

Learning Tasks

1. Explain the terms budding and grafting and outline the differences between them.
2. Describe the steps involved in performing the procedure for budding and grafting.
3. Discuss the relevance of budding and grafting in modern agriculture.

Pedagogical Exemplars

Collaborative Learning: Learners, in groups, search for information on budding and grafting and present reports.

Experiential Learning

- A technician/resource person demonstrates the processes of budding and grafting.
- Learners practise the processes until perfection.
- Learners measure the success rates of their budding and grafting efforts.

Key Assessment Level 3: Group Research Work

Guide learners to graft a selected fruit tree successfully. Outline the programme's objectives, materials, and anticipated challenges and solutions. (20 marks)

HINT

Assign a group research project to learners and give them a reasonable time to complete it. Use the SS App to generate the project and the rubric. Learners' projects should be marked immediately and scores entered into the SAP.

PLC Session 1 & 2

45 minutes | **Planning & Reviewing the Learning Plan**

1. Begin the session by recapping lessons from the previous session, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
   a. explain the week's concepts in a practical way that will make it easier for learners to understand.
   b. identify three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
   a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
   b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q).
   c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).

Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Use your app to plan and administer the mode of assessment for the student Assessment Portal (SAP).
   a. The key assessment for the week is group research work. Chat with your app to plan this assessment by reviewing or developing the assessment items/tasks and marking schemes/ rubrics for the research work (NTS 3k-3q).

10 minutes **Content Exploration**

5. As a subject group, select one problem or topic/idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
   a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
   b. all teachers in the group work through the problem individually for 3–4 minutes
   c. the group then works through it together the problem, step by step
   d. highlight the most common errors made at each step (NTS 1c, 1e, 2c, 2e, 3e-3j).

Note

- *This part is not 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes **Enactment**

6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).
   a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
   b. After the enactment, ask for structured feedback from the group
      i. was the concept explained in a way that a learner with no prior knowledge could follow?
      ii. were the examples grounded in contexts familiar to Ghanaian learners?
      iii. did any misconceptions surface and if so, how were they addressed?

5 minutes **Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
    a. transfer your chats into your learning planner template.
    b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
    c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

SECTION 1 REVIEW

The lessons under this section were covered in two weeks. The first week dealt with the meaning and importance of budding and grafting in tree fruit crop cultivation, while the second week delved into the acquisition of skills in budding and grafting. At least two of mango, citrus and avocado were used in the practical activity. The learners went through the raising of root stocks, scion collection and preparation, various ways of root stalk incision, scion placement and binding, and setup watering and nutrition. Teachers or technicians ensured, as far as possible, that all groups of learners reached the same level of competency in the budding and grafting process. The teacher conducted the appropriate assessments with regular feedback to the learners.

MARKING SCHEMES FOR THE KEY ASSESSMENTS

Week 1 & 2 Group Research Work

Expected work components and mark allocation.

1. Programme objectives.
    a. To equip smallholder farmers with practical skills in budding and grafting techniques for fruit trees.
    b. To improve survival rates and productivity of fruit trees in farmers' orchards.
    c. To promote the adoption of improved propagation methods to increase farmers' incomes.

    Any 2 × 1 mark = 2 marks
2. Overview of budding and grafting techniques
    a. Types of budding (e.g., T-budding, patch budding) (1 mark)
    b. Types of grafting (e.g., whip-and-tongue, cleft grafting) (1 mark)
    c. Materials and resources
        - Budwood (scion sticks)
        - Rootstock seedlings
        - Budding and grafting knives
        - Grafting/budding tape or polythene strips
        - Labels and markers
        - Watering cans
        - A demonstration field or orchard

    Any 5 × 1 mark = 5 marks
3. Practical demonstration by each learner to show mastery of budding/grafting
    a. Selection and preparation of rootstock and scion
    b. The step-by-step budding and grafting process
    c. After-care of budded and grafted plants
    d. Record-keeping and monitoring of success rates

    At least 3 processes carried out correctly for 3 marks each = 9 marks
4. Common challenges and troubleshooting (2 marks).

SECTION 2: BEE-KEEPING AND ITS ROLE IN PROMOTING TREE FRUIT CROP PRODUCTION

STRAND: NEW DAWN IN AGRICULTURE

Sub-Strand: Emerging Technologies in Agriculture

Learning Outcome: *Distinguish between existing and emerging technologies used in plantation and fruit tree enterprises*

Content Standard: *Demonstrate knowledge and understanding of emerging technologies and their benefits in plantation and fruit tree enterprises*

INTRODUCTION AND SECTION SUMMARY

Section 2 will evaluate the role of bees and bee-keeping in tree fruit crop enterprises. Many tree crops rely largely on bees for pollination. Encouraging bees naturally, or strategically placing bee hives in orchards, will enhance pollination and increase fruit production. By the end of Week 4, the learners should be able to explain the importance of bee-keeping in tree fruit crop enterprises. Relevant pedagogies, such as activity-based and digital learning, will be employed to engage learners in acquiring the necessary skills required in beekeeping. By the end of the section, learners should have acquired skills to engage in small-scale beekeeping individually or on a large scale in groups.

The weeks and the indicators covered by the section are:

- **Weeks 3 & 4:** Explain the importance of bee-keeping in tree fruit crop enterprises.

SUMMARY OF Pedagogical Exemplars

Strategies such as activity-based digital learning and structured talk for learning will be used to teach the meaning, components, objectives, benefits and challenges of beekeeping. Teachers should consider the diverse cultural backgrounds and learning abilities of learners when deploying these pedagogical strategies to meet their needs. These teaching and learning strategies and the learning tasks will help learners develop and enhance their collaborative and entrepreneurial skills.

ASSESSMENT SUMMARY

In this Section, learners will be assessed at DoK Level 3, strategic reasoning. The assessment will be based on class exercises and tests, individual and group projects and demonstration of skills in the performance of hands-on activities. The teacher will provide regular feedback to learners to identify their strengths and areas for improvement. The assessment responses will be either oral or written and presented by individuals or groups, and the teacher is expected to record the learners' performance in the Assessment Portal.

Table 2.1.: *Assessment summary for the indicator*

Indicators	DoK Level	Assessment Strategy and/or Mode
Explain the importance of bee-keeping in tree fruit crop enterprises	3	Class exercises and tests, individual and group projects

WEEKS 3 & 4

Learning Indicator: *Explain the importance of bee-keeping in tree fruit crop enterprises*

Focal Area: The role of bee-keeping in promoting tree fruit crop production

1. Importance of bees in agriculture

An adult bee is a flying insect of the order Hymenoptera, with honeybees specifically belonging to the genus *Apis*. Bees play a vital role in agriculture by pollinating many crops. Approximately 35 % of global food crops depend on pollinators, with bees among the most effective and reliable pollinators. Their pollination contributes to larger yields and higher quality produce.

Beekeeping, also known as **apiculture**, is the practice of maintaining bee colonies, usually of the species *Apis mellifera* (the Western honey bee), primarily for products like honey, beeswax, royal jelly and propolis (bee glue). However, one of its most vital contributions is pollination (the transfer of pollen between flowers), which is essential for the reproduction of many plants, especially fruit-bearing trees.

Beekeeping involves hive management, bee health monitoring, and seasonal care, eg feeding honey bees when nectar and pollen sources are scarce in the environment because few plants are blooming.

Beekeepers (Apiarists) may operate stationary hives or practise migratory beekeeping by moving their hives to different orchards as particular plants begin to flower.

2. Importance of bees in fruit tree production

a. Pollination (natural hybridisation) services: Bees carry pollen from one flower to another on the same tree or a different tree or in another orchard. The resultant seeds may have varied genetic makeup and produce different varieties.

b. Yield improvement: Many fruit crops like citrus, mango, guava, avocado, passionfruit, pumpkins, melons and cucumbers depend heavily (or entirely) on bee pollination for optimal yields.

c. Biodiversity support: Managed bees can complement native pollinators and help maintain floral biodiversity in orchards.

d. Economic value: Bee pollination service is often worth more than honey production, accounting for billions of dollars in agricultural value worldwide.

3. Role of beekeeping in tree fruit cultivation

Beekeeping enhances tree fruit crop production through pollination services. Honey bees are among the most effective pollinators, and their managed colonies can be placed strategically near orchards to boost the quantity and quality of fruit yields. Beekeeping supports tree fruit production through the following;

a. Enhanced pollination: Honey bees transfer pollen as they move from flower to flower, ensuring cross-pollination, which is critical for fruit set in many tree crops. Inadequate pollination could lead to some fruit trees producing smaller, deformed fruits or not bearing fruit at all.

b. Increased fruit yield: Research has shown that the presence of honey bees can significantly increase fruit yield. For instance, apples, pears, plums and cherries rely heavily on pollinators

for larger yields. Honey bee pollination boosts the number of flowers that develop into fruits, ultimately increasing the total crop yield.

c. Improved fruit quality: Well-pollinated flowers develop into fruits with better shape, bigger and more uniform sizes.

d. Extended pollination season: Beekeeping provides a steady and reliable source of pollinators over the flowering period, supporting consistent pollination even during adverse weather conditions. Honey bee hives can be relocated to orchards during peak bloom times, ensuring the flowers receive ample pollination.

e. Economic benefits: Increased fruit production leads to higher profitability for orchard growers. Larger yields and better fruit quality reduce the need for thinning, minimise production waste, and boost revenue. Honey and other bee products also provide an additional income.

f. Biodiversity and ecosystem health: Honey bees promote biodiversity by supporting the reproduction of flowering plants in the ecosystem surrounding orchards. This, in turn, enhances the habitat for other beneficial insects and wildlife, contributing to healthier, more resilient agro-ecosystems.

g. Sustainability and reduced reliance on synthetic pollination alternatives: Beekeeping reduces the need for artificial pollination, which can be costly and less effective.

4. Key benefits of bees in agriculture

a. Increased crop yields: Bees enhance the productivity of many crops by improving the fertilisation process. Crops such as apples and tomatoes benefit significantly from bee pollination, which boosts both quantity and quality of the produce.

b. Improved food quality: Pollination by bees leads to better-sized and more uniformly shaped fruits and vegetables. This significantly impacts the market value and nutritional quality of the produce. In other words, well-pollinated crops often have higher nutritional content.

c. Support of biodiversity: Bees contribute to plant species diversity by pollinating wild plants around farms. This diversity creates habitats for other organisms, promoting ecological health and resilience.

d. Economic value: Bee pollination contributes billions of dollars annually to the global economy by improving crop productivity. This economic impact is of particular importance in areas dependent heavily on agriculture.

5. Biology of bees

a. Classification and diversity of bees

Bees belong to the order **Hymenoptera**, family **Apidae**, which includes honey bees, bumble bees and stingless bees. There are over 20,000 known species globally. Many bee species, including the honey bee, are social insects and live together in large, well-organised colonies. A honey bee colony typically consists of adult bees: workers, drones and a queen. Several thousand worker bees cooperate in nest building, food collection and brood rearing. In addition to worker bees, a colony normally has one queen and a few drones.

b. Different castes of bees and their roles

i. The queen bee (Figure 2.1) is the sole fertile egg-laying female in a hive and regulates the colony. It develops from a fertilised egg and is fed in the larval stages with royal jelly**.** When mature, she mates once and stores sperm for life. The queen lives a maximum of five years.

ii. Drones are male bees that develop from unfertilised eggs. Their sole role is to mate with the virgin queens and die soon after or during mating.

iii. Worker bees are sterile females that perform various tasks within the hive. The sub- castes are: scout bees, which can travel 18 km away from the hive to locate new food sources; foragers, which follow the trail of scout bees to fetch pollen and nectar from fields and blooms located by the scouts; guard bees that guard the hive against intruders and stray foreigners. and nurse bees, which care for the hive with special attention to the developing queens and drones. The workers live for up to three months.

c. Bee morphology

Bees have a three-part body consisting of a head, thorax, and abdomen. The head bears a pair of compound eyes, simple eyes (ocelli), a pair of antennae and the mouthparts. The thorax has three segments (prothorax, mesothorax and the metathorax). In the adult bee, each thoracic segment bears a pair of walking legs, while the mesothorax (middle segment) and metathorax (last segment) bear a pair of wings. In the honey bees, the majority of adults are sterile, winged females who function as workers and soldiers, defending the colony. All female honey bees have a sting organ at the end of their abdomen used for defence and offence. The workers also have some special organs eg proboscis for sucking up nectar and other juices, pollen baskets for transporting pollen and wax glands for building combs.

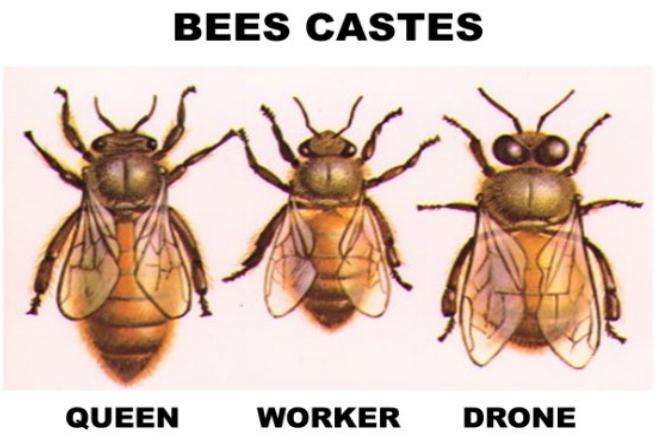


Figure 2.1: *The main bee castes*

d. Ecological role of bees

Bees are key pollinators, essential for reproduction in 70–80 % of flowering plants. Their decline poses serious threats to biodiversity, agriculture, and food security.

e. Threats to the conservation of bees

Major threats to honey bees are pesticides (e.g., neonicotinoids), habitat loss, climate change, parasites, e.g., the Varroa mite (*Varroa destructor*) that attacks and feeds on honey bee larvae, the fungal pathogen, *Nosema* sp., and many viruses, such as the Sacbrood virus.

6. Beekeeping in Ghana

Like in many other parts of the world, beekeeping in Ghana is an increasingly valuable agricultural practice, enhancing income generation, biodiversity, and crop productivity. Ghana's climate and

vegetation are well-suited to honeybee activities, making it an ideal environment for honey production. The process of beekeeping in Ghana is as follows:

i. Choosing hive types and sites

Hive types: The most common hives in Ghana include the Kenyan Top-Bar Hive and the Langstroth (Figure 2.2), both suited to local beekeeping practices. Top-bar hives are popular for their simplicity, low cost, and ease of maintenance.

Figure 2.2: *Examples of Langstroth hives (BeesWiki.com)*

ii. Site selection: Hives are ideally placed near water sources and abundant flowering plants, such as farms with flowering crops or areas with wild flora. The site should be away from strong winds and human activity, providing a safe and productive environment for the bees.

iii. Obtaining and introducing bees: Beekeepers can start colonies by capturing wild swarms, which is common in Ghana, or by purchasing bees from other beekeepers. Swarm capture involves placing an empty hive in a location where swarms are likely to settle or using bait hives to attract bees. Once bees are introduced to the hive, beekeepers must closely monitor the colony to ensure it becomes established and the queen is laying eggs.

iv. Feeding and colony management: Feeding may be necessary during the dry season when nectar is scarce. A sugar solution can be provided to supplement the bees' diet and maintain colony strength. The farmer should check regularly for brood, honey stores, and signs of disease or pests like the Varroa mite. In Ghana, ants are common pests, so protecting hives from ant infestations is crucial. Coating the stands with grease will prevent ants from climbing into the hive.

v. Harvesting honey and other products: Honey harvesting typically occurs during the main flowering seasons, with two major harvest periods each year in Ghana. When the honey cells have been capped or sealed, it means the honey is mature and ready to harvest. Honey is harvested by removing the frames from the hive and extracting honey, either through manual squeezing or using a honey extractor. Other bee products like beeswax and propolis are also collected for sale.

vi. Protective clothing in beekeeping: Bees are gentle insects, but when ruffled, can attack and sting the intruder. Bee venom is highly toxic and can kill if the attack is severe. It is therefore necessary to acquire and wear the appropriate protective clothing when dealing with bees. White colour is preferred, but blue is also acceptable. (See Figure 2.3).

Figure 2.3: *Protective bee gear*

vii. Processing and selling honey: After extraction, honey is filtered to remove impurities and stored in airtight containers to prevent contamination. Local markets and export opportunities exist for high-quality honey, as Ghana has a growing demand for natural and organic products. Ghanaian honey is sought after due to its unique floral flavours, and many beekeepers sell their products at local markets or collaborate with cooperatives to reach larger buyers.

viii. Training and sustainable practices: Many Ghanaian beekeepers receive training through organisations like the Ghanaian Beekeepers Association, agricultural extension services, and NGOs. Training often covers sustainable practices, pest management, and business skills for profitable beekeeping. Sustainable practices, such as minimising the use of pesticides and providing forage for bees, are emphasised to support healthy colonies and promote biodiversity.

ix. Challenges and opportunities:

Challenges in beekeeping: Beekeepers in Ghana contend with bushfires, pesticide drift from nearby farms, and difficulties accessing markets. Limited access to resources and knowledge also prevents some beekeepers from scaling up their operations.

Opportunities: With a strong demand for honey and bee products locally and internationally, beekeeping presents a significant rural income generation and economic empowerment. Support from the government and NGOs helps provide equipment, training, and market access.

Learning Tasks

1. Conduct a comparative analysis between a fruit orchard with managed beehives and one without. Present your findings using diagrams and explanations.
2. In small groups, learners visit a local fruit farm or observe a fruit tree in the school vicinity. Prepare a report explaining how bee pollination specifically benefits this crop and what would happen without it.
3. Design a proposal for integrating beekeeping into a tree fruit enterprise, evaluating economic, environmental and social benefits. Include a cost-benefit analysis and sustainability plan.

Pedagogical Exemplars

Digital Learning: Learners in mixed groups research and list the types of bees and their importance in agriculture.

Talk for Learning: In mixed groups, learners discuss how beekeeping enhances fruit tree crop production.

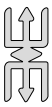
Activity-based digital learning: Learners, in groups, watch video documentaries on beekeeping, discuss the benefits of beekeeping, write up and present their findings on cardboard posters, and paste them on the walls.

Activity-based learning

1. The teacher guides learners to construct beehives (where feasible) and mount them at strategic positions in the school farm or compound
2. Learners visit the hives regularly to observe the activities of the bees and make notes for discussion in class

Key Assessment Level 3: Individual Class Exercise (Case Study)

A major mango-growing district in Ghana has experienced declining yields over the past five years. Research indicates inadequate pollination as a significant factor, with native pollinator populations reduced by approximately 40 % due to habitat loss, pesticide use, and climate variability. The District Agricultural Office is considering promoting integrated bee-keeping as a solution. Drawing on your knowledge in bee-keeping, fruit tree production, ecological principles, and agricultural economics, analyse the ecological, economic, and social impacts of integrating bee-keeping with tree fruit production in this district. (25 marks).



Note

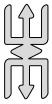
Each subsection to the question - ecological, economic and social impacts can be used as a question on its own).

PLC Session 3 & 4

45 minutes | **Planning & Reviewing the Learning Plan**

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
   a. explain the week's concepts in a practical way that will make it easier for learners to understand
   b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
   a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
   b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)

c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Plan the week's key assessment with your app

   a. The key assessment for the week is case study. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the case study (NTS 3k-3q).

10 minutes **Content Exploration**

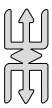
5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then

   a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)

   b. all teachers in the group work through a similar problem individually for 3–4 minutes

   c. the group then works through the problem together step by step

   d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes **Enactment**

6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).

   a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.

   b. After the enactment, ask for structured feedback from the group

      i. was the concept explained in a way that a learner with no prior knowledge could follow?

      ii. were the examples grounded in contexts familiar to Ghanaian learners?

      iii. did any misconceptions surface and if so, how were they addressed?

5 minutes	Reflection

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
    a. transfer your chats into your learning planner template.
    b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
    c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

SECTION 2 REVIEW

The lessons in this section were facilitated within two weeks, covering the importance of bee-keeping in tree fruit crop enterprises, the role of bees in agriculture and the biology of bees. Learners engaged in digital, experiential and activity-based learning, and have acquired skills in bee hive construction and deployment, and were able to construct and mount bee hives at strategic positions in and around the school compound. Learner observations have led them to appreciate the role of bees in pollination. The teacher conducted the appropriate formative and summative assessments with regular feedback to the learners. Hopefully, some learners are likely to become bee enthusiasts and apiarists.

MARKING SCHEMES FOR THE KEY ASSESSMENT

Week 3 & 4 – Individual Class Exercise (Case Study)

Critical analysis of potential impacts

Ecological impacts (10 marks)

i. The integration of bee-keeping with mango production would significantly enhance pollination services through increased pollinator density and diversity. (1 mark)

ii. Research indicates that adequate honeybee densities can improve mango fruit set by 35-60 % compared to pollinator-deficient orchards. (1 mark)

iii. Integration would create a positive feedback where improved pollination leads to increased flowering success in subsequent seasons, further strengthening the plant-pollinator relationship. (1 mark)

iv. However, the introduction of managed honeybees (*Apis mellifera*) requires careful ecological balance. (1 mark)

v. While honeybees provide excellent pollination services, over-reliance on a single pollinator species can create vulnerability in the system. (1 mark)

vi. A comprehensive approach should support both managed honeybees and remnant native pollinator populations, including solitary bees, carpenter bees, and other insects that have co-evolved with local fruit tree species and may provide complementary pollination services for specific mango varieties. (2 marks)

vii. The establishment of bee-keeping in the orchards necessitates habitat enhancement measures such as maintaining flowering understory plants and establishing hedgerows, which would benefit multiple ecosystem services beyond pollination. (1 mark)

viii. These include natural pest control through increased predator habitat, improved soil health through reduced erosion, and enhanced nutrient cycling. (1 mark)

ix. Research in similar agroecosystems demonstrates that such habitat enhancement can reduce pest pressure by 20-30 % through supporting natural enemy populations. (1 mark)

Economic impacts (10 marks)

From an economic perspective, the integration offers substantial benefits through multiple mechanisms.

i. Improved pollination would directly enhance mango yields through increased fruit set, reduced fruit drop, and improved fruit quality. (1 mark)

ii. Studies from similar agroecological zones suggest potential yield increases of 15-25 % with adequate pollination, representing significant revenue enhancement for farmers. (1 mark)

iii. A cost-benefit analysis must consider the initial investment requirements (approximately GH₵2,000-3,000 per initial hive setup (1 mark), including equipment and training), ongoing management costs (estimated at GH₵500-800 per hive annually) (1 mark), and the expected returns from both improved mango production and bee products (1 mark)**.** With proper management, each hive could produce 20-40kg of honey annually, with current market values of GH₵25-35 per kilogram, creating a valuable secondary income stream that improves economic resilience. (1 mark)

iv. Additional products like beeswax, propolis, and potentially queen breeding provide further diversification opportunities. (1 mark)

v. The economic sustainability of this integration hinges on developing appropriate business models (1 mark). These might include:

- Individual farmer ownership of hives
- Cooperative management of apiaries serving multiple orchards
- Specialised bee-keeping entrepreneurs providing pollination services

(Any of these two points for 2 marks)

Social impacts: (5 marks)

The social dimensions of the integration are complex and multifaceted.

i. Successful implementation requires substantial knowledge and skill development among farmers who may have limited prior experience with beekeeping. (1 mark)

ii. There is a need for effective extension services and farmer-to-farmer learning networks to transfer both technical knowledge and skills around bee management and honey production. (1 mark)

iii. Labour implications must be carefully considered. While bee-keeping creates new employment opportunities, it also requires labour inputs during specific periods that may compete with existing farm activities. (1 mark)

iv. For example, labour is critical during mango flowering and harvest periods when both enterprises demand attention. (1 mark)

v. The integration can increase social capital through cooperative management of bee-keeping equipment, collective marketing of bee products, and shared learning. (2 marks)

vi. However, this requires effective community organisation and governance structures. (1 mark)

vii. Existing cultural attitudes toward bees may also influence adoption patterns – in some Ghanaian communities, traditional beliefs about bees as spiritual entities may affect management practices and require culturally sensitive implementation approaches. (1 mark)

(Any 5 correct points for 1 mark each)

SECTION 3: REDUCING DRUDGERY IN AGRICULTURAL PRODUCTION

STRAND: NEW DAWN AGRICULTURE

Sub-Strand: Agricultural Machinery

Learning Outcome: *Explain the functions of various machines and computing tools used in agriculture to reduce drudgery.*

Content Standard: *Demonstrate knowledge and application of machines and computing tools to reduce drudgery in agriculture.*

INTRODUCTION AND SECTION SUMMARY

Difficult and strenuous manual food production methods are the bane of increased production and discourage young people from staying in agriculture. This section intends to address this challenge by introducing young learners to ways of reducing this drudgery. Learners will be introduced to machines and computers as tools for reducing drudgery. Learners will be taken through digital, collaborative talk for learning and the use of computer software to reduce drudgery in agriculture. It is expected that learners' interests in farming will be aroused with a greater reliance on mechanical and computer-based farming methods.

The weeks and the indicators covered by the section are:

- **Week 5:** Demonstrate the application of machines to reduce drudgery in Agriculture
- **Week 6:** Demonstrate the application of computing tools to reduce drudgery in Agriculture

SUMMARY OF Pedagogical Exemplars

The lessons under this section will be taught with digital and collaborative learning methods, with high learner participation and hands-on activities. The teacher will provide the Internet links to guide the learners' search for information. Learners must understand what drudgery is and suggest actions and activities to reduce it. Learners should be able to use the various applications effectively.

ASSESSMENT SUMMARY

In this section, learners will be assessed at DoK Level 3, strategic reasoning. The assessment will be based on written class exercises and tests, and group projects, with demonstration of skills in the hands-on activities. Learners will be expected to analyse complex situations, apply theoretical knowledge to specific contexts, make evidence-based decisions, and solve multi-step problems with justification. The teacher will provide regular feedback to learners to identify their strengths and areas for improvement.

The assessment responses will be mostly written, with a few oral presentations. The teacher is expected to record the learners' performance in the Assessment Portal.

Table 3.1: *Assessment summary for the indicators*

Indicators	DoK Level	Assessment Strategy and/or Mode
Week 5: Demonstrate the application of machines to reduce drudgery in Agriculture	3	Written class exercises and tests, and demonstration of skills in hands-on activities, with a few oral responses
Week 6: Demonstrate the application of computing tools to reduce drudgery in Agriculture	3	Written class exercises and tests, and demonstration of skills in hands-on activities

WEEK 5

Learning Indicator: *Ability to use machines to reduce drudgery in agriculture*

Focal Area: Reducing drudgery in agriculture

Note

The teacher should remind learners about the work carried out on various types of machinery and their uses mentioned in Year 1 Week 2 and Year 2 Weeks 10 & 11. There would be value in spending some time recapping what had been covered in these earlier years.

1. Meaning and common examples of drudgery in agriculture

Drudgery in agriculture refers to the difficult, physically demanding and often repetitive tasks that farmers and agricultural workers endure while producing crops and raising livestock. These tasks typically require significant manual effort, are time-consuming, and can lead to fatigue or health issues over time. Drudgery is often associated with traditional or low-tech farming systems with limited mechanisation and advanced tools. Common examples of drudgery in agricultural production include:

a. Manual land preparation: Using hand tools like hoes and cutlasses for land clearing, tilling, or weeding, which can be physically exhausting.

b. Human labour for sowing, planting and harvesting: Tasks like sowing, weeding, and harvesting involve repetitive bending, stooping, and working in hot weather. This can cause fatigue.

c. Irrigation: Where mechanised irrigation is lacking, humans carry water to irrigate crops. This activity is labour-intensive.

d. Post-harvest processing: Activities such as threshing, winnowing, sorting and drying produce are done manually.

e. Livestock care: Carrying heavy feed, cleaning pens, and manually milking animals are laborious and time-consuming.

2. Ways of using machines to reduce drudgery in agriculture

The availability of, and the ability to use, machines to reduce drudgery in agriculture are essential for improving efficiency, productivity and making the sector more appealing, especially to young people. Mechanisation helps to automate labour-intensive tasks, saving time and physical effort, while increasing the precision and effectiveness of farm operations. Machines are used to reduce drudgery in agriculture in the following ways:

a. Land preparation

i. Tractors and ploughs: Instead of manual tilling (Figure 3.1A), tractors equipped with ploughs or harrows (Figure 3.1B) can prepare large areas of land quickly and efficiently, reducing physical labour and time spent on land preparation.

ii. Rotary tillers and cultivators: These machines help break up soil, remove weeds, and prepare the seedbed, replacing labour-intensive manual work.

Figure 3.1: *A. Manual land tilling/ridging* *B. Mechanised land tilling*

a. Sowing and planting

   i. Seed drills and planters: Machines such as seed drills ensure that seeds are planted at the correct depth and spacing, which is difficult and time-consuming to achieve manually. This saves labour and increases crop yields due to planting precision.

   ii. Transplanters: Machines for transplanting seedlings, particularly for crops like rice and vegetables, eliminate manual planting, reduce labour requirements and enhance efficiency.

b. Weed control

   i. Power slashers: Manual weeding is labour-intensive and time-consuming. Power slashers or mechanised hoes can significantly reduce the effort required to remove weeds from the farm, improving crop growth and reducing the drudgery involved.

   ii. Herbicide sprayers: Instead of manually controlling weeds, machines like herbicide sprayers ensure quick and effective weed control with minimal physical effort.

c. Irrigation (The teacher should remind learners about the various irrigation systems from Year 1, Weeks 8 & 9)

   i. Mechanised irrigation systems: Mechanised irrigation systems such as drip irrigation (Figure 3.2B), overhead sprinklers, or centre-pivot irrigation automate water supply to crops. This ensures optimal water usage and conserves resources and labour.

   ii. Motorised pumps: Motorised water pumps eliminate the need for manual water fetching, making irrigation more efficient and less labour-intensive**.**

Figure 3.2: *A. Manual irrigation* *B. Drip irrigation*

d. Harvesting

i. Harvesters: Machines like combine harvesters can perform multiple tasks (cutting, threshing, and winnowing) in one operation, reducing the manual effort required for crops such as maize, rice and wheat.

ii. Fruit and vegetable harvesters: Specialised harvesters for fruits like tomatoes, oranges, or vegetables reduce the backbreaking work of picking by hand, especially when dealing with large farms.

e. Post-harvest processing

i. Threshers and winnowers: Threshing and winnowing machines replace traditional manual methods of separating grains from straw, making post-harvest processing faster and less strenuous.

ii. Grain dryers: Instead of manually drying grains under the sun, which is labour-intensive and time-consuming, mechanical grain dryers offer a more efficient alternative, especially in regions where weather conditions are unpredictable.

iii. Milling machines: For crops like maize, rice, and cassava, milling machines eliminate the need for hand grinding, making food processing faster and easier.

f. Livestock farming

i. Milking machines: In dairy farming, milking machines (Figure 3.3B) reduce the physical labour of manually milking cows (Figure 3.3 A), speeding up the process and improving hygiene.

ii. Feed mixers and dispensers: Machines that mix and automatically dispense feed reduce the effort in feeding large numbers of livestock, enhancing efficiency.

iii. Manure collectors and spreaders: These machines reduce the need for manual labour in cleaning livestock pens and spreading manure in fields.

Figure 3.3.: *A. Manual cow milking* *B. Mechanised cow milking*

g. Transporting farm produce

i. Farm trucks and carts: Mechanised transport vehicles, such as farm trucks or motorised carts, reduce the physical effort required to transport produce from the farm to storage or markets.

ii. Conveyor systems: For large-scale processing, conveyor belts can move products within processing plants, reducing the manual effort required for handling produce.

h. Pest and disease control

i. Drones for spraying: Drones equipped with pesticide sprayers can cover large areas in a short time, reducing the physical labour of manual spraying and minimising human exposure to chemicals.

ii. Motorised sprayers: Motorised backpack sprayers or boom sprayers are efficient tools for applying pesticides, herbicides, or fertilisers over large areas, reducing manual labour and increasing precision.

i. Precision agriculture (The teacher should remind learners about aspects of precision agriculture covered in Year 1 Week 4)

i. GPS-guided machinery: Precision agricultural equipment (like GPS-guided tractors or combines) improves accuracy in planting, spraying, and harvesting, reducing waste and labour while enhancing productivity.

ii. Automated monitoring systems: Automated systems (Figure 3.4), including sensors and cameras, help monitor crop health, water levels, and soil conditions, reducing the need for manual labour in crop inspection.

Figure 3.4: *Crop pest monitoring system*

3. Benefits of using machines to reduce drudgery

a. Reduced physical fatigue: Mechanised farming minimises the physical strain associated with labour-intensive tasks, making farming less exhausting and more manageable.

b. Time savings: Mechanisation significantly reduces the time required for farm operations, allowing farmers to focus on other aspects of the business or expand their farming operations.

c. Increased efficiency and productivity: Machines perform tasks faster and more accurately than manual labour, increasing output per unit of time and per unit of labour input.

d. Improved precision: Machines can perform tasks like planting, spraying, and harvesting with greater precision, leading to better crop health, reduced wastage, and larger yields.

e. Increased cultivation: Relying on machines can lead to increased areas of cultivation.

f. Attracting youth to farming: The introduction of technology and machinery into agriculture makes it more appealing to young people, who are often more tech-savvy and interested in modern, less labour-intensive work.

4. **Challenges and solutions to mechanised farming**
    a. Cost of machinery: High initial farm machinery cost is a disincentive to farming, especially for smallholdings. Solutions include government subsidies, leasing options, cooperative ownership, and low-interest loans.
    b. Low technical know-how: Farmers need training on how to operate and maintain agricultural machinery. Extension agents, technicians from large-scale, well-established farms can provide the necessary skills.
    c. Maintenance and repairs: Access to spare parts and skilled mechanics is essential. Establishing local service centres can address this challenge.
5. **Designing a simple drip irrigation system**

Creating drip irrigation with used plastic bottles

1. **Materials from the Community**
    a. Used plastic bottles (500ml to 1.5L water or soft drink bottles)
    b. Nail, pin, or heated metal rod (for making holes)
    c. Knife or blade (to cut bottles)
    d. Rope, string, or wire (for hanging or tying)
    e. Stones or sticks (to support bottles if needed)
    f. Water (from borehole, rainwater, or tap)
2. **Step-by-Step Procedure**
    a. Collect and clean old plastic bottles
        i. Ask learners to collect used bottles from homes, schools, or local shops.
        ii. Wash the bottles thoroughly to remove any dirt or sugar residues.
    b. Perforate Bottles
        i. Use a needle, pin, or nail (heated if necessary) to make 1–3 small holes on the neck near the bottle cap. This controls how fast water drips.
    c. Setting up the Bottles: There are two main ways:
        i. Inverted Buried Bottle
            - Cut off or make a large hole in the base of the bottles, keeping the cap in place
            - Dig one small hole beside each plant.
            - Insert one bottle upside down, without removing the cap, in each hole.
            - Ensure the neck of the bottles, with the holes, is at least 10 cm below the soil surface.
        ii. Hanging Bottle (Drip from Above)
            - For the hanging bottle set-up, do not cut off, but rather make a small hole at the base of the bottle, and three tiny holes in the cap.
            - Tie a string or wire around the bottom third of the bottle and hang it from a stick, stake, or structure above the plant, so that the water from the bottle can drip directly to the base of the plant.

d. Fill bottles with clean water.

e. Monitor the flow of water and adjust

i. Observe how fast the water drips.

ii. If it's too fast, make fewer or smaller holes.

iii. Refill bottles as needed, to last 1–3 days depending on the weather and flow rate.

3. **Benefits of drip irrigation**

a. Cost-free**:** It uses waste bottles, so there is no need to buy irrigation tools.

b. Water-efficient**:** Delivers water slowly to roots where it's needed.

c. Recycling: Reduces plastic waste in the environment.

d. Educational**:** Teaches appropriate technology through innovation and conservation.

Learning Tasks

1. Learners to define and list examples of drudgery in agricultural production.
2. Learners to discuss ways of using machines to reduce drudgery in agricultural production.
3. Learners to design a simple drip irrigation system for vegetable cultivation.
4. Learners to practise pest and disease monitoring with computer applications.
5. Learners to evaluate the benefits of reducing drudgery in agriculture.

Pedagogical Exemplars

Think-Pair-Share: The teacher helps learners brainstorm the meaning of drudgery in agriculture. They should list examples of drudgery and discuss their findings with the person next to them. The teacher then calls on some pairs to share their findings with the class. Teachers should encourage learners to listen to the points raised by their colleagues.

Digital Learning: Learners in mixed ability groups surf the Internet to download and watch video documentaries on how machines reduce drudgery in agriculture. The teacher should provide a checklist of agricultural production activities to download and assist learners who may be having difficulty. Learners who are adept at browsing the Internet should be encouraged to lead the groups and help their colleagues**.**

Collaborative Talk for Learning: Learners in mixed-ability groups discuss how machines reduce drudgery in agriculture. They should list the benefits of reduced drudgery in agriculture, write reports and make presentations to the class.

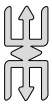
Key Assessment Level 3: Group Project

Design a low-cost drip irrigation system using old plastic bottles to water crops and promote environmental sustainability (Group project work).

PLC Session 5

45 minutes **Planning & Reviewing the Learning Plan**

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
   a. explain the week's concepts in a practical way that will make it easier for learners to understand
   b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
   a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
   b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
   c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



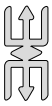
Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Plan the week's key assessment with your app
   a. The key assessment for the week is group project. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the project (NTS 3k-3q).

10 minutes **Content Exploration**

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
   a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
   b. all teachers in the group work through a similar problem individually for 3–4 minutes
   c. the group then works through the problem together step by step
   d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*

- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes **Enactment**

6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).
   a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
   b. After the enactment, ask for structured feedback from the group
      i. was the concept explained in a way that a learner with no prior knowledge could follow?
      ii. were the examples grounded in contexts familiar to Ghanaian learners?
      iii. did any misconceptions surface and if so, how were they addressed?

5 minutes **Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
   a. transfer your chats into your learning planner template.
   b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
   c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 6

Learning Indicator: *Ability to use computing tools to reduce drudgery in agriculture*

Focal Area: Reducing drudgery in agriculture

Note

Remind learners about the work covered on emerging technologies and tools in Year 1 Week 7

1. **Digital agriculture:** The use of computing tools in agriculture, commonly referred to as digital agriculture or smart farming, significantly reduces drudgery by automating processes, optimising resource use and improving decision-making. By integrating Internet of Things (IoT) technologies such as data analytics, sensors, drones and software platforms, farmers can reduce the physical and cognitive workload associated with traditional farming practices.
2. **Ways computing tools reduce drudgery in agriculture**
   a. Automation and precision farming**:** Computing tools like GPS-guided tractors (Figure 3.5), automated irrigation systems, and drone-based crop monitoring systems reduce the manual labour required for field operations, allowing for more precise and efficient farming. GPS-enabled tractors reduce the need for human operators, thus saving time and effort in planting, fertiliser application and spraying crops. Automated irrigation systems ensure crops receive the optimal amount of water, reducing the labour-intensive task of hand watering.

Figure 3.5: *GPS-guided tractor*

   b. Data-driven decision making**:** Using computing tools such as farm management software, sensors, and big data analytics allows farmers to monitor crop conditions, soil health and weather patterns in real-time. This reduces the drudgery of manual inspections and guesswork. For example, IoT-based sensors and big data analytics help farmers track soil moisture, nutrient levels and pest infestations, minimising the need for labour-intensive fieldwork. These systems inform precise interventions, such as when to irrigate or apply fertilisers, reducing the physical effort and time spent on these activities.
   c. Remote sensing and drones: Drones equipped with cameras and sensors (Figure 3.6) reduce the drudgery associated with field surveillance, crop monitoring and pest control. Remote sensing via drones captures aerial images that provide data on soil fertility status, plant growth and areas affected by pests and diseases. This eliminates the need for manual scouting, a time-

consuming and labour-intensive task. Automated drones can also spray pesticides and fertilisers, further reducing the need for manual labour.

Figure 3.6: *Drone technology in agriculture*

d. Robotics in harvesting**:** Agricultural robots (Figure 3.7) automate planting, weeding and harvesting. Robotic harvesters, like those used for fruits and vegetables, can pick crops efficiently without human intervention. These robots use machine learning systems to identify ripe produce, reducing the need for manual labour during harvesting. In large-scale farming, such systems eliminate the physical strain associated with harvesting and save time.

Figure 3.7: *Robots harvesting crops*

e. Farm Management Software (FMS): Farm Management Software simplifies operational planning, record-keeping and financial management, reducing the administrative workload for farm supervisors. Tools like FarmLogs or Agri-Edge allow farmers to manage inventories, schedule planting and track crop performance and harvesting. These systems reduce the time and effort spent on farm planning and paperwork.

f. Supply chain optimisation through Blockchain**:** Blockchain and cloud-based tools streamline supply chains, reducing the administrative drudgery associated with tracking produce from farm to market. Blockchain platforms allow transparent tracking of agricultural produce from farm to consumer, ensuring quality and reducing the need for time-consuming manual record-keeping. This system simplifies auditing and certification processes, ensuring compliance with less human effort.

g. Cloud computing for collaborative farming**:** Cloud-based platforms enable collaboration and data sharing among farmers, agronomists and advisors, reducing the time spent on communication and decision-making. Smart farming platforms hosted in the cloud (Figure 3.8) allow farmers to upload and analyse data from weather forecasts, soil sensors and crop growth models to make informed decisions collectively and efficiently. Platforms like Climate

FieldView enable farmers to share data with experts in real-time for quick insights, advice and recommendations, reducing the need for on-site visits and time-consuming consultations.

Figure 3.8: *Cloud-based computing platform*

h. Mobile applications and sensors (Pest predictor): The pest predictor specialises in pest monitoring and prediction, using weather data and pest biology to forecast potential outbreaks. It helps farmers detect early signs of pest infestations through environmental factor analysis and make prompt decisions on pest control. This offers early warning systems that allow farmers to take preventive actions before pests cause economic damage.

i. Automated livestock health monitoring: An Artificial Intelligence (AI) system that uses sensors to monitor livestock health and behaviour. These systems can detect early signs of illness or abnormal activity, allowing farmers to take action without manually inspecting each animal. For example, wearable AI devices for livestock can monitor body temperature, movement and feeding patterns, notifying farmers of any health concerns and eliminating the need for frequent manual checks. AI can control automated feeding systems and robotic milking machines, reducing the time and physical effort required to manage livestock.

3. Benefits of computing tools in agriculture

Computer-based tools provide numerous benefits, especially in reducing the drudgery associated with traditional farming practices. These tools improve efficiency, precision, and decision-making, thereby minimising physical labour and enhancing productivity. Here are some key benefits of using computing tools to reduce drudgery in agriculture:

a. Reduction of physical strain**:** Computing tools minimise the physical labour associated with tilling, planting, and crop monitoring. Instead of walking fields, farmers can use drones or remote sensing tools to monitor crop health, reducing fatigue and the risk of injury.

b. Labour savings**:** Computing tools reduce the need for human labour, particularly for planting, weeding and harvesting, freeing up time for other farm activities.

c. Enhanced precision**:** Precision agriculture uses computing tools like GPS, sensors and drones to apply inputs (seeds, water, fertilisers, pesticides) in a targeted manner, reducing waste and improving yield.

d. Increased efficiency and productivity**:** Computer-based tools like GPS-guided tractors, automated irrigation systems, and drones enable farmers to carry out tasks more quickly and accurately. By automating repetitive tasks, farmers can cover more land in less time.

e. Improved decision-making**:** Data analytics, artificial intelligence and farm management software provide farmers with real-time insights into soil conditions, weather patterns and crop health. This information allows better decision-making and reduces the time spent on guesswork or trial-and-error methods.

f. Minimised resource waste**:** Precision tools ensure that resources such as water, fertilisers and pesticides are used efficiently. This reduces waste and cuts down on the labour needed for input application.

g. Cost saving: Computing tools reduce operational costs through task automation and improving resource use. Although there is an initial investment in technology, the long-term savings on labour, inputs and time can significantly increase profitability.

h. Improved farm management**:** Farm management software allows farmers to streamline administrative tasks such as record-keeping, inventory management and financial planning. This reduces the mental workload and time spent on these tasks.

i. Real-time monitoring and alerts**:** Computing tools like IoT sensors and drones offer real-time monitoring of farm conditions, providing instant feedback on issues such as pest infestations, weather changes, or equipment failures. Farmers can act immediately, reducing the labour required for manual monitoring and damage control.

j. Sustainability and environmental benefits**:** Computing tools help optimise input usage, leading to more sustainable farming practices. Reduced use of fertilisers, pesticides and water lowers costs and minimises environmental impact, reducing the labour required for managing long-term negative environmental issues.

k. Enhanced collaboration**:** Cloud-based computing platforms allow for better collaboration between farmers, agronomists, and agricultural advisors. This helps reduce the time and effort spent on decision-making and farm planning.

Learning Tasks

1. Learners to define digital/precision agriculture.
2. Learners to discuss how computing tools reduce drudgery in agriculture.
3. Learners to synthesise the benefits of using computing tools to reduce drudgery in agriculture.
4. Learners to design a low-cost drip irrigation system using recycled plastic bottles, to water crops efficiently and promote environmental sustainability.

Pedagogical Exemplars

Digital Learning: Learners in mixed-ability groups watch video documentaries that demonstrate computing tools performing various farm activities that reduce drudgery in agriculture. The teacher guides learners through probing questions to deduce the meaning of digital agriculture from the video documentaries. Teachers should encourage learners to identify various farm activities where computing tools can be used to reduce drudgery in agriculture.

Collaborative Learning: Learners in mixed-ability groups practise (where applicable) or discuss computing skills to reduce drudgery in agriculture, write reports and make presentations to the class. Teachers should provide additional guidance on writing reports and presentations to groups who need extra support, while offering more open-ended report writing and presentation skills to more competent learners.

Structured Talk for Learning: Learners in mixed-ability groups discuss the benefits of using computing tools to reduce drudgery in agricultural production and give oral or written presentations to the class. Teachers should encourage more proficient learners to lead the groups to explain concepts to their peers, thus reinforcing their learning while helping others.

Project-Based Learning: Learners in small groups should work together to design a low-cost drip irrigation system using recycled plastic bottles. This will be used to water crops efficiently and promote environmental sustainability. Give learners step-by-step guidelines to design the drip irrigation system. After the project, the groups should explain and demonstrate how their model works to the entire class.

Key Assessment: Mid-Semester Examination

Case Study

The final year agricultural science class is starting a vegetable farm in a rural community in Ghana. They want to reduce labour in activities such as land mapping, pest control, and marketing. Suggest appropriate computing tools for each activity and explain how these tools would help them achieve their goal. Support your answer with reasons. (15 marks)

HINT

*Conduct **a mid-semester examination**. It should cover the contents taught from Week 1 to 5. Refer to the **Table of Specifications and Structure of the Paper** to guide you. Learners' papers should be marked immediately, and scores entered into the SAP.*

Structure

MCQs = 30 questions (Answer all for 30 marks)

Essay = 3 questions (Answer 2 for 20 marks)

Table of Specification

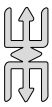
Week	Learning indicator	Type of Question	DoK Level				Total
			1	2	3	4	
1&2	Carry out budding and grafting in tree fruit crops	Multiple Choice	3	4	3	-	10
		Essay type	-	-	1	-	1
3&4	Explain the importance of bee-keeping in tree fruit crop enterprises	Multiple Choice	3	4	3	-	10
		Essay type	-	1	-	-	1

5	Ability to use machines to reduce drudgery in agriculture	Multiple Choice	3	4	3	-	10
		Essay type	-	1	-	-	1
Total							
Multiple Choice			9(30%)	12(40%)	9(30%)	-	30(100%)
Essay type				2	1		3

Table of Specification
PLC Session 6

45 minutes **Planning & Reviewing the Learning Plan**

1. Begin the session by recapping lessons from the previous session, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
   a. explain the week's concepts in a practical way that will make it easier for learners to understand.
   b. identify three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
   a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
   b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q).
   c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Use your app to plan and administer the mode of assessment for the student Assessment Portal (SAP).
   a. The key assessment for the week is mid-semester examination. Chat with your app to plan this assessment by reviewing or developing the assessment items/tasks and marking schemes/ rubrics for the mid-semester examination (NTS 3k-3q).

10 minutes **Content Exploration**

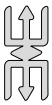
5. As a subject group, select one problem or topic/idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then

a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)

b. all teachers in the group work through the problem individually for 3–4 minutes

c. the group then works through it together the problem, step by step

d. highlight the most common errors made at each step (NTS 1c, 1e, 2c, 2e, 3e-3j).



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- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes **Enactment**

6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).
   a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
   b. After the enactment, ask for structured feedback from the group
      i. was the concept explained in a way that a learner with no prior knowledge could follow?
      ii. were the examples grounded in contexts familiar to Ghanaian learners?
      iii. did any misconceptions surface and if so, how were they addressed?

5 minutes **Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
   a. transfer your chats into your learning planner template.
   b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
   c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

SECTION 3 REVIEW

Section 3 covered content for 2 weeks (Weeks 5 and 6). Learners were exposed to the use of machines and computing tools in agriculture and their roles in reducing drudgery and improving overall decision-making, precision and efficiency in agricultural production. These technologies free up time for other activities, save costs, and enhance productivity, ultimately improving the quality of life for farmers and promoting sustainable agricultural practices. Learners had the chance to operate some of these machines and try the computer-based applications. Learners also designed a simple irrigation system for the production of vegetables.

MARKING SCHEMES FOR THE KEY ASSESSMENTS

Week 5

Refer to notes for guidelines and design of a simple drip irrigation system using old plastic bottles.

Week 6

Land mapping (5 marks)

i. Correct computing tool expected (GPS, GIS software, or farm mapping app): (1 mark)

ii. Explanation of how the tool helps with mapping (accurately measures farm size, aids in planning planting zones, efficient land use): (2 marks)

iii. Justification of how it reduces labour, eliminates manual measurements, saves time, and provides precision: (2 marks)

a. Pest control (5 marks)

i. Correct computing tool expected (drone with pesticide sprayer, pest monitoring apps, sensor-based alert systems). (Any 1 for 1 mark).

ii. Explanation of how the tool aids pest control (targets affected areas, monitors pest populations). (Any 2 × 1 mark = 2 marks).

iii. Justification of how it reduces labour (reduces the need for manual spraying, ensures safety, increases efficiency). (Any 2 × 1 mark = 2 marks).

b. Marketing (5 marks)

i. Correct computing tool expected (online marketing platforms, mobile apps like AgroCenta, WhatsApp, e-commerce sites). (Any 1 for 1 mark)**.**

ii. Explanation of how the tool helps market produce (connects to buyers, provides pricing information, wider reach). (Any 2 × 1 mark = 2 marks).

iii. Justification of how it reduces labour (avoids physical travel to market, saves time, reduces transport costs). (Any 2 × 1 mark = 2 marks).

Total (15 marks)

SECTION 4: SOIL SCIENCE

STRAND 2: FARMING FOR JOBS AND INCOMES

Sub-Strand 1: Economic Production of Crops

Week 7, 8, 9 &10

Learning Outcome: *Use the knowledge and skills acquired to explain soil formation processes and properties.*

Content Standard: *Demonstrate knowledge and understanding of soil formation processes and properties.*

Week 11, 12 &13

Learning Outcome: *Use the knowledge and skills acquired to manage and conserve soils.*

Content Standard: *Demonstrate knowledge and understanding of soil management and conservation.*

INTRODUCTION AND SECTION SUMMARY

This section covers seven weeks (Weeks 7-13) and exposes learners to soil formation processes, soil conservation and fertility management in the school environment and farmlands. Learners will understand the role of the soil in sustaining life and the fragility of the environment as it is affected by human activities, and hence develop a sense of communal responsibility towards the environment. Learners' understanding will be assessed at DoK Levels 2 to 3 in the various weeks.

The weeks and the indicators covered by the section are:

- **Week 7:** Investigate soil formation processes - weathering, erosion, deposition and soil profile development.
- **Weeks 8 & 9:** Explain the physical properties of soil, including texture and structure.
- **Week 10:** Explain the chemical and biological properties of soil.
- **Week 11:** Describe soil conservation principles and practices - crop rotation, contour ploughing, terracing, and windbreak establishment.
- **Week 12:** Outline the role of soil organisms in nutrient cycling and soil fertility.
- **Week 13:** Evaluate the impact of human activities - deforestation, farming, and urbanisation - on soil degradation and erosion rates.

SUMMARY OF Pedagogical Exemplars

Soil formation and soil physical, chemical and biological properties, degradation and conservation will be covered under this section. Different teaching methods will have to be employed for effective teaching and learning. The main methods to adopt include structured talk for learning, collaborative, experiential, exploratory and digital learning. Experiments will be conducted on the chemical and biological properties of soil. The teacher will ensure all learners take part in all activities and tasks. The teacher should employ the pedagogy in a manner that will instil resourcefulness and collaboration in the learners.

ASSESSMENT SUMMARY

In this section, learners will be assessed at DoK Levels 2 to 3, depending on the learning indicator. The assessment will be based on written class exercises, tests, and group projects, with skills demonstration required for the hands-on activities. Learners will be expected to analyse complex situations, apply theoretical knowledge to specific contexts, make evidence-based decisions, and solve multi-step problems with justification. The teacher will provide regular feedback to learners to identify their strengths and areas for improvement. The assessment responses will be mostly written, with a few oral presentations. The teacher is expected to record the learners' performance in the Assessment Portal.

Table 4.1: *Assessment Summary for the Indicators*

Indicators	DoK Level	Assessment Strategy and/or Mode
Weeks 7 – 9: Investigate soil formation processes – weathering, erosion, deposition and soil profile development.	3	Essay-type individual homework
Week 10: Explain the chemical and biological properties of soil	2-3	Written class exercises and tests
Week 11: Describe soil conservation principles and practices – crop rotation, contour ploughing, terracing, and windbreak establishment.	3	Written class exercises and tests
Week 12: Outline the role of soil organisms in nutrient cycling and soil fertility	2	First semester practice examination
Week 13: Evaluate the impact of human activities – deforestation, farming, and urbanisation – on soil degradation and erosion rates.	3	Written class exercises and tests

WEEK 7

Learning Indicator: *Investigate soil formation processes – weathering, erosion, deposition and soil profile development*

Focal Area: Soil formation processes

1. Weathering of rocks

Weathering of rocks (parent materials) is a fundamental process in soil formation, where rocks break down into smaller particles that eventually become soil. This process occurs through a combination of physical**,** chemical and biological mechanisms. The parent material refers to the original rock or the mineral subjected to these processes. Over time, the weathering transforms the solid bedrock into a loose layer of particles that mix with organic matter, water and air to form soil. Types of weathering in soil formation are:

a. Physical (mechanical) weathering: Physical weathering is the breakdown of rocks into smaller fragments without any change in the chemical composition of the fragments. This process occurs due to environmental factors such as temperature changes, water, ice, wind, and pressure.

   i. Temperature fluctuations**:** Rocks expand and contract due to temperature changes. During the day, the heat causes rocks to expand, but they cool and contract at night. The repeated expansion and contraction cycles cause the rocks' surface to crack and break apart. This process is especially common in desert regions where temperature fluctuations are extreme.

   ii. Exfoliation: In areas where rocks are exposed to intense heat (eg in deserts), the outer layers of rocks may expand and peel off in thin sheets, much like the layers of an onion. This happens because the surface layers heat up faster than the interior.

   iii. Pressure release (unloading)**:** When overlying material (such as soil or another rock layer) is removed by erosion, the underlying rock experiences a decrease in pressure. This pressure release causes the rock to expand and crack, contributing to the breaking up of the parent material.

   iv. Frost action (freeze-thaw)**:** This process occurs more in higher latitudes. Water enters cracks in rocks and freezes and thaws according to temperature fluctuations. Due to the anomalous expansion of water, freezing water expands between 4 0C and 0 0C. This expansion exerts pressure on the rock, causing it to fracture and eventually break apart.

   v. Abrasion**:** Wind, water and ice can act as agents of erosion, gradually scraping rock surfaces over time. For example, flowing rivers or glaciers can carry sediments that abrade rocks, gradually wearing them down.

b. Chemical weathering: Chemical weathering involves the alteration of the rock's chemical composition through reactions with water, air, and other chemicals. This process is most effective in warm, humid climates. The processes that contribute to chemical weathering are:

   i. Oxidation: Oxidation involves the reaction of minerals, particularly those containing iron, with oxygen. Oxidation weakens the rock structure and facilitates further weathering. Example reaction: Iron in minerals reacting with oxygen and water to form iron oxides ($4Fe^{2+} + O_2 + 6H_2O \rightarrow 4Fe^{3+}O(OH) + 4H^+$)

   ii. Hydrolysis: Hydrolysis occurs when minerals react with water, resulting in the chemical alteration of the mineral structure. This process involves the splitting of water molecules

(H_2O) into hydrogen (H^+) and hydroxyl ions (OH^-), which then react with minerals, particularly silicates. For example, feldspar, a common rock-forming mineral, undergoes hydrolysis to form clay minerals and releases soluble ions like potassium, calcium, or sodium. This reaction weakens the original rock and promotes further weathering,

$(KAlSi_3O_8) + H_2O + H^+ \rightarrow (clay) + K^+ + Silica\ (SiO_2)$

Feldspar Kaolinite

iii. Carbonation**:** Carbon dioxide in the atmosphere dissolves in rainwater, forming a weak carbonic acid. This acid reacts with certain minerals like limestone (calcium carbonate), causing them to dissolve. Over time, this process can create cavities or cracks in rocks, contributing to their breakdown.

iv. Dissolution: Some minerals are directly dissolved by water, especially in areas with high rainfall. Salts like halite (sodium chloride) and gypsum (calcium sulphate) dissolve easily in water and are carried away, leaving behind smaller particles that contribute to soil.

v. Hydration: Hydration occurs when minerals in rocks absorb water molecules, leading to an expansion and change in their structure. For example, anhydrite ($CaSO_4$) can absorb water and convert into gypsum ($CaSO_4{\cdot}2H_2O$), a softer and more expansive mineral. This process weakens the rock, making it more susceptible to further breakdown. Hydration is common in clay soils, where water incorporation causes the material to swell and helps initiate other weathering processes.

vi. Reduction: Reduction is the chemical reaction where minerals lose oxygen or gain electrons, often occurring in environments with low oxygen, like waterlogged soils. For example, ferric (Fe^{3+}) oxides are reduced to ferrous (Fe^{2+}) oxides, which are more soluble and can be leached away from the rock. This process is common in wet and anaerobic environments.

c. Biological weathering: Biological weathering occurs when organisms contribute to the breakdown of rocks. Plants, animals and microorganisms play a role in this process.

i. Root growth**:** Plant roots grow into cracks and fissures in rocks, exerting pressure as they expand. This can cause the rock to split over time. In addition, roots release organic acids that chemically react with minerals, further breaking down the rock.

ii. Microorganisms**:** Bacteria, fungi, and lichens can produce acids as part of their metabolic processes, which can chemically weather rocks. Lichens, in particular, are effective at colonising rock surfaces and contributing to the breakdown of minerals.

iii. Burrowing animals: Animals such as rodents, ants and earthworms disturb the soil and rocks as they burrow. This physical disturbance brings rock fragments to the surface, exposing them to weathering processes.

2. Movement and deposition of weathered materials

The movement and deposition of weathered materials is an essential part of soil formation, following the initial weathering of rocks. Once the parent material is broken down into smaller particles through physical, chemical and biological weathering, these materials are transported and deposited by various natural forces. This process helps form different soil horizons and influences the soil's texture, composition and fertility. The movement and deposition of parent material involves:

a. Erosion and transportation of weathered materials

Weathered materials are often moved by natural forces like water, wind, ice and gravity. These forces transport the particles, sometimes over great distances, to new areas where they are deposited. The key mechanisms of movement include:

i. Water (Fluvial action): Flowing water is one of the most effective agents for transporting weathered materials. During heavy rainfall, runoffs carry soil particles downhill through sheet erosion. In steeper terrains, rill and gully erosion occurs, carving out small channels or gullies in the soil. Streams and rivers pick up loose sediments, carrying them downstream. Larger particles like sand grains and gravel are deposited closer to the source, while smaller particles such as silt and clay are transported farther. Over time, this process leads to the formation of river valleys and floodplains, which are often fertile due to the rich deposits of fine sediments. In coastal areas, ocean currents and waves can also transport weathered materials, contributing to the formation of beaches, sandbars, and deltas.

ii. Wind (Aeolian) action: In dry arid environments, wind is a powerful agent of erosion and transportation. Wind lifts fine particles of silt, clay, and fine sand, carrying them over long distances. This process forms dunes in deserts and loess deposits, which are fertile soils formed from wind-deposited dust.

iii. Ice (Glacial) action: Glaciers transport large amounts of weathered material as they move across the landscape. They grind and erode rock, carrying the debris along. When the glaciers melt, they deposit this material, forming features like moraines, which are accumulations of unsorted rock debris.

iv. Gravity action (Mass wasting): Mass wasting is the downward movement of weathered materials under the influence of gravity. This includes landslides, mudslides, rockfalls and soil creep. On steep slopes, gravity pulls weathered materials downhill, where they accumulate at the base of hills or mountains, forming deposits called colluvium.

b. Deposition of weathered materials

Once transported, weathered materials are eventually deposited in new locations. The process of deposition plays a crucial role in shaping the landscape and forming new soils. The nature of deposition depends on the transporting agent and the size of the particles being moved:

i. Alluvial deposition: When rivers or streams slow down, they lose their energy and begin to deposit the materials they are carrying. Coarser particles like gravel and sand are deposited first, while finer particles such as silt and clay settle out later. This results in the formation of alluvial soils, which are found in river valleys, deltas and floodplains. These soils are often fertile due to the fine texture and abundance of nutrients.

ii. Aeolian deposition: Wind-deposited materials form distinctive soil types. For example, loess, a fine, wind-blown sediment, is deposited in thick layers over large areas. Loess deposits are commonly found in regions like China, the American Midwest, and parts of Europe. Soils formed from loess tend to be fertile because of their fine texture and ability to hold moisture.

iii. Glacial deposition: As glaciers melt, they leave behind glacial till, a mix of clay, silt, sand, gravel, and boulders. This material is unsorted and forms the base for many soils in regions once covered by glaciers. In addition, glacial meltwater can carry finer materials that are deposited in outwash plains, creating well-sorted soils.

iv. Colluvial deposition: Materials moved by gravity, such as from landslides or soil creep, accumulate at the base of slopes in a process called colluviation. Colluvial soils often contain a mix of rock fragments and finer particles. These soils may be less fertile than alluvial soils, but can still support vegetation.

v. Marine deposition: Coastal areas where rivers meet the sea, or in tidal zones, often see the deposition of weathered materials carried by water. This can result in the formation of coastal plains and deltas, where fine sediments like clay and silt accumulate. These deposits create fertile soils.

3. Soil profile development

Soil profile development is a critical process in soil formation that involves the layering of distinct horizons within the soil over time. These horizons, which are vertically arranged in a soil profile, reflect the various physical, chemical and biological processes that have acted upon the soil. These processes include weathering, organic matter accumulation, leaching, eluviation and illuviation of materials, and bioturbation. Soil profile development involves several processes that contribute to the formation of different horizons. A typical soil profile has the following horizons:

a. O horizon (Organic horizon): This is the uppermost layer, composed mainly of organic material such as decomposing leaves, twigs, and plant roots (Figure 4.1). The O horizon is present in forests or grasslands where organic material accumulates on the soil surface. In cultivated soils, this layer may be absent or very thin.

b. A horizon (Topsoil): The A horizon, or topsoil, is rich in organic matter and minerals. It is usually darker in colour than the other horizons because of the high humus content. The A horizon is the most fertile layer and is critical for plant growth. It contains a mixture of organic matter and weathered mineral particles. This horizon experiences the eluviation process, which is the removal of clays, iron and organic matter from this horizon, leaving behind a concentration of sand and silt.

c. B horizon (Subsoil): The subsoil is where materials leached from the upper horizons are deposited and accumulate through illuviation. This horizon often contains higher concentrations of clay, iron, and aluminium oxides, giving it a dense, compact structure. The B horizon may be red or yellow due to the presence of iron oxides (Figure 4.1).

d. C horizon (Weathered parent material): The C horizon comprises partially weathered parent material that has not yet undergone significant soil formation processes. It is typically coarser in texture and less affected by leaching and illuviation. This horizon represents the transition between the soil and the unweathered bedrock below.

e. D horizon (Bedrock): The D horizon consists of unweathered bedrock, which may be granite, limestone, or other types of rock. Over time, this bedrock weathers to form the parent material for the overlying soil horizons.

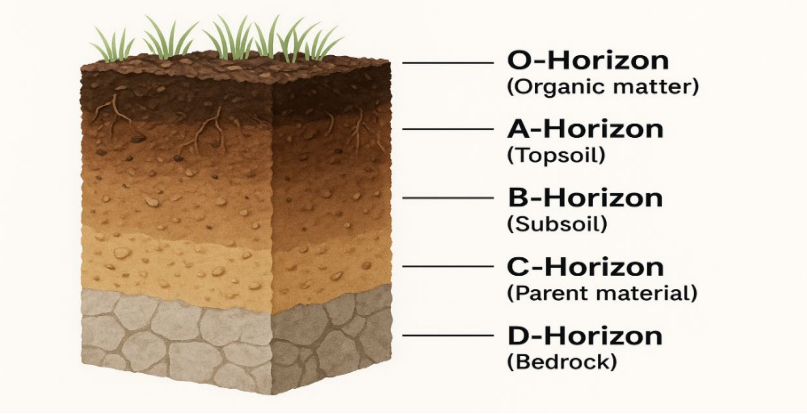


Figure 4.1: *Diagram of Soil Profile*

4. **Factors that influence soil formation**

Several factors influence soil profile development and horizon formation. Among these factors are:

a. Parent material: The mineral composition of the parent material influences the soil texture, structure, and nutrient content. Soils derived from volcanic rock, for example, may be rich in nutrients, while soils from quartz-rich rocks may be sandier and less fertile.

b. Climate: Temperature and precipitation play a major role in soil formation. In warm, humid climates, chemical weathering and leaching are more intense, leading to thicker, more developed soil profiles. In contrast, soils in cold or dry climates may have less organic matter and fewer distinct horizons.

c. Organisms: Plants, animals, and microorganisms contribute to soil formation through organic matter decomposition, bioturbation and root activity. Vegetation, particularly deep-rooted plants, helps stabilise soil and promotes horizon development.

d. Topography: The slope of the land influences water movement and erosion. Soils on steep slopes may be thin and poorly developed due to erosion, while soils in low-lying areas may accumulate more organic matter and develop thicker profiles.

e. Time: Soil formation is a slow process that takes thousands to millions of years. The age of the soil affects the development of its horizons. Young soils may only have a few horizons, while older soils may have well-developed, distinct horizons.

Learning Tasks

1. Learners to analyse the processes involved in the movement and deposition of weathered materials to form soil and the kind of soil formed.
2. Learners to evaluate the factors that contribute to soil formation.
3. Learners to perform a field experiment to investigate soil profile development.

Pedagogical Exemplars

1. **Structured Talk for Learning:** The teacher leads learners in mixed-ability groups to identify the weathering of rocks and how it leads to soil formation. The teacher should use probing questions to guide learners to describe the processes involved in the weathering of rocks into soil. The teacher should move around the classroom and gently prompt less confident learners to join in the group work.
2. **Collaborative Learning:** Learners in mixed-ability groups discuss processes involved in the movement and deposition of weathered material to form soil, write reports and make presentations to the class.
3. **Experiential Learning:** The teacher guides learners to dig a pit at least 2 m x 1 m x 1 m (L x B x D) to observe the topsoil and subsoil, and discuss their observations. The teacher should clearly explain the goal of the task and ask guiding questions to enable learners to write reports on their observations, including a diagram showing the layers of the soil. Alternatively, use videos or pictures of a soil profile to help learners identify the various layers of the soil profile.
4. **Digital learning:** Learners in mixed-ability groups surf the Internet to find factors that influence soil formation and investigate how the factors identified cause soil formation. The teacher should

guide learners having difficulty with leading questions and encourage all the learners to participate actively in the group task. Learners should present oral or written reports on their findings.

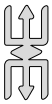
Key Assessment Level 3: Essay-type individual homework

Analyse how the characteristics of the A horizon (topsoil) and the B horizon (subsoil) in a soil profile influence the types of crops that can be successfully cultivated on a given soil. (10 marks)

PLC Session 7

45 minutes | **Planning & Reviewing the Learning Plan**

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
   a. explain the week's concepts in a practical way that will make it easier for learners to understand
   b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
   a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
   b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
   c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

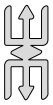
- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Plan the week's key assessment with your app
   a. The key assessment for the week is essay-type individual homework. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the homework (NTS 3k-3q).

10 minutes | **Content Exploration**

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
   a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
   b. all teachers in the group work through a similar problem individually for 3–4 minutes
   c. the group then works through the problem together step by step

d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes **Enactment**

6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).
   a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
   b. After the enactment, ask for structured feedback from the group
      i. was the concept explained in a way that a learner with no prior knowledge could follow?
      ii. were the examples grounded in contexts familiar to Ghanaian learners?
      iii. did any misconceptions surface and if so, how were they addressed?

5 minutes **Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
   a. transfer your chats into your learning planner template.
   b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
   c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 8

Learning Indicator: *Explain the physical properties of soil – texture and structure*

Focal Area: Physical properties of soil (texture and structure)

SOIL PHYSICAL PROPERTIES

Soil physical properties are the characteristics of the soil that influence plant growth, water movement, and farming activities. The most important soil physical properties are texture, structure, temperature, colour, aeration and moisture.

1. Soil texture

The soil consists of sand, silt and clay particles, and its texture refers to the relative amounts of sand, silt and clay particles in a soil sample. It describes how fine or coarse the soil is, depending on the sizes of the soil particles present in it (Table 4.2).

Table 4.2.: *Properties of soil particles*

Soil Property	Particle characteristics		
	Sand	Silt	Clay
Size of particles (diameter)	0.02-2.0mm	0.002-0.02mm	Less than 0.002mm
Coarseness	Coarse	Moderate in number and size	Very fine
Space between particles	Large and more spaces	Moderate	Small and fewer spaces
Drainage	High	Moderate	Low
Water holding capacity	Low	Moderate	High
Ease of moulding into shapes	Cannot be moulded into shapes	Slightly easy to mould into shapes	Very easy to mould into shapes
Condition when wet	Non-sticky grains, remain separate	Slightly sticky	Very sticky
Condition when dry	Loose and grains remain separate	Slightly compact and hard	Very compact and hard
Ease of tillage	Very easy to till (light soils)	Slightly difficult to till	Very difficult to till or work (heavy soils)

a. Soil texture determination using the feel method

i. Experimental objective: To determine the relative proportions of sand, silt, and clay particles in soil samples using touch.

ii. Materials required

- Soil samples (representing different textures if possible)
- Small containers for soil samples
- Water spray bottle or dropper
- Paper towels
- Hand sanitiser or soap and water for cleaning hands
- Reference soil texture guide/chart
- Data recording sheets
- Plastic gloves (optional)

iii. Detailed procedure

Part A: Sample preparation

- Obtain soil samples, removing any visible debris (stones, roots, organic matter)
- Place approximately 2 tablespoons of soil in your palm
- Add water dropwise to moisten the soil until it reaches a putty-like consistency
- Mix thoroughly with fingers until uniformly moist but not soggy

Part B: Tactile assessment techniques

Step 1: Initial feel assessment

1. Rub the soil between thumb and forefinger
2. Note the dominant feeling:
    - Gritty (sand dominant)
    - Silky/floury (silt dominant)
    - Sticky/plastic (clay dominant)

Step 2: Ribbon test

1. Form the soil into a ball about 3-4 cm in diameter
2. Compress the ball between your thumb and forefinger, attempting to form a ribbon
3. Measure how long the ribbon extends before breaking:
    - Less than 2.5 cm: Low clay content
    - 2.5-5 cm: Medium clay content
    - Greater than 5 cm: High clay content

Step 3: Ball formation and ring test

1. Roll the soil into a cylinder shape about 6-7 cm long
2. Attempt to bend it into a ring
    - Forms a ring without cracks (high clay)
    - Forms a ring with cracks (moderate clay)
    - Cannot form a ring (low clay)

Part C: Texture determination: Use the combined observations to classify the soil sample according to texture:

- Sandy soil: Gritty feel, won't form a ball or ribbon
- Sandy loam: Gritty feel, forms a ball that crumbles easily, minimal ribbon
- Loam: Equal mixture of gritty/smooth/sticky, forms a short ribbon (1-2 cm)
- Clay loam: Sticky and smooth, forms a medium ribbon (2-5 cm)
- Clay: Very sticky, forms a long ribbon (>5 cm), can form a full solid ring.

b. Classification of soil based on texture

Soil can be classified into three main types based on the textural characteristics of the soil. These are:

i. Sandy soil**:** (Large particle size (2.0 - 0.05 mm). Sandy soil is light, dry and gritty to the touch. It consists mainly of large particles and has a loose texture, which allows water to drain quickly. As a result, it tends to dry out rapidly and does not retain nutrients well. While it is easy to till and heats up quickly, it often requires organic matter to improve its fertility and moisture retention. This soil cannot form rolls or rings when moistened.

ii. Clayey soil: Clay soil is heavy and dense, with very fine particles that pack closely together. It feels sticky when wet and can form hard clumps when dry. Clay soils retain water and nutrients well, but drain poorly and can become waterlogged. They are slow to heat up and difficult to dig, but they can be very fertile when managed properly.

iii. Loamy soil (balanced mixture, ideal for farming). Loamy soil is considered ideal for most plants. It is a balanced mixture of sand, silt, and clay, and has a fine, crumbly texture. This soil type retains moisture and nutrients effectively while still draining well. It is soft, rich in organic matter, and easy to cultivate, making it highly suitable for gardening and farming.

2. Soil structure

Soil structure refers to the arrangement of the soil particles into aggregates or peds. The aggregates consist mainly of fine soil particles held in a single mass or cluster, separated by pores, cracks, or natural planes of weakness. A good soil structure enhances water infiltration, air circulation and root penetration, while a poor soil structure can cause compaction, waterlogging, and poor plant growth.

a. Types of soil structure**:** Based on the way aggregates are arranged in the soil, the following soil structures exist:

i. Granular structure: It consists of small, rounded particles which appear in clusters of more or less spherical aggregates with spaces between them. This structure is commonly found in the A horizon (topsoil) and is prevalent in soils rich in organic matter, such as those in grasslands. Granular structure promotes good aeration and water movement, making it ideal for plant growth.

ii. Blocky structure: Soil aggregates are shaped like blocks or irregular cubes. The peds (natural soil clumps) have more or less equal dimensions in all directions. It is common in clay-rich subsoils with moderate water movement and root penetration.

iii. Platy structure: The soil aggregates are arranged in thin, flat plates or sheets. These plates are oriented horizontally, often impeding water movement and root growth. Typically found in compacted surface layers or soils with high clay content or poor drainage.

iv. Prismatic structure: Soil aggregates form vertical columns or pillars with flat or slightly rounded tops. Prismatic soils are found in subsoils, particularly in arid and semi-arid regions with high clay content. It allows vertical water movement but with restricted lateral movement.

v. Crumb structure: Similar to granular but has larger, more porous aggregates, with high porosity and excellent drainage. It is ideal for agricultural production as it has fertile topsoil with high biological activity.

vi. Columnar structure: It is characterised by vertical columns with rounded, dome-like tops and high sodium content. It does not support agricultural production because drainage is poor. It is found in sodic soils in arid and semi-arid regions.

vii. Single grain structure: it has individual particles with no aggregation. It is characterised by excessive drainage and poor water retention, hence limited fertility and drought-prone. It is very common in sandy soils with low organic matter.

viii. Massive structure: It has large cohesive masses with no visible aggregations. Drainage, aeration and root penetration are all poor. It severely restricts plant growth and is mostly found in compacted subsoils and heavy clay soil.

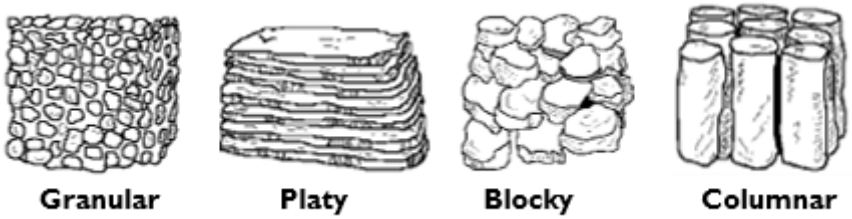


Figure 4.2: *Diagram of types of soil structure*

b. Experiment to assess soil structure

i. Materials needed**:**

- Soil samples from different locations
- Water
- Hand lens or magnifying glass (optional)

ii. Procedure**:**

- Collect moist (not soaking wet) soil samples.
- Gently break the soil apart by hand.
- Observe how the soil naturally breaks into lumps (aggregates).
- Sprinkle a little water on the sample to observe stability.

iii. Observation**:** Note the shape, size and feel of the aggregates — whether crumbly, blocky, or compacted.

iv. Conclusion: Relate observed structure to its ability to allow water and air movement.

c. Importance of knowledge about soil texture and structure to farmers

Knowing soil texture and structure helps farmers in several practical and impactful ways. These include:

i. Farmers can match crops to soil conditions, hence reducing crop failure

ii. Knowledge of soil structure helps farmers to improve soil health and long-term productivity.

iii. Farmers can save money and reduce waste by applying the right amount of fertiliser at the right time, in the knowledge that the soil structure supports proper uptake.

iv. Farmers can adopt practices like minimum tillage, cover cropping or contour farming based on the structure of their soil to prevent soil loss.

v. Understanding the soil structure helps the farmer to choose the right tillage method in land preparation.

vi. Farmers can use this knowledge to plan better irrigation schedules and prevent waterlogging in poorly drained areas.

vii. Farmers who understand soil structure can select practices that promote healthy root growth, more vigorous plants and larger yields.

Learning Tasks

1. Learners to identify the physical properties of the soil.
2. Learners to discuss the soil texture and structure, and bring out the types and their characteristics.
3. Learners to experiment to investigate the soil texture and structure.
4. Learners to examine the importance of the knowledge of soil texture and structure to the farmer.

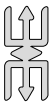
Pedagogical Exemplars

1. **Inquiry-based learning:** Learners in mixed-ability groups surf the Internet to list soil physical properties. Learners who are more familiar with the Internet should help others as necessary. The teacher should also encourage all learners to be involved in browsing the Internet to improve their digital literacy skills. The teacher should monitor the content being browsed by learners. All learners should be encouraged to interact, cooperate and accept and tolerate the views of others.
2. **Initiating talk for learning**: Learners in mixed-ability groups should brainstorm the meaning of soil texture and structure, identify the various types and discuss their characteristics. Learners should be guided with probing questions to help them to understand the meaning of soil texture and structure, soil types and their characteristics. Learners should present their findings to the class.
3. **Experiential Learning:** The teacher guides learners in mixed-ability groups to perform experiments to determine the soil texture and structure and present reports on their findings to the class. Where necessary, learners should be helped to use the guide provided in order to perform the experiment. The teacher should encourage all learners to be involved in carrying out the experiment in order to improve their collaborative and scientific inquiry skills.
4. **Problem-based learning**: Learners in mixed-ability groups examine the importance of the knowledge of soil texture and structure to the farmer. The teacher should lead learners with probing questions to critically analyse how beneficial the knowledge of soil texture and structure is to farmers in improving their farming. The teacher should praise learners for their contributions to motivate others to participate

Key Assessment: See the end of Week 9 for the assessment item PLC Session 8

45 minutes **Planning & Reviewing the Learning Plan**

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
   a. explain the week's concepts in a practical way that will make it easier for learners to understand
   b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
   c. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
   d. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
   e. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



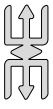
Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Plan the week's key assessment with your app
   a. The key assessment for the week is discussion and homework. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the homework (NTS 3k-3q).

10 minutes **Content Exploration**

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
   a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
   b. all teachers in the group work through a similar problem individually for 3–4 minutes
   c. the group then works through the problem together step by step
   d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*

- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes **Enactment**

6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).
   a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
   b. After the enactment, ask for structured feedback from the group
      i. was the concept explained in a way that a learner with no prior knowledge could follow?
      ii. were the examples grounded in contexts familiar to Ghanaian learners?
      iii. did any misconceptions surface and if so, how were they addressed?

5 minutes **Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
   a. transfer your chats into your learning planner template.
   b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
   c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 9

Learning Indicator: *Explain the physical properties of soil – texture and structure*

Focal Area: Physical properties of soil (temperature, colour and moisture)

1. Soil temperature

Soil temperature refers to the amount of heat in the soil. It influences seed germination, root development, microbial activity, and nutrient uptake.

a. Factors affecting soil temperature: Several factors influence soil temperature and affect seed germination, root activity, microbial processes, and plant growth. The key factors include:

i. Solar radiation (Sunlight): Solar radiation is the primary source of heat for the soil. Soils receive more heat when days are longer and sunlight is more intense, typically in summer or in tropical regions.

ii. Soil colour: Dark-coloured soils absorb more heat and become warmer than light-coloured soils, which reflect more sunlight.

iii. Soil moisture content: Wet soils heat up and cool down more slowly than dry soils due to water's high heat capacity. Moist soils may stay cooler during the day and warmer at night than dry soils.

iv. Soil texture: Sandy soils heat up and cool down faster than clay or loamy soils due to lower water retention and fewer fine particles.

v. Soil structure and porosity: Well-aerated soils with larger pores allow better heat transfer, while compacted soils resist temperature changes.

vi. Vegetative cover: Plants and mulch act as insulation, reducing the amount of sunlight that reaches the soil and slowing temperature changes.

vii. Topography (Slope and aspect): South-facing slopes (in the northern hemisphere) receive more direct sunlight and tend to be warmer. Flat or shaded areas receive less sunlight and may remain cooler.

viii. Atmospheric temperature: The ambient temperature affects soil temperature; warmer air tends to warm the soil and vice versa.

b. Importance of soil temperature in agriculture

i. Many crops germinate within an optimal soil temperature range, outside of which they fail to germinate or experience a very low germination rate.

ii. Soil temperature influences root growth and nutrient availability.

iii. The rate of microbial activity in the soil is dependent on the soil temperature. This is important for decomposition and nutrient recycling.

c. Experiment to investigate soil temperature

i. Objective: To measure and compare soil temperatures at different depths and locations.

ii. Materials: Soil thermometer, ruler, note book, soils from different sites (eg shaded vs. open).

iii. Method:

- Insert the thermometer 5 cm and 10 cm deep into soil at selected sites.
- Record the temperature at the same time of day for 5 to 7 days.
- Compare results across depths and locations.

iv. Observation: Shaded soils are cooler; deeper layers fluctuate less.

d. How farmers apply the knowledge of soil temperature in farming

i. Knowing the right temperature helps farmers plant at the most favourable time for optimum and uniform germination.

ii. Knowledge of soil temperature helps in selecting suitable crops or using mulches to modify temperature for better root growth.

iii. Understanding soil temperature allows farmers to make informed decisions that increase efficiency, reduce waste and improve crop yields.

iv. Some soil-borne pests and diseases thrive at specific temperatures. Monitoring soil temperature helps in predicting and managing outbreaks.

v. Soil temperature helps determine the best time for ploughing and other mechanical operations.

vi. Farmers growing crops in controlled environments use soil temperature data to adjust heating and improve seedling growth.

vii. Soil temperature affects evaporation rates and how water moves in the soil. It helps in scheduling irrigation to maintain adequate moisture.

2. Soil colour

Soil colour refers to the appearance of the soil due to three main pigments: black – from organic matter, red – from iron and aluminium oxides, and pale colour – due to silicates and salts.

a. Determination of soil type based on soil colour

i. Dark brown/black soil: (Figure 4.1)

- Rich in organic matter, especially humus, giving it a dark colour.
- Often found in fertile regions, ideal for crop farming.
- Has good moisture retention and structure.

ii. Red/yellow soil:

- The colour is due to the presence of iron and aluminium oxides.
- Found in tropical and subtropical regions.
- Usually, well-drained but low in fertility unless managed.
- Often requires lime and fertilisers for productive farming.

iii. Grey/blue soil:

- Indicates poor drainage and waterlogging.
- The grey or bluish colour is due to reduced iron under anaerobic conditions.
- Common in swamps or poorly drained lowlands.
- Not ideal for most crops unless drainage is improved.

iv. White soil:

- Light coloured due to high silica, salt or lime content.
- Often sandy and infertile, with poor nutrient and water retention.
- Found in arid or semi-arid regions.
- May support only limited vegetation unless amended.

Dark Brown/Black Red/Yellow Grey/Blue Soil Pale/White

Figure 4.1: *Images of Soil Types Based on Soil Colour*

b. Importance of soil colour in agriculture

i. Indicates fertility status and organic matter content of the soil.

ii. Provides clues about drainage conditions and mineral content of the soil.

iii. Assists in soil classification and crop suitability decision making.

c. Farmers' use of knowledge of soil colour in farming

i. It helps to predict soil fertility: Dark soils (black or dark brown) often contain more organic matter and nutrients, indicating higher fertility. Light-coloured soils (grey or white) may have low organic matter and nutrients.

ii. Helps assess drainage and aeration: Red or yellow soils usually indicate good drainage and aeration, often due to iron and aluminium oxides. Grey or bluish soils suggest poor drainage or waterlogging, which hinders root growth.

iii. Guides crop selection: Soil colour can hint at suitability for certain crops. For example, crops sensitive to waterlogging may not perform well in grey, poorly drained soils.

iv. Assists in land management practices: Farmers can decide where to apply organic matter, lime, or drainage improvements based on the soil colour.

v. Helps in planning for erosion control, as certain colours may indicate erosion-prone soils.

vi. Provides clues to soil temperature: Dark soils absorb more heat, heating up faster and supporting earlier planting. Light soils reflect more sunlight and stay cooler, affecting crop growth timing. This applies in the cooler regions.

vii. Helps identify soil types and layers: Colour differences in soil horizons (layers) help farmers understand soil depth, composition and structure, important for root development and nutrient management.

3. Soil moisture

Soil moisture refers to the water present in the soil. It exists in different forms based on how it is held within the soil particles, hence available or not for plant use

a. Types of soil moisture

The main types of soil water are:

i. Gravitational water: This drains through the soil due to the force of gravity. It occupies the large pores (macropores) in the soil after heavy rainfall or irrigation. It is generally not available to plants because it moves too quickly through the root zone**.**

ii. Capillary water: This water is held in the soil micropores (small pores). It moves slowly and is the most important source of water for plants. It is available to plants because it is held loosely around soil particles and can be absorbed by roots.

iii. Hygroscopic water: Forms a thin film tightly bound around soil particles. It is unavailable to plants because it is held too tightly and cannot be absorbed by plant roots. It remains in the soil even when very dry.

b. Importance of soil moisture in agriculture:

i. Essential for plant growth and development.

ii. Affects soil temperature and microbial activity.

iii. Dissolves soil nutrients for plant uptake.

iv. Essential for seed germination.

c. Experiment to determine soil moisture content:

i. Objective: To measure the moisture content of different soil samples.

ii. Materials: Soil samples, weighing scale, oven, containers.

iii. Method:

- Weigh a fresh soil sample (wet weight).
- Dry it in an oven at 105°C for 24 hours.
- Weigh the dried sample (dry weight).
- Use the formula:
- Moisture content (%) = (Wet weight – Dry weight)/Dry weight) × 100

iv. Observation: Soils with higher moisture retain water better, hence will support longer plant growth during dry periods.

d. Application of knowledge in soil moisture in farming

i. Farmers can apply the right amount of water at the right time, avoiding overwatering and underwatering. Saves water and reduces irrigation costs.

ii. It helps with better timing of farm operations. Soil moisture levels influence when to plough, plant, or harvest

iii. Farmers can adjust fertiliser application based on moisture levels to enhance nutrient efficiency.

iv. It helps farmers to maintain long-term soil health by avoiding erosion, salinisation, or degradation due to improper water management

v. It helps farmers prepare for or mitigate the effects of droughts or excessive rainfall by choosing appropriate crops or soil conservation practices.

Learning Tasks

1. Learners to define soil temperature, colour and moisture.
2. Learners to experiment to investigate soil temperature and moisture.
3. Learners to examine the importance of the knowledge of soil temperature, colour and moisture to the farmer.

Pedagogical Exemplars

1. **Think-pair-share:** Learners in pairs brainstorm soil temperature, colour and moisture. Learners having difficulty should be assisted with probing questions that will help them understand the meaning of soil temperature, colour and moisture. Teachers should challenge the highly proficient learners to explain the effects of these physical properties of the soil on agriculture.
2. **Experiential Learning:** The teacher guides learners in mixed-ability groups to perform experiments to investigate soil temperature, colour and moisture and present reports on their findings to the class. Learners should be assisted in using the guide provided in the content to perform the experiment. The teacher should also encourage all learners to be involved to improve their collaborative and scientific inquiry skills.
3. **Collaborative learning**: Learners in mixed-ability groups examine the importance of the knowledge of soil temperature, colour and moisture to the farmer. The teacher should lead learners with probing questions to enable them to critically analyse how beneficial the knowledge of soil temperature, colour and moisture is to farmers in improving their farming. All learners should respect each other's views. Teachers should praise learners for their contributions to motivate others.

Key Assessment Level 2: Essay-type individual homework

Explain how soil texture and structure can influence the amount of water that a soil can hold (10 marks)

PLC Session 9

45 minutes	Planning & Reviewing the Learning Plan

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Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Plan the week's key assessment with your app

   a. The key assessment for the week is essay-type individual homework. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the homework (NTS 3k-3q).

10 minutes **Content Exploration**

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then

   a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)

   b. all teachers in the group work through a similar problem individually for 3–4 minutes

   c. the group then works through the problem together step by step

   d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).

Note

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
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6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).

   a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.

   b. After the enactment, ask for structured feedback from the group

      i. was the concept explained in a way that a learner with no prior knowledge could follow?
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      iii. did any misconceptions surface and if so, how were they addressed?

5 minutes **Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).

8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
   a. transfer your chats into your learning planner template.
   b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
   c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 10

Learning Indicator: *Explain the chemical and biological properties of soil*

Focal Area: Chemical and biological properties of soil

1. Soil pH

Soil pH is the acidity or alkalinity of the soil solution, expressed on a scale from 0 to 14. A pH of 7 is neutral; values below 7 indicate acidic soils, and values above 7 indicate alkaline soils.

a. Importance of soil pH in agriculture

i. Nutrient availability: Soil pH directly affects the solubility and availability of essential nutrients. For example, phosphorus is most available in the pH range of 6.0–7.0, while iron and manganese are more soluble under acidic conditions.

ii. Microbial activity: Many beneficial microorganisms thrive in neutral to slightly acidic soils (pH 6–7). Strongly acidic or alkaline soils suppress microbial activity, which slows organic matter decomposition and nitrogen fixation.

iii. Toxic elements: At low pH, toxic elements like aluminium and manganese may become more soluble, making the soil harmful to plant roots (Brady & Weil, 2016).

b. Factors influencing soil pH

i. Parent material (basic rocks yield higher pH soils)

ii. Rainfall and leaching (more rainfall tends to lower pH)

iii. Fertiliser use (e.g. ammonium-based fertilisers acidify the soil)

iv. Organic matter decomposition

c. Causes of soil acidity

Soil acidity occurs when hydrogen ions (H^+) and aluminium ions (Al^{3+}) dominate the soil's exchange sites, leading to a low pH (usually below 6.5). Several natural and human-induced factors contribute to the development of acidic soils. Some of these are:

i. High rainfall and leaching: Heavy and consistent rains leach away basic cations such as calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+), and sodium (Na^+). These are replaced by hydrogen (H^+) and aluminium (Al^{3+}) ions, increasing soil acidity.

ii. Use of acid-forming fertilisers: Ammonium-based fertilisers (eg ammonium sulphate, urea) are converted to nitrate (NO_3^-) by soil microbes, releasing hydrogen ions into the soil. This acidifies the soil over time.

iii. Organic matter decomposition: Decomposition of organic matter produces organic acids (e.g. fulvic and humic acids) that can increase soil acidity, especially in poorly buffered soils.

iv. Crop uptake of basic cations: Plants absorb more cations (e.g., Ca^{2+}, Mg^{2+}) than anions (e.g. NO_3^-), and in exchange, roots release H^+ ions into the soil, contributing to acidification.

v. Parent material: Soils formed from acidic rocks (e.g., granite, sandstone) tend to be more acidic than those formed from basic rocks (e.g., basalt, limestone).

vi. Acid rain: Rain containing sulphuric (H_2SO_4) and nitric (HNO_3) acids from industrial emissions releases large amounts of H+ ions in the soil, which can lower soil pH over time, leading to soil acidity.

vii. Poor drainage and waterlogging: Anaerobic conditions in poorly drained soils cause the accumulation of organic acids and the reduction of iron and manganese, leading to acidification.

d. Correcting soil acidity

i. Application of liming materials: The most effective method to neutralise soil acidity is by applying liming materials to the soil. They are alkaline in nature and help to raise the soil pH and reduce toxic levels of aluminium and manganese. Some common liming materials include:

- Calcitic lime (Calcium carbonate – $CaCO_3$)
- Dolomitic lime (Calcium magnesium carbonate – $CaMg(CO_3)_2$)
- Quicklime (Calcium oxide – CaO)
- Hydrated lime (Calcium hydroxide – $Ca(OH)_2$

ii. Use of gypsum (in certain cases)**:** Calcium sulphate (gypsum) is not a liming material, but can **s**upply calcium without significantly altering pH. The calcium ions displace aluminium ions from the root zone in acidic subsoils. It is useful in acidic subsoils where lime incorporation is difficult.

iii. Organic amendments: Compost**,** manure and green manure can help buffer soil pH. Organic matter improves soil structure and microbial activity, which can reduce acidity over time.

iv. Acid-tolerant crops**:** Sowing/planting crops that thrive in low pH soils can be an interim strategy to improve the soil. Examples of acid-tolerant crops are sweet potato, pineapple, cowpea and millet. This is very useful in areas where liming is not immediately feasible.

v. Improved drainage**:** Waterlogged soils can accumulate organic acids, increasing acidity; therefore, proper drainage reduces acidity build up, especially in clayey soils.

vi. Controlled use of fertilisers**:** Minimised use of acid-forming fertilisers (eg ammonium sulphate, urea) and neutral or alkaline fertilisers (e.g. calcium nitrate, potassium nitrate) will reduce soil acidity. Fertiliser application should be based on soil test results.

vii. Crop rotation and cover cropping**:** Rotating deep-rooted crops with surface feeders improves pH balance. Cover crops can prevent nutrient leaching and build organic matter.

e. An experiment to test soil acidity using litmus paper

i. Title: Litmus paper determination of soil acidity

ii. Objective: To determine whether a soil sample is acidic, neutral, or alkaline using litmus paper.

iii. Materials needed

- Soil samples (from different locations/sites)
- Distilled water
- Clean beakers or plastic cups (1 for each sample)

- Stirring stick or spoon
- Filter paper or coffee filter
- Funnel (optional)
- Blue and red litmus papers
- Pen and notebook for recording results.

iv. Procedure

- Label each cup or beaker according to the soil sample location or number.
- Place two tablespoons of soil into each cup. (Either heaped or flat).
- Add 50 ml of distilled water to each soil sample to make a slurry.
- Stir thoroughly for about one minute and leave for 15–30 minutes.
- Filter the mixture through filter paper into another clean container.
- Test with litmus paper**:**
  - Dip a strip of blue litmus paper into the filtrate and note the colour change.
  - Dip a strip of red litmus paper into the filtrate and note the colour change.
- Record the observations and interpret the results (Table 4.3).

Table 4.3: *Soil acidity test results*

Soil Sample	Blue Litmus Paper Result	Red Litmus Paper Result	Conclusion
A	Turns red	No change	Acidic Soil
B	No change	Turns blue	Alkaline Soil
C	No change	No change	Neutral Soil

v. Conclusion: This experiment shows whether a soil is acidic, neutral, or alkaline based on litmus paper reactions, which helps in determining soil suitability for different crops.

2. Soil organic matter and fertility

Soil organic matter comprises all organic components in the soil, including plant and animal residues at various stages of decomposition, cells and tissues, and substances/chemicals produced by the soil organisms.

a. Components of soil organic matter

i. Fresh residues: Recently added plant materials

ii. Particulate organic matter: Partially decomposed organic materials

iii. Humus: Stable, fully decomposed organic matter resistant to further rapid decomposition

iv. Living biomass: All microorganisms and soil fauna (macro-organisms).

b. Experiment to determine the organic matter content of soil: Combustion method

i. Objective: To determine the percentage organic matter content of a soil sample.

ii. Materials Needed/Apparatus

- Soil sample (air-dried and sieved)
- Crucible or heat-resistant container
- Oven (for drying)
- Muffle furnace or open flame source (for heating)
- Balance (accurate to 0.01 g)
- Tongs or heatproof gloves

iii. Procedure

A. Drying the soil sample

- Weigh about 100 g of air-dried, sieved soil into a clean, dry crucible.
- Dry in an oven at 105°C for 24 hours to remove moisture.
- Cool in a desiccator and weigh accurately (Weight 1).

B. Heating/combusting the soil sample:

- Place the crucible with the dried soil in a muffle furnace at 360–400°C for two hours**,** or heat carefully over an open flame until the soil turns greyish (indicating organic matter is burned off).
- Cool in a desiccator and weigh again (Weight 2).

C. Calculate organic matter conten

Organic Matter Content (%) = (W1 -W2)/(W1) × 100.

D. Sample calculation

- Weight of dry soil before combustion (W1) = 100 g
- Weight of soil after combustion (W2) = 85 g
- Organic matter Content =100−85/100×100 = 15 %.

c. The role of organic matter in the soil

i. Improves soil structure: It enhances soil aggregation, thereby increasing porosity, aeration and facilitating root penetration.

ii. Increases water retention: Organic matter acts like a sponge, holding water. This helps soils retain moisture during dry periods.

iii. Enhances nutrient availability: Serves as a reservoir of essential nutrients (eg nitrogen, phosphorus, sulphur), releasing nutrients slowly through decomposition.

iv. Boosts Cation Exchange Capacity (CEC): Increases the soil's ability to hold and exchange positively charged ions (eg K^+, Ca^{2+}, Mg^{2+}), which improves nutrient retention and reduces leaching.

v. Promotes soil microbial activity: Provides food and energy for soil microorganisms, which supports beneficial organisms involved in decomposition and nutrient cycling.

vi. Buffers soil pH: Helps neutralise acids and bases, stabilising soil pH levels and helps reduce harmful effects of extreme soil pH.

vii. Suppresses soil-borne diseases: Supports populations of beneficial microbes that compete with or suppress pathogens.

viii. Regulates soil temperature: Improves soil insulation, reducing temperature extremes.

ix. Reduces soil erosion: Improves soil cohesion and reduces susceptibility to wind and water erosion.

x. Sequesters carbon: Plays a vital role in climate change mitigation by storing carbon in the soil.

3. Cation Exchange Capacity (CEC) of the soil

CEC refers to the soil's ability to hold and exchange positively charged ions (cations) such as potassium (K^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), and ammonium (NH_4^+) ions. It is measured in centimoles of charge per kilogram of soil (cmol(+)/kg).

a. Importance of Cation Exchange Capacity (CEC) of the soil

Cation Exchange Capacity (CEC) is a key indicator of soil fertility and health. It refers to the soil's ability to hold and exchange cations in the soil. Some of the importance of CEC are:

i. Enhances nutrient retention: Soils with high CEC hold more essential nutrients such as potassium (K^+), calcium (Ca^{2+}), and magnesium (Mg^{2+}). This prevents nutrients from being easily leached by rain or irrigation water.

ii. Improves soil fertility**:** Higher CEC means greater nutrient-holding capacity, contributing to better plant growth. It also supports sustained nutrient supply throughout the growing season.

iii. Regulates soil pH: CEC contributes to soil buffering, helping to resist rapid changes in soil acidity. This helps maintain a stable chemical environment for plant roots and microbes.

iv. Supports efficient fertiliser use: Soils with higher CEC retain applied fertilisers better, increasing efficiency and reducing costs.

v. Indicates soil type and quality: Sandy soils have low CEC and tend to be less fertile, while clay and organic-rich soils have higher CEC and better nutrient-holding potential.

vi. Enhances microbial activity: A stable nutrient environment promotes microbial growth and biological activity.

vii. Aids in soil amendment decisions: It helps guide the application of lime or fertilisers based on nutrient-holding capacity.

b. Factors affecting CEC of soils

Cation Exchange Capacity varies from one soil to another based on several physical and chemical characteristics. The major factors that influence CEC:

i. Soil texture: Clayey soils have higher CEC due to the large surface area and presence of negatively charged clay particles, while sandy soils have low CEC because of their coarse texture and small surface area.

ii. Organic matter content: Organic matter (especially humus) has a very high CEC, therefore, soils rich in organic matter can retain more nutrients and have a higher total CEC.

iii. Soil pH: As soil pH increases, the negative charge on soil particles (especially organic matter and variably-charged clays like kaolinite) increases, raising CEC. Acidic soils tend to have lower effective CEC.

iv. Soil moisture: Soil moisture affects the mobility of cations and their ability to interact with exchange sites, therefore, well-hydrated soils allow for better cation exchange.

v. Type and concentration of cations present: Polyvalent cations (e.g. Ca^{2+}, Mg^{2+}) can affect how strongly cations are held and exchanged. Sodium-dominated soils may have a lower effective CEC due to the dispersion of clays.

vi. Soil temperature: High soil temperatures can accelerate organic matter decomposition, potentially lowering CEC over time.

Learning Tasks

1. Learners to discuss the chemical properties of soil (soil acidity, soil organic matter and soil cation exchange capacity).
2. Learners to perform experiments to determine the chemical properties of soil (soil acidity and soil organic matter) and present reports.

Pedagogical Exemplars

1. **Collaborative learning**: Learners in mixed-ability groups discuss the chemical properties of soil (soil acidity, soil organic matter and soil cation exchange capacity). The teacher should lead learners with probing questions to enable them to critically analyse how these soil chemical properties influence soil fertility. All learners should respect each other's views. Teachers should praise learners for their contributions to motivate others to contribute.
2. **Experiential Learning:** The teacher guides learners in mixed-ability groups to perform experiments to investigate the chemical properties of soil (soil acidity and soil organic matter) and present reports to the class. Learners should be assisted in using the guide provided to experiment. The teacher should also encourage all learners to be involved in the experiment to improve their collaborative and scientific inquiry skills.

Key Assessment Level 3: Written class exercises and tests

A community of farmers in the transitional zone of Ghana has observed declining crop yields over the past five years despite consistent application of NPK fertilisers. Initial soil testing reveals the following information:

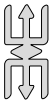
- pH: 5.2
- Organic Matter: 1.3 %
- Cation Exchange Capacity (CEC): 8 meq/100g
- Base Saturation: 45 %
- Visible earthworm population: Low
- Soil microbial activity: Reduced

Analyse how these chemical and biological properties are interrelated and explain their combined impact on nutrient availability, soil health, and crop productivity. Develop a comprehensive soil management strategy that addresses both the chemical and biological limitations of this soil while promoting long-term sustainability. Justify your recommendations with specific reference to the provided soil data. (25 marks)

PLC Session 10

45 minutes | **Planning & Reviewing the Learning Plan**

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
   a. explain the week's concepts in a practical way that will make it easier for learners to understand
   b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
   a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
   b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
   c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



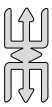
Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Plan the week's key assessment with your app
   a. The key assessment for the week is written class exercises and tests. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the assessments (NTS 3k-3q).

10 minutes | **Content Exploration**

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
   a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
   b. all teachers in the group work through a similar problem individually for 3–4 minutes
   c. the group then works through the problem together step by step
   d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*

- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes	Enactment

6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).
   a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
   b. After the enactment, ask for structured feedback from the group
      i. was the concept explained in a way that a learner with no prior knowledge could follow?
      ii. were the examples grounded in contexts familiar to Ghanaian learners?
      iii. did any misconceptions surface and if so, how were they addressed?

5 minutes	Reflection

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
   a. transfer your chats into your learning planner template.
   b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
   c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 11

Learning Indicator: *Describe soil conservation principles and practices – crop rotation, contour ploughing, terracing, and windbreak establishment*

Focal Area: Principles of soil conservation

1. Introduction to soil conservation

Soil conservation is the application of sustainable practices to protect soil from degradation. Soil is a finite resource that forms over extremely long periods, hundreds to thousands of years, yet can be degraded rapidly through erosion, compaction, contamination and other processes. The need for soil conservation arises from several critical factors such as:

a. Topsoil is lost at rates 10-40 times faster than it forms naturally.

b. Over 33 % of global soils are moderately to highly degraded.

c. Soil degradation directly threatens food security and ecosystem functions.

d. Once severely degraded, soil restoration becomes extremely difficult, costly and time-consuming.

2. Fundamental principles of soil conservation: Effective soil conservation requires understanding the principles that guide conservation efforts and the specific practices implemented in different agricultural contexts. Some of these principles include:

a. Principle of soil surface cover: Maintaining vegetative or residue cover on the soil surface is fundamental to soil protection. This helps to:

i. Intercept raindrops, reducing their erosive impact.

ii. Slow surface water flow, allowing greater infiltration.

iii. Reduces wind velocity at the soil surface.

iv. Provides organic material for soil building.

b. Principle of minimum disturbance: Minimising soil disturbance helps maintain soil structure and biological functions by:

i. Preserving natural soil aggregation and porosity.

ii. Maintaining root channels and earthworm burrows for water infiltration.

iii. Preventing the rapid decomposition of organic matter.

iv. Reducing oxidation of soil carbon to CO_2.

c. Principle of biodiversity: Enhancing biological diversity above and below ground promotes soil health through:

i. Diverse root structures that explore different soil depths.

ii. Varying nutrient demands that prevent single-element depletion.

iii. Enhanced resilience against pests and diseases.

iv. Greater microbial diversity supporting nutrient cycling.

d. Principle of continuous living roots: Maintaining living roots in the soil throughout the year provides continuous food for soil microorganisms and stabilises soil aggregates through root exudates. It also creates channels for water infiltration and captures nutrients that might otherwise leach.

e. Principle of integrated soil management: This principle combines multiple approaches that adapt to local conditions. This approach recognises that no single practice is sufficient for all situations. This principle can be achieved by:

i. Adapting conservation methods to local soil types, topography and climate.

ii. Combining cultural and mechanical approaches for comprehensive protection.

iii. Monitoring outcomes and adjusting strategies accordingly.

3. Cultural methods of soil conservation

Cultural methods focus on agronomic and biological approaches to soil management that enhance soil protection while maintaining agricultural productivity. These methods include:

a. Crop rotation: Crop rotation is the systematic and sequential planting of different crops on the same land across many growing seasons. The aim is to improve soil fertility, reduce pest and disease cycles, control weeds, and enhance overall crop productivity. The benefits of crop rotation are:

i. Improves soil fertility – legumes such as cowpea fix nitrogen.

ii. Reduces pest and disease build-up – rotating crops breaks life cycles.

iii. Prevents nutrient depletion – different crops use different nutrients.

iv. Improves soil structure – deep-rooted and shallow-rooted crops alternate.

v. Enhances yield and income stability

- 4-Year crop rotation programme (Table 4.4).
  - Crops: Maize, tomato, cowpea, cassava
  - Land size: Let's assume 4 plots of equal size (Plots A, B, C, D), one crop per plot per year.

Table 4.4: *Four-year crop rotation plan involving four crops*

Year/Plot	Plot A	Plot B	Plot C	Plot D
Year 1	Maize	Tomato	Cowpea	Cassava
Year 2	Tomato	Cowpea	Cassava	Maize
Year 3	Cowpea	Cassava	Maize	Tomato
Year 4	Cassava	Maize	Tomato	Cowpea

- Guide to implement the rotation
  - o Sequence crops wisely: Follow heavy feeders with legumes (eg maize → cowpea), avoid planting crops from the same family consecutively and alternate deep and shallow-rooted crops (eg cassava → tomato).

- Soil fertility management: Let legumes like cowpea build nitrogen naturally, add compost/manure before heavy feeders like maize and tomato and test soil annually and add lime or fertiliser as needed.
- Pest and disease control: Avoid planting crops from the same family consecutively to reduce the build-up of specific pests/diseases. Monitor regularly and use integrated pest management (IPM).
- Record keeping**:** Keep a rotation calendar or farm map and track yields, pest issues and soil amendments.

b. Cover cropping: Growing plants to cover and protect the soil when main crops are not growing. This can be achieved by:

i. Planting immediately after harvesting the main crop.
ii. Selecting species based on specific conservation goals.
iii. Terminating before planting the next main crop.
iv. Considering mixtures of multiple species for enhanced benefits.

- Benefits of cover cropping:
  - Prevents erosion during otherwise fallow periods
  - Captures and recycles nutrients
  - Suppresses weeds
  - Builds organic matter
  - Enhances soil biology

c. Windbreak establishment**:** Windbreaks are rows of trees or shrubs planted to block or reduce wind speed over the soil surface (Figure 4.2). Trees or tall plants are planted strategically, often at right angles to prevailing winds. The foliage and branches lessen the force of the wind, reducing its ability to carry away topsoil. Its benefits for soil conservation are:

i. Reduces wind erosion, especially in dry, sandy, or bare soils.
ii. Protects crops from wind damage and moisture loss.
iii. Improves microclimate by reducing evaporation and providing shade.
iv. Enhances biodiversity and adds organic matter through fallen leaves.

Figure 4.2: *Windbreak in arable farmland.*

d. Strip cropping: Growing strips of different crops in alternating bands across a field, typically along contours (Figure 4.3). It is achieved by alternating erosion-reducing crops (grasses, forages) with erosion-susceptible crops (maize, soybeans). The width of strips depends on slope steepness, erosion risk and equipment size. The benefits of strip cropping are:

   i. Reduces the rate of soil erosion.

   ii. Creates a diversified habitat for beneficial insects.

   iii. Reduces pest movement between susceptible crops.

   iv. Combines the benefits of crop rotation and contour farming

Figure 4.3: *Strip-cropped land*

e. Mulching: Applying plant materials, compost, or other suitable materials to the soil surface. Its benefits are:

   i. Reduces raindrop impact on the soil.

   ii. Suppresses weeds.

   iii. Moderates soil temperature.

   iv. Conserves soil moisture.

   v. Adds organic matter as mulch decomposes

f. Conservation tillage systems: Tillage approaches that maintain at least 30 % residue cover after planting. Types include:

   i. No-tillage**:** Planting directly into undisturbed residue with specialized equipment, after herbicidal or mechanical destruction of weeds/vegetation, or slashing and burning vegetation.

   ii. Strip-tillage: Tilling only narrow strips where seeds will be planted.

   iii. Ridge-tillage**:** Creating permanent ridges and planting on ridge tops.

   iv. Mulch-tillage**:** Incorporating some residue into the soil while leaving significant amounts on the surface.

4. Benefits of conservation tillage

a. Dramatically reduces erosion rates

b. Improves soil organic matter

c. Enhances soil biological activity

d. Reduces fuel and labour requirements

e. Improves water infiltration and retention

5. **Agroforestry**: Integrating trees and shrubs into agricultural systems. Types include:

   a. Alley cropping: Planting rows of trees or shrubs (the "alleys") and growing crops in the spaces between them. The trees can improve soil fertility, reduce erosion, and provide additional income (e.g., from fruit or timber).

   b. Silvopasture: Integrating trees, forage (grasses) and livestock on the same land. It improves pasture quality, provides shade for animals, and allows for timber or fruit cultivation alongside livestock farming.

   c. Riparian buffers: These are planted areas usually with trees and shrubs along waterways. They help filter runoff, reduce erosion, improve water quality, and provide habitat for wildlife.

   d. Windbreaks/shelterbelts: These are rows of trees or shrubs planted to protect crops, livestock, or buildings from strong winds. They reduce wind erosion, improve microclimates, and can serve as a wildlife sanctuary.

6. **Mechanical soil conservation**

Mechanical soil conservation involves physical structures or earth-moving operations that control water flow and soil movement. The common types in agriculture are:

   a. Terracing: A soil conservation practice where sloped land is transformed into a series of flat, step-like platforms or "terraces" (Figure 4.4). These structures reduce water runoff, minimise soil erosion and make it easier to cultivate crops on hilly or mountainous terrain. Terracing helps retain moisture and improves soil fertility, making it suitable for farming on steep slopes. The types of terracing include:

      i. Bench terraces: These are step-like platforms cut into steep slopes. The land is levelled or gently sloped for farming, with vertical or slightly sloped risers between them. They are common in hilly areas and help control erosion and water runoff.

      ii. Broad-based terraces: These are wide terraces with gentle slopes on both sides, suitable for use with machinery. They are designed for areas with moderate slopes and are often used for large-scale farming to manage water and reduce erosion.

      iii. Narrow-based terraces: These are narrow ridges with steep slopes, mainly used for erosion control rather than crop production. They are built on steeper lands and are usually planted with grasses or other cover crops.

Figure 4.4: *Bench terraces (Utopia.org)*

b. Contour ploughing: Contour ploughing is the practice of ploughing along the natural contours of a slope, rather than up and down the slope. The ploughing lines follow the shape of the land's elevation, forming ridges and furrows across the slope. These ridges act as barriers to reduce the runoff speed during rainfall. Its benefits for soil conservation are:

   i. Reduces soil erosion by preventing water from gaining speed as it moves down the slope.

   ii. Improves water infiltration into the soil, allowing more water to be absorbed rather than running off.

   iii. Prevents nutrient loss since runoff speed is slow.

c. Diversion ditches and bunds: Channels with supporting ridges designed to intercept and divert water before it gains erosive velocity. It can be implemented by:

   i. Constructing across slopes or around vulnerable areas.

   ii. Ensuring proper gradient for water flow without causing erosion.

   iii. Directing water to stable outlets or storage structures.

   iv. Ensuring regular maintenance to prevent breaches.

d. Check dams: Small, temporary or permanent dams constructed across drainage ditches or small watercourses. The benefits of check dams are:

   i. Reduces water velocity in channels

   ii. Traps sediment behind structures

   iii. Creates a step-like gradient in channels

   iv. Relatively inexpensive and simple to construct

e. Contour bunding: This is a soil and water conservation technique where small earthen embankments (bunds) are constructed along the contour lines of a slope. These bunds help reduce runoff speed, allowing it to soak into the soil rather than washing it away. This reduces soil erosion, conserves moisture, and improves crop productivity, especially in hilly or semi-arid areas

f. Gabion structures: They are wire mesh boxes or cages filled with stones, used to control erosion and stabilise slopes, riverbanks, or stream channels. They reduce the speed of flowing water, prevent soil from being washed away and support weakened landscapes. Gabions are durable and flexible, and allow water to pass through, making them effective for long-term soil and water conservation.

7. **Integration of conservation methods**: Effective soil conservation typically requires combining multiple approaches into integrated systems:

   a. Conservation farming systems: Comprehensive approaches that combine multiple conservation practices:

      i. Conservation agriculture: A farming system based on three key principles—minimal soil disturbance (no-till), permanent soil cover (using crop residues or cover crops) and crop rotation. It improves soil health, reduces erosion, conserves water and ensures long-term productivity.

      ii. Regenerative agriculture: A holistic approach to restoring and enhancing soil health, biodiversity, and ecosystem functions. It includes composting, cover cropping, reduced tillage, and rotational grazing to regenerate the land and capture carbon.

iii. Agroecological systems: These integrate ecological principles into farming, combining traditional knowledge with modern science. They promote biodiversity, sustainability and resilience by mimicking natural ecosystems and using locally adapted practices.

b. Watershed approach: The watershed approach in soil conservation involves managing the entire land that drains into a common water body (like a river or lake) to conserve soil and water resources. It treats the land and water as a connected system, implementing measures like afforestation, terracing, check dams, contour bunding and water harvesting structures. This approach helps reduce soil erosion, improves water availability and enhances agricultural productivity across the whole watershed.

Learning Tasks

1. Learners to discuss the various cultural and mechanical methods of soil conservation and clearly outline how these methods help in soil conservation.
2. Learners to design and practise some soil conservation methods like crop rotation and windbreak establishment in the school grounds.

Pedagogical Exemplars

1. **Structured Talk for Learning:** The teacher leads learners in mixed-ability groups to discuss the cultural and mechanical methods of soil conservation. Teachers should use probing questions to guide learners to identify the various soil conservation methods and make oral presentations on their findings. The teacher should move around the classroom and gently prompt quiet learners to get involved in the group work and praise active participation in the group to motivate others to get involved.
2. **Project-based Learning:** The teacher guides learners to practise the soil conservation methods, such as crop rotation and windbreak establishment in the school grounds. The teacher guides learners to design and practise a crop rotation programme in the school farm. Four groups should be formed and the land should be divided into four plots. Each group should be assigned a plot and a crop to be planted using the guide for designing crop rotation. Short-duration crops should be used so that at least two crops can be grown in a year. After harvesting, the groups should rotate the plots and the crops assigned for the second planting. An award scheme should be instituted to appreciate the best-performing group(s).

Key Assessment Level 3: Written class exercises and tests

A farmer in your district has grown maize on the same 10-hectare field for the past five years. The farmer has observed several concerning trends: declining yields (from 6 tons/ha to 3.5 tons/ha), increasing pest problems (particularly stem borers and fall armyworm), rising fertiliser costs, and deteriorating soil structure. The farmer now seeks your advice as an agricultural expert. Analyse this situation and develop a comprehensive crop rotation plan for this farm that addresses these challenges. (20 marks)

Your essay should:

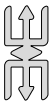
a. Analyse the identified problems of the continuous maize cultivation and explain the underlying biological, chemical, and physical processes causing these issues.

b. Design a 4-year crop rotation plan for this farm, providing clear reasoning for your crop selection and sequence, based on scientific principles.

PLC Session 11

45 minutes | **Planning & Reviewing the Learning Plan**

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
   a. explain the week's concepts in a practical way that will make it easier for learners to understand
   b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
   c. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
   d. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
   e. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



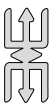
Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Plan the week's key assessment with your app
   a. The key assessment for the week is Written class exercises and tests. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the assessments (NTS 3k-3q).

10 minutes | **Content Exploration**

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
   a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
   b. all teachers in the group work through a similar problem individually for 3–4 minutes
   c. the group then works through the problem together step by step
   d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*

- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes **Enactment**

6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).
   a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
   b. After the enactment, ask for structured feedback from the group
      i. was the concept explained in a way that a learner with no prior knowledge could follow?
      ii. were the examples grounded in contexts familiar to Ghanaian learners?
      iii. did any misconceptions surface and if so, how were they addressed?

5 minutes **Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
   a. transfer your chats into your learning planner template.
   b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
   c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 12

Learning Indicator: *Outline the role of soil organisms in nutrient cycling and soil fertility*

Focal area: Role of soil organisms in nutrient cycling

1. Introduction

Soil is more than just a medium for plant growth – it is an ecosystem filled with organisms that perform critical functions. These soil organisms play vital roles in nutrient cycling and maintaining or improving soil fertility, which directly influences agricultural productivity and environmental sustainability. Soil organisms are living organisms found in the soil. They include microorganisms (too small to be seen with the unaided eye), e.g. bacteria, fungi, protozoa, and macro-organisms (large and visible), e.g. insects, mites, nematodes, earthworms, centipedes and millipedes.

2. Types of soil organisms involved in nutrient cycling

a. Bacteria: These are microscopic, single-celled organisms. Some bacteria decompose organic matter (dead plants and animals), releasing nutrients into the soil. Nitrogen-fixing bacteria like *Rhizobium* live in the root nodules of legume plants and convert nitrogen gas from the air into a form that plants can use (nitrates). Nitrifying bacteria change ammonia into nitrites and then nitrates. Denitrifying bacteria convert nitrates back into nitrogen gas, completing the nitrogen cycle.

b. Fungi: Fungi also decompose organic matter. Mycorrhizal fungi form partnerships with plant roots and help plants absorb nutrients like phosphorus in exchange for sugars from the plant.

c. Earthworms: Earthworms eat soil and dead plant material. They digest the materials and excrete them as nutrient-rich waste (worm casts). Their excavation and movement through the soil also mix the soil, improving its structure and allowing air and water to move more easily.

d. Protozoa and nematodes: These are tiny animals that attack crop roots and feed on bacteria and fungi. When they eat these microbes, they release nutrients in forms that plants can absorb. They also help control the population of bacteria and fungi in the soil.

e. Arthropods: These organisms, for example, ants, beetles, and mites, feed on and break down large pieces of organic matter into smaller parts, making it easier for bacteria and fungi to continue the decomposition process.

3. Role of soil organisms in nutrient cycling

Nutrient cycling refers to the movement and transformation of essential elements (like nitrogen, phosphorus, and carbon) through the soil, plants and atmosphere. Soil organisms are key players in this process.

a. Decomposition of organic matter: Bacteria and fungi break down dead plants, animals, and organic materials into simpler compounds. This decomposition releases nutrients like nitrogen, phosphorus, and potassium into the soil, making them available for plant uptake.

b. Nitrogen fixation: Certain bacteria (eg *Rhizobium*) form symbiotic relationships with legume roots and convert atmospheric nitrogen (N_2) into ammonia (NH_3), a form that plants can use. Free-living bacteria like *Azotobacter* also fix nitrogen independently in the soil for plant use.

c. Nitrification and denitrification: Nitrifying bacteria convert ammonia into nitrites and then into nitrates, which plants absorb. Denitrifying bacteria (eg *Pseudomonas*) convert excess nitrates into nitrogen gas, completing the nitrogen cycle and preventing nutrient buildup.

d. Mineralisation: Soil organisms convert organic forms of nutrients into inorganic forms (eg converting organic phosphorus into phosphate ions), making them accessible to plants.

e. Mycorrhizal associations: Mycorrhizal fungi form symbiotic relationships with plant roots, extending their network and helping with phosphorus and water absorption.

4. Role of soil organisms in soil fertility

Soil fertility refers to the ability of soil to provide essential nutrients to plants in adequate amounts.

a. Improving soil structure: Earthworms and other macro-organisms burrow through soil, mixing it and creating air spaces. Their movement improves aeration**,** drainage, and root penetration.

b. Enhancing soil organic matter: Through decomposition, soil organisms increase the amount of humus, which improves the soil's ability to retain nutrients and water.

c. Controlling soil-borne diseases: Some soil microorganisms produce antibiotics or outcompete harmful pathogens, protecting plant roots from disease.

d. Recycling plant nutrients: Soil organisms continuously recycle nutrients tied up in plant residues and animal wastes, keeping the soil fertile over time.

5. Experiment to determine the population of macro-organisms in selected soils

Title: An experiment to detect macro-organisms in the soil

a. Objective: To observe, collect, and identify macro-organisms present in soil samples.

b. Materials Required:

i. Small garden trowel or spoon

ii. Transparent plastic trays or containers

iii. Sieve or mesh screen (optional)

iv. Magnifying glass

v. White paper sheets or cloth (to spread soil on)

vi. A rule or measuring tape

vii. Gloves (for hygiene)

viii. Pencil and notebook for recording observations

c. Procedure:

Step 1: Choose the sampling site

- Select 3 different locations within the school grounds or nearby (eg under a tree, garden soil, bare ground).
- Ensure the locations are safe and accessible.

Step 2: Collect soil samples

- Dig a small hole about 15–20 cm deep using a trowel or spoon.
- Remove a sample of the soil (about a bowlful) and place it in a tray.
- Label each tray based on the sample location.

Step 3: Spread and examine the soil

- Pour the soil onto a white sheet or cloth to easily spot organisms.
- Carefully observe the soil using the unaided eye and then a magnifying glass.
- Use a sieve or mesh screen to separate larger particles and reveal hidden organisms.

Step 4: Identify macro-organisms

- Look for the following:
  - Earthworms
  - Ants
  - Beetles
  - Millipedes
  - Termites
  - Spiders
  - Centipedes
  - Snails
- Record each type and count how many you find.

Learning Tasks

1. Learners to identify and discuss the specific role of soil organisms in nutrient cycling and soil fertility.
2. Learners to conduct experiments to detect macro-organisms in the soil and present reports.

Pedagogical Exemplars

1. **Structured Talk for Learning:** The teacher leads learners in mixed ability groups to discuss the role of soil organisms in nutrient cycling and soil fertility. Teachers should use probing questions to guide learners to identify and discuss the specific roles of soil organisms in nutrient cycling and soil fertility. Teachers should assign learners to roles such as facilitator and recorder, to contribute in ways that match their confidence levels and skills.
2. **Experiential Learning:** The teacher leads learners in mixed-ability groups and guides them to conduct experiments to detect macro-organisms in the soil and present reports. The teacher should prompt learners to use the guide provided to carry out the experiment. The teacher should encourage all learners to be actively involved in the experiment and presentation of their report.

Key Assessment: Practice Paper 1

HINT

*Conduct **Practice Paper 1**. It should cover the contents taught from Years 1 to 3. Refer to the **Table of Specification and Structure of the Paper** at the end of this section. Learners' papers should be marked immediately and scores entered into the SAP.*

TEST SPECIFICATION TABLE
PAPER 1, OPTION A

Strand	Sub-strand	Learning Outcome	Content Standard	Learning Indicator	LEVEL OF ASSESSMENT				TOTAL
					1	2	3	4	
1. NEW DAWN IN AGRICULTURE	1. Misconceptions and Prospects in Agriculture and Farming	1.1.1.LO.1 Explain the meaning and importance of agriculture	1.1.1.CS.1 Demonstrate knowledge and understanding of the meaning and importance of agriculture	1.1.1.LI.1 Explain the meaning and importance of agriculture		1			1
	2. Emerging Technologies in Agriculture	1.1.2.LO.3 Compare and contrast existing and emerging technologies used in vegetable crop and ornamental plant enterprises and their benefits.	1.1.2.CS.1 Demonstrate knowledge and skills in emerging technologies of vegetable crop and ornamental plant production and their benefits relating to real life situations.	1.1.2.LI.3 Grow vegetable crops and ornamental plants using known procedures and technologies.		1			1
	2. Emerging Technologies in Agriculture	3.1.2.LO.2 Distinguish between existing and emerging technologies used in plantation and fruit tree enterprises and their benefits	3.1.2.CS.1 Demonstrate knowledge and skills in emerging technologies of plantation and fruit tree and their benefits relating to real-life situation	3.1.2.LI.1 Grow Plantation and Fruit trees using the known procedures and technologies	1	1	1		3

	3. Agricultural Machinery	1.1.3.LO.1 Evaluate the various forms of irrigation systems in vegetable crop and ornamental plant production	1.1.3.CS.1 Demonstrate knowledge, understanding and skills in the use of various forms of irrigation systems in vegetable crop and ornamental plant cultivation	1.1.3.LI.3 Use the appropriate irrigation system to produce vegetable crops and ornamental plants		1			1
	3. Agricultural Machinery	1.1.3.LO.1 Explain the functions of farm tools and equipment	1.1.3.CS.1 Demonstrate knowledge, understanding and skills in the operation of farm tools, implements and machines	1.1.3.LI.2 Classify and operate different types of machinery used in crop production in Ghana.	2	1			3
2. FARMING FOR JOBS AND INCOME	1. Economic Production of Crops	1.2.1.LO.1 Produce vegetables and ornamental plants for profit	1.2.1.CS.1 Demonstrate knowledge and understanding of market-oriented production of vegetables and ornamentals	1.2.1.LI.2 Organise and produce selected vegetable crops and ornamental plants		1	1		2
	1. Economic Production of Crops	1.2.1.LO.1 Produce vegetables and ornamental plants for profit	1.2.1.CS.1 Demonstrate knowledge and understanding of market-oriented production of vegetables and ornamentals	1.2.1.LI.3 Carry out required post-harvest practices and market the produce				1	1

	1. Economic Production of Crops	2.2.1.LO.1 Describe the role of farm machinery in arable crop production (cereals, legumes, and tuber crops) for profit.	2.2.1.CS.1 Demonstrate knowledge and understanding of market-oriented production of arable crops (cereals, legumes, and tuber crops).	2.2.1.LI.2 Organise and produce selected arable crop (cereals, legumes, and tuber crops).	3	3	1		7
	1. Economic Production of Crops	2.2.1.LO.1 Describe the role of farm machinery in arable crop production (cereals, legumes, and tuber crops) for profit.	2.2.1.CS.1 Demonstrate knowledge and understanding of market-oriented production of arable crops (cereals, legumes, and tuber crops).	2.2.1.LI.3 Carry out required post-harvest practices and market crops produced.		2			2
	1. Economic Production of Crops	3.2.1.LO.1 Use the knowledge and skills acquired to explain the processes of soil formation and properties of soil.	3.2.1.CS.1 Demonstrate knowledge and understanding of soil formation processes and soil properties	3.2.1.LI.1 Investigate soil formation processes - weathering, erosion, deposition and soil profile development		1			1
	1. Economic Production of Crops	3.2.1.LO.1 Use the knowledge and skills acquired to explain the processes of soil formation and properties of soil.	3.2.1.CS.1 Demonstrate knowledge and understanding of soil formation processes and soil properties	3.2.1.LI.2 Explain the physical properties of soil - texture, structure	2				2

	1. Economic Production of Crops	3.2.1.LO.1 Use the knowledge and skills acquired to explain the processes of soil formation and properties of soil.	3.2.1.CS.1 Demonstrate knowledge and understanding of soil formation processes and soil properties	3.2.1.LI.3 Explain the chemical and biological properties of soil	1	1			2
	1. Economic Production of Crops	3.2.1.LO.1 Use the knowledge and skills acquired to explain the processes of soil formation and properties of soil.	3.2.1.CS.1 Demonstrate knowledge and understanding of soil formation processes and soil properties	3.2.1.LI.4 Describe soil conservation principles and practices		3	4	2	9
	1. Economic Production of Crops	3.2.1.LO.1 Use the knowledge and skills acquired to explain the processes of soil formation and properties of soil.	3.2.1.CS.1 Demonstrate knowledge and understanding of soil formation processes and soil properties	3.2.1.LI.5 Outline the role of soil organisms in nutrient cycling and soil fertility.		1			1
	2. Economic Production of Animals	1.2.2.LO.1 Explain the key processes involved in poultry production	1.2.2.CS.1 Demonstrate knowledge, skills and understanding of the economic production of poultry	1.2.2.LI.2 Organise and produce the poultry type that is common in the locality for eggs and meat	1	2	1		4
	2. Economic Production of Small Ruminants	2.2.2.LO.1 Use the knowledge acquired to produce small ruminants.	2.2.2.CS.1 Demonstrate knowledge, skills and understanding of the economic production of small ruminants	2.2.2.LI.2 Produce small ruminants common in the locality for meat.	2		1		3

	2. Economic Production of Pigs and Fish	3.2.2.LO.1 Explain the key processes in the successful production of pigs or fish	3.2.2.CS.1 Demonstrate knowledge, skills and understanding of the economic production of pigs or fish	3.2.2.LI.2 Organise and produce pigs and fish	1	1			2
3. MOBILISATION OF RESOURCES AND NETWORKS	2. Support Systems in Agriculture	1.3.2.LO.1 Explain the different types of support systems in vegetable and ornamental crop production and marketing	1.3.2.CS.1 Demonstrate knowledge and understanding of the different types of support systems in vegetable and ornamental crop production and marketing	1.3.2.LI.2 Describe Technology Transfer Methods with Emphasis on Participatory Approaches				1	1
		3.3.2.LO.1 Explain the different types of support systems in vegetable and ornamental crop production and marketing	3.3.2.CS.1 Demonstrate knowledge and understanding of the different types of support systems in pig or fish production and marketing	3.3.2.LI.1 Describe the economic importance of pigs or fish production in the livelihood of the producers and the broader value chain	1				1
4. AGRICULTURE AND CLIMATE	1. Climate Variability, Adaptation and Mitigation Strategies	1.4.1.LO.1 Explain climate change and its implications on agriculture	1.4.1.CS.1 Demonstrate knowledge and understanding of climate change and its threat to environmental stability and rural livelihood sustainability	1.4.1.LI.2 Discuss the Consequences of Climate Change on Crop Yields.		1		1	2

	2. Climate change adaptation	1.4.2.LO.2 Explain the adaptation of society and agriculture to climate change	1.4.2.CS.2 Demonstrate knowledge and understanding of climate change and its relevance to sustainable rural agriculture	1.4.2.LI.1 Explain Indigenous and Conventional Strategies for Dealing with Climate Change and Variability.				1	1
TOTAL					15	20	9	6	50

PAPER 2 – OPTION A
ITEM SPECIFICATION TABLE

Strand	Sub-strand	Learning Outcome	Content Standard	Learning Indicator	LEVEL OF ASSESSMENT				TOTAL
					1	2	3	4	
1. NEW DAWN IN AGRICULTURE	1. Misconceptions and Prospects in Agriculture and Farming	1.1.1.LO.1 Explain the meaning and importance of agriculture	Demonstrate knowledge and understanding of the meaning and importance of Agriculture	Meaning and importance of Agriculture	1	1	0	0	2
1. NEW DAWN IN AGRICULTURE	1. Misconceptions and Prospects in Agriculture and Farming	1.1.1.LO.1 Explain the importance of agriculture and address misconceptions about the sector	1.1.1.CS.1 Demonstrate knowledge and understanding of the meaning and importance of agriculture	1.1.1.LI.2 Identify and address misconceptions in agriculture and farming at the community and national level.	1	1	1	0	3
1. NEW DAWN IN AGRICULTURE									

1. NEW DAWN IN AGRICULTURE	2. Emerging Technologies in Agriculture	1.1.2.LO.2 Identify emerging technologies in vegetable crop and ornamental plant enterprises.	1.1.2.CS.1 Demonstrate knowledge and understanding of emerging technologies in vegetable crop and ornamental plant enterprises.	1.1.2.LI.2 Appraise emerging technologies in vegetable crop and ornamental plant production.	1	0	0	0	1
2. FARMING FOR JOBS AND INCOME	1. Economic production of crops	1.1.1.LO.1.1.1 Describe the role of farm machinery in arable crop production (cereals, legumes, and tuber crops) for profit	2.2.1.CS.2 Demonstrate knowledge and understanding of market-oriented production of arable crop (cereals, legumes, and tuber crops).	2.2.1.LI.2 Organise and produce selected arable crop (cereals, legumes, and tuber crops).	1	1	1	0	3
2. FARMING FOR JOBS AND INCOME	2. Economic production of animals	1.2.2.LO.1 Explain the key processes involved in poultry production	1.2.2.CS.1 Demonstrate knowledge, skills and understanding of the economic production of poultry	1.2.2.LI.1. Identify resources and market needs for poultry production.	0	1	0	0	1
2. FARMING FOR JOBS AND INCOME	2. Economic production of animals	1.2.2.LO.1 Explain the key processes involved in poultry production	1.2.2.CS.1 Demonstrate knowledge, skills and understanding of the economic production of poultry	1.2.2.LI.2 Organise and produce poultry type that is common in the locality for eggs and meat.	0	1	0	0	1
2. FARMING FOR JOBS AND INCOME	2. Economic production of animals	1.2.2.LO.1 Explain the key processes involved in poultry production	1.2.2.CS.1 Demonstrate knowledge, skills and understanding of the economic production of poultry	1.2.2.LI.3 Outline various distribution outlets and ways of marketing poultry produce and products.	0	0	1	0	1

4. AGRICULTURE AND CLIMATE	2. Climate change adaptation	1.4.1.LO.1 Explain climate change and its implications on agriculture	1.4.1.CS.1 Demonstrate knowledge and understanding of climate change and its threat to environmental stability and rural livelihood sustainability.	1.4.1.LI.2 Discuss increasing drought, pestilence and decreasing crop yields.	0	1	0	0	1
4. AGRICULTURE AND CLIMATE	2. Climate change adaptation	1.4.1.LO.1 Explain climate change and its implications on agriculture	1.4.1.CS.1 Demonstrate knowledge and understanding of climate change and its threat to environmental stability and rural livelihood sustainability.	1.4.1.LI3 Discuss the Consequences of Climate Change on Crop Yields.	0	0	1	0	1
4. AGRICULTURE AND CLIMATE	2. Climate change adaptation	1.4.2.LO.2 Explain the adaptation of society and agriculture to climate change	1.4.2.CS.2 Demonstrate knowledge and understanding of climate change and its relevance to sustainable rural agriculture	1.4.2.LI.1 Explain Indigenous and Conventional Strategies for Dealing with Climate Change and Variability.	0	1	0	0	1
3. MOBILIZATION OF RESOURCES AND NETWORKS	2. SUPPORT SYSTEMS IN AGRICULTURE	3.3.2.LO.1 Explain the different types of support systems in vegetable and ornamental crop production and marketing	3.3.1.CS.2 Demonstrate knowledge and understanding of the approaches and methods of agricultural extension delivery.	3.3.1.LI.2 Explain the operations of rural credit.	1	1	1	0	3
TOTAL					5	8	5	0	18

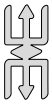
PAPER 3A OPTION A
ITEM SPECIFICATION TABLE

Strand	Sub-strand	Learning Outcome	Content Standard	Learning Indicator	LEVEL OF ASSESSMENT				TOTAL
					1	2	3	4	
2. FARMING FOR JOBS AND INCOME	1. Economic production of crops	1.1.1.LO.1.1.1 Describe the role of farm machinery in arable crop production (cereals, legumes, and tuber crops) for profit	2.2.1.CS.2 Demonstrate knowledge and understanding of market-oriented production of arable crop (cereals, legumes, and tuber crops).	2.2.1.LI.2 Organise and produce selected arable crop (cereals, legumes, and tuber crops).	2	2	1		5
2. FARMING FOR JOBS AND INCOME	2. Economic production of animals	1.2.2.LO.1 Explain the key processes involved in poultry production	1.2.2.CS.1 Demonstrate knowledge, skills and understanding of the economic production of poultry	1.2.2.LI.2 Organise and produce poultry type that is common in the locality for eggs and meat.	2	2			4
2. FARMING FOR JOBS AND INCOMES	2 ECONOMIC PRODUCTION OF SMALL RUMINANTS	2.2.2.LO.1 Use the knowledge acquired to produce ruminants.	2.X.2.2.CS.1. Demonstrate knowledge, skills and understanding of economic production of ruminants	2.X.2.2.LI.2 Organise and produce small and large ruminants common in the locality for meat.	1	1	1		3
2. FARMING FOR JOBS AND INCOMES	1 ECONOMIC PRODUCTION OF CROPS	Use the knowledge and skills acquired to explain the processes of soil formation and	Demonstrate knowledge and understanding of soil formation processes and soil properties	Explain the physical properties of soil - texture, structure, etc.		2	2		4
TOTAL					5	7	4	0	16

PLC Session 12

45 minutes | **Planning & Reviewing the Learning Plan**

1. Begin the session by recapping lessons from the previous session, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
   a. explain the week's concepts in a practical way that will make it easier for learners to understand.
   b. identify three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
   a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
   b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q).
   c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



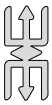
Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Use your app to plan and administer the mode of assessment for the student Assessment Portal (SAP).
   a. The key assessment for the week is practice paper 1. Chat with your app to plan this assessment by reviewing or developing the assessment items/tasks and marking schemes/rubrics for the practice paper (NTS 3k-3q).

10 minutes | **Content Exploration**

5. As a subject group, select one problem or topic/idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
   a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
   b. all teachers in the group work through the problem individually for 3–4 minutes
   c. the group then works through it together the problem, step by step
   d. highlight the most common errors made at each step (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*

- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes **Enactment**

6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).
   a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
   b. After the enactment, ask for structured feedback from the group
      i. was the concept explained in a way that a learner with no prior knowledge could follow?
      ii. were the examples grounded in contexts familiar to Ghanaian learners?
      iii. did any misconceptions surface and if so, how were they addressed?

5 minutes **Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
   a. transfer your chats into your learning planner template.
   b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
   c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 13

Learning Indicator: *Evaluate the impact of human activities – deforestation, farming, and urbanisation – on soil degradation and erosion rates*

Focal Area: Impact of human activities on soil erosion and degradation

1. Impact of human activities on soil erosion

Soil erosion is the removal of the fertile topsoil layer by water, wind, or other natural forces. This reduces soil fertility, affects crop productivity and contributes to land degradation. The process is greatly accelerated by human activities such as deforestation, farming, urbanisation, and surface mining.

a. Deforestation**:** Removal of trees and vegetation, through logging, agriculture or urban expansion, exposes the soil surface to the agents of erosion. The vegetation protects the soil from the direct impact of raindrops, runoff and wind, reducing soil vulnerability to erosion.

b. Unsustainable farming practices**:** Practices like frequent ploughing, especially along the slope, disturb the soil, making it more prone to being washed or blown away. Overgrazing removes ground cover and exposes the topsoil to potential loss. Monoculture reduces ground cover and increases the risk of erosion. Slash-and-burn land preparation removes protective vegetation and leaves the topsoil bare.

c. Urbanisation and infrastructure development**:** Construction activities and land development remove vegetation cover and disturb the soil.

d. Mining activities**:** Strip mining and open-pit or excavation mining remove and disturb large areas of soil cover. Loose, disturbed soil is highly susceptible to wind and water erosion and disrupts natural drainage.

e. Poor irrigation water management: Supplying too much irrigation water can lead to runoff and soil erosion. Sprinkler or overhead irrigation on slopes, without contour ploughing or terracing, increases erosion.

f. Climate change (indirect human impact)**:** Human-induced climate change leads to more intense rainfall and droughts, which increase erosion risks.

2. Consequences of soil erosion

a. Loss of fertile topsoil

b. Reduced agricultural productivity

c. Sedimentation in rivers and dams

d. Desertification in extreme cases

e. Decline in water quality due to soil particles and agrochemicals (fertilisers and pesticides) entering waterways

3. Role of human activity in soil degradation

Soil degradation is the decline in soil quality and productivity due to various factors, many of which are human-induced, reducing fertility, structure, and biodiversity of the soil. It threatens sustainable land use, food security and environmental health.

a. Types of soil degradation

i. Chemical degradation due to nutrient loss, pollution and acidification.

ii. Physical degradation due to erosion, compaction and crusting.

iii. Biological degradation due to loss of organic matter and soil organisms.

a. Main ways human activities contribute to soil degradation

i. Agrochemical pollution: Agrochemical overuse – synthetic fertilisers, pesticides (including herbicides), contaminates the soil and disrupts soil pH, causes chemical build-up and nutrient imbalance and kills beneficial organisms.

ii. Over-irrigation and poor drainage: Excessive watering leads to waterlogging and salinisation (salt build-up), especially in poorly drained soils. This damages plant roots, hardens or destroys soil structure, reduces fertility and lowers productivity.

iii. Intensive Agriculture: Continuous cropping without allowing soil to recover depletes nutrients. The use of heavy machinery compacts soil, reducing air and water infiltration and root growth, leading to loss of soil structure and reduced agricultural productivity. Overuse of fertilisers and pesticides depletes soil nutrients and pollutes the soil. Continuous cropping exhausts soil fertility and biological life.

iv. Industrial waste disposal: Dumping industrial waste can introduce heavy metal (eg lead and mercury) and toxic substances into the soil, making it unfit for agriculture.

v. Deforestation: This removes trees that protect and enrich the soil. The soil becomes vulnerable to erosion, loses organic matter, and reduces its ability to retain water and nutrients.

vi. Urbanisation and industrialisation: Construction, paving, and pollution occur during urbanisation, all of which cause soil compaction, sealing with concrete/asphalt, and contamination with heavy metals and waste.

vii. Mining activities: Surface mining disturbs large areas of the soil, as the land is often stripped of nutrients and structure.

viii. Climate change (indirect human impact or human-induced): Altered rainfall patterns and increasing temperatures and droughts or floods affect soil moisture and structure, disrupting soil water retention and fertility (Table 4.5).

Table 4.5: *Summary of human activity and the type of degradation and specific effects*

SN	Human Activity	Type of Degradation	Specific Effects
	Overuse of agrochemicals	Chemical	Soil toxicity, reduced fertility
	Intensive farming	Chemical/ Biological	Nutrient depletion, loss of microorganisms

	Urbanisation/ Industry	Physical/Chemical	Soil compaction, pollution
	Mining	Physical/Chemical	Topsoil loss, heavy metal contamination
	Climate change	Physical/ Biological	Droughts, reduced soil moisture and reduced soil organisms
	Over-irrigation	Physical/Chemical	Waterlogging, salinisation
	Deforestation	Physical/ Biological	Erosion, loss of organic matter

A B

Figure 4.5.: *Effect of minimal (A) and significant (B) human disturbance on land degradation*

4. How human activity impacts soil degradation and erosion rates

a. Farming practices (agriculture): Unsustainable farming leads to both accelerated erosion and degradation by depleting, polluting, and physically damaging the soil (Figure 4.5A).

b. Deforestation**:** It significantly increases both erosion rates and long-term soil degradation, especially on slopes or in tropical regions.

c. Urbanisation: Urbanisation contributes more to physical degradation and runoff-induced localised erosion, often permanently altering soil functions (Figure 4.5B).

d. Mining: Mining creates severe, often irreversible soil degradation and highly erodible landscapes.

e. Over-irrigation: Poor irrigation practices lead to chemical and physical soil degradation more than erosion.

5. **Case study: Conservation strategies** successfully implemented in **Ghana** to address **human-caused soil erosion**, due to deforestation, farming, and overgrazing.

Topic: Soil conservation in the Upper East Region of Ghana.

Background: The Upper East Region of Ghana is a semi-arid area with fragile soils, severe land degradation challenges and erratic rainfall. Over the years, the region has experienced:

a. Severe **soil erosion** due to **deforestation** (for fuel wood and farming),

b. Overgrazing by livestock,

c. Slash-and-burn agriculture, and

d. Climate variability (long dry seasons and heavy storms).

These factors led to:

a. Gully erosion,
b. Declining soil fertility,
c. Loss of agricultural productivity, and
d. Increased poverty among farming communities.

Conservation strategies implemented

1. Stone bunds (Stone lines)

a. What was done: Farmers placed lines of stones along the contours of sloped farmland.
b. How it worked**:** Slowed water runoff, captured soil and organic matter.
c. Impact:
   i. Reduced erosion by over 40 % in some areas.
   ii. Improved crop yields by 20–30 %**.**

Scientific principles involved

a. Reduced runoff velocity by up to 60 %
b. Trapped sediment moving downslope (15-25 tons/hectare/year)
c. Created favourable microenvironments for crop growth
d. Progressive terrace formation through sediment accumulation

2. **Zai pits and half-moon basins**

a. What was done: Small pits or basins were dug into the ground to collect rainwater and debris, which, with time, form compost.
b. How it worked: Concentrated water and nutrients around plants.
c. Impact: The project revived degraded lands and increased soil fertility.

Scientific principles involved

a. Concentrated water and nutrients where plants needed them
b. Improved water infiltration by breaking surface crusting
c. Enhanced organic matter in specific growing zones
d. Facilitated microbial activity in otherwise hostile soil conditions

3. **Agro-forestry and Farmer-Managed Natural Regeneration (FMNR)**

a. What was done: Farmers protected and managed naturally sprouting trees on their land.
b. How it worked: Encouraged tree growth to reduce wind and water erosion.
c. Impact: Increased ground cover, reduced wind erosion and improved microclimate for crops.

Scientific principles involved

a. Utilised existing seed bank and root systems for rapid revegetation.
b. Created multi-functional agroforestry landscapes.
c. Improved soil structure through diverse root systems.
d. Reduced wind erosion and moderated the microclimate.

4. **Contour ploughing and mulching**
   a. What was done: Farmers ploughed along contour lines and covered the soil with crop residues.
   b. How it worked: Prevented water runoff and maintained moisture.
   c. Impact: Reduced soil erosion, improved organic matter and moisture retention.

   Scientific principles involved

   a. Concentrated water and nutrients where plants needed them.
   b. Improved water infiltration by breaking surface crusting
   c. Increased organic matter in specific growing zones
   d. Facilitated microbial activity in otherwise hostile soil conditions

   Implementation process

   a. Community engagement
      i. Mobilisation through traditional authority structures (chiefs, elders and opinion leaders)
      ii. Formation of community land management committees
      iii. Training of local "conservation champions" to demonstrate techniques
      iv. "Farmer Field Forums" were instituted for experiential learning.
   b. Technical support
      i. Collaboration between the Ministry of Food and Agriculture and NGOs (including CARE Ghana and World Vision)
      ii. Provision of simple measuring tools for contour layout
      iii. Training in compost production using locally available materials
      iv. Regular field visits from extension agents during critical implementation phases
   c. Financial mechanisms
      i. Introduction of "food for work" during the initial labour-intensive phases
      ii. Community savings groups established to finance conservation inputs
      iii. Gender-inclusive microcredit schemes set up for conservation agriculture
      iv. Creation of community-based tree nurseries as micro-enterprises
   d. Results and success factors
      i. Over 10,000 hectares of degraded land have been rehabilitated in communities like Bawku West**,** Garu-Tempane, and Talensi.
      ii. Improved resilience to droughts and food security.
      iii. Community participation and training from NGOs (like CIKOD and CARE Ghana) were key.

Classroom Task

Role-play exercise: Place learners into groups (farmers, extension officers, NGOs) to develop a plan to reduce erosion on farmland in a fictional village based on this case study.

Include: Mapping out stone bunds, tree planting, and training sessions.

Lessons Learned

1. **Success factors**
    a. Integration of indigenous knowledge with technical approaches
    b. Early productivity gains generated and maintained farmer interest
    c. Treatment of entire micro catchments rather than individual farms
    d. Strong community bylaws and local enforcement mechanisms
2. **Challenges overcome**
    a. Initial labour requirements addressed through communal work arrangements
    b. Land tenure concerns addressed through engagement with traditional authorities
    c. Competition between livestock and conservation objectives resolved through designated grazing areas
    d. Technical complexity simplified through farmer-to-farmer teaching

Learning Tasks

1. Learners to identify three human activities (deforestation, farming practices, and urbanisation) that contribute to soil degradation and erosion.
2. Learners to conduct a comparative field study of two locations - one with minimal human disturbance and another with significant agricultural activity.
3. Learners to research and evaluate three soil conservation strategies that address human-caused erosion

Pedagogical Exemplars

Experiential Learning: The teacher guides learners to perform simple experiments to determine the rate of erosion, for example, run-off capture.

Project-based Learning: The teacher guides learners to practise two soil conservation methods – crop rotation and windbreak establishment.

Key Assessment Level 4: Written class exercises and tests

In recent years, Koforidua, in the Eastern Region of Ghana, has experienced increased soil erosion rates due to deforestation, intensive farming, and climate change. As an agricultural scientist, you have been tasked with developing recommendations for sustainable soil conservation. Critically evaluate three different soil conservation strategies that could address human-caused erosion in this town. (30 marks)

PLC Session 13

45 minutes	Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to

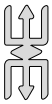
a. explain the week's concepts in a practical way that will make it easier for learners to understand
b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).

3. Use your subject specific app to plan your lesson. Ask the app to

   a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.

   b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)

   c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Plan the week's key assessment with your app

   a. The key assessment for the week is Written class exercises and tests. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the assessments (NTS 3k-3q).

10 minutes **Content Exploration**

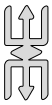
5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then

   a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)

   b. all teachers in the group work through a similar problem individually for 3–4 minutes

   c. the group then works through the problem together step by step

   d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes	Enactment

6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).
    a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
    b. After the enactment, ask for structured feedback from the group
        i. was the concept explained in a way that a learner with no prior knowledge could follow?
        ii. were the examples grounded in contexts familiar to Ghanaian learners?
        iii. did any misconceptions surface and if so, how were they addressed?

5 minutes	Reflection

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
    a. transfer your chats into your learning planner template.
    b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
    c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

SECTION 4 REVIEW

Section 4 covered content for 7 weeks (Weeks 7 to 13), and dealt with soil formation, its physical, chemical and biological properties, and soil conservation. Learners understood not only the role of the soil in sustaining life on Earth, but also its fragility and, therefore, the need to avoid activities that can degrade the land. Learners performed experiments to determine some physical, chemical, and biological properties and conservation procedures, and applied them in their agricultural activities. All learners played active roles during the various activities and displayed good collaboration.

MARKING SCHEMES FOR THE KEY ASSESSMENTS

Week 7

General Approach

Candidates are expected to identify and explain how specific characteristics of the A horizon (topsoil) and B horizon (subsoil) influence the types of crops that grow well in a particular soil. The explanation must go beyond listing; there should be a cause-and-effect relationship between the soil feature and crop suitability, with specific crop examples provided for full marks.

1. A Horizon (Topsoil) – 4 marks

   Candidates must provide at least two relevant characteristics of the A horizon, with each linked to a specific crop and a proper explanation of its influence.

   Award 1 mark for a correct characteristic of the A horizon and 1 mark for a clear explanation of how it affects crop suitability, including a specific crop example

   Expected points include

   i. The A horizon is rich in organic matter and nutrients, which supports vigorous early growth of crops like maize**,** lettuce, and spinach.

   ii. The topsoil has a granular, loose structure that enhances aeration and root penetration, ideal for crops like carrots, onions**,** and cowpeas**.**

   iii. Good moisture retention in the A horizon promotes seed germination and early establishment, suitable for beans and tomatoes**.**

   iv. A dark-coloured topsoil often indicates high humus content, supporting shallow-rooted crops like cabbage**,** okra, and garden eggs**.**

   (Any 2 correct points out of the 4 for 2 marks each = 4 marks)

2. B Horizon (Subsoil) – 4 marks

   Candidates must also provide at least two relevant characteristics of the B horizon, each linked to crop growth potential and supported with a crop example.

   Award 2 marks per correct point

   a. 1 mark for identifying a characteristic of the B horizon

   b. 1 mark for linking it effectively to crop type and explaining the influence

   Expected points

   i. The B horizon may be clayey and compacted, restricting root penetration. This makes it less suitable for cassava or cocoa**,** which require deep rooting.

   ii. High clay content may lead to poor drainage, supporting crops like paddy rice but harming crops like groundnuts and maize.

   iii. Mineral accumulation (iron, aluminium oxides) in the B horizon can lead to soil acidity, favouring acid-tolerant crops like pineapple while discouraging crops like soybeans**.**

   iv. A firm or cemented subsoil limits deep water infiltration, affecting the performance of deep-rooted crops such as yams and plantain**.**

   Maximum: 4 marks (2 × 2 marks)

3. Crop-Specific Linkage – 2 marks

   Candidates should give at least two specific examples where the characteristics of the A or B horizon are matched with suitable crops, showing understanding of how the soil condition directly supports or limits the crop.

   Award 1 mark per valid, well-explained crop–horizon relationship**.**

   Expected points:

   a. Maize prefers fertile, well-drained topsoil (A horizon).

   b. Rice thrives in compacted, water-retentive subsoil (B horizon).

   c. Carrots grow best in loose, friable topsoil that allows straight root development.

   d. Cocoa requires deep, well-drained subsoil for strong root anchorage and nutrient uptake.

   Maximum: 2 marks (2 × 1 mark)

   Summary of Mark Allocation:

   a. A horizon: 4 marks (2 characteristics × 2 marks)

   b. B horizon: 4 marks (2 characteristics × 2 marks)

   c. Crop-horizon linkages: 2 marks (2 examples × 1 mark)

   Total: 10 marks

Week 8 & 9

Soil texture

1. Definition of soil texture*:* relative proportion of sand, silt, and clay particles in a soil. (1 mark)
2. Clayey soils*:* fine particles with small pore spaces; hold more water but drain poorly. (2 marks)
3. Sandy soils*:* coarse particles with large pore spaces; hold less water, drain quickly. (2 marks*)*
4. Loamy soils*:* balanced mix of sand, silt, and clay; moderate water retention and good drainage. (1 mark)

Soil structure

1. Definition of soil structure*:* arrangement of soil particles into aggregates (crumbs, blocks, etc.). (1 mark)
2. Well-structured soil*:* stable aggregates create good pore spaces for water retention and movement. (2 marks)
3. Poorly structured soil*:* compacted or massive structure restricts water infiltration and storage. (1 mark*)*

Mark Allocation

- The candidate is expected to provide at least 5 correct points covering both texture and structure to score full marks.
- Allocate 2 marks per point based on completeness and clarity, as indicated above.

  Maximum marks: 10

Week 10

- The soil analysis reveals multiple interrelated chemical and biological limitations that collectively contribute to declining crop yields despite consistent fertiliser application. (1 mark)
- At this acidic soil pH (5.2) level, several essential nutrients become less available to plants, particularly phosphorus, which forms insoluble complexes with aluminium and iron in acidic conditions. (1 mark)
- Acidic conditions increase the solubility of aluminium, which can reach toxic levels that damage root systems and inhibit their development. (1 mark)
- The low pH reduces microbial activity, as most beneficial soil microorganisms perform optimally in near-neutral conditions (pH 6.0-7.0). (1 mark)
- The low organic matter content (1.3 %) indicates poor biological health (1 mark) and is interrelated with both chemical and biological soil properties.
- Organic matter contributes significantly to cation exchange capacity (CEC), which at 8 meq/100g is relatively low for agricultural soils. (1 mark)
- The limited CEC restricts the soil's ability to retain nutrient cations (K+, Ca2+, Mg2+, NH4+), leading to leaching losses and reduced fertiliser efficiency. (1 mark)
- The low base saturation (45 %) implies that a significant portion of the limited exchange sites are occupied by acidifying cations (H+ and Al3+) rather than beneficial base cations. (1 mark)
- The reduced earthworm population and microbial activity represent significant biological limitations that affect nutrient cycling. (1 mark)
- The consistent application of NPK fertilisers without addressing these underlying chemical and biological constraints has likely resulted in poor fertiliser use efficiency. (1 mark)

(Total = 10 marks)

Comprehensive soil management strategy:

1. pH Correction: (1 mark)
    - Apply agricultural lime (calcium carbonate) at approximately 2-3 tons/ha based on the soil pH and CEC values. This will neutralise soil acidity, increase base saturation, reduce aluminum toxicity, and create more favorable conditions for microbial activity and nutrient availability. (1 mark)

    (Total = 2 marks)
2. Organic matter enhancement: (1 mark) + (Any 2 of the following 4 points for 2 marks)

    Implement a systematic organic matter addition program through:

    - Cover cropping with leguminous species (eg *Mucuna*, *Canavalia*) to add biomass and fix nitrogen (1 mark)
    - Application of composted manure at 10-15 tons/ha to increase organic matter content and stimulate biological activity (1 mark)
    - Crop residue retention with minimal tillage to protect the soil surface and gradually increase organic matter (1 mark)
    - These practices will increase CEC, improve soil structure, enhance water-holding capacity, and provide substrates for soil microbial communities. (1 mark)

(Total = 3 marks)

3. Biological stimulation: (1 mark) + (Any 1 of the following 3 points for 1 mark)
   - Apply bio-fertilisers containing beneficial microorganisms such as nitrogen-fixing bacteria, phosphorus-solubilising bacteria, and mycorrhizal fungi to jumpstart biological activity (1 mark)
   - Reduce tillage intensity to protect fungal networks and soil habitat (1 mark)
   - Implement crop rotations that include diverse root systems to stimulate varied microbial communities (1 mark)

   (Total = 2 marks)
4. Balanced nutrient management: (1 mark) + (Any 2 of the following 4 points for 2 marks)
   - Adjust fertiliser applications based on specific crop needs and improved soil testing (1 mark)
   - Include secondary nutrients (Ca, Mg, S) and micronutrients (particularly Zn, B) that may be deficient in acidic soils (1 mark)
   - Apply phosphorus fertilisers in bands near plant roots to improve efficiency in this acidic soil (1 mark)
   - Consider foliar applications of micronutrients as a short-term solution while soil conditions improve (1 mark)

   (Total = 3 marks)
5. Monitoring and adaptation: (1 mark)
   - Implement annual soil testing to track changes in pH, organic matter, and CEC and analyse plant tissue to identify nutrient deficiencies not apparent from soil tests (1 mark)
   - Establish test plots to evaluate the effectiveness of interventions before full-scale implementation (1 mark)

   (Total = 3 marks)
6. Conclusion (2 marks)
   - This integrated approach is justified by the specific soil data provided, targeting the most limiting factors first (pH and organic matter) while recognising that sustainable improvement requires addressing both chemical and biological soil properties as an integrated system rather than isolated components.

   Total (25 marks)

Week 11

Marking instructions

Candidates are expected to demonstrate a full understanding of the agronomic and ecological consequences of continuous maize monocropping, followed by a well-justified four-year crop rotation plan. The response should link each crop and rotation choice to the biological, chemical, and physical problems previously analysed.

The marking scheme is split into two major parts: analysis of problems (8 marks) and crop rotation plan and justification (12 marks)**.** Candidates are expected to blend multiple relevant points under each section. Specific crop names must be provided for full marks.

1. Analysis of continuous maize cultivation problems – 8 marks

   Candidates should provide five well-developed points covering biological, chemical, and physical issues.
   Award up to 2 marks per point (1 mark for identifying the issue and 1 mark for explaining the underlying process).

   Expected answers

   a. Declining yields due to nutrient depletion – Continuous maize cropping removes large amounts of nitrogen, phosphorus, and potassium from the soil. Without adequate replenishment or organic matter return, soil fertility drops, reducing yields. (2 marks)

   b. Increased pest build-up – Continuous maize provides a consistent food source and habitat for pests like stem borers and fall armyworm**,** allowing populations to increase year after year due to a lack of crop diversity or disruption. (2 marks)

   c. Development of pesticide resistance – Repeated use of the same pesticides to control the same pests leads to selection pressure, resulting in resistant pest populations. (2 marks)

   d. Soil structure degradation – Maize is a shallow-rooted crop and contributes little organic matter to the soil. Repeated maize cropping leads to poor soil aggregation, compaction, and reduced water infiltration. (2 marks)

   e. Increasing fertiliser requirement and costs – As organic matter declines and nutrient reserves decrease; more synthetic fertiliser is needed to maintain production. This increases production costs and further acidifies or damages the soil over time**.** (2 marks)

   Maximum: 8 marks

   Any 4 of the 5 points listed for 2 marks each.

2. Four-year crop rotation plan and scientific justification – 12 marks

   Candidates are to present a scientifically sound four-year rotation sequence. The rotation should address the major issues identified above: pest cycles, nutrient depletion, soil structure, and input dependency.

   Award up to 2 marks per year in the rotation:

   i. 1 mark for naming the crop

   ii. 2 marks for sound agronomic justification tied to at least one problem (nutrient management, pest suppression, soil health)

   Expected crop rotation plan and explanations include:

   Year 1 – Legume crop (eg cowpea, groundnut, or soybean).

   Legumes fix atmospheric nitrogen through symbiosis with Rhizobium bacteria, thereby enriching the soil with nitrogen for subsequent crops. They also break the maize pest and disease cycles. Suitable legume: soybean**.** (3 marks)

   Year 2 – Cereal crop (maize, millet).

   With nitrogen fixed from the previous legume crop and reduced pest presence, maize can perform better with less fertiliser input and fewer pest outbreaks. Rotation prevents monoculture effects. (3 marks)

   Year 3 – Root or tuber crop (e.g., cassava, yam, sweet potato).

Root crops utilise different soil layers and root architecture, helping to break soil compaction. They disrupt maize pest cycles and require less nitrogen. Suitable crop: cassava. (3 marks)

Year 4 – Vegetables (e.g., tomatoes, okra, or garden eggs, cabbage).

Vegetables are high-value crops that benefit from improved soil fertility, enabling more intensive use of organic manure or compost, which improves soil structure and provides income diversification. They also utilise different pest and disease profiles. (3 marks)

Maximum: 12 marks

(If the candidate proposes a different but valid rotation sequence with sound scientific reasoning and crop-specific relevance, award full marks.)

Total: 20 marks

Week 13

General Guidelines for Marking

1. Candidates are expected to critically evaluate three distinct and appropriate soil conservation strategies relevant to the specific context of Koforidua.
2. Each strategy must be identified**,** explained**,** and evaluated in terms of effectiveness, limitations, and applicability to human-induced erosion (deforestation, farming pressure, climate factors).
3. The answer should reflect scientific understanding**,** critical thinking, and local relevance**.**
4. Candidates should provide three full evaluations.
    - Each strategy is marked out of 10**,** broken down as follows:
        i. 2 marks for correct identification of a suitable soil conservation strategy.
        ii. 3 marks for a clear explanation of how the strategy works to prevent erosion.
        iii. 3 marks for critical evaluation (strengths, limitations, feasibility, and relevance to Koforidua).
        iv. 2 marks for scientific justification and contextual relevance (climate, topography, farming practices, etc.)

Total number of expected correct strategies: 3 x 10 marks each = 30 marks

Expected Response (Any 3 of the following strategies):

i. Afforestation / Agroforestry
    - Identification (2 marks*):* Replanting of trees or integration of trees with crops.
    - Explanation *(*3 marks): Trees reduce runoff, stabilise the soil with their roots, intercept raindrop impact, and improve soil structure.
    - Evaluation (3 marks*):* Sustainable long-term solution; improves biodiversity and water cycle regulation. However, land availability, community buy-in, and long gestation period are concerns.
    - Contextual relevance (2 marks): Koforidua has undergone deforestation; reintroducing vegetation would directly target the root cause.

ii. Contour Farming / Contour Bunding
    - Identification (2 marks*):* Tillage and planting across the slope along natural contours.

- Explanation (3 marks): Slows water flow, encourages infiltration, and reduces soil displacement.
- Evaluation (3 marks*):* Cost-effective and appropriate for moderate slopes; however, improper construction could cause waterlogging or erosion between bunds.
- Contextual relevance (2 marks*):* Applicable to Koforidua's undulating landscape, where farming on slopes is common.

iii. Cover Cropping

- Identification (2 marks): Growing of fast-growing plants like legumes or grasses during off-seasons.
- Explanation (3 marks*):* Covers the soil, reduces erosion, improves fertility through nitrogen fixation.
- Evaluation (3 marks): Low-cost, enhances soil structure; however, requires good management and water availability.
- Contextual relevance (2 marks*):* Farmers in Koforidua practising continuous cropping would benefit from off-season soil protection.

iv. Terracing

- Identification (2 marks): Constructing flat platforms on slopes.
- Explanation (3 marks*):* Reduces runoff speed, allows water retention, and prevents soil loss.
- Evaluation (3 marks*):* Suitable for steep terrain; labour-intensive and costly to establish.
- Contextual relevance (2 marks): Ideal for highland farming areas in Koforidua, where steep slopes accelerate erosion.

v. Conservation Tillage (Minimum Tillage)

- Identification (2 marks): Reducing the frequency and intensity of ploughing.
- Explanation (3 marks): Preserves soil structure, maintains organic cover, and reduces runoff.
- Evaluation (3 marks): Reduces soil degradation; adoption may be limited by traditional farming methods and weed control challenges.
- Contextual relevance (2 marks): Intensive maize farming in Koforidua could benefit from less disturbance to the topsoil.

vi. Mulching

- Identification (2 marks): Application of crop residue, leaves or organic material on soil surface.
- Explanation (3 marks): Protects against rainfall impact, conserves moisture, suppresses weeds.
- Evaluation (3 marks*):* Easily accessible and effective; might be less practical for large-scale farms or where mulch material is scarce.
- Contextual relevance (2 marks): Applicable for farmers in Koforidua with access to organic waste or crop residue.

SECTION 5: PRINCIPLES OF PLANTATION TREE CROP PRODUCTION

STRAND 2: FARMING FOR JOBS AND INCOMES

Sub-Strand 1: Economic Production of Crops

Learning Outcome: *Analyse the successful production of plantation tree crops*

Content Standard: *Demonstrate knowledge and understanding of market-oriented production of plantation trees.*

INTRODUCTION AND SECTION SUMMARY

Tree crops play a vital role in agricultural production, especially in tropical regions like Ghana. Fruit trees such as mango, orange, cocoa and oil palm provide long-term benefits to both farmers and society. Understanding the principles of tree crop production is essential for ensuring healthy growth, large yields and sustainable land use. In this section, learners will study the key practices involved in tree crop cultivation, including site selection, planting, maintenance, and harvesting. The section will also explore the economic, nutritional, and environmental benefits that fruit trees offer. By the end of this section, learners will be able to discuss the principles of tree crop production and explain how these trees contribute to improved livelihoods, food security and ecological balance in society.

The weeks and the indicators covered by the section are:

- **Week 14:** Discuss the principles of tree crop production

Week 15

- LI 1 - Explain the benefits of fruit trees to farmers and society
- LI 2 - Grow a fruit tree using the known procedures and technologies.

SUMMARY OF Pedagogical Exemplars

To help learners discuss the principles of tree crop production, teachers will use collaborative talk for Learning**,** Exploratory Learning and Gallery Walk**.** These strategies will promote active engagement, critical thinking and peer sharing as learners explore various tree-crop practices. **Experiential Learning** will deepen understanding through real-life observations and practices. *To* explain the benefits of fruit trees to farmers and society, **Talk for Learning** will encourage learners to share ideas and relate benefits to their communities, while Project-Based Learning will involve researching and presenting on specific tree crops. Finally, to grow a fruit tree using known procedures and technologies, learners will engage in Project-Based Learning by planning, planting, and managing a tree crop. This hands-on approach reinforces skills and connects classroom knowledge to real-life agricultural practices, ensuring meaningful and lasting learning.

ASSESSMENT SUMMARY

To properly assess learners on the principles of tree crop production, the benefits of fruit trees to farmers and society, and growing a fruit tree using the known procedures and technologies, formative assessment will be deployed at DoK Level 2-3, requiring learners to apply, analyse and evaluate information. Essay questions will be used during individual or group class exercises and as homework assignments to encourage critical thinking and deeper understanding. These essays will assess learners' ability to connect theory to practice, justify decisions and propose sustainable solutions. Teachers should provide prompt and constructive feedback to help learners identify their strengths and improve upon their weaknesses. This approach promotes reflective learning and supports learners in refining their ideas, enhancing their problem-solving skills and building confidence in applying knowledge to real-life agricultural contexts.

Table 5.1: *Assessment summary for the indicator*

Indicators	DoK Level	Assessment Strategy and/or Mode
Week 14: Discuss the principles of tree crop production	2	Essay-type questions Class exercise
Week 15 LI 1: Explain the benefits of fruit trees to farmers and society	2	Essay-type questions Group Class exercise
Week 15 LI 2: Grow a fruit tree using the known procedures and technologies	3	Essay-type questions Group Project

WEEK 14

Learning Indicator: *Discuss the principles of tree crop production*

Focal Area: Principles of tree crop production

1. **Principles of tree crop production:** This refers to the fundamental concepts and practices necessary for the successful cultivation, management and harvesting of perennial woody plants that produce fruits, nuts, oils, or other economically valuable products. It involves applying a comprehensive, scientific approach to cultivate trees for various purposes, including fruit, timber and other products. It includes understanding tree agronomy, physiology and soil science and optimising practices like pre-planting preparations, planting, post-planting care, harvesting and post-harvest handling. The key principles also involve developing good agricultural practices, promoting agribusiness and ensuring environmental sustainability.

    a. Understanding the crop and its environment

        i. Crop physiology: It is crucial to understand how trees grow, their nutrient needs and response to environmental factors.

        ii. Soil science**:** For successful tree crop production, it is essential to understand soil types, fertility and drainage.

        iii. Agronomy**:** Applying scientific principles to optimise planting, spacing, fertiliser application, irrigation and pest/disease management.

    b. Pre-planting and planting

        i. Site selection and land preparation

        - Climate suitability: The crop should be adapted to local temperature, rainfall and humidity conditions.
        - Soil type, soil testing and analysis: Deep, well-drained soils with adequate fertility. Waterlogged or highly acidic/alkaline soils should be avoided. Soil fertility and pH should be determined to select appropriate tree species and amend the soil as needed.
        - Topography: Gentle slopes are preferred to reduce erosion and improve drainage.
        - Land preparation**:** Land preparation involves clearing, ploughing and digging planting holes to prepare for tree establishment.
        - Seed/seedling selection**:** High-quality, disease-free planting material suitable for the local climate and soil should be chosen.
        - Spacing and planting techniques**:** The recommended planting space should be used to optimise sunlight penetration and resource utilisation.

        ii. Selection of suitable tree crop species and varieties**:** Tree crop species that are adapted to the local environment and in demand (eg mango, cocoa, cashew, oil palm) should be chosen. Improved or grafted varieties that offer greater yields, are disease-resistant and of better quality should be selected.

        iii. Propagation techniques: Tree crops can be propagated by seeds (eg mango, citrus), or by vegetative methods such as grafting, budding and cuttings, for uniformity and early maturity.

iv. Spacing and planting

- Proper plant spacing ensures adequate sunlight, air circulation and ease of maintenance.
- Planting should be done during the rainy season to reduce water stress.
- Use organic or inorganic fertilisers in the planting hole where necessary.

c. Post-planting care

i. Nutrient management**:** Apply fertilisers (organic or inorganic) based on soil test results, tree growth stage and nutrient requirements.

ii. Water management**:** Irrigate effectively during dry periods, especially young trees, and ensure proper drainage. Mulching helps retain soil moisture and reduce weed competition.

iii. Pruning and training**:** This helps to control tree growth, improve fruit quality and ensure structural integrity. Pruning maintains tree shape, removes dead or diseased branches, and improves sunlight penetration, whereas training young trees helps form a strong framework for fruit production.

iv. Weed, pest and disease management: Preventive and control measures should be implemented as needed. Regular weeding is necessary to reduce competition for nutrients and water. The use of Integrated Pest Management (IPM), a holistic approach to pest control that combines various methods, should supersede synthetic pesticide use. Monitor for diseases and pests and apply control measures promptly.

v. Monitoring crop progress: Tree health and development should be assessed regularly.

vi. Intercropping and soil conservation: Intercropping with compatible crops (eg legumes) improves yield, soil fertility and income. Cover crops and terracing help to prevent erosion, especially on sloped land.

d. Harvesting and post-harvest handling

i. Timing and technique: Harvest at the optimal/correct maturity stage to maximise fruit quality and quantity. Using proper tools reduces tree and fruit damage.

ii. Handling and storage: Proper handling and storage methods are crucial to maintain quality and reduce post-harvest losses.

iii. Record keeping: Systematically document planting, fertilisation, pest control, and harvest data. Accurate records of planting, inputs, yield, labour and sales should be kept.

iv. Marketing: Market opportunities need to be identified and value added to products through processing or packaging.

v. Sustainability and environmental considerations: Sustainable practices minimise environmental impact through water conservation, reduced fertiliser use and integrated pest management.

vi. Crop diversification: Introduce a variety of tree crops to diversify income and reduce risk.

vii. Agroforestry: Integrate trees into farming systems to enhance soil health and improve biodiversity.

e. Importance of tree crops in agriculture

Tree crops are woody perennial plants that are cultivated mainly for their fruits, nuts, oils, or other economically useful parts. They play a vital role in both ecological sustainability and human livelihoods. Their importance includes:

i. Environmental benefits

- Soil conservation: Tree roots hold soil together, thereby reducing erosion.

- Climate regulation: Many fruit trees provide shade and also absorb carbon dioxide, which helps to mitigate climate change.
- Biodiversity support: Tree crops provide habitats for wildlife.
- Water cycle maintenance: Trees reduce runoff and enhance groundwater recharge.

ii. Economic benefit

- Income generation: Many tree crops are cash crops that provide income for farmers (eg cocoa, coffee).
- Export revenue: Countries earn foreign exchange through the export of tree produce and products.
- Employment opportunities: People can be employed in farming, processing and marketing industries.

iii. Food and nutrition

- Edible fruits and nuts: These provide essential vitamins, minerals and fats (eg mango, cashew).
- Fodder for animals: Some trees (eg moringa, leucaena) are used as animal feed.

iv. Medicinal and cultural uses

- Many tree crops (eg neem) have medicinal properties.
- Trees are used in traditional ceremonies and beliefs in many communities.

Table 5.2: *Some important tree crops, growing areas and major uses*

Tree Crop	Major Growing Countries	Major Uses
Cocoa	Ivory Coast, Ghana, Nigeria, Brazil	Chocolate production, beverages, and butter
Oil Palm	Nigeria, Indonesia, Malaysia	Palm oil (used in cooking, cosmetics, industry)
Coconut	Coastal areas in Asia and Africa	Oil, water, fibre (coir), milk
Mango	Tropical and subtropical regions	Consumed fresh or processed
Cashew	India, Ghana, Nigeria, Brazil	Roasted nut, fruit juice and wine
Rubber	Southeast Asia, West Africa	Natural rubber (latex) production
Shea	Savanna region of Africa	Shea butter (cosmetics, food)
Avocado	Central America, Kenya, South Africa	Nutrient-rich fruit
Banana/ Plantain	Africa, South America, Asia	Staple food crop

f. Nursery practices in tree crop production

Nursery practices are the processes and techniques used to raise seedlings before they are transplanted. Proper nursery management is essential for ensuring healthy, vigorous plants that establish well in the field. These practices are important in the production of tree crops such as cocoa, oil palm, mango, citrus, avocado and cashew. They ensure healthy, uniform, and vigorous

seedlings. They also increase the field survival rate and allow early detection and management of problems.

i. Site selection for nursery: The site should have good drainage, adequate sunlight and be protected from strong winds. It should be accessible and close to a water source for irrigation. The area should not be prone to flooding or erosion.

   i. Types of nursery

      - Temporary nursery: This is set up for short-term use, often in polythene bags or seedbeds (Figure 5.1).
      - Permanent nursery: These are larger and more structured, with facilities like shade nets and water tanks (Figure 5.2).

g. Growing media preparation: The ideal medium should be loamy, well-drained and rich in organic matter. A common mixture is topsoil + compost + sand (in ratios like 3:2:1). The soil needs to be sterilised (solarisation or heat) to prevent pests and diseases.

h. Seedling containers: These may be polythene bags (black, with holes for drainage), seed trays, or pots in more structured nurseries (Figure 5.3).

Figure 5.1: *Small-scale tree nursery (Source: ECHO; Published: 29-03-2021)*

Figure 5.2: *Permanent tree seedling nurseries*

A (Source: BAM's Clonal Nursery) B (Source: Ghana Cocoa Board Nursery)

Figure 5.3: *Oil palm seedlings in polythene bags*

i. Sowing and planting**:** Seeds should be sown at the right depth and spacing. In vegetative propagation, ensure the cuttings/grafts are properly placed and cared for. It is important to label the plants to keep track of varieties and dates.

j. Watering and irrigation: Watering should be done regularly to keep the soil moist but not waterlogged. Watering cans, hosepipes or drip systems can be used for efficiency.

k. Shade management: Young seedlings often need protection from direct sunlight. Shade nets, palm fronds or grass thatch could be used to provide partial shade. Shading should be gradually reduced as seedlings mature (hardening off).

l. Weed, pest and disease control**:** Regular weeding is essential to reduce competition for nutrients and water. Organic or chemical controls should be used judiciously for pests and diseases. Sanitation and monitoring are key to their early detection and control.

m. Nutrient management: Organic manure or balanced NPK fertilisers should only be applied when necessary. Overuse of fertilisers can damage young plants and should be avoided.

n. Hardening off: To prepare seedlings for transplanting, watering and shade should be reduced gradually. Helps improve survival in the field.

o. Planting/transplanting of tree crops seedlings: Planting or transplanting of tree crops refers to the process of moving young tree seedlings from a nursery to their permanent field location. Seedlings are transplanted when they have developed enough roots and are healthy. Seedlings need to be watered immediately after transplanting. Proper planting techniques are essential for the healthy establishment, early growth and long-term productivity of the tree crop.

   i. Importance of proper transplanting

      - Promotes healthy root establishment
      - Enhances early growth and survival
      - Reduces transplant shock
      - Increases long-term productivity

   ii. Site preparation: The following could be done before planting:

      - Clear the land of weeds, stumps, and debris.
      - Plough or dig the soil to loosen it for better root penetration.
      - Mark the planting spots using the recommended spacing for the crop (eg 10 m x 10 m for mango, 9 m x 9 m x 9 m or 9 m triangular pattern for oil palm) (Table 5.3).
      - Dig planting holes (usually 30–60 cm deep and wide) depending on the root ball or seedling bag size.
      - Backfill holes with topsoil mixed with organic matter (eg compost or well-cured manure).

Table 5.3: *Some common tree crops and their recommended spacing*

Tree Crop	Recommended Spacing
Avocado	7 m x 7 m
Cashew	7 m x 7 m or 8 m x 8 m

Cocoa	3 m x 3 m
Citrus	6 m x 6 m
Mango	9 m x 9 m
Oil Palm	9 m x 9 m (triangular)

iii. Selection of planting materials

- Use healthy, disease-free and well-hardened seedlings.
- Avoid seedlings that are too young or have damaged roots.

iv. Timing of transplanting: The best time to transplant is at the **onset of the rainy season.** early morning or evening to reduce transplant shock.

v. The planting process (Steps for transplanting seedlings):

- Water the seedling in the nursery before removal to reduce stress.
- Carefully remove the seedling from its container to avoid root damage.
- Place it upright in the centre of the planting hole.
- Backfill with soil and gently firm the soil around the base to eliminate air pockets.
- Water the seedling immediately after planting.

vi. Mulching: Apply organic mulch (eg dry grass, leaves) around the base of the seedling to retain soil moisture, suppress weeds and regulate soil temperature.

p. Protection of young plants: Different methods are employed to protect the young plants. These include using stakes to support tall seedlings or applying pesticides or repellents for pests. Protective fencing or tree guards can also be used to prevent damage from animals or strong winds.

q. Aftercare: Watering should be done regularly, especially during dry spells. There is a need for weed control around the base to reduce competition. It is necessary to monitor for pests and diseases so that they can be controlled early. Based on the fertility of the soil, the appropriate fertiliser should be applied.

2. Cultural practices in tree crop production

Cultural practices are all the routine care and management activities carried out to ensure the healthy growth, good yield and longevity of tree crops. These practices begin after transplanting and continue throughout the tree's life. They boost growth and productivity, extend tree lifespan, prevent crop failure and enhance fruit quality.

a. Weed control: This reduces competition for nutrients, water, and light. It can be done manually using hoes, cutlasses, or hand pulling. Organic material can be applied around the base to suppress weeds. The use of appropriate chemicals, eg herbicides, should be done with caution to avoid damaging the young trees.

b. Watering/irrigation: This maintains plant vigour and supports fruit development. It is essential in dry seasons or drought-prone areas. Watering cans, drip irrigation and sprinklers may be used.

c. Mulching: This is done to conserve soil moisture, suppress weeds and improve soil fertility as it decomposes. Materials like dry grass, leaves, or sawdust are applied around the base of trees.

d. Pest and disease control: This is to prevent yield loss and tree death. To prevent their occurrence, infected parts or fallen fruits should be removed (good sanitation). There should be regular inspections of trees for early detection. They can be controlled by using approved pesticides or biological control.

e. Pruning: It enhances fruit quality and reduces pest problems. It involves the removal of dead, diseased, overcrowded or unproductive branches, which encourages air circulation, light penetration and shaping of the tree.

f. Fertiliser application: This supports vigorous growth and high fruit yield. Organic manure (compost, poultry droppings) or inorganic fertilisers (NPK) may be used depending on crop needs.

g. Thinning and spacing maintenance: This is done to reduce competition and improve access to sunlight. Removing excess or poorly positioned trees helps maintain the right population and spacing.

h. Intercropping: Where applicable, short-duration crops like maize, beans, or vegetables can be grown between young tree crops. This maximises land use, controls erosion and provides early income while trees mature.

i. Staking and windbreaks: Staking young trees helps to keep them upright while windbreaks (eg tall grasses or shrubs) are planted to reduce wind damage.

j. Training and canopy management: Training involves shaping the growth of young trees to encourage a strong framework. The canopy is managed for optimal light exposure.

3. Pest and disease management in tree crop production

Tree crops such as cocoa, mango, citrus, oil palm, cashew, and coffee are vital for food, income, and industry. However, they are susceptible to various pests (insects, mites, rodents) and diseases (fungal, bacterial, viral), which can severely reduce productivity. Pest and disease management is a critical component of successful tree crop production, ensuring healthy growth, high yields, and long-term sustainability.

a. Common insect pests of tree crops

Table 5.4: *Some common tree crops and their major insect pests*

Crop	Major Insect Pests	Damage
Cocoa	Cocoa mirids, cocoa mealybugs, stink bugs	Pod lesions, premature cherelle drop, cocoa dieback
Mango	Fruit flies, mango stone weevil	Fruit rot, seed damage
Citrus	Citrus psyllid, swallowtail butterfly, fruit borers	Leaf damage, reduced photosynthesis, fruit yield loss
Oil Palm	Palm weevil, rhinoceros beetle, bagworms	Crown damage, defoliation
Cashew	Tea mosquito, cashew stem borer, thrips	Dieback, stem tunnelling, flower drop

b. Common diseases of tree crops

Table 5.5: *Some common tree crops and their major diseases*

Crop	Major Disease	Symptoms
Cocoa	Black pod disease	Brown-black pods, fruit rot
Mango	Anthracnose	Leaf spots, fruit lesions
Citrus	Citrus canker, greening disease	Leaf spotting, fruit drop
Oil Palm	Ganoderma basal stem rot	Wilting, trunk decay
Cashew	Coffee leaf rust	Yellow-orange spots on leaves

c. Integrated pest and disease management (IPDM) strategies

i. Monitoring and early detection

- The field should be inspected regularly for signs of pests and diseases.
- Traps (pheromone, sticky traps) can also be used for early detection.

ii. Cultural practices

- Pruning to improve air circulation and reduce humidity
- Removal of diseased plant parts (sanitation)

iii. Intercropping with non-host species

iv. Biological control

- Use of natural enemies (eg lady beetles prey on aphids; parasitic wasps control mealybugs).
- Application of biopesticides (eg *Bacillus thuringiensis*, neem extracts)

v. Resistant varieties:

- Planting pest and disease-resistant/tolerant tree crop varieties

vi. Chemical control

- Judicious use of pesticides and fungicides
- Following recommended doses and pre-harvest intervals
- Use of selective, less persistent chemicals

vii. Environmental considerations

- Avoid overuse of persistent synthetic chemicals to protect beneficial insects and soil health
- Promote agroecological approaches and organic farming principles
- Encourage farmer field schools for participatory learning

4. Suggested classroom/field activities (At least one of them)

a. Experiential: Visit a tree crop farm and identify symptoms of pests and diseases.

b. Demonstration: Show how to prepare and apply a neem-based pesticide.

c. Case study: Analyse the success of IPM in cocoa production in Ghana.

Learning Tasks

1. In groups, learners compare tree crop production with arable crop production, focusing on differences in land preparation and crop maintenance.
2. Learners to examine a case study of a successful tree crop farm (eg cocoa or citrus plantation) and identify the application of key principles of tree crop production such as site selection, propagation methods, spacing and pest management; or,
3. Learners to visit a nearby tree crop farm and assess the soil conditions, spacing, irrigation and management practices.

Pedagogical Exemplars

1. **Collaborative Talk for Learning:** The teacher leads learners to discuss plantation and fruit crops and make a list of the major economic tree crops grown in Ghana. Less confident learners should be encouraged to participate by assigning them specific roles.
2. **Exploratory Learning**: The teacher embarks on educational visits with learners to successful plantation or fruit tree enterprises so that learners can study nursery practices, planting/transplanting, cultural practices, pest and disease management, and take notes for discussion in class. Precautionary measures should be in place to ensure the safety of all learners.
3. **Gallery Walk**: Learners in small groups create a comparative concept map showing differences between tree crop production and arable crop production under these headings: Land preparation, maintenance and economic returns. The teacher assigns each group to one of these headings. The groups will provide short explanations, symbols, or diagrams to discuss and organise their ideas. Each group will be guided to create a visual concept map on their poster. Learners will be expected to share their findings by attaching their posters to the classroom walls.
4. **Experiential Learning:** The teacher guides learners through the production steps of one of the following tree crops, chosen according to their importance in the area. They should at least nurse and transplant a few tree species (cocoa, oil palm, rubber, teak and cashew).

Key Assessment Level 3: Essay-type questions (Class exercise)

Design a sustainable tree crop production plan for a smallholder farmer in a tropical region. The plan should include land preparation, crop selection, propagation methods, spacing, maintenance practices and expected outcomes. (15 marks)

PLC Session 14

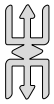
45 minutes	Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
   a. explain the week's concepts in a practical way that will make it easier for learners to understand
   b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to

a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.

b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)

c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Plan the week's key assessment with your app

a. The key assessment for the week is class exercise. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the exercise (NTS 3k-3q).

10 minutes **Content Exploration**

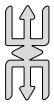
5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then

a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)

b. all teachers in the group work through a similar problem individually for 3–4 minutes

c. the group then works through the problem together step by step

d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes **Enactment**

6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).

a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.

b. After the enactment, ask for structured feedback from the group

i. was the concept explained in a way that a learner with no prior knowledge could follow?

ii. were the examples grounded in contexts familiar to Ghanaian learners?
iii. did any misconceptions surface and if so, how were they addressed?

5 minutes	Reflection

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
    a. transfer your chats into your learning planner template.
    b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
    c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 15

Learning Indicators

1. *Explain the benefits of fruit trees to farmers and society*
2. *Grow a fruit tree using the known procedures and technologies*

Focal Area 1: Benefits of fruit trees

Benefits of fruit trees

Fruit trees offer a wide range of benefits – environmental, economic, nutritional and social. Fruit trees are a nutritious food source, enhance biodiversity, improve air quality and the aesthetic value of the landscape. Once established, fruit trees require relatively little maintenance compared to other types of food crops, resulting in a low production cost. Some varieties are even adaptable to different climates.

1. **Environmental benefits**
   a. Soil erosion and conservation: Deep roots of crops help prevent soil erosion and improve soil structure.
   b. Carbon sequestration: They absorb carbon dioxide, helping to reduce climate change effects.
   c. Biodiversity: Trees provide habitat and food for birds, insects (including pollinators) and other wildlife, contributing to a healthy ecosystem.
   d. Microclimate regulation: They provide shade and shelter, which reduce temperatures and increase humidity and are valuable in warm climates.
   e. Water retention: Trees reduce runoff, improve infiltration and promote groundwater recharge.
   f. Air quality improvement: Trees absorb carbon dioxide and release oxygen, thus helping to improve air quality.
2. **Economic benefits**
   a. Income generation: The sale of seedlings, fruits and processed products (eg juices, jams) generates income for the farmer.
   b. Employment opportunities: Fruit farming, processing and marketing provide jobs,
   c. Long-term engagement: Perennial fruit cropping provides long-term employment.
   d. Cottage industry evolution: Fruit tree cropping on large scale and expanse leads to the establishment of small-scale factories to produce fruit juices, jams, dried fruits, oils and cosmetics.
3. **Nutritional benefits**
   a. Health benefits: Fruits contain roughage, vitamins, minerals and antioxidants that reduce the risk of diseases like diabetes, heart disease and certain cancers.
   b. Diet diversification**:** Fruits increase food choices in many homes and cultures.
   c. Food security: This is due to a year-round or seasonal supply of fruits for families.

4. **Social and educational benefits**
    a. Community greening/aesthetic benefits: Fruit trees beautify landscapes, parks, schools and roadsides.
    b. Educational value: School gardens can be used to teach sustainability, biology and nutrition.
    c. Cultural importance: Fruit trees and fruits are used for festivals and traditions.
    d. Shade and shelter: Fruit trees can provide shade and shelter, which can be valuable in warm climates.
5. **Agro-forestry integration**: Fruit trees can be grown with food crops to reduce soil erosion, enhance water percolation, as wind breaks to enhance **l**and use efficiency.

Learning Tasks

1. Learners to create a fact sheet listing at least five economic, environmental and social benefits of fruit trees in rural communities.
2. Learners will analyse a real or hypothetical small farm and identify how fruit tree integration has improved or could improve income, nutrition and the ecosystem.
3. Learners explain how fruit trees contribute to food security, income generation and climate resilience in society.

Pedagogical Exemplars

1. **Talk for Learning:** Learners in mixed ability groups discuss the benefits (financial, environmental and health) of fruit trees to growers and society. They present a report in their groups and display their findings on manila cards pasted on the walls for others to read.
2. **Project-based Learning:** Learners visit the website of the Ghana Investment Promotion Council (GIPC) to assess the contribution of tree fruits to the Gross Domestic Product of Ghana, and discuss the impact of their findings on the economy of the country.

Focal Area 2: Cultivating a fruit tree

Cultivating a fruit tree

1. **Planning and site selection**
    a. Selecting the fruit tree species**:** Choose the right tree species for your agroecological zone (eg mango, orange, guava, pawpaw).
    b. Soil type: Most fruit trees prefer well-drained loamy soil with pH of 5.5 – 7.0.
    c. Sunlight: Ensure the site receives at least 6 hours of direct sunlight daily**.**
    d. Spacing: Depends on species, eg mango is planted at 10 m x 10 m spacing**.**
2. **Land preparation**
    a. Clear the land of weeds and debris.
    b. Dig planting holes: Usually 60 cm x 60 cm x 60 cm.
    c. Enrich soil with well-decomposed organic manure (compost or poultry droppings). Mix topsoil with phosphorus fertiliser (eg Triple Superphosphate, TSP) to promote root growth.

3. **Seedling selection**: Select grafted or budded seedlings of choice that are disease-free and growing vigorously. They ensure early fruiting, disease resistance, and uniform fruit quality.
4. **Planting**: Planting should be done at the beginning of the rainy season to ensure adequate water. The seedling should be removed from the nursery bag carefully and placed upright in the hole and filled with the soil-manure mix. The soil around the base should be firmed and watered immediately.
5. **Maintenance and care**
   a. Watering: There should be regular watering of trees during the first year, especially in dry periods. Drip irrigation can be used for water efficiency.
   b. Mulching: Apply dry grass or leaves around the base to retain moisture and suppress weeds.
   c. Pruning: Dead or diseased branches should be removed to encourage healthy growth and fruiting. Shape/trim young trees to allow light penetration.
   d. Fertiliser application: Apply NPK (eg 15-15-15) or organic compost annually based on tree age and soil test results.
   e. Pest and disease control: Use Integrated Pest Management (IPM) and monitor pests regularly. Neem extracts or biopesticides can be used. Natural predators like spiders and beetles should be conserved
6. **Technologies that can be integrated**
   a. Soil testing kits for soil fertility analysis.
   b. Mobile apps for weather alerts and pest identification (eg Esoko, AgroCenta).
   c. Drip irrigation systems for efficient use of water.

Pedagogical Exemplars

Project-Based Learning: In mixed groups, learners carry out projects to grow a selected fruit tree using substrate and other media and the principles studied earlier. Learners should be supervised to avoid harming themselves with any sharp objects.

Key Assessment Level 3: Essay-type questions (Group Class exercise)

Analyse how fruit tree cultivation can reduce economic vulnerability and environmental degradation in your community. Support your analysis with two evidence-based examples. (15 marks)

PLC Session 15

45 minutes	Planning & Reviewing the Learning Plan

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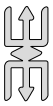

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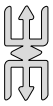

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   c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

SECTION 5 REVIEW

In this section, learners explored the principles of tree crop production, including pre-planting, planting and post-planting care, harvesting, and post-harvest handling. They learned the importance of tree crops such as mango, citrus, and cocoa, and their role in income generation, nutrition and environmental protection. They also studied nursery practices for raising healthy seedlings and understood the value of pest and disease management in maintaining tree crop health and yield. The section also highlighted the benefits of fruit trees to farmers and society, including food security, income, employment, and climate regulation. Learners gained practical skills in growing a fruit tree using known procedures, from site preparation to seedling care. Learners were introduced to budding and grafting techniques used to produce improved seedlings with greater yields and resistance. These lessons equipped learners with essential knowledge for sustainable tree crop production.

MARKING SCHEMES FOR THE KEY ASSESSMENTS

Week 14

S/N	Section	Criteria	No. of Correct Answers Expected	Marks per Correct Answer	Total Mark
	Land preparation	*a. Clearing method* *b. Soil testing* *c. Organic matter application*	*2*	*1*	*2*
	Crop selection	*a. Crop suitable for climate/soil* *b. Market demand consideration*	*2*	*1*	*2*
	Propagation method	*a. Suitable propagation method (eg grafting, budding, cuttings)* *b. Source of planting materials (nursery or certified seed)*	*2*	*1*	*2*
	Spacing and planting	*a. Recommended spacing for the selected crop* *b. Planting technique or layout (eg intercropping or use of shade trees)*	*2*	*1*	*2*
	Maintenance practices	*a. Weeding* *b. Irrigation* *c. Adding fertiliser* *d. Pest and disease control* *e. Pruning*	*Any 4*	*1*	*4*
	Expected outcomes	*a. Yield expectations (timeline and amount)* *b. Economic return* *c. Environmental benefit (biodiversity, soil protection)*	*3*	*1*	*3*

Week 15

Economic benefits (Any 4 correct points for 1 mark each)

a. Income generation (eg selling fruits/products)

b. Employment opportunities

c. Value-added enterprises (eg drying, processing)

d. Income diversification, multiple income streams through different products (fruits, leaves, wood)

e. Year-round income generation: continuous income flow

f. Value-added opportunities: processing potential (jams, juices, dried fruits) that increase product value

g. Reduced input costs: Explanation of how the perennial nature of fruit trees reduces annual planting costs compared to annual crops

Reduction in economic vulnerability (Any 2 correct points for 1 mark each)

a. Seasonal income diversification

b. Household food security

c. Cost-saving benefits (eg reduced food purchases)

Environmental benefits (3 correct points for 1 mark each)

a. Soil erosion control

b. Biodiversity conservation

c. Climate resilience (carbon sequestration, microclimate improvement)

Reduction in environmental degradation (Any 4 correct points for 1 mark each)

a. Replacing destructive land use (eg slash-and-burn)

b. Improved land cover

c. Natural regeneration support

d. Soil conservation: prevention of soil erosion and improvement of soil structure

e. Biodiversity enhancement: habitats for beneficial organisms and pollinators

f. Water management: reduce runoff, improve water infiltration, and recharge groundwater

g. Microclimate regulation: moderation of temperatures and providing windbreaks

Evidence-based examples (2 examples for 1 mark each)

a. Local case studies or community experiences

b. Reference to successful regional/national programmes

Total marks = 4 + 2 + 3 + 4 + 2 = 15

SECTION 6: FISH FARMING

Week 16, 17 &18

STRAND 2: FARMING FOR JOBS AND INCOMES

Sub-Strand 2: Economic Production of Fish

Learning Outcome: *Explain the key processes in the successful production of fish.*

Content Standard: *Demonstrate knowledge, skills and understanding of fish production.*

Weeks 19 & 20

STRAND 3: MOBILISATION OF RESOURCES AND NETWORKS

Sub-Strand 2: Support Systems in Agriculture

Learning Outcome: *Use the knowledge acquired to outline the different types of support systems in fish production and marketing.*

Content Standard: *Demonstrate knowledge and understanding of the different types of support systems in fish production and marketing.*

INTRODUCTION AND SECTION SUMMARY

Fish production is an important part of agriculture that contributes significantly to food security, income generation, and employment, especially in rural communities. In this section, learners will explore the economic importance of fish production, including its role in national development. They will also learn how to raise fish in a pond or tank using appropriate methods and technologies. The section introduces learners to support organisations that assist fish farmers and highlights technology transfer methods that promote modern fish farming practices. In addition, learners will examine the role of rural credit in supporting small-scale farmers. By the end of this section, learners should understand the economic value of fish farming, demonstrate knowledge of fish production practices, identify key support agencies, and appreciate the importance of access to credit and technology in improving fish farming in Ghana and beyond.

The weeks and the indicators covered by the section are:

- **Week 16:** Discuss the economic importance of fish production in the livelihood of the producers and the broader value chain.
- **Week 17:** Raise fish in a pond or tank**.**

- **Week 18:** Identify all relevant support organisations that offer services to key stakeholders such as fish farmers, distributors and small-scale traders.
- **Week 18:** Identify all relevant support organisations that offer services to key stakeholders such as fish farmers, distributors and small-scale traders.
- **Week 19:** Describe transfer-of-technology approaches and methods for fish farming.
- **Week 20:** Explain the operations and importance of rural credit in agriculture.

SUMMARY OF Pedagogical Exemplars

To teach the economic importance of fish production, teachers will use structured talk for learning, enquiry-based learning, role-play and gallery walk to promote critical thinking and meaningful discussions. For the practical aspect of raising fish in a pond or tank, exploratory learning and project-based learning will allow learners to investigate and apply techniques through hands-on activities. Learners will engage in collaborative digital learning and exploratory learning to research and share information using digital tools. To understand technology transfer methods for fish farming, exploratory learning will help learners discover how innovations are shared and applied in the industry. The operation and importance of rural credit in agriculture will be taught through a structured talk for learning, encouraging learners to analyse how financial support contributes to farming success. These approaches promote active participation and deeper understanding of modern fish farming systems.

ASSESSMENT SUMMARY

This section focuses on formative assessment that aims to measure learners' grasp of concepts related to the economic importance of fish production, methods of raising fish in ponds or tanks, support organisations involved in fish farming, technology transfer methods and the role of rural credit in agriculture. A variety of assessment strategies will be used, including essay questions. These will be delivered through individual class work, group work, and homework assignments to encourage active participation and collaboration. Emphasis will be placed on real-life applications of fish farming and agricultural finance. Teachers should provide timely and detailed feedback to help learners reflect on their performance and correct their errors. This process supports continuous learning and helps improve academic outcomes. The assessment also fosters problem-solving skills and awareness of support structures in the agricultural sector, equipping learners with knowledge relevant to rural development and sustainable fish farming practices.

Table 6.1: *Indicators, DoK Levels and Assessment Strategies for Weeks 16 to 20*

SN	Indicators	DoK Level	Assessment Strategy
	Week 16. Discuss the economic importance of fish production in the livelihood of the producers and the broader value chain.	3	Essay question Classroom work
	Week 17. Raise fish in a pond or tank	3	Essay question Homework
	Week 18. Identify all relevant support organisations that offer services to key stakeholders such as fish farmers, distributors and small-scale traders	1	Essay question Classroom work

	Week 19. Describe transfer-of-technology approaches and methods for fish farming.	2	Multiple choice questions Class exercise
	Week 20. Explain the operations and importance of rural credit in agriculture	3	Essay question Classroom work

WEEK 16

Learning Indicator: *Discuss the economic importance of fish production in the livelihood of the producers and the broader value chain*

Focal Area 1: Economic importance of fish production

Fish production plays a crucial economic role for the livelihoods of producers (fish farmers) and the broader value chain (processing, marketing, distribution and export). It supports income generation, employment, food security, gender equity and rural development, making it a cornerstone of many local and national economies. The economic importance of fish production is significant at local, national and global levels. Some key areas where fish production contributes economically include:

1. **Economic importance for producers (Fish farmers)**
    a. Income generation: Fish farming (aquaculture) often serves as a primary or supplementary income source, especially in rural areas.
    b. Employment and livelihoods: Aquaculture is an important part of Ghana's fisheries sector. It provides an alternative source of fish, contributing to food security, employment, and rural development. Aquaculture provides direct employment for millions of people worldwide in the trapping and rearing of fish. Direct employment includes fishing, fish farming, processing, transportation, and marketing. It is often a critical source of income for low-income families and small-scale farmers. The sector supports an estimated 10 % of the population and indirectly supports the livelihoods of 2.2 million people in Ghana. In many developing countries, entire families are involved, ensuring sustainable livelihoods.
    c. Food security and nutrition: Fish is a major and accessible source of animal protein and essential nutrients like omega-3 fatty acids for many Ghanaians, with an average per capita fish consumption around 20-25 kg per annum, which is higher than the world average. Subsistence fish farmers rely on part of their catch for household consumption and for improving dietary diversity. It is affordable and accessible, and helps to combat malnutrition and hunger in many regions. Fish production also supports local and national efforts toward sustainable food systems. About 75 % of the total fish produced is consumed locally. As much as 60 % of animal protein in the Ghanaian diet is fish. The sector plays a vital role in ensuring food and nutrition security, especially in coastal and riverine communities.
    d. Tourism and recreation: Fishing supports recreational industries, such as sport fishing and eco-tourism. Healthy aquatic ecosystems enhance coastal tourism, generating additional revenue.
    e. Asset building: The investment in nets, cages and earth ponds creates capital assets for producers. These assets can improve long-term economic stability and resilience to shocks like crop failures, especially for those who do both.
2. **Economic importance for the broader value chain**
    a. Processing and value addition: Fish undergoes various processing stages such as drying, smoking, freezing and canning, thereby creating jobs and adding value to the fish. Processing boosts income through higher-priced products for both domestic and export markets.
    b. Market development and trade: Fish and fish products are among the most traded food commodities globally, contributing significantly to GDP. The export of fish brings in foreign

exchange for many nations. Aquaculture is one of the fastest-growing food-producing sectors in many developing countries. Fish production plays a crucial role in Ghana's economy, contributing significantly to the GDP, providing livelihoods and ensuring food security. The "Aquaculture for Food and Jobs" programme in Ghana aims to produce an additional 20,000 tonnes of fish annually, create 60,000 jobs and contribute about $40 million to the GDP.

c. Foreign exchange earnings: Some of the fish, especially smoked catfish, are exported to neighbouring countries on a small scale.

d. Employment in allied sectors/Industrial growth and development: Aquaculture leads to indirect employment in ice production and cold chain logistics; fish processing, packaging and marketing; retail and export logistics; fishing gear manufacturing; and feed production.

3. **Broader socioeconomic impacts**

a. Poverty alleviation: Community-based aquaculture initiatives help reduce vulnerability and dependency.

b. Gender empowerment: Women play key roles in fish processing and trading, especially in small-scale fish farming. It also supports gender equity through income opportunities and skills development.

Learning Tasks

1. Learners to explain economic activities, benefits, and challenges of players in the fish food chain and how each contributes to income generation and employment.
2. Learners to design a poster showing how fish production improves the livelihood of a rural community.
3. Learners to create a table comparing the economic benefits of fish farming with another agricultural enterprise.

Pedagogical Exemplars

1. **Structured Talk for Learning:** Learners in mixed ability groups discuss the economic importance of fish production to farmers and the community, and present reports in a plenary session. All learners should be encouraged to take part in the discussion.
2. **Enquiry-based Learning:** Learners in mixed ability groups contact fish farmers, middlemen/women and vendors of fish products and solicit information on the effects of fish production and or trading on their livelihoods.
3. **Gallery Walk**: Learners to design posters on how fish production improves the livelihood of a rural community through education, food, jobs and trade. They should include statistics, drawings, or infographics. Learners should attach their posters to the walls and explain their key message to the class.

Focal Area 2: Prerequisites for fish farming

The prerequisites for aquaculture are the essential conditions and resources to start and maintain a fish farm. Here are the key requirements:

1. **Suitable site**
    a. Water availability: A reliable and clean water source (eg rivers, boreholes, springs, or reservoirs) is needed.
    b. Soil type: For earthen or dugout ponds, preferably clayey, but also loamy soil that can retain water.
    c. Topography: The site should be gently sloping to facilitate drainage and pond construction.
    d. Accessibility: Good roads and proximity to markets for inputs and fish sales are essential.
2. **Capital and financial resources**: Funds are needed for
    a. Pond or tank construction
    b. Fingerlings or juveniles (young fish)
    c. Fish feed
    d. Water supply and aeration equipment
    e. Labour, transport and maintenance
3. **Knowledge and skills**: There is the need to understand fish biology and behaviour, feeding practices and nutrition, water quality control, disease prevention and management, and harvesting and marketing. Training or technical support is recommended from agricultural extension services or aquaculture experts.
4. **Quality fish feed**: There should be balanced, high-quality feed, commercial or locally made. The feed must meet the nutritional needs of the species and age group of the fish being raised.
5. **Market access**: Target markets for the fish should be identified before fish farming starts. Links should be established with buyers, restaurants, processors, or local consumers for a ready market before production.

Learning Tasks

1. Research: Learners to investigate what is needed to start a fish farm.
2. Community mapping exercise: Learners to map out their community to identify suitable areas for fish farming based on availability of water, access to inputs and infrastructure.
3. Simulation and planning: Learners to create a simplified fish farm model (on paper or use recyclable materials) and present the key prerequisites they included, eg pond layout, water system, species selected and feed plan.

Pedagogical Exemplars

1. **Exploratory Learning:** Learners visit the community market (Cold stores), to collect information on the types of fish that are most popular. Learners, in mixed groups, visit recognised fish farms to identify types of fish grown, tank or pond sizes, fingerling stock rate and how they are maintained

and kept healthy. Where fish farms are not available or accessible, learners watch a video of a fish farm and record activities from pond construction to the sale of produce and products.

2. **Problem-based Learning**: Learners in groups investigate and list the basic requirements for starting a fish farm in their local area. These should include water sources, land, species suitability and climate conditions. They then discuss their findings in their groups and present their findings for assessment.
3. **Experiential learning**: Learners in the same groups map out their community to identify suitable areas for fish farming based on the availability of water, access to inputs and infrastructure. They create a simplified fish farm model (on paper or using recyclable materials) and present the key prerequisites they included (eg pond layout, water system, species selected, feed plan).

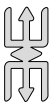
Key Assessment Level 3: Essay question (Classwork)

Analyse how fish production contributes to the livelihood of producers and explain the ways it supports the broader value chain. Support your answer with specific examples. (15 marks)

PLC Session 16

45 minutes	Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
   a. explain the week's concepts in a practical way that will make it easier for learners to understand
   b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
   c. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
   d. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
   e. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Plan the week's key assessment with your app
   a. The key assessment for the week is classwork. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the classwork (NTS 3k-3q).

10 minutes	Content Exploration

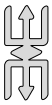
5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then

   a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)

   b. all teachers in the group work through a similar problem individually for 3–4 minutes

   c. the group then works through the problem together step by step

   d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes **Enactment**

6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).

   a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.

   b. After the enactment, ask for structured feedback from the group

      i. was the concept explained in a way that a learner with no prior knowledge could follow?
      ii. were the examples grounded in contexts familiar to Ghanaian learners?
      iii. did any misconceptions surface and if so, how were they addressed?

5 minutes **Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).

8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).

9. Remember to

   a. transfer your chats into your learning planner template.

   b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).

   c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 17

Learning Indicator: *Raise fish in a pond or tank*

Focal Area: Fish rearing

Fish rearing (aquaculture) is the practice of raising fish in controlled environments such as tanks, ponds, or cages for commercial or subsistence purposes. Aquaculture contributes significantly to food security, income generation and sustainable fisheries.

1. **Methods of raising fish**: Fish can be raised using different methods depending on the available space, resources, type of water body and farming goals. Below are the main fish farming methods used globally:

    a. Pond culture: Fish are raised in man-made or natural ponds (earthen, concrete, tarpaulin). It is the most common method, especially in rural areas. Water can be obtained from rain, a borehole, a stream, or a river. Fish are fed and monitored regularly. It is suitable for rearing tilapia, catfish and carp.

    b. Cage culture: Fish are grown in floating net cages placed in rivers, lakes, or reservoirs. It uses natural water bodies. Cages are made of mesh supported by floating frames and the water quality relies on the surrounding source. It is suitable for rearing tilapia, catfish and trout.

    c. Tank culture: Fish are raised in concrete, plastic, or fibreglass tanks on land. It is easy to control water quality and feeding. Requires a constant water supply and proper drainage. It is often used in urban or intensive systems. It is suitable for rearing fingerlings, ornamental fish and tilapia.

    d. Raceway (Flow-through) culture: Fish are raised in long, narrow concrete channels with flowing water (Figure 6.1). It requires a continuous flow of clean water from a spring or river with high oxygen levels. It is suitable for rearing trout, salmon and catfish.

    e. Recirculating Aquaculture System (RAS): A high-tech method where water is filtered, cleaned and reused in indoor tanks. It uses mechanical and biological filters. It is environmentally friendly and space-efficient. It is expensive to set up and operate but suitable for tilapia, barramundi and ornamental fish.

    f. Integrated fish farming: This method combines fish farming with agriculture or livestock (e.g. fish + rice, fish + poultry). The waste from one component (eg manure) is used to fertilise the pond. It increases farm productivity and reduces waste management. It is suitable for rearing carp, tilapia and catfish.

2. **Water quality management**: The temperature, turbidity, pH, dissolved oxygen and ammonia levels of the water should be monitored.

    a. Clean and unpolluted water

    The water should be free from chemicals, heavy metals, and industrial waste. The turbidity (the cloudiness or haziness of water) caused by the presence of suspended particles should be checked. High water turbidity can negatively impact fish health and growth by reducing light penetration, harming gill function and affecting food availability. It can also block the biofilter and degasser in recirculating systems, potentially leading to water quality issues and fish mortality.

b. Proper pH and temperature:

Most fish species prefer pH 6.5–8.5 and temperatures between 25-30°C.

c. Oxygen levels:

Sufficient dissolved oxygen is critical for fish survival and growth. Regular water exchange or aeration is required

3. **Selection of fish species**: Species chosen should be suitable for the climate and water conditions, and have high market demand. Tilapia, catfish, carp and trout are suitable for freshwater environments, while milkfish, mullet, sea bass, shrimp and salmon are reared in brackish/marine environments.
4. **Seed (Fingerlings) selection**: Use healthy, disease-free fingerlings from a certified hatchery. Stocking density should be based on species and pond size.
5. **Pond or tank infrastructure**: This can be earthen ponds, concrete tanks, cages, raceways, or recirculating aquaculture systems (RAS), depending on resources and goals. There should be proper drainage, inlet/outlet systems for water management and security to prevent theft or predator attacks.
6. **Health and disease managemen**t: Regular monitoring of fish health and water quality is necessary. Preventive measures like quarantine, vaccination and use of probiotics or approved medications are recommended.
7. **Licensing and regulations**: Fish farmers should comply with local environmental and aquaculture laws, including permits for pond construction, water use and fish sales.
8. **Fish Feeding**: The feed must meet the nutritional needs of the species and age group of the fish being raised. Fish feed on natural food sources such as algae and plankton, but in aquaculture, they are typically fed a combination of bran, pellets, fish meal, and rice polish. Feed should be given 2 – 3 times daily, depending on the age and species. Generally, young fish should be fed three times, while older fish should be fed two times.

Figure 6.1: *A Picture of a Raceways fish pond*

(Superior Raceway Systems Africa)

9. **Construction of fish ponds**: There are three main types of fish ponds used in aquaculture, each designed based on terrain, water source and fish farming goals. These are earthen ponds, concrete ponds and tarpaulin (mobile) ponds. However, cage ponds are also common in Ghana, especially on the Volta Lake.

a. Earthen ponds: They are constructed by excavating the soil or by building embankments with clayey soil to hold water (Figure 6.2). Water for such ponds comes from rainfall, streams, rivers, or underground sources. It is best for rural areas with suitable clayey soil and access to land and water. They have a large surface area, which often supports semi-intensive or extensive fish farming. The types of fish reared in such ponds are tilapia, catfish and carp. The advantages of earthen ponds are their low construction costs and suitability for extensive or semi-intensive fish farming. However, they are easily silted, with low water quality, and particularly low oxygen tension.

Figure 6.2.: *Pictures of Earthen Dugout Fish Ponds*

Steps in constructing earthen fish ponds

i. Site selection: Choose a flat or gently sloping land with clayey soil in an area with high rainfall or a natural source of water.

ii. Design and marking: Decide pond dimensions (eg 20 m × 10 m), and mark boundaries using pegs and ropes.

iii. Excavation: Dig out soil, preferably with excavators, to the desired depth (usually 1–1.5 metres).

iv. Embankment construction: Use excavated soil to build walls around the pond and compact the walls properly to avoid leaks.

v. Inlet and outlet installation: Install PVC pipes or channels to bring water in and drain it out. Ensure a proper slope for drainage.

vi. Adding lime and fertiliser: Apply agricultural lime to reduce acidity and add organic manure to promote plankton growth (natural fish food).

vii. Filling the pond: Fill with clean water and leave it for 5–7 days before stocking fish.

b. Concrete ponds: They are made with concrete walls and floors and are often rectangular or circular (Figure 6.3). Concrete ponds usually measure 3 m × 2 m × 1.2 m (LxBxD). All the inner surfaces are tiled or plastered with waterproof cement or sealant to prevent leakage and bruising of the fish. They are built above or partly below ground for easy water and aeration control. They are common in urban and peri-urban areas and last for many years, and are used for rearing fingerlings, ornamental fish and catfish. Their main advantages include easy management and cleaning, good water supply and drainage control, and suitability for intensive fish farming. The disadvantages are that:

i. The concrete ponds require expertise to build properly to avoid cracks and leaks.

ii. They are more expensive to construct than other pond types, like tarpaulin ponds.

iii. If not properly maintained, algae and bacteria can overgrow, requiring regular cleaning and disinfection.

This is a video link to the demonstration of a concrete catfish pond construction.

https://www.youtube.com/watch?v=4TKgR_ELjEs&t=129

Figure 6.3 A: *– A circular concrete tank under construction.* *B – A completed rectangular concrete tank*

c. **Tarpaulin (Mobile) ponds**: They are made from PVC or heavy-duty tarpaulin material stretched over a metal, plastic, or wooden frame (Figure 6.4). They are portable and easy to install, and ideal for small spaces, where soil or space is unsuitable for earthen ponds. They are less expensive to build and good for beginners, urban fish farmers, small-scale projects, or backyard fish farming. They are easy to clean and manage diseases. Their Advantages are:

   i. Low cost and easy to set up.

   ii. Portable and space-saving.

   iii. Ideal for beginners and urban fish farming.

Figure 6.4: *Tarpaulin pond for backyard aquaculture*

c. **Cage pond (Cage culture)**: Cage fish ponds are floating enclosures (cages) placed in natural water bodies like rivers, lakes, reservoirs, or large ponds (Figure 6.5). The cages are usually made from netting or mesh and supported by metal, plastic, or bamboo frames that float on the surface. They are suspended in open water, allowing water to flow freely through them. Fish are confined in cages but share the water body with wild species. The sizes of cages can vary depending on the number of fish and the type of water body. They are usually rectangular or circular and secured with floats and anchors. The common fish raised are tilapia, catfish, trout and carp.

i. Advantages of cage ponds

- Low construction cost compared to concrete ponds.
- Utilises existing natural water.
- Easier to monitor and harvest fish.
- Ideal for intensive farming in areas with large water bodies.

ii. Disadvantages

- Susceptible to water pollution and disease spread from the open water.
- Theft and predation risk if not protected.
- It requires water bodies with good oxygen flow and depth.

Figure 6.5: *Cage fish pond on Volta Lake in Ghana*

Learning Tasks

1. Learners to design a mini fish farm.
2. Learners to research and compare fish species suitable for pond or tank culture and create a comparison chart to evaluate which fish species are suitable for specific environments and purposes.

Pedagogical Exemplars

1. **Project-based Learning:** The teacher helps learners to develop a fish tank using a large plastic tank or an abandoned concrete water tank on the school premises. The school should supply clean water and procure fingerlings and feed for the project. Learners determine feed weight per fingerling and master the use of scales and feed scoops. Learners measure the growth rate of tagged fish in their tank. Where access has been granted, a group of five learners will follow up bi-weekly to measure the growth rate of tagged fish in the commercial farm. Learners take records for discussion and write group reports. Precautionary measures should be in place to prevent accidents.
2. **Experiential Learning**: The teacher guides learners to create a simple layout of a small-scale fish pond or tank system using drawings or 3D models. They should include features like a water source, a filtration system, a feeding area, and a fish shelter.

Key Assessment Level 3: Homework

How can a fish farming system be adapted to ensure sustainability and productivity in a rural area facing seasonal water shortages and limited access to fish feed? (20 marks)

PLC Session 17

45 minutes | **Planning & Reviewing the Learning Plan**

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
   a. explain the week's concepts in a practical way that will make it easier for learners to understand
   b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
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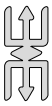

Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Plan the week's key assessment with your app
   a. The key assessment for the week is homework. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the homework (NTS 3k-3q).

10 minutes | **Content Exploration**

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
   a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
   b. all teachers in the group work through a similar problem individually for 3–4 minutes
   c. the group then works through the problem together step by step
   d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).

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- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
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30 minutes **Enactment**

6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).
   a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
   b. After the enactment, ask for structured feedback from the group
      i. was the concept explained in a way that a learner with no prior knowledge could follow?
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      iii. did any misconceptions surface and if so, how were they addressed?

5 minutes **Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
   a. transfer your chats into your learning planner template.
   b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
   c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 18

Learning Indicator: *Identify all relevant support organisations that offer services to key stakeholders such as fish farmers, distributors and small-scale traders*

Focal Area 1: Support organisations for key stakeholders in fish production

Note

The teacher should remind learners about the work covered in Year 2 Week 21 on support organisations available to help arable crop farmers, traders and processors.

Support Organisations in Fish Production

Some relevant support organisations offer services to key stakeholders in the fisheries value chain, including fish farmers, distributors and small-scale traders. These organisations operate locally, nationally, and internationally, and provide training, access to finance, extension support, market access, policy advocacy, and research.

1. Government institutions that support the fisheries value chain

Table 6.2.: *Government Institutions involved in the Fisheries Value Chain*

SN	Organisation	Services Provided	Stakeholders Supported
	Ministry of Fisheries and Aquaculture	Formulation of policy, training, regulations, subsidies, research	Fish farmers, traders, and distributors
	Agricultural Extension Services (Ministry of Local Government)	On-site technical support, disease control, best farming practices	Fish farmers
	Fisheries Development Boards or Agencies (e.g. Ghana Fisheries Commission)	Licensing, training, technical assistance, aquaculture promotion	Fish farmers and processors

2. International Organisations and Non-Governmental Organisations (NGOs)

Table 6.3. International Organisations and Non-Governmental Organisations involved in the Fisheries Value Chain

SN	Organisation	Services	Stakeholders Supported
	Food and Agriculture Organisation (FAO) – Fisheries and Aquaculture Department	Supports small-scale aquaculture, provides training and manuals; works with government on sustainable fisheries policies and value chain improvement. Projects like FISH4ACP aim to improve value chains.	All stakeholders: fish farmers, processors, traders

	WorldFish	Partners with local institutions to promote sustainable aquaculture practices, gender inclusion, nutrition-sensitive fish farming, research and technology transfer	Small-scale fish farmers, women traders
	United States Agency for International Development (USAID) and Feed the Future Programs	Through Feed the Future and Ghana Fisheries Recovery Activity (GFRA), USAID supports fisheries governance, livelihoods, and resilience for fishers. Helps in market development, input access and infrastructure support	Farmers, traders, Small and Medium-scale Enterprise (SMEs), small-scale traders, women in fisheries
	AquaFish Innovation Lab (USAID-funded)	Capacity building, sustainable practices and aquaculture innovation	Fish farmers, researchers
	WWF (World Wide Fund for Nature)	Sustainable fisheries, eco-certification, ecosystem restoration	Fishers, traders, conservation partners
	Oxfam, CARE and Netherlands Development Organisation (SNV)	Livelihood support, women's empowerment, market access	Small-scale traders, processors

3. Cooperatives and Farmer-Based Organisations (FBOs)

Table 6.4: *Cooperatives and Farmer-Based Organisations involved in the fish value chain*

SN	Organisation	Services	Stakeholders Supported
	National Fish Farmers' Associations (e.g., Nigerian Tilapia and Aquaculture Developers Association)	Bulk input purchase, training, advocacy, market linkage	Fish farmers
	Ghana National Association of Fish Farmers (GNAFF)	Advocacy on behalf of fish farmers, organises training workshops and technical seminars, facilitates access to inputs like fingerlings and feed, promotes best practices in aquaculture	Smallholder fish farmers, medium-scale commercial aquaculture businesses, youth in aquaculture
	Fisherfolk or Traders' Cooperatives	Credit access, bulk selling, collective bargaining	Distributors, small traders
	Volta Fish Farmers Association (VoFFA)	Coordinates bulk purchase of feed and fingerlings, provides peer-to-peer technical support, promotes cage farming best practices, liaises with development partners (eg, FAO, SNV) for capacity building	Cage fish farmers on Lake Volta, small-scale aquaculture entrepreneurs, youth and women in fish farming

	Women in Fisheries Networks (e.g., AWFISHNET – African Women Fish Processors and Traders Network)	Advocacy, empowerment, training	Women traders and processors

4. Financial and Microfinance Institutions

Table 6.5: *Financial and microfinance institutions involved in the fish value chain*

SN	Organisation	Services	Stakeholders Supported
	Agricultural Development Banks	Loans, insurance, financial training	Farmers, traders
	Microfinance Institutions (MFIs)	Small loans, mobile banking, savings groups	Small-scale traders
	Credit Unions & Savings and Loans Groups	Access to working capital	Distributors, processors

5. Private Sector & Input Suppliers

Table 6.6: *Private Sector & Input Suppliers involved in the fish value chain*

SN	Organisation	Services	Stakeholders Supported
	Aquaculture feed and equipment companies (e.g., Skretting, Aller Aqua, Agritech Ghana Ltd)	Training, input supply, technical assistance	Fish farmers
	Fish processing and cold chain companies	Storage, value addition, logistics	Distributors, traders
	Retail and export companies	Market access, quality assurance, logistics	Distributors, processors

6. Research and Academic Institutions

Table 6.7: *Research and academic institutions involved in the fish value chain*

SN	Organisation	Services	Stakeholders Supported
	Universities with aquaculture or fisheries programmes (e.g., University of Cape Coast, CSIR-Water Research Institute	Training, extension, applied research	Fish farmers, learners, extension officers
	National Aquaculture Research Institute	Breeding research, disease control, extension support	Fish farmers

Learning Tasks

1. Learners to investigate and list national and local organisations that support fish farmers, distributors and small-scale traders. They should create a mind map showing each organisation, its services and which stakeholder group it supports.
2. Learners to conduct a mock advisory meeting (fish farmers, distributors, traders and support organisations) where the stakeholders present their needs and the organisations propose solutions.
3. Learners to create a table listing at least five support organisations with the headings: services provided (eg training, credit, equipment), type of stakeholder served and evaluation of how well each organisation meets the needs of the stakeholder.

Pedagogical Exemplars

1. **Collaborative Digital Learning**: Learners in mixed ability groups surf the Internet to come up with a list of national and international organisations that support aquaculture, and list the types of support offered by these support groups, categorise the services and discuss their roles. Learners then present reports of their groups.
2. **Role-Play**: Learners divide into role-play groups representing different stakeholders (fish farmers, distributors, traders and support organisations). They conduct a mock advisory meeting where the stakeholders present their needs and the support organisations propose solutions. After the role play, they should create a Support Service Comparison Table, listing support organisations with these headings: services provided (eg training, credit, equipment), type of stakeholder served and evaluation of how well each organisation meets the needs of the stakeholder. The teacher should guide learners in their groups to analyse and compare the type and effectiveness of support services.

Key Assessment: Practice Paper 2

Evaluate how at least three support organisations differ in the types of services they provide to fish farmers, distributors, and small-scale traders. Based on your evaluation, recommend the most appropriate organisation for each stakeholder group and justify your choices with specific examples. (15 marks)

HINT

*Conduct **Practice Paper 2**. It should cover the contents taught from Year 1 to Year 3. Refer to the **Table of Specifications and Structure of the Paper** at the end of this section to guide you. Learners' papers should be marked immediately and scores entered into the SAP.*

ITEM SPECIFICATION TABLE
PAPER 1 – OPTION B

Strand	Sub-strand	Learning Outcome	Content Standard	Learning Indicator	LEVEL OF ASSESSMENT				TOTAL
					1	2	3	4	
1. NEW DAWN IN AGRICULTURE	1. Misconceptions and Prospects in Agriculture and Farming	1.1.1.LO.1 Explain the meaning and importance of agriculture	1.1.1.CS.1 Demonstrate knowledge and understanding of the meaning and importance of agriculture	1.1.1.LI.1 Explain the meaning and importance of agriculture	1	0	0	0	1
1. NEW DAWN IN AGRICULTURE	2. Emerging Technologies in Agriculture	1.1.2.LO.2 Identify emerging technologies in vegetable crop and ornamental plant enterprises.	1.1.2.CS.1 Demonstrate knowledge and understanding of emerging technologies in vegetable crop and ornamental plant enterprises.	1.1.2.LI.3 Grow vegetable crops and ornamental plants using known procedures and technologies.	0	1	0	0	1
1. NEW DAWN IN AGRICULTURE	2. Emerging Technologies in Agriculture	3.1.2.LO.2 Distinguish between existing and emerging technologies used in plantation and fruit tree enterprises and their benefits	3.1.2.CS.1 Demonstrate knowledge and skills in emerging technologies of plantation and fruit tree and their benefits relating to real-life situation	3.1.2.LI.1 Grow Plantation and Fruit trees using the known procedures and technologies.	1	2	1	0	4
1. NEW DAWN IN AGRICULTURE	3. Agricultural Machinery	1.1.3.LO.1 Evaluate the various forms of irrigation systems in vegetable crop and ornamental plant production	1.1.3.CS.1 Demonstrate knowledge, understanding and skills in the use of various forms of irrigation systems in vegetable crop and ornamental plant cultivation	1.1.3.LI.3 Use the appropriate irrigation system to produce vegetable crops and ornamental plants.	0	1	0	0	1

1. NEW DAWN IN AGRICULTURE	3. Agricultural Machinery	1.1.3.LO.1 Explain the functions of farm tools and equipment	1.1.3.CS.1 Demonstrate knowledge, understanding and skills in the operation of farm tools, implements and machines	1.1.3.LI.2 Classify and operate different types of machinery used in crop production in Ghana.	2	1	0	0	3
2. FARMING FOR JOBS AND INCOME	1. Misconceptions and Prospects in Agriculture and Farming	1.2.1.LO.1 Produce vegetables and ornamental plants for profit	1.2.1.CS.1 Demonstrate knowledge and understanding of market-oriented production of vegetables and ornamentals	1.2.1.LI.2 Organise and produce selected vegetable crops and ornamental plants.	0	3	1	0	4
2. FARMING FOR JOBS AND INCOME	1. Misconceptions and Prospects in Agriculture and Farming	2.2.1.LO.1 Describe the role of farm machinery in arable crop production (cereals, legumes, and tuber crops) for profit.	2.2.1.CS.1 Demonstrate knowledge and understanding of market-oriented production of arable crops (cereals, legumes, and tuber crops).	2.2.1.LI.2 Organise and produce a selected arable crop (cereals, legumes, and tuber crops).	3	3	1	0	7
2. FARMING FOR JOBS AND INCOME	1. Misconceptions and Prospects in Agriculture and Farming	2.2.1.LO.1 Describe the role of farm machinery in arable crop production (cereals, legumes, and tuber crops) for profit.	2.2.1.CS.1 Demonstrate knowledge and understanding of market-oriented production of arable crops (cereals, legumes, and tuber crops).	2.2.1.LI.3 Carry out required post-harvest practices and market crops produced.	0	0	1		1
2. FARMING FOR JOBS AND INCOME	1. Misconceptions and Prospects in Agriculture and Farming	3.2.1.LO.1 Use the knowledge and skills acquired to explain the processes of soil formation and properties of soil	3.2.1.CS.1 Demonstrate knowledge and understanding of soil formation processes and soil properties	3.2.1.LI.1 Investigate soil formation processes - weathering, erosion, deposition and soil profile development	0	1	0	0	1

2. FARMING FOR JOBS AND INCOME	1. Misconceptions and Prospects in Agriculture and Farming	3.2.1.LO.1 Use the knowledge and skills acquired to explain the processes of soil formation and properties of soil	3.2.1.CS.1 Demonstrate knowledge and understanding of soil formation processes and soil properties	3.2.1.LI.2 Explain the physical properties of soil – texture, structure	2	1	0	0	3
2. FARMING FOR JOBS AND INCOME	1. Misconceptions and Prospects in Agriculture and Farming	3.2.1.LO.1 Use the knowledge and skills acquired to explain the processes of soil formation and properties of soil	3.2.1.CS.1 Demonstrate knowledge and understanding of soil formation processes and soil properties	3.2.1.LI.3 Explain the chemical and biological properties of soil.	1	1	1	0	3
2. FARMING FOR JOBS AND INCOME	1. Misconceptions and Prospects in Agriculture and Farming	3.2.1.LO.1 Use the knowledge and skills acquired to explain the processes of soil formation and properties of soil	3.2.1.CS.1 Demonstrate knowledge and understanding of soil formation processes and soil properties	3.2.1.LI.4 Describe soil conservation principles and practices.	0	1	3	2	6
2. FARMING FOR JOBS AND INCOME	1. Misconceptions and Prospects in Agriculture and Farming	3.2.1.LO.1 Use the knowledge and skills acquired to explain the processes of soil formation and properties of soil	3.2.1.CS.1 Demonstrate knowledge and understanding of soil formation processes and soil properties	3.2.1.LI.5 Outline the role of soil organisms in nutrient cycling and soil fertility.	0	1	0	0	1
2. FARMING FOR JOBS AND INCOME	2. Emerging Technologies in Agriculture	1.2.2.LO.1 Explain the key processes involved in poultry production	1.2.2.CS.1 Demonstrate knowledge, skills and understanding of the economic production of poultry	1.2.2.LI.2 Organise and produce poultry type that is common in the locality for eggs and meat.	1	2	1	0	4
2. FARMING FOR JOBS AND INCOME	2. Emerging Technologies in Agriculture	2.2.2.LO.1 Use the knowledge acquired to produce small ruminants.	2.2.2.CS.1 Demonstrate knowledge, skills and understanding of the economic production of small ruminants	2.2.2.LI.2 Produce small ruminants common in the locality for meat.	2	0	1	0	3

2. FARMING FOR JOBS AND INCOME	2. Emerging Technologies in Agriculture	3.2.2.LO.1 Explain the key processes in the successful production of pigs or fish	3.2.2.CS.1 Demonstrate knowledge, skills and understanding of the economic production of pigs or fish	3.2.2.LI.2 Organise and produce pigs and fish.	1	1	0	0	2
3. MOBILISATION OF RESOURCES AND NETWORKS	2. Emerging Technologies in Agriculture	1.3.2.LO.1 Explain the different types of support systems in vegetable and ornamental crop production and marketing	1.3.2.CS.1 Demonstrate knowledge and understanding of the different types of support systems in vegetable and ornamental crop production and marketing	1.3.2.LI.2 Describe Technology Transfer Methods with Emphasis on Participatory Approaches.	0	0	0	1	1
3. MOBILISATION OF RESOURCES AND NETWORKS	2. Emerging Technologies in Agriculture	3.3.2.LO.1 Explain the different types of support systems in vegetable and ornamental crop production and marketing	3.3.2.CS.1 Demonstrate knowledge and understanding of the different types of support systems in pig or fish production and marketing	3.3.2.LI.1Describe the economic importance of pigs or fish production in the livelihood of the producers and the broader value chain.	1	0	0	0	1
4. AGRICULTURE AND CLIMATE	1. Misconceptions and Prospects in Agriculture and Farming	1.4.1.LO.1 Explain climate change and its implications on agriculture	1.4.1.CS.1 Demonstrate knowledge and understanding of climate change and its threat to environmental stability and rural livelihood sustainability	1.4.1.LI.2 Discuss the Consequences of Climate Change on Crop Yields.	0	1	0	1	2
4. AGRICULTURE AND CLIMATE	2. Climate change adaptation	1.4.2.LO.2 Explain the adaptation of society and agriculture to climate change	1.4.2.CS.2 Demonstrate knowledge and understanding of climate change and its relevance to sustainable rural agriculture	1.4.2.LI.1 Explain Indigenous and Conventional Strategies for Dealing with Climate Change and Variability.	0	0	0	1	1
TOTAL					15	20	10	5	50

PAPER 2 – OPTION B
ITEM SPECIFICATION TABLE

Strand	Sub-strand	Learning Outcome	Content Standard	Learning Indicator	LEVEL OF ASSESSMENT				TOTAL
					1	2	3	4	
1. New dawn in agriculture	2. Emerging Technologies in Agriculture	1.1.2.LO.2 Identify emerging technologies in vegetable crop and ornamental plant enterprises.	1.1.2.CS.1 Demonstrate knowledge and understanding of emerging technologies in vegetable crop and ornamental plant enterprises.	1.1.2.LI.3 Grow vegetable crops and ornamental plants using known procedures and technologies.	0	1	0	0	1
1. New dawn in agriculture	1. Misconceptions and Prospects in Agriculture and Farming	1.X.1.1.LO.2 Explain how to start and manage successful vegetable crop and ornamental plant enterprises in Ghanaian communities.	1.1.1.CS.2 Demonstrate knowledge and understanding of factors and processes that influence successful vegetable crop and ornamental plant enterprises .	1.1.1.LI.2 Catalogue the characteristics and patterns of growth of successful vegetable crop and ornamental plant enterprises.	1	1	0	0	2
1. New dawn in agriculture	3. Agricultural Machinery	1.1.3.LO.1 Explain the functions of farm tools and equipment	1.1.3.CS.1 Demonstrate knowledge, understanding and skills in the operation of farm tools, implements and machines	1.1.3.LI.2 Classify and operate different types of machinery used in crop production in Ghana.	1	0	1	0	2

2. Farming for jobs and income	1 Economic production of crops	**1.2.1.LO.1** **Produce vegetables and ornamental plants for profit**	1.2.1.CS.1. Demonstrate knowledge and understanding of market-oriented production of vegetables and ornamentals	1.2.1.LI.3 Carry out required post-harvest practices and market the produce. .	0	1	1	0	2
2. Farming for jobs and income	**1.** Economic Production of Fish	Explain the key processes in the successful production of fish. .	Demonstrate knowledge, skills and understanding of fish production.	Raise fish in a pond or tank.	1	1	1		3
3. Mobilisation of resources and networks	2 Support systems in agriculture.	**3.3.2.LO.2** Evaluate extension services delivery on vegetable and ornamental crop enterprises in the school's catchment area.	1.3.2.CS.1. Demonstrate knowledge and understanding of the different types of support systems in vegetable and ornamental crop production and marketing.	1.3.2.LI.3 Describe the interactions within the various key stakeholders in the commodity value chains.	0	0	1	0	1
3. Mobilisation of resources and networks	2 Support systems in agriculture.	1.3.2.LO.2 Evaluate extension services delivery on vegetable and ornamental crop enterprises in the school's catchment area	1.3.2.CS.2. Demonstrate knowledge and understanding of the approaches and methods of agricultural extension delivery	1.3.2.LI.1 Describe transfer-of-technology approaches and methods involved.	1	1	1	0	3

3. Mobilisation of resources and networks	1 Land tenure systems for agriculture.	1.3.1.LO.1 Explain the different types of land tenure systems.	1.3.1.CS.1 Demonstrate knowledge and understanding of the different types of land tenure systems for agricultural production.	1.3.1.LI.1 Describe various types of customary and statutory land tenure systems.	1	0	0	0	1
4 Agriculture and climate	3 Climate change mitigation strategies	1.4.1.LO.1 Explain climate change and its implications on agriculture	1.4.3.CS.1. Demonstrate knowledge and understanding of climate change mitigation measures and their relevance to sustainable rural agriculture	1.4.3.LI.1. Discuss effects of indigenous and conventional mitigation measures for combating climate change on agricultural production.	0	0	1	0	1
4. Agriculture and climate	2. Climate change adaptation	1.4.2.LO.2 Explain the adaptation of society and agriculture to climate change	1.4.2.CS.2 Demonstrate knowledge and understanding of climate change and its relevance to sustainable rural agriculture	1.4.2.LI.1 Explain Indigenous and Conventional Strategies for Dealing with Climate Change and Variability.	0	1	0	0	1
Total					5	6	6	0	17

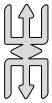
PAPER 3A OPTION B
ITEM SPECIFICATION TABLE

Strand	Sub-strand	Learning Outcome	Content Standard	Learning Indicator	LEVEL OF ASSESSMENT				TOTAL
					1	2	3	4	
1. NEW DAWN AGRICULTURE	2 EMERGING TECHNOLOGIES IN AGRICULTURE	2.1.2.LO.1 Appraise and use emerging technologies in arable crop (cereals, legumes, and tuber crops) enterprises.	2.1.2.CS.2 Demonstrate knowledge and skills in emerging technologies of arable crop (cereals, legumes, and tuber crops) enterprises and their benefits relating to real-life situations.	2.1.2.LI.1. Grow an arable crop (cereals, legumes, and tuber crops) using the emerging procedures and technologies.	2	2	2		6
2. FARMING FOR JOBS AND INCOME	2. Economic production of animals	1.2.2.LO.1 Explain the key processes involved in poultry production	1.2.2.CS.1 Demonstrate knowledge, skills and understanding of the economic production of poultry	1.2.2.LI.2 Organise and produce poultry type that is common in the locality for eggs and meat.	2	2			4
2. FARMING FOR JOBS AND INCOME	2. Economic production of animals	Discuss neo-traditional animal rearing and their benefits.	Demonstrate knowledge and understanding of some neo-traditional animal-rearing methods and their benefits to the community.	Explain the methods for rearing grasscutters.	1	1	1		3
2. FARMING FOR JOBS AND INCOMES	1 ECONOMIC PRODUCTION OF CROPS	Use the knowledge and skills acquired to explain the processes of soil formation and	Demonstrate knowledge and understanding of soil formation processes and soil properties	Explain the chemical and biological properties of soil	1	2	2		5
TOTAL					6	7	5	0	18

PLC Session 18

45 minutes | **Planning & Reviewing the Learning Plan**

1. Begin the session by recapping lessons from the previous session, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
   a. explain the week's concepts in a practical way that will make it easier for learners to understand.
   b. identify three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
   a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
   b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q).
   c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



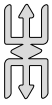
Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Use your app to plan and administer the mode of assessment for the student Assessment Portal (SAP).
   a. The key assessment for the week is practice paper 2. Chat with your app to plan this assessment by reviewing or developing the assessment items/tasks and marking schemes/rubrics for the practice paper (NTS 3k-3q).

10 minutes | **Content Exploration**

5. As a subject group, select one problem or topic/idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
   a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
   b. all teachers in the group work through the problem individually for 3–4 minutes
   c. the group then works through it together the problem, step by step
   d. highlight the most common errors made at each step (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*

- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes **Enactment**

6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).
   a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
   b. After the enactment, ask for structured feedback from the group
      i. was the concept explained in a way that a learner with no prior knowledge could follow?
      ii. were the examples grounded in contexts familiar to Ghanaian learners?
      iii. did any misconceptions surface and if so, how were they addressed?

5 minutes **Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
   a. transfer your chats into your learning planner template.
   b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
   c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 19

Learning Indicator: *Describe Transfer of Technology approaches and methods for fish farming*

Focal Area: Technology transfer methods for fish farming

Note

The teacher should remind learners about the content of Year 1 Week 19 on technology transfer approaches, with particular emphasis on agricultural extension systems.

1. **Introduction to Transfer of Technology (ToT) in Fish Farming**

   Transfer of Technology in fish farming refers to the process of disseminating new knowledge, innovations and improved fish farming techniques from research institutions, universities and experts to fish farmers to improve farm management practices, enhance productivity, increase profitability, and promote sustainable aquaculture.

2. **Importance of Transfer of Technology in Fish Farming**

   a. Promotes adoption of modern and efficient practices.

   b. Helps fish farmers improve production and income.

   c. Encourages sustainable use of water and feed resources.

   d. Facilitates disease management and biosecurity.

   e. Enhances access to markets and value chains.

3. **Approaches to Transfer of Technology in Fish Farming**

   The effectiveness of technology transfer depends on the strategy or approach used to deliver the information and innovations to fish farmers. The main approaches used are:

   a. Top-down approach**:** In this approach, technology originates from research institutions or universities. Researchers develop new practices or innovations such as improved fish feed, pond management techniques, or disease control measures. These technologies are then passed on to farmers through extension agents or government agencies. This approach is implemented in Ghana through government-led initiatives by the Fisheries Commission.

      i. Strengths of the top-down approach**:**

      - It ensures rapid dissemination of scientifically validated technologies
      - It promotes uniform message delivery across regions
      - It provides clear metrics for measuring adoption rates
      - It is efficient for introducing basic techniques to new farmers.

      ii. Limitations of the top-down approach**:**

      - It often fails to consider local context and indigenous knowledge
      - It limits farmer input in technology development
      - It suffers high dropout rates when external support ends
      - Often does not align with farmers' needs and resources.

b. Bottom-up approach: This approach starts with the involvement of farmers themselves in identifying their challenges and setting priorities. They participate in the design, testing and evaluation of the new technology. Extension and research bodies provide support rather than dictating solutions. Emphasis is on farmer empowerment and ownership.

i. Strengths of the bottom-up approach**:**

- Farmers are actively involved, boosting their confidence and ownership of new technologies.
- Because technologies stem from farmers' actual needs and realities, they are more easily adopted.
- Solutions are tailored to local conditions and cultural practices, making them more practical.
- Farmers develop skills in problem-solving and innovation, which can be applied to other challenges.
- Farmers' local knowledge can lead to creative, low-cost solutions that outsiders might not think of.

ii. Limitations of the bottom-up approach

- Farmers might lack scientific understanding or advanced techniques, which can slow innovation.
- Building consensus and involving everyone takes time compared to top-down approaches.
- Farmers might not have access to the financial resources, materials, or equipment needed to test ideas.
- Locally developed solutions might work in one place, but need to be adapted to be used more widely.
- Without strong facilitation, ideas might remain fragmented or not move beyond the farm level.

c. Participatory approach: This approach combines elements of top-down and bottom-up strategies. It encourages joint decision-making and cooperation between researchers, extension officers and farmers. Farmers are actively involved in technology development and adaptation by contributing their local knowledge and practices, while researchers provide scientific expertise. For example, co-designing fish hatchery systems, where farmers' ideas on water supply and breeding practices are combined with researchers' technical knowledge, depicts this approach. Participatory approach is implemented through NGO-led projects, emphasising farmer participation, co-development of technologies with fish farmers, peer-learning networks and demonstration by lead farmers.

i. Strengths of the participatory approach**:**

- Enhanced adoption of technology: Involving fish farmers in the development and testing of technologies increases their understanding, trust, and willingness to adopt innovations.
- Context-specific solutions: Technologies are adapted to local environmental, social, and economic conditions, making them more relevant and sustainable for farmers.

- Empowerment and capacity building: Farmers gain practical knowledge and confidence through hands-on involvement, fostering self-reliance and skill development.
- Stronger collaboration: Encourages cooperation among researchers, extension agents, and farmers, leading to continuous feedback and improvements in technology.
- Ownership and responsibility: Farmers feel a sense of ownership over the technology, increasing commitment to proper implementation and maintenance

ii. Limitations of the participatory approach**:**

- Time-consuming process: Participatory methods often require longer periods for planning, consultation, and implementation, which can delay results.
- Resource-intensive: Requires more human, financial, and logistical resources for organising meetings, training sessions, and follow-ups.
- Possible conflicts: Differences in opinions among stakeholders may lead to conflicts, which slow down decision-making and adoption.
- Variability in participation**:** Not all farmers may actively engage due to differences in interest, education level, or influence within the community.
- Limited scientific control**:** Involvement of non-experts can lead to inconsistencies in data collection and application, potentially affecting research quality and outcomes.

d. Integrated approach: This approach involves multiple stakeholders working together – government agencies, NGOs, private companies, research institutions and farmers. It coordinates resources, knowledge and efforts to achieve common goals in fish farming. A Public-Private Partnership (PPP) project that brings together feed companies, government agencies and extension services to train farmers on cage fish farming is an example of this method. This approach operates with two different models:

i. Adaptive transfer model:

- Combines technical expertise with farmer knowledge
- Initial introduction of technologies, followed by participatory adaptation
- Feedback mechanisms to inform ongoing research
- Flexible implementation based on the farmer's capacity

ii. Innovation systems approach:

- Recognises multiple sources of innovation (not just research)
- Networks of diverse stakeholders collaborating
- Focuses on an enabling environment for innovation
- Emphasises linkages between actors in the system
- It facilitates resource sharing and comprehensive support to farmers.
- It also brings in diverse expertise and funding opportunities.
- But coordination among many stakeholders can be complex, and the risk of conflicting interests if roles and responsibilities are not clearly defined is real.

4. Methods of Transfer of Technology in Fish Farming

Effective technology transfer ensures that fish farmers adopt improved practices to enhance productivity, sustainability, and profitability. The main methods used to transfer technology in fish farming include:

a. On-farm demonstrations**:** Practical training held on model farms or progressive farmers' ponds, where farmers observe and practise key activities like pond preparation, water management, stocking, feeding, and harvesting. This hands-on method builds confidence, deepens understanding, and allows immediate expert feedback.

b. Training workshops and seminars**:** Organised by government agencies, researchers, universities, or NGOs, these events cover topics such as hatchery management, feed processing, disease control, and water monitoring. They combine lectures, practical work, and discussions for effective, applicable learning.

c. Field days and exposure visits: Farmers visit successful fish farms, research centres, or demonstration sites to observe real-world best practices. These visits motivate farmers and encourage them to adopt proven techniques on their farms.

d. Extension services: Trained officers, NGOs, or private experts visit farms regularly to give advice, solve problems, and guide farmers on good pond management, feeding, and disease control, bridging the gap between research and on-farm practice.

e. Use of mass media**:** Radio, television, posters, newsletters, and magazines share key messages on improved fish farming, reaching a wide audience, especially in remote areas with limited training opportunities. Educational broadcasts help reinforce learning.

f. ICT and digital tools: Mobile apps, SMS, WhatsApp groups, and YouTube videos provide farmers with regular technical advice and updates, for example, on feeding or water management. These tools offer practical, cost-effective, and rapid knowledge sharing.

g. Farmer Field Schools (FFS): Groups of farmers meet regularly to learn by doing, monitoring their ponds, discussing challenges, and exploring solutions together. This participatory method builds peer learning and confidence in adopting new technologies.

h. Model fish farms or technology villages**:** Specially developed centres showcasing integrated modern fish farming technologies, serving as hubs for skills development, research, and knowledge exchange.

5. Challenges in Technology Transfer for Fish Farming

The process of sharing and adopting new technologies in fish farming is often hindered by several practical challenges, such as:

a. Low literacy levels among Ghanaian farmers**:** Many small-scale fish farmers have limited education, making it hard to understand technical manuals, interpret data, or follow written instructions, which hampers the adoption of new practices.

b. Inadequate extension personnel and logistics: There is a shortage of trained aquaculture extension officers, and many lack resources to reach remote farmers, resulting in poor outreach and weak follow-up.

c. Resistance to change from traditional methods: Farmers often stick to long-practised methods out of fear or uncertainty, making them reluctant to adopt innovations such as formulated feeds.

d. Limited access to financial and technological resources**:** Smallholders often lack funds to invest in improved technologies and may also struggle to obtain necessary equipment or quality fingerlings.

e. Poor infrastructure and communication channels: Bad roads, weak phone and internet connectivity, and limited electricity and water supply in rural areas restrict access to extension services and modern technologies.

6. Strategies to Improve Transfer of Technology

Successful technology transfer in fish farming depends on overcoming key challenges and adopting targeted strategies. Here is how some strategies can make a big impact:

a. Strengthen public–private partnerships in aquaculture: Bringing together government, NGOs, the private sector, and research bodies helps pool resources, share expertise, and ensure regulation. Joint training and market linkages speed up technology adoption and make it more sustainable.

b. Increased investment in training and recruiting extension officers: Recruiting and continuously training more extension officers ensures farmers receive up-to-date, practical advice. This reduces farmer-to-officer ratios, improves outreach, and supports timely guidance, especially in remote areas.

c. Develop localised and farmer-friendly learning materials**:** Using simple, illustrated materials in local languages with real-life examples makes technical information clearer and more relevant, encouraging adoption among farmers with low literacy levels.

d. Incorporate ICT solutions tailored to farmers' context: Mobile apps, SMS, WhatsApp, and YouTube content in local languages, featuring relatable examples, can deliver practical, timely advice and overcome distance barriers where extension services are limited.

e. Encourage farmer cooperatives and groups: Cooperatives and groups support peer learning, resource sharing, and collective bargaining, while making it easier for extension officers to reach and train multiple farmers, boosting technology adoption.

7. Stakeholder Roles in Aquaculture Technology Transfer

Table 6.8: *Summary of stakeholder roles in aquaculture technology transfer*

SN	Stakeholder	Roles in Technology Transfer
	Government Institutions	Set policies, license farms, provide extension services and develop national plans
	Research Institutions	Innovate, breed improved strains, develop feed and disease management protocols
	Educational Institutions	Train professionals, conduct applied research and extend knowledge directly to farmers
	Input Suppliers	Provide fingerlings, feeds, equipment and vet services
	Fish Farmers	Adopt technology, adapt technology to suit local needs, provide feedback and train peers
	Financial Institutions	Offer credit, microfinance and insurance to enable adoption
	International Organisations	Fund infrastructure, introduce new technologies and offer technical assistance
	NGOs	Train farmers, pilot technologies and strengthen farmer networks

Learning Tasks

1. Learners to study extension methods by the Department of Extension Services and a non-governmental organisation, e.g. World Vision International, for fish production and present reports in a plenary session.
2. Learners to role-play a participatory extension service meeting involving fish farmers and extension agents on the adoption of improved formulated feed to improve yield.
3. Create a simple fish farming technology brochure or radio advert in a local language.

Pedagogical Exemplars

Exploratory Learning: Learners, in mixed ability groups, study extension methods used by the Department of Extension Services and a non-governmental organisation, eg World Vision International, for fish production and present reports in a plenary session. The teacher should guide learners with probing questions and assist learners having difficulty.

Role-Play: Learners, in mixed ability groups, role-play a participatory extension service meeting involving fish farmers and extension agents on the adoption of improved formulated feed. Some of the learners play the role of fish farmers (with challenges of poor growth of their fish), whilst others take on roles as extension agents (linking science with practice), while some serve as researchers (bringing scientific findings or innovations). The learners should work together to find the root causes of the problem and suggest innovative solutions. The teacher should:

a. Set the scene and objectives for the role-play.
b. Guide the process to ensure active participation.
c. Encourage inclusive dialogue and ensure that all viewpoints are heard.
d. Summarise key learning points at the end and relate them to real-world extension practice.

Project-based learning: Learners, in mixed ability groups, create a simple fish farming technology brochure or radio advert in a local language. The teacher should assign this as a group project with the criteria for assessment, to enable learners to conduct the project successfully.

Key Assessment Level 2: Class Exercise

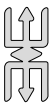
Explain five methods used in the transfer of technology in fish farming. (10 marks)

PLC Session 19

45 minutes	Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
   a. explain the week's concepts in a practical way that will make it easier for learners to understand
   b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).

3. Use your subject specific app to plan your lesson. Ask the app to
   a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
   b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
   c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



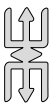
Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Plan the week's key assessment with your app
   a. The key assessment for the week is class exercises. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the exercise (NTS 3k-3q).

10 minutes **Content Exploration**

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
   a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
   b. all teachers in the group work through a similar problem individually for 3–4 minutes
   c. the group then works through the problem together step by step
   d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes **Enactment**

6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).
   a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
   b. After the enactment, ask for structured feedback from the group

i. was the concept explained in a way that a learner with no prior knowledge could follow?

ii. were the examples grounded in contexts familiar to Ghanaian learners?

iii. did any misconceptions surface and if so, how were they addressed?

5 minutes **Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to

   a. transfer your chats into your learning planner template.

   b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).

   c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 20

Learning Indicator: *Explain the operations and importance of rural credit in agriculture*

Focal Area: Rural credit for farming

1. Basic concepts of rural credit

Rural credit refers to loans and financial support extended to farmers and rural households for agricultural and related activities. The objective of the credit is to enhance agricultural productivity, improve livelihoods and reduce rural poverty. It is also a financial service provided to agricultural producers and rural enterprises to support production, marketing and other agricultural activities.

a. Types of rural credit: Based on the source and regulation, three types of credit exist:

i. Formal credit: These are structured loans given to farmers and rural entrepreneurs by regulated financial institutions. The major financial institutions and the credit facilities offered are:

- Commercial banks**:** Offer large loans with strict requirements and collateral, often difficult for smallholder farmers to access.
- Rural banks: Operate in rural areas to serve local communities with more flexible terms for agricultural and small business needs.
- Agricultural development banks: Specialise in financing agricultural projects and rural development, often with government support and sector-specific loan products.

ii. Semi-formal credit**:** These institutions are registered and operate under financial regulations, but are more flexible than formal banks. Examples are:

- Cooperatives**:** Member-owned groups that pool resources to offer loans at reasonable interest rates to members.
- Credit unions**:** Community-based financial organisations that provide savings and credit services to members, often with low interest rates and minimal collateral.
- Microfinance institutions**:** Provide small loans (microcredit) to low-income rural individuals, particularly women, to support small-scale enterprises and farming.

iii. Informal credit: These are unregulated, community-based credit sources that offer quick loans but usually lack legal protection or standard terms. Some informal credit providers are:

- Money lenders**:** Provide quick loans, often at high interest rates and without formal procedures.
- Relatives and friends**:** Offer interest-free or low-interest loans based on trust and personal relationships.
- Rotating savings groups (Susu)**:** Community-based savings groups where members contribute regularly and take turns receiving lump-sum payments.
- Traders**:** Advance credit to farmers for inputs or in exchange for future harvests, often tying farmers to specific buyers.

Table 6.9: *Advantages and Disadvantages of the Sources of Rural Credit*

SN	Source of Rural Credit	Advantages	Disadvantages
	Formal Sources (eg, Commercial banks, Agricultural Development banks, Rural banks, Cooperative banks)	a. Provide large amounts of credit, suitable for long-term projects b. Offer lower interest rates, regulated by central authorities c. Ensure legal protection for both lender and borrower d. Offer technical advice and support services e. Encourage financial discipline and documentation	a. Require collateral/security, which many rural farmers may lack b. Lengthy procedures and documentation c. Often located far from rural areas, causing access issues d. May not cater for urgent or short-term credit needs- e. High rate of loan rejection for small or unregistered farmers
	Semi-formal Sources (eg Microfinance institutions, NGOs, Credit unions, self-help groups, Village Savings and Loans Associations – VSLAs)	a. Easier access than formal institutions b. Provide credit to smallholder and marginalised farmers c. Group lending helps reduce default risks d. Often involve financial literacy training e. May accept non-traditional collateral like group guarantees	a. Interest rates may be higher than formal sources b. Loan sizes are often small, limiting investment c. Limited reach and geographical coverage d. Sustainability of some institutions is a concern e. Group pressure or dynamics may cause social friction
	Informal Sources (eg moneylenders, traders, friends, relatives, rotating savings groups – susu)	a. Quick and easy access with minimal documentation b. No collateral is usually required c. Highly flexible repayment arrangements- d. Readily available during emergencies e. Culturally familiar and trusted by rural dwellers	a. Often charge very high interest rates b. Risk of exploitation or coercion by lenders- c. No legal protection for borrowers d. May lead to debt traps e. Typically, limited loan amounts and short-term duration

b. Types of rural credit based on repayment duration

Agricultural credit can be classified based on the duration of the loan and its purpose**.** These classifications help financial institutions and policymakers design tailored credit products for farmers' diverse needs. These include:

i. Short-term credit**:** This type of credit has a repayment period of up to 12 months. It is usually taken to meet immediate farm production needs for a single growing season. It is used to purchase seeds, fertilisers, pesticides, payment for hired labour and day-to-day operating expenses.

ii. Medium-term credit: This has a repayment duration of one to five years. It is mostly contracted to acquire assets that improve farm productivity and income over multiple seasons. It is used to purchase farm machinery (eg tractors, irrigation pumps), livestock breeds and the development of permanent structures like farm sheds. Repayment is structured in instalments based on asset usage and income generated.

iii. Long-term credit**:** This type of rural credit has a repayment duration of over five years. It is usually contracted to finance large investments in land and infrastructure for long-term farm development. Its main uses include:

- Land purchase and consolidation
- Establishing irrigation systems or water harvesting structures
- Plantation establishment (eg oil palm, cocoa, orchards).

2. Operations of rural credit systems

a. Formal credit operations: Formal rural credit is provided by licensed financial institutions such as commercial banks, agricultural banks, and Rural and Community Banks (RCBs). The process follows structured procedures to ensure responsible lending.

i. Application process

- Loan application submission: Farmers or agribusinesses submit detailed applications, often with a farm business plan, outlining production goals, cash flow projections, and loan usage.
- Verification of borrower information**:** The bank verifies personal identification, farm ownership or tenancy agreements, and financial records to assess eligibility.
- Collateral assessment**:** Lenders evaluate available collateral such as land titles, machinery, or use group guarantees (especially in cooperative lending).
- Loan approval and disbursement: After assessment, loans are approved and funds are disbursed either in cash or in-kind (eg inputs). Approval times vary depending on institution policies.

ii. Repayment mechanisms

- Fixed instalment schedules: Borrowers repay loans in equal monthly or quarterly instalments that include both principal and interest.
- Seasonal repayment: For agricultural loans, repayment may be structured around harvest periods, allowing flexibility when cash inflow is seasonal.

iii. Interest calculation methods:

- Flat rate**:** Interest is charged on the total loan amount, regardless of repayments made.
- Reducing balance**:** Interest is charged on the outstanding balance, reducing over time as the loan is repaid.

b. Microfinance operations: Microfinance institutions (MFIs) are specialised financial entities that provide small loans, savings, and other financial services to low-income individuals, especially

smallholder farmers and rural micro-entrepreneurs. Unlike traditional banks, MFIs often do not require conventional collateral. Instead, they rely on group guarantees, character assessments, or the use of social networks to ensure repayment. Their operations are designed to improve financial inclusion, support income-generating activities, and reduce poverty in underserved rural areas. MFIs also offer training in financial literacy and business management to enhance loan effectiveness and sustainability. Borrowers access loans by forming groups.

i. Groups for accessing microfinance loans:

- Solidarity groups: Farmers form small groups of 5–10 members who apply for loans collectively.
- Joint liability groups: Each group member is responsible for ensuring the others repay, creating strong peer pressure and mutual accountability**.**
- Peer monitoring groups**:** Members monitor each other's loan use and repayment behaviour, reducing default risk.

ii. Innovative features of microfinance operations

- Progressive lending: Loan sizes increase with successful repayment history, encouraging good credit behaviour.
- Frequent repayment schedules**:** Loans are repaid weekly or monthly, making it easier for borrowers with irregular income streams.
- Mandatory savings**:** Borrowers are often required to save a small amount before or during the loan period, building financial discipline.
- Non-traditional collateral: Instead of land titles, MFIs may accept group guarantees**,** household items**,** or community reputation as collateral.

3. Government credit programmes

Governments intervene in rural credit to improve access, affordability and food security by supporting farmers directly or through partnerships. Some government interventions are:

a. Input credit schemes

i. Subsidised inputs on credit**:** Farmers receive fertilisers, improved seeds and chemicals on credit and repay after harvesting.

ii. Block farming programmes: The government supports groups of farmers cultivating a common crop on adjacent lands, supplying inputs and supervising production.

iii. Planting for Food and Jobs (PFJ)**:** Includes a credit component where farmers receive inputs with deferred payment, encouraging increased food production.

b. Implementation mechanisms of government credit programmes

i. Direct provision: Some programmes are implemented directly by government agencies like the MOFA (Ministry of Food and Agriculture) to farmers.

ii. Public-Private Partnerships (PPPs)**:** The Government partners with agribusinesses or financial institutions to reach more farmers with credit and inputs.

iii. Interest rate subsidies: The Government absorbs part of the interest to reduce borrowing costs for farmers through selected banks and MFIs

c. Importance of rural credit in agriculture

i. Economic importance.

- Increased agricultural productivity**:** It enables farmers to adopt improved technologies (seeds, fertilisers), facilitates mechanisation and irrigation investments. It also promotes the transition from subsistence to commercial farming
- Income enhancement**:** It helps to break poverty cycles through productive investments, creates employment opportunities in rural areas and stabilises seasonal income fluctuations.
- Market participation**:** It promotes bulk selling rather than distress sales, strengthens farmers' bargaining power and supports value addition activities.

ii. Social importance

- Food security enhancement: It helps stabilise food production, reduces vulnerability to production shocks and improves household nutrition through diversified production.
- Rural development: Rural credit to farmers helps to reduce rural-urban migration, support infrastructure developments and reinforce community institutions.
- Empowerment of vulnerable groups: Rural credit enables vulnerable groups like women and the youth who are interested in farming to have access to credit, promoting integration of marginalised communities.

d. Challenges and innovations in rural credit

i. Persistent challenges

- High transaction costs**:** rural credit faces limited rural banking infrastructure due to the dispersion of clients, which results in small loan sizes with high administrative costs.
- Risk management issues**:** Rural credit usually faces high risk as agriculture is weather-dependent in Ghana, prices are unstable, with limited insurance of produce.
- Information irregularity**:** Rural credit is prone to challenges such as a lack of credit history for smallholder farmers, difficulty in assessing borrower creditworthiness and limited collateral options for smallholder farmers.

ii. Innovative approaches to addressing challenges faced by rural credit

Digital financial services

- Mobile money platforms: Mobile money services allow farmers to receive loan disbursements and repay instalments directly through their mobile phones. This reduces transaction costs and eliminates the need for travel to bank branches.
- Agent banking models: Local shops and kiosks act as agents for banks, enabling farmers in remote areas to access loan services, deposit and withdraw funds, and make repayments easily, expanding rural credit coverage.
- Digital credit scoring: Instead of relying on traditional credit history, financial institutions use data from mobile phone usage, utility payments, and farming records to assess borrowers' creditworthiness. This helps extend credit to farmers without formal collateral or credit history.

Value chain financing

- Contract farming with embedded financing: Agribusinesses provide upfront financing or inputs to farmers under production contracts. In return, farmers agree to supply their harvest to the agribusiness, securing repayment and improving access to credit.
- Warehouse receipt systems: Farmers store harvested produce in certified warehouses and receive a receipt. These receipts serve as collateral for loans from banks or microfinance institutions, helping farmers access credit during post-harvest periods.
- Out-grower schemes with input credit: Large processors or exporters support smallholder farmers by providing seeds, fertilisers, and other inputs on credit. Farmers repay these inputs from the proceeds of selling their produce, often through a deduction at sale.

Risk mitigation tools

- Weather index insurance: Farmers and lenders are protected from climate-related risks by insurance linked to weather indices (like rainfall or drought levels). This ensures loan repayment even during adverse weather conditions.
- Price guarantees (Forward contracts): Agreements to sell produce at pre-determined prices reduce market risks and provide more stable incomes. This encourages lenders to extend credit, knowing farmers have secured buyers.
- Portfolio guarantees: Development organisations or governments provide partial guarantees to financial institutions' loan portfolios targeting smallholder farmers. This reduces the lending risk and motivates banks to lend more to rural communities.

Learning Tasks

1. Learners to discuss the meaning of rural credit and sources of obtaining it and present reports in a plenary session.
2. Learners to compare the advantages and disadvantages of the sources of rural credit for smallholder farmers.
3. Learners to conduct a field visit to a rural bank or microfinance institution (where applicable) or invite a resource person to help them examine the loan application process and calculate interest costs.

Pedagogical Exemplars

1. **Structured Talk for Learning:** Learners in mixed ability groups discuss the meaning of rural credit and sources of obtaining it, and present reports in a plenary session. The teacher should use leading questions to direct learners' discussion and should encourage all learners to take an active part in the discussion. Assign leadership roles to learners and set ground rules for the discussion.
2. **Collaborative Learning**: Learners, in mixed ability groups, compare the advantages and disadvantages of the sources of rural credit for smallholder farmers. The teacher should guide learners with probing questions to enable them to list the advantages and disadvantages of the sources of rural credit.
3. **Experiential Learning:** Learners, in their groups, visit a rural bank or microfinance institution (where applicable) to examine the loan application process and calculate interest on loans. Alternatively, teachers should invite resource persons to discuss the loan application process and calculate interest costs.

Key Assessment Level 2: Essay

Compare and contrast the suitability of formal versus informal credit sources for smallholder farmers in Ghana. (10 marks)

PLC Session 20

45 minutes | **Planning & Reviewing the Learning Plan**

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
   a. explain the week's concepts in a practical way that will make it easier for learners to understand
   b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
   a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
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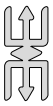


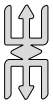
Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Plan the week's key assessment with your app
   a. The key assessment for the week is essay. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the essay (NTS 3k-3q).

10 minutes | **Content Exploration**

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
   a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
   b. all teachers in the group work through a similar problem individually for 3–4 minutes
   c. the group then works through the problem together step by step
   d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*

- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes **Enactment**

6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).
   a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
   b. After the enactment, ask for structured feedback from the group
      i. was the concept explained in a way that a learner with no prior knowledge could follow?
      ii. were the examples grounded in contexts familiar to Ghanaian learners?
      iii. did any misconceptions surface and if so, how were they addressed?

5 minutes **Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
   a. transfer your chats into your learning planner template.
   b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
   c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

SECTION 6 REVIEW

This section explored the vital role fish production plays in economic development, particularly in improving food security, creating employment and generating income. Learners examined methods of raising fish in ponds and tanks, highlighting factors such as site selection, water quality management, feeding and harvesting techniques. Attention was also given to support organisations that assist fish farmers, including government agencies, NGOs and cooperatives, which provide training, funding, inputs and market access. The section further discussed various technology transfer methods, including on-farm demonstrations, farmer field schools, workshops, and extension services, which promote the adoption of improved fish farming practices. Finally, the importance of rural credit in agriculture was reviewed, focusing on how access to affordable finance enables farmers to invest in infrastructure, buy quality fingerlings and feed, as well as expand their operations. Overall, this section provided a comprehensive understanding of the interconnected elements that support successful and sustainable fish farming. Having reviewed all the learning indicators in Section 6, learners should be able to demonstrate knowledge, skills, and understanding of successful fish production.

MARKING SCHEMES FOR THE KEY ASSESSMENTS

Week 16

Introduction

Fish production is a key source of income and employment for many rural and urban producers and plays a vital role in stimulating activities along the aquaculture value chain. (1 mark)

Part A: Contribution to livelihoods of producers (6 marks)

a. Income generation: Selling fish provides a steady income for producers.

b. Employment: Fish farming provides jobs for families and labourers.

c. Food security: Farmers consume part of their produce, reducing food costs.

d. Access to education and healthcare: Increased income helps cover school fees and medical bills.

e. Encourages entrepreneurship: Producers expand into hatcheries and feed production.

f. Asset acquisition: Profits may be used to build houses, buy tools and many more goods.

(1 mark each for the 6 correct answers: 6 x 1 = 6 marks)

Part B: Support to broader value chain (6 marks)

a. Boosts input supply businesses (eg feed, nets, fingerlings).

b. Creates downstream jobs in fish processing, packaging, and transport.

c. Promotes local markets and fish vendors' income.

d. Drives export potential, increasing national revenue.

e. Stimulates demand for services like refrigeration, storage, and distribution.

f. Encourages innovation, such as fish drying and smoking techniques.

g. Promotes use of technology in drying, storage and distribution.

h. Encourages infrastructure development (eg cold storage).

(1 mark for each of any 6 of these 8 correct answers: 6 x 1 = 6 marks)

Any 1 example given x 1 = 1 mark

Conclusion (1 mark)

Fish production not only improves household livelihoods but also boosts the economy by connecting multiple sectors. Its value goes beyond farming.

Total = 1 + 6 + 6 + 1 + 1 = 15 marks

Week 17

Introduction (1 mark)

Brief explanation of sustainable fish farming in rural conditions: Sustainability means maintaining consistent fish production while conserving resources and ensuring long-term viability.

Adaptations to seasonal water shortages (1 mark each for any 5 of the following points = 5 marks)

a. Pond design optimisation: Adequate pond depth, surface area, shade structures, or lining to reduce evaporation and seepage,

b. Use of lined or concrete ponds to reduce water loss.

c. Rainwater harvesting and storage ponds with rainwater harvesting structures (ponds, tanks, reservoirs) to collect and store water during the rainy season

d. Integration of aquaponics to recycle water

e. Use of groundwater (eg boreholes) efficiently

f. Use of water-efficient fish species (eg tilapia)

g. Integrated multi-trophic systems: Integrating plants/algae to improve water quality and reduce water replacement frequency

h. Recirculating aquaculture systems (RAS): Water can be filtered and reused to minimise consumption

Adaptations to limited fish feed (6 marks)

a. Use of locally available agricultural by-products such as local crop residues, food processing waste, or brewery waste can be incorporated into fish diets as feed (eg rice bran, maize husks) (2 marks)

b. On-farm feed production: Growing own fish feed ingredients locally (eg duckweed, Azolla, insects, earthworms, plant materials) (2 marks)

c. Supplementing with kitchen or farm waste (1 mark)

d. Use of integrated systems (eg livestock-fish systems) to reuse manure as fish feed (1 mark)

System design and implementation (2 marks each for any 4 of the following 5 points = 8 marks)

a. Species selection: Choose drought-tolerant or omnivorous fish species that can thrive under limited water and feed conditions

b. Polyculture systems: Multiple fish species stocking to utilise different ecological niches and feeding habits

c. Seasonal production planning: Adapting production cycles to match water availability (harvesting before dry season)

d. Small-scale intensive systems: Building small but intensive production units that maximise output while minimising resource use

e. Community-based management: Shared resource management approaches to maximise collective access to water and inputs

Week 18

A. Identification and evaluation of support organisations (6 marks)

(Any 3 of the support organisations for 1 mark each and the correct roles for 1 mark each)

1. Ministry of Fisheries or Fisheries Department: Extension services, policy guidance, subsidies, and regulation enforcement.
2. NGOs like WorldFish**:** Training on sustainable practices, capacity building and community-based resource management.

3. Microfinance Institutions or Rural Banks: Provide credit, savings and insurance tailored to the aquaculture or fisheries sector.
4. Private Aquaculture Companies or Co-operatives: Offer fingerlings, feeds, market linkages, cold storage and technical solutions.

B. Appropriate organisations for each stakeholder group (9 marks)

Stakeholder Group	Marks	Scoring schedule
Fish Farmers	3 marks	1 mark for correct recommendation + 2 marks for relevant justification with example
Distributors	3 marks	As above
Small-scale Traders	3 marks	As above

Candidates must recommend the most appropriate organisation for each stakeholder group (Fish farmers, distributors, and small-scale traders) and justify their choice.

Examples of correct matches and justifications

- Fish Farmers versus NGOs (e.g., WorldFish): They offer capacity building, disease control training, and pond management education.
- Distributors versus private sector co-ops: They offer value chain linkages, cold chain logistics, and wholesale market access.
- Small-scale traders versus microfinance institutions: They provide small loans, mobile banking, and insurance to sustain their businesses.

Week 19

(Any 5 of the following for 2 marks per correctly explained method):

1. On-farm demonstrations: Practical demonstration of fish farming techniques on farmers' farms to encourage adoption.
2. Training workshops and seminars: Organised sessions to build skills and knowledge among fish farmers.
3. Farmer-to-farmer extension: Farmers sharing experiences, knowledge, and skills with other farmers.
4. Extension visits/advisory services: Visits by extension officers to provide one-on-one guidance and problem-solving.
5. Printed materials (leaflets, brochures, manuals): Distributing easy-to-read materials with step-by-step methods for farmers to follow.
6. Mass media (radio, TV, social media): Broadcasting fish farming practices to reach a wider audience.
7. Field days/exhibitions: Organised events where farmers observe new technologies in practice.
8. Mobile phone extension services: Using calls or SMS to send advisory messages to fish farmers.

Total Marks (2 x 5 = 10)

Week 20

1. **Introduction/Definitions** (2 marks)
   a. Formal credit source**:** Loans from banks, microfinance institutions, rural banks *(*1 mark)
   b. Informal credit source**:** Loans from friends, family, moneylenders, traders, susu groups *(*1 mark)
2. **Comparison – Similarities** (2 marks)
   a. Both provide financial assistance to smallholder farmers
   b. Both can be used for agricultural investment
   c. Both involve risk and repayment obligations

   (Any two for 1 mark each)
3. **Contrast – Key Differences in Suitability** (4 marks)

   Candidates should write four correct and relevant contrasting pairs in Table 6.10.

Table 6.10: *Key differences between formal and informal credit*

SN	Formal Credit Sources	Informal Credit Sources
	Require collateral	Usually, no collateral required
	Bureaucratic and time-consuming	Quick and easily accessible
	Lower interest rates	Higher and negotiable interest rates
	Regulated by law	Unregulated and based on social trust
	Require formal documentation	Often based on verbal agreement
	Long repayment periods	Short-term and flexible repayment

   (1 mark per correct and relevant contrasting pair = 4 marks)
4. **Evaluation/Conclusion** (2 marks)
   a. Balanced judgment comparing both sources (1 mark)
   b. Highlights which is more suitable depending on context (e.g., ease vs. security) (1 mark)

Total marks = (2 + 2 + 4 + 2 = 10)

SECTION 7: NATIONAL AND GLOBAL POLICIES ON CLIMATE CHANGE

STRAND 4: AGRICULTURE AND CLIMATE

Sub-Strand 1: Climate variability and climate change

Learning Outcome: *Analyse global and national policies on climate change*

Content Standard: *Demonstrate knowledge and understanding of global and national policies on climate change*

INTRODUCTION AND SECTION SUMMARY

Climate change poses a major threat to global food security, ecosystems and livelihoods, including animal production systems. This section introduces learners to the key international and national policies that address climate change, highlighting Ghana's efforts to mitigate its effects. It also explores the REDD+ strategy (Reducing Emissions from Deforestation and Forest Degradation), examining its goals, implementation and relevance to Ghana's environmental sustainability. Additionally, learners will learn about animal welfare issues, focusing on how proper treatment of animals influences productivity, health and ethical farming practices. By understanding these topics, learners will appreciate the link between climate action, sustainable agriculture and responsible animal care.

The weeks and the indicators covered by the section are:

- **Week 21:** Discuss Global and national policies on climate change
- **Week 22:** Evaluate REDD+ strategy and its feasibility in Ghana
- **Week 23:** Discuss animal welfare issues and their significance in animal production

SUMMARY OF Pedagogical Exemplars

Collaborative and inquiry-based learning will be employed for the key agreements like the Paris Accord, while problem-based learning will be used to address real-life climate challenges affecting agriculture. To evaluate the REDD+ strategy and its feasibility in Ghana, individual and collaborative learning will be used to research REDD+ components, followed by a structured talk for learning to encourage critical discussion and peer feedback. For animal welfare and its significance in production, exploratory learning will guide learners in identifying welfare issues through observation and questioning. Project-based learning will be used to design welfare-friendly animal housing or care models, while structured talk for learning will promote ethical reasoning and the sharing of findings. These approaches will foster critical thinking, teamwork and problem-solving skills in learners, ensuring deeper understanding and real-world application of concepts.

ASSESSMENT SUMMARY

The Assessment items for this section will primarily be essay-type questions through class exercises to evaluate students' understanding and reasoning. On the discussion of global and national policies on climate change, tasks will be aligned with DoK Level 3 (Strategic Reasoning), requiring learners to analyse and draw connections between policies and their impacts. For evaluating REDD+ strategy and its feasibility in Ghana, the assessment will focus on DoK Level 2 (Conceptual Understanding), where learners explain REDD+ concepts and assess their relevance to Ghana. Similarly, to discuss animal welfare issues and their significance in animal production, learners will demonstrate DoK Level 2 skills by explaining welfare concerns and their implications. Formative assessment will be emphasised, with teachers providing prompt feedback to ensure improvement, encourage reflection and support deeper learning.

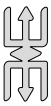
Table 7.1: *Assessment summary for the indicators*

Indicators	DoK Level	Assessment Strategy and/or Mode
Week 21. Discuss global and national policies on climate change	3	Essay-type questions Class exercise
Week 22. Evaluate REDD+ strategy and its feasibility in Ghana	2	Essay-type questions Class exercise
Week 23. Learners explain REDD+ concepts and assess their relevance to Ghana	2	Essay-type questions Class exercise

WEEK 21

Learning Indicator: *Discuss global and national policies on climate change*

Focal Area: Global and national policies on climate change



Note

The teacher should remind learners of the material on climate change studied in Year 1, Weeks 20, 21, 22 and 23 and Year 2, Week 24.

1. Introduction to global and national policies on climate change

Climate change policies are the formal decisions, plans, and actions taken by governments at all levels to address the causes and impacts of climate change, for more resilient societies and ecosystems. Notable among the policies are the international Paris Agreement and Ghana's National Climate Change Policy. This week is devoted to examining how these policies are designed to address climate change, their implementation strategies and their impacts at both global and national levels. Policy:

a. Key climate change policy dimensions:
   i. Mitigation: Involves policies that focus on reducing greenhouse gas emissions to limit climate change severity (e.g., shifting to renewable energy, promoting low-carbon transport).
   ii. Adaptation: Concerns actions to adjust systems and communities to the unavoidable impacts of climate change (e.g., climate-resilient infrastructure, early warning systems).
   iii. Resilience-building**:** Broader strategies to enhance the capacity of communities and ecosystems to withstand, recover from, and transform in response to climate stresses.

b. Policy instruments:
   i. Legal frameworks: Laws, regulations, and standards that set climate targets and enforce compliance (e.g., national climate acts, emission caps).
   ii. Economic incentives**:** Tools like carbon taxes, subsidies for green technologies, and market-based instruments to encourage climate-positive investments.
   iii. Regulatory standards**:** Mandates for energy efficiency, land use, and emissions control to guide sectors and industries.
   iv. Education programmes: Awareness campaigns and training programmes to build understanding and support for climate action across society.

c. Multi-level governance:
   i. International: Agreements like the Paris Agreement set global targets and coordinate national efforts.
   ii. Regional**:** Cooperation among neighbouring countries or regions to address shared climate challenges (e.g., African regional climate strategies).
   iii. National**:** National climate policies and strategies that translate global commitments into country-specific action plans.

iv. Local**:** Local government and community-level initiatives tailored to local contexts and vulnerabilities.

2. Evolution of Climate Change Policies

The global response to climate change has evolved from early scientific recognition in the 1980s to policy frameworks and national action plans today. Over time, climate change has become a central part of the global development and sustainability agenda.

a. First wave: Scientific Assessment and Awareness (1980s – Early 1990s)

i. The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 to assemble scientific evidence and raise global awareness.

ii. Key scientific reports in this period laid the foundation for climate action, highlighting greenhouse gas emissions as a driver of global warming.

b. Second wave: International Framework Development (1990s – 2000s)

i. The United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992, providing a legal basis for global cooperation.

ii. The Kyoto Protocol (1997) introduced binding emission targets for industrialised countries, marking the first serious step toward emissions reduction.

c. Third wave: Implementation and Nationally Determined Contributions (2010s – Present)

i. The Paris Agreement (2015) shifted the focus to nationally determined contributions, where each country defines its own climate goals.

ii. Countries began integrating climate action into national policies, focusing on mitigation (reducing emissions) and adaptation (managing impacts)**.**

d. Current trends: Integrated Approaches Linking Climate, Development and Sustainability

i. Climate policies are now integral to achieving the Sustainable Development Goals (SDGs)**.**

ii. There is a push for nature-based solutions, green financing, and climate-resilient infrastructure**.**

iii. Emerging focus on loss and damage and climate justice to protect vulnerable communities.

e. United Nations Framework Convention on Climate Change (UNFCCC)

The Establishment: The UNFCCC was adopted in 1992 during the Rio Earth Summit in Brazil and officially entered into force in 1994. It is the foundational treaty for global cooperation on climate change, and nearly all countries (198 parties) signed it. The UNFCCC aims to stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic (human-caused) interference with the climate system. This objective is intentionally broad to accommodate future scientific insights and policy frameworks. Key principles of the UNFCCC include:

i. Common but differentiated responsibilities: Recognises that while climate change is a global challenge, developed countries (with historically higher emissions) have a greater responsibility to provide support to developing countries.

ii. Intergenerational equity: Stresses the rights and well-being of future generations when addressing climate change.

iii. Precautionary principle: Encourages preventing or minimising climate change impacts even in the absence of complete scientific certainty.

f. Conference of Parties (COP): The COP is the supreme decision-making body of the UNFCCC. It convenes annually to review implementation progress, set new targets and negotiate international agreements (like the Kyoto Protocol in 1997 and the Paris Agreement in 2015). COP meetings also provide a platform for countries to share knowledge and build partnerships.

g. Financing mechanisms**:** The UNFCCC established several financial support mechanisms to help developing countries mitigate and adapt to climate change:

i. Global Environment Facility (GEF): Provides grants and concessional funding for climate projects in developing countries.

ii. Special Climate Change Fund (SCCF): Focuses on adaptation, technology transfer, and capacity building for vulnerable countries.

iii. Additional funding bodies (like the Green Climate Fund established later) also work to support the objectives of the UNFCCC.

3. Kyoto Protocol

The Kyoto Protocol was adopted in December 1997 in Kyoto, Japan, and entered into force in 2005. It set the legally binding greenhouse gas emission reduction targets for developed (Annexe I) countries, averaging a 5.2 % cut below 1990 levels during its first commitment period (2008–2012). A second period (2013–2020) was agreed under the Doha Amendment but not fully ratified. To help achieve targets, the Protocol introduced flexibility mechanisms including the Clean Development Mechanism (CDM), Joint Implementation (JI) and emissions trading. Ghana, as a developing (Non-Annexe I) country, had no binding targets but benefits from CDM projects supporting sustainable development.

4. Paris Agreement

Adopted in December 2015 at COP21 in Paris and entered into force in November 2016, the Paris Agreement aims at keeping the global temperature rise well below 2°C, striving for 1.5°C. Unlike the Kyoto Protocol, it requires all countries to submit Nationally Determined Contributions (NDCs), updated every five years to increase ambition. It commits developed nations to mobilise $100 billion annually for climate action in developing countries and establishes a common transparency framework. Although agriculture is not explicitly detailed, the Agreement recognises its links to food security, adaptation, and mitigation, with the Koronivia Joint Work on Agriculture later addressing agricultural climate actions.

5. Ghana's National Climate Change Policies

Ghana has developed a comprehensive set of policies and plans to guide its response to climate change. These policies are:

a. National Climate Change Policy (NCCP): The NCCP was adopted in 2013 as Ghana's primary policy document for addressing climate change. It sets the strategic direction for climate-related actions and guides national, regional, and local-level efforts. The policy envisions Ghana as a climate-resilient and climate-compatible economy**,** capable of achieving sustainable development while addressing climate change challenges. The NCCP is built on five key pillars:

i. Governance and coordination**:** Establishing robust institutional structures and ensuring effective stakeholder collaboration for climate action.

ii. Science, technology and innovation: Harnessing research, technology transfer and innovation to support climate resilience and reducing emissions.

iii. Finance**:** Mobilising both domestic and international climate finance to implement climate actions and build resilience.

iv. International cooperation**:** Promoting Ghana's engagement in global climate processes and fostering partnerships for effective implementation.

v. Adaptation and mitigation**:** Integrating climate actions into priority sectors (such as agriculture, forestry, energy, and water resources) to reduce emissions and manage climate risks.

b. Ghana's Nationally Determined Contributions (NDCs) on Agriculture

Recognising the importance of agriculture for livelihoods on the one hand, and climate-harming emissions from agricultural activities, Ghana prioritises climate-smart agricultural practices, including:

i. Modified community-based conservation agriculture**:** Promoting sustainable soil and water management while improving yields.

ii. Livestock emission reduction through feed improvement**:** Enhancing feed quality to reduce enteric fermentation and methane emissions.

iii. Rice straw composting and biogas production**:** Turning rice residues into valuable resources, reducing emissions from burning or decomposition.

iv. Climate-smart agriculture in 43 administrative districts**:** Scaling up sustainable practices to enhance resilience and reduce vulnerability across a significant portion of the country.

v. Savannah restoration and sustainable forest management**:** Restoring degraded lands and conserving forest ecosystems to increase carbon sinks and improve local livelihoods.

c. National Adaptation Plan: Ghana's National Adaptation Plan (NAP) provides a structured, multi-sectoral, and participatory framework to address medium- and long-term climate adaptation needs by integrating them into national development planning. Prioritising the agriculture sector, the NAP promotes drought-resistant crops, improved irrigation, livelihood diversification, early warning systems, and sustainable land management to build resilience and reduce vulnerability to climate change.

Learning Tasks

1. Learners to search different sources to obtain information on the global and national policies on climate change, discuss and present a report.
2. Learners to evaluate the implementation of global and national policies on climate change.
3. Learners to analyse the influence of global and national climate change policies on agriculture in Ghana.

Pedagogical Exemplars

1. **Inquiry-based Learning:** Learners, in mixed groups, search different sources to obtain the global and national policies on climate change. Learners discuss the materials retrieved from the Internet. The teacher should keep learners focused during the lesson and prevent them from veering off-topic.

2. **Collaborative Learning:** Learners in mixed groups evaluate the implementation of global and national policies on climate change. Learners should be guided with leading questions to enable them to critically examine the implementation of these policies. More confident learners should be probed further to criticise the implementation of global and national policies on climate change.
3. **Problem-based learning:** Learners in their groups analyse how global and national climate change policies are influencing agriculture in Ghana. The teacher should guide the discussion using probing questions to enable them to analyse the impacts of global and national climate change policies on agriculture in Ghana. All learners should be encouraged to contribute to the discussion.

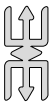
Key Assessment Level 3: Class Exercise

Analyse how global and national climate change policies are influencing agriculture in Ghana. (10 marks)

PLC Session 21

45 minutes	Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
   a. explain the week's concepts in a practical way that will make it easier for learners to understand
   b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
   a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
   b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
   c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



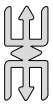
Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Plan the week's key assessment with your app
   a. The key assessment for the week is class exercises . Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the exercise (NTS 3k-3q).

10 minutes	Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
   a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
   b. all teachers in the group work through a similar problem individually for 3–4 minutes
   c. the group then works through the problem together step by step
   d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes **Enactment**

6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).
   a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
   b. After the enactment, ask for structured feedback from the group
      i. was the concept explained in a way that a learner with no prior knowledge could follow?
      ii. were the examples grounded in contexts familiar to Ghanaian learners?
      iii. did any misconceptions surface and if so, how were they addressed?

5 minutes **Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
   a. transfer your chats into your learning planner template.
   b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
   c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 22

Learning Indicator: *Evaluate REDD+ strategy and its feasibility in Ghana*

Focal Area: The REDD+ Strategy on climate change

1. Definition and Evolution of REDD+

REDD+ stands for Reducing Emissions from Deforestation and Forest Degradation, plus conservation, sustainable management of forests, and enhancement of forest carbon stocks. The historical development of REDD+ includes:

a. RED (2005): Initially focused only on reducing emissions from deforestation.

b. REDD (2007): Expanded to include forest degradation.

c. REDD+ (2009): Further broadened to encompass conservation, sustainable forest management, and the enhancement of forest carbon stocks.

The core concept of REDD+ revolves around performance-based payments for measurable forest carbon outcomes. Globally, REDD+ is under the umbrella of the United Nations Framework Convention on Climate Change (UNFCCC).

2. The Three Phases of REDD+ Implementation

REDD+ is implemented in phases. The phases develop progressively to ensure countries are fully prepared, piloted, and equipped for performance-based carbon payments.

a. Phase 1. Readiness: This involves developing national policies, building institutional capacity, creating governance structures, and preparing a REDD+ strategy with stakeholder consultations, safeguards, baselines, and forest monitoring systems to lay a strong foundation for REDD+ implementation.

b. Phase 2. Implementation: This focuses on pilot projects and demonstration activities, developing incentive mechanisms and benefit-sharing, strengthening governance, clarifying tenure, and addressing capacity gaps to put REDD+ plans into practice while delivering co-benefits.

c. Phase 3. Results-Based Payments: The objective of this phase is to provide sustainable, performance-based funding to maintain long-term emission reductions and forest management efforts. This phase involves full-scale implementation of REDD+ activities across the country or selected landscapes, including measurement, reporting and verification (MRV) systems to quantify emission reductions and removals accurately. Results-based finance (RBF) – payments are made based on verified emission reductions (e.g., through carbon markets or international donors). Ensuring social and environmental safeguards are met during implementation.

d. Ghana's Current Status: Transitioning from Phase 2 to Phase 3

   i. Ghana has completed the readiness phase, including the formulation of its REDD+ Strategy and development of robust forest monitoring and safeguard systems.

   ii. Ghana has implemented several demonstration and pilot activities, notably through the Ghana Cocoa Forest REDD+ Programme (GCFRP) in the high forest zone, which addresses deforestation in cocoa landscapes.

iii. Currently, Ghana is transitioning into Phase 3 in selected landscapes. This involves moving towards results-based payments for verified emission reductions, such as through its partnership with the World Bank's Forest Carbon Partnership Facility (FCPF) Carbon Fund.

iv. Ghana has already received payments for verified emission reductions under the FCPF Carbon Fund, indicating early steps into Phase 3.

3. Ghana's Forest Context and Drivers of Deforestation

Ghana's biodiverse forests are crucial for livelihoods and the economy but are under severe threat from deforestation and degradation, which affect the ecosystems, carbon stocks, and dependent communities. These pressures mainly stem from direct human activities. This includes:

a. Agricultural Expansion: Agriculture is the largest driver, responsible for 50-60 % of forest loss**.** It occurs through**:**

i. Cocoa farming: Cocoa cultivation is a major economic activity in Ghana's forest zones. The shift to full-sun cocoa varieties (as opposed to shade-grown cocoa) significantly increases forest clearing to create open farms for higher yields. Full-sun cocoa farms deplete soil fertility quickly and require continuous expansion into forest areas.

ii. Food crop cultivation: Traditional slash-and-burn methods are still widely practised. In this system, farmers clear forest land by cutting and burning vegetation to create temporary farmland. Soil fertility declines rapidly, forcing farmers to move to new forest areas and this results in continuous forest loss.

iii. Oil palm plantations: Expansion of oil palm as a cash crop also drives deforestation, especially in forested areas with good rainfall. This often involves large-scale clearing of forest land for monoculture plantations.

b. Logging: Both legal and illegal logging contribute significantly to forest degradation (about 15-20 %)**.** Legal timber extraction is regulated but often poorly monitored, while illegal logging is widespread, driven by domestic demand and export. Selective logging degrades forests by opening canopies and fragmenting habitats, even if it does not fully clear forest cover.

c. Fuelwood and charcoal production: In Ghana, fuelwood and charcoal remain the primary energy sources for about 76 % of households (especially in rural and peri-urban areas). Trees are cut to meet this demand, leading to gradual forest degradation, especially around communities.

d. Mining activities: Both legal large-scale mining and illegal small-scale (galamsey) operations destroy large stretches of forest cover. Illegal mining is particularly devastating due to the use of excavators and other heavy equipment to clear forests, which disturbs river courses and degrades soils.

e. Infrastructure development: Road construction, settlements and energy projects (eg hydropower, transmission lines) result in permanent forest loss. Roads, for example, provide access to previously remote forests, enabling further encroachment for agriculture, logging, or mining. Urban expansion and settlements continue to eat into forest margins.

4. Underlying Causes of Deforestation and Forest Degradation

The direct drivers of deforestation and forest degradation are fuelled by deeper, systemic issues that make forest loss persistent and difficult to reverse. Some of the underlying causes are:

a. Economic factors: Economic factors that drive deforestation and degradation include:

i. Poverty**:** Many rural communities rely heavily on forest resources for survival, such as fuelwood, hunting and farming.

ii. Market demand: High demand for commodities like cocoa, timber and charcoal encourages forest clearing.

iii. Limited alternative livelihoods: Without viable income options, communities continue these unsustainable activities.

b. Policy and governance issues: Policy and governance issues that directly drive deforestation and degradation are:

i. Weak enforcement: Forestry laws exist, but they're not fully enforced, especially in remote areas.

ii. Unclear land tenure: Confusion about forest and land ownership discourages sustainable management.

iii. Policy inconsistencies: Agricultural policies can conflict with forest conservation efforts.

c. Demographic pressures: Demographic factors that promote deforestation and degradation are:

i. Population growth: Increasing demand for land and resources as the population expands.

ii. Migration**:** Movement to forest frontiers for farming and jobs adds pressure on forest areas.

d. Technological factors: Limited access to intensification technologies also leads to deforestation and degradation. For example, farmers often lack tools and know-how for greater yields on existing farmland, leading to forest clearing to expand their farms.

e. Cultural practices: Some cultural practices also promote deforestation and degradation in Ghana. These include:

i. Traditional farming methods: Slash-and-burn, shifting cultivation and open burning are common traditional practices that contribute significantly to deforestation and degradation in Ghana

ii. Land management approaches: Long-standing norms often prioritise short-term gains over long-term sustainability.

Learning Tasks

1. Learners to surf the Internet for information about REDD+ and read it.
2. Learners to discuss the REDD+ strategy and the phases in the strategy

Pedagogical Exemplars

1. **Individual/Collaborative Learning:** The teacher provides links for learners to read about the REDD+ strategy. The teacher should monitor all learners to ensure that they stick to only authorised sites and only search for information relevant to the lesson.
2. **Structured Talk for Learning:** The teacher guides learners of mixed ability to discuss the REDD+ strategy and the phases in the strategy. The teacher should use probing questions to guide learners to unravel the REDD+ strategy and its various phases. The teacher should ensure that all learners participate in the discussions.

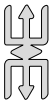
Key Assessment Level 2: Exercise

Describe the governance structure for REDD+ in Ghana and the roles of the key institutions. (10 marks)

PLC Session 22

45 minutes | **Planning & Reviewing the Learning Plan**

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
   a. explain the week's concepts in a practical way that will make it easier for learners to understand
   b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
   c. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
   d. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
   e. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Plan the week's key assessment with your app
   a. The key assessment for the week is class exercises . Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the exercise (NTS 3k-3q).

10 minutes | **Content Exploration**

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
   a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
   b. all teachers in the group work through a similar problem individually for 3–4 minutes
   c. the group then works through the problem together step by step
   d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).

Note

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes **Enactment**

6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).
   a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
   b. After the enactment, ask for structured feedback from the group
      i. was the concept explained in a way that a learner with no prior knowledge could follow?
      ii. were the examples grounded in contexts familiar to Ghanaian learners?
      iii. did any misconceptions surface and if so, how were they addressed?

5 minutes **Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
   a. transfer your chats into your learning planner template.
   b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
   c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 23

Learning Indicator: *Discuss animal welfare issues and their significance in animal production*

Focal Area: Introduction to Animal Welfare

1. Meaning and importance of animal welfare

a. Definition of animal welfare

Animal welfare refers to the physical and mental state of animals, concerning the conditions in which they live and die. It encompasses how an animal copes with its environment, including its health, comfort, nutritional status, safety, ability to express natural behaviours and freedom from distress, pain and suffering. In animal production, welfare includes providing proper nutrition, shelter, disease prevention, humane handling and freedom from stress.

b. Importance of animal welfare in animal production

i. Ethical considerations: That animals experience pain, suffering and also exhibit positive states

ii. Productivity and economics: Better animal welfare leads to:

- higher growth rates and production levels
- improved reproduction rates
- lower disease incidence and mortality
- reduced veterinary costs
- better quality animal products

iii. Food safety and public health: Poor welfare increases stress, which can:

- compromise immune function
- increase disease susceptibility
- elevate the risk of zoonotic disease transmission
- lead to higher antimicrobial drug use, contributing to resistance

iv. International trade: Meeting welfare standards is increasingly important for:

- access to export markets
- compliance with trade requirements
- meeting consumer expectations in global markets

c. The Ghanaian context of animal welfare

The traditional animal production systems in Ghana:

i. often provide some aspects of good welfare (free-range, natural behaviours)

ii. is creating new welfare challenges due to the intensification of production

iii. is witnessing increasing demand for animal welfare assurances from the growing middle class

iv. are sometimes at odds with modern welfare concepts

v. is balancing improved productivity with welfare considerations

2. The Five Freedoms of animal welfare

The Five Freedoms framework, developed by the UK Farm Animal Welfare Council, provides a comprehensive approach to assessing animal welfare. In Ghana, these principles are increasingly recognised as benchmarks for animal production and improvement practices. Table 7.2 shows the five freedoms of animal welfare, the Ghanaian context and its applications.

3. National and international laws and regulations governing animal welfare

Both national and international laws and regulations play a vital role in setting standards for the humane treatment of animals. In Ghana, animal welfare is addressed through:

a. Ghana's national legal framework:

i. Current legislation

- Animals (Control of Importation) Ordinance (Cap 247)**:** Controls animal imports but has limited welfare provisions
- Criminal Offences Act, 1960 (Act 29): Section 47 prohibits the cruel treatment of animals
- Veterinary Surgeons Law, 1992 (PNDC Law 305): Regulates veterinary practice, including animal treatment
- Diseases of Animals Act, 1961 (Act 83): Focuses on disease control but includes some welfare aspects
- Local Government Act, 2016 (Act 936): Empowers district assemblies to make by-laws on animal keeping

ii. Policy frameworks

- Livestock Development Policy and Strategy (2016): Incorporates animal welfare as a component of sustainable livestock development
- Ghana Veterinary Services Strategic Plan**:** Includes welfare considerations in veterinary service delivery
- Food and Agriculture Sector Development Policy (FASDEP II): References animal welfare in livestock production

iii. Gaps and challenges in Ghanaian animal welfare laws

- Lack of comprehensive animal welfare legislation
- Outdated legal provisions not reflecting current scientific understanding of animal welfare
- Limited enforcement mechanisms and resources
- Inadequate penalties for welfare violations
- Fragmented responsibility across multiple agencies

Table 7.2: *The Five Freedoms of Animal Welfare*

SN	Freedom of Animal Welfare	Weaknesses in the Ghanaian Context	Responses / Application
	Freedom from hunger and thirst (Ready access to fresh water and a diet to maintain health and vigour)	• Seasonal feed and water shortages during dry seasons • Limited knowledge of feed quality and nutrition among smallholders • Water accessibility challenges in rural production systems • Free-range systems often require animals to forage extensively	• Development of drought-resistant fodder crops • Training in balanced ration formulation using local ingredients • Water harvesting and storage systems for livestock
	Freedom from discomfort (Appropriate environment, including shelter and comfortable resting areas)	• Extreme temperatures (particularly in the northern regions) • Limited housing infrastructure in smallholder systems • Inappropriate flooring and bedding materials • Overcrowding in some intensive systems	• Low-cost, locally-appropriate housing designs • Shade provision in pastoral systems • Ventilation improvements in intensive care units • Appropriate stocking density guidelines
	Freedom from pain, injury, and disease (Prevention, rapid diagnosis and treatment)	• Limited veterinary services in rural areas • High prevalence of preventable diseases • Traditional practices like branding and castration without anaesthesia • Insufficient biosecurity measures	• Community-based animal health workers • Vaccination programmes for endemic diseases • Training in humane handling and management • Improved access to veterinary pharmaceuticals
	Freedom to express normal behaviour (Sufficient space, proper facilities, and company of the animal's kind)	• Traditional systems often allow natural behaviours • Increasing confinement in peri-urban production • Tethering practices limit movement • Social isolation in some production systems	• Promoting appropriate group housing • Enrichment in confined systems • Balancing free-range benefits with protection needs • Education on the behavioural needs of different species

	Freedom from fear and distress (Ensuring conditions and treatment that avoid mental suffering)	• Rough handling during transportation • Stressful marketing and slaughter practices • Mixed-species housing, causing fear • Limited understanding of animal psychology	• Training in low-stress handling techniques • Improved transport conditions • Humane slaughter methods • Separation of species where appropriate

b. International regulations

i. The World Organisation for Animal Health (WOAH): WOAH sets internationally recognised standards and guidelines for animal health and welfare. Its standards cover various aspects of animal care, including housing, feeding, transport, and slaughter. Member countries are encouraged to adopt these guidelines to ensure humane treatment of animals and facilitate safe international trade in animals and animal products.

ii. The European Union (EU): The EU has some of the most stringent animal welfare laws in the world. These regulations cover the entire lifecycle of animals - from rearing and housing conditions to transportation and slaughter practices. The EU mandates minimum space requirements, bans certain harmful practices (eg battery cages for laying hens), and enforces regular inspections to ensure compliance.

iii. The Universal Declaration on Animal Welfare (UDAW):

UDAW is a proposed global agreement supported by various governments and organisations, aimed at recognising animals as sensitive beings and promoting their welfare worldwide. Although not legally binding, it seeks to encourage countries to adopt and improve animal welfare laws and policies in line with internationally accepted principles.

iv. Other international frameworks on animal welfare Include:

- UN Sustainable Development Goals (SDGs): Animal welfare is directly or indirectly woven into SDGs like Zero Hunger (2), Good Health (3), Responsible Consumption (12), and Life on Land (15), with the plea to promote sustainable and ethical livestock practices.
- FAO Good Agricultural Practices (GAP): These guidelines integrate animal welfare into sustainable farming systems, emphasising health, nutrition, and humane treatment.
- ISO Technical Specification on Animal Welfare Management: A voluntary global standard that helps organisations implement structured animal welfare practices across the supply chain.
- World Trade Organisation (WTO): While not regulating welfare directly, WTO acknowledges animal welfare in trade policies, especially regarding sanitary and phytosanitary (SPS) measures.

c. Regional agreements on animal welfare

i. African Union Animal Health Strategy: Integrates animal welfare into broader animal health and disease control efforts, promoting humane treatment as part of sustainable livestock development across Africa.

ii. ECOWAS Agricultural Policy (ECOWAP): Highlights the importance of animal welfare in regional livestock trade and production systems, aiming to harmonise welfare standards among West African states.

iii. African Platform for Animal Welfare (APAW):

Serves as a regional coordination mechanism to advocate, harmonise, and implement animal welfare policies and practices across African countries.

4. The role of government agencies in enforcing animal welfare laws

a. Veterinary Services Directorate (Ministry of Food and Agriculture): Lead agency for animal health and welfare in Ghana. Its specific functions are:

i. Enforcement of existing welfare regulations

ii. Inspection of animal production facilities

iii. Regulation of animal transport and markets

iv. Disease surveillance and control.

v. Training and certification of slaughterhouse workers

b. Environmental Protection Agency (EPA): The agency plays the following roles in Animal Welfare in Ghana:

i. Environmental impact assessment of livestock facilities: The EPA assesses the environmental impact of livestock farms, ensuring that animal housing and farming operations meet welfare standards.

ii. Pollution control in animal production: It monitors emissions such as ammonia and greenhouse gases from animal farms, to ensure they do not reach levels that can affect both animal and human health.

iii. Waste management standards affecting animal housing: The agency enforces proper manure management practices to maintain hygienic conditions in animal housing.

c. Ghana Standards Authority (GSA): GSA's roles in ensuring animal welfare are:

i. Development of standards for animal products: GSA formulates national standards to ensure the safety, quality, and humane handling of animal-derived products such as meat, milk and eggs, aligning with international best practices.

ii. Welfare certification schemes: It implements certification programmes that incorporate animal welfare criteria, ensuring that production systems meet ethical and hygienic requirements.

iii. Inspection of production facilities for compliance: GSA inspects farms, abattoirs and processing units to verify adherence to established standards, including those related to animal health, housing, and treatment.

d. Local Government Authorities: They are responsible for:

i. Enforcement of by-laws on animal keeping: Local governments implement and enforce municipal by-laws regulating the proper care, housing, and number of animals kept within communities to promote welfare and public health.

ii. Licensing of animal businesses: They issue licenses to animal-related businesses such as farms, veterinary clinics and pet shops, ensuring compliance with welfare and operational standards.

iii. Management of public slaughter facilities: Local authorities oversee the operation and hygiene of public abattoirs, ensuring animals are handled and slaughtered humanely and facilities meet safety standards.

iv. Control of stray animals: They are responsible for managing stray animal populations through capture, sheltering, and public awareness campaigns to prevent cruelty and disease transmission.

e. Universities and Research Institutions: Universities and research institutions in Ghana play a key role in promoting animal welfare through:

i. Research on animal welfare issues: Conduct studies on animal behaviour, health, housing and stress to inform evidence-based welfare improvements.

ii. Training of animal science and veterinary students**:** Integrate animal welfare principles into curricula to equip future professionals with knowledge and ethics.

iii. Development of context-appropriate welfare assessment tools: Design tools tailored to local farming systems for evaluating animal well-being under Ghanaian conditions.

iv. Extension services to farmers**:** Provide outreach and training to farmers on humane animal handling, housing, and health management practices.

5. Challenges in enforcing animal welfare issues

a. Limited legal authority for prosecution: Weak or outdated laws and limited enforcement powers hinder effective legal action against animal cruelty.

b. Resource constraints for regular inspections: Insufficient funding, personnel, and logistics limit the ability to conduct routine monitoring and enforcement.

c. Competing priorities within enforcement agencies: Agencies often prioritise public health and safety over animal welfare due to limited capacity and broad mandates.

d. Cultural and economic barriers to compliance: Traditional practices and financial limitations may conflict with modern animal welfare standards.

e. Lack of awareness among producers and consumers: Many stakeholders are unaware of welfare principles, reducing motivation for humane practices and consumer demand for ethically produced products.

6. Vegetarianism

a. Definition: Vegetarianism is the practice of not eating meat and, in some cases, other animal products. It is often motivated by:

i. Animal welfare concerns**:** Many vegetarians believe that avoiding animal products helps reduce cruelty and exploitation in industrial farming systems.

ii. Environmental reasons**:** Livestock farming contributes to deforestation, greenhouse gas emissions and water pollution.

iii. Health benefits**:** Some people adopt vegetarian diets to reduce the risk of chronic diseases such as obesity, heart disease and diabetes.

iv. Cultural or religious beliefs**:** In some traditions, non-violence and respect for all life forms encourage plant-based diets.

b. Vegetarianism in the Ghanaian context and cultural attitudes

In Ghana, vegetarianism is influenced by cultural, social, and religious beliefs. While not widely practised as a formal lifestyle choice, many elements of traditional Ghanaian life naturally align with plant-based eating:

i. Traditional diets are often plant-based: Historically, many Ghanaian meals have centred around plant-based staples such as cassava, yam, plantain, rice, beans, and leafy vegetables. Animal protein, when used, is often served as a supplement rather than the main focus of the meal. This naturally encourages a semi-vegetarian dietary pattern, especially in rural areas.

ii. Cultural significance of animal products: Despite the plant-heavy diet, meat and fish hold symbolic and social value**.** In traditional ceremonies – such as funerals, naming ceremonies, festivals, and weddings – animal products (eg, goat, chicken, fish) are often considered essential for hospitality and status. This has contributed to the perception that a meal is incomplete or less prestigious without meat.

iii. Religious influences: Some religious groups in Ghana promote vegetarianism as part of their beliefs and practices. For example, Seventh-Day Adventists, who have a notable presence in Ghana, advocate for vegetarianism on both health and spiritual grounds. This has helped raise awareness of the benefits of plant-based diets in certain communities.

c. Importance of vegetarianism in animal welfare

The importance of vegetarianism in animal welfare includes:

i. Reduction in animal slaughter: Every year, millions of animals are slaughtered for human consumption. Many of these animals are raised in inhumane conditions. Vegetarianism reduces the need to kill animals, helping to protect their right to life.

ii. Reduction in cruel farming practices: In industrial livestock systems, animals are often confined in small, overcrowded spaces, painful procedures without anaesthesia (eg, debeaking, tail docking) and stressful transportation and slaughter methods. A vegetarian diet reduces these practices.

iii. Promotion of humane treatment: Vegetarianism supports the idea that animals are beings that feel pain, stress, and exhibit fear, and should not be subjected to unnecessary suffering. It encourages respect for animal life and promotes the development of more ethical food systems.

iv. Encouragement of sustainable and ethical alternatives: The rise in vegetarianism encourages innovation in plant-based meat alternatives and ethical farming practices. This shift can lead to a reduction in factory farming, where most welfare abuses occur.

Learning Tasks

1. Learners search the Internet for information on the meaning and importance of animal welfare.
2. Learners to discuss the meaning and importance of animal welfare in light of climate change.

3. Learners to embark on an educational visit to an animal shelter or farm to observe and ask questions about the practice of animal welfare issues and take notes for discussion in class.
4. Learners to research and present on the impact of cultural attitudes and practices on animal welfare.
5. Learners to discuss the meaning and importance of vegetarianism in light of the increasing cost of animal production and welfare and the increasing production of vegetables and plant protein in Ghana.

Pedagogical Exemplars

1. **Collaborative Learning:** Learners in mixed ability groups search the Internet for information on the meaning and importance of animal welfare. The teacher should ensure that learners focus on searching for information concerning the lesson. Learners who are very good in browsing the Internet should be encouraged to lead, whilst learners having difficulty should be assisted.
2. **Structured Talk for Learning:** The teacher guides learners in their groups to discuss the meaning and importance of animal welfare in light of climate change. The teacher should assign a leadership role to more confident learners so that they can lead the discussion in class. Less confident learners should be encouraged to talk in class.
3. **Exploratory Learning:** Learners in mixed ability groups embark on an educational visit to an animal shelter or farm to observe and ask questions about animal welfare issues and take notes for discussion in class. The teacher should ensure that all safety measures and protocols are strictly adhered to by learners during the visit to the animal shelter or farm.
4. **Project-based learning:** Learners in mixed ability groups, research and present on the impact of cultural attitudes and practices on animal welfare. The teacher should encourage creativity and independent inquiry and assist any learners having difficulties.
5. **Structured Talk for Learning:** The teacher guides learners in their groups to discuss the meaning and importance of vegetarianism in light of the increasing cost of animal production and welfare, and the increasing production of vegetables and plant protein in Ghana. The teacher should guide learners with leading questions and encourage all learners to fully participate in the discussion.

Key Assessment Level 2: Essay-type Question

Compare the roles of the Veterinary Services Directorate and non-governmental organisations in enforcing animal welfare standards (10 marks)

PLC Session 23

45 minutes	Planning & Reviewing the Learning Plan

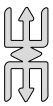
1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
   a. explain the week's concepts in a practical way that will make it easier for learners to understand
   b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).

3. Use your subject specific app to plan your lesson. Ask the app to

   a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.

   b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)

   c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Plan the week's key assessment with your app

   a. The key assessment for the week is essay-type questions. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the assessment (NTS 3k-3q).

10 minutes **Content Exploration**

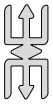
5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then

   a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)

   b. all teachers in the group work through a similar problem individually for 3–4 minutes

   c. the group then works through the problem together step by step

   d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes **Enactment**

6. Enact a teaching activity based on your learning plan (NTS la-1b, 1e-lg, 2c, 2e, 2f, 3c-3j and 3o).

   c. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.

   d. After the enactment, ask for structured feedback from the group

i. was the concept explained in a way that a learner with no prior knowledge could follow?
ii. were the examples grounded in contexts familiar to Ghanaian learners?
iii. did any misconceptions surface and if so, how were they addressed?

5 minutes **Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
   a. transfer your chats into your learning planner template.
   b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
   c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

SECTION 7 REVIEW

This section exposed learners to the key environmental and ethical issues in agriculture. Students examined the evolution of global and national climate change policies, including the Kyoto Protocol, Paris Agreement, Ghana's National Climate Change Policy, NDCs, and National Adaptation Plan (NAP). The REDD+ strategy was introduced, covering its definition, three implementation phases, components of national systems, Ghana's forest context, REDD+ framework, and financing mechanisms for climate action. Learners assessed the feasibility of REDD+ in Ghana's environmental and socio-economic setting. Also, the section addressed animal welfare, defining its principles and highlighting the Five Freedoms, laws and regulations at national and international levels, and the role of government in enforcement. Learners also explored enforcement challenges, the influence of vegetarianism and Ghanaian cultural attitudes toward animal welfare. These lessons helped learners connect environmental responsibility with ethical animal production practices.

MARKING SCHEME FOR THE KEY ASSESSMENTS

Week 21

Candidates are expected to identify and analyse at least 5 relevant ways global or national policy influences agriculture, with each point well explained**.** Each valid point earns 2 marks (1 mark for identification, 1 mark for explanation/analysis).

Expected Points

1. Promotion of Climate-Smart Agriculture (CSA): Global policies like those by FAO and UNFCCC have influenced Ghana to adopt CSA techniques such as drought-resistant crops and improved irrigation. (2 marks)
2. Green Climate Fund Support**:** Ghana receives funding and technical support from international climate finance mechanisms to implement climate-resilient agriculture projects. (2 marks)
3. Ghana's National Climate Change Policy (NCCP)**:** Advocates sustainable land use and promotes conservation agriculture to reduce vulnerability of the sector. (2 marks)
4. Paris Agreement Commitment**:** Ghana, as a signatory, has incorporated agricultural emissions and adaptation strategies into its Nationally Determined Contributions (NDCs). (2 marks)
5. Early Warning Systems & Research Policies: These have led to improved weather forecasting and extension services to help farmers respond to climate variability. (2 marks)
6. Reforestation and Agroforestry Initiatives: National and global policies encourage tree planting and integrating trees into farming to reduce the carbon footprint and improve soil health. (2 marks)
7. Promotion of Organic and Sustainable Inputs**:** This policy discourages the overuse of harmful agrochemicals and encourages eco-friendly alternatives. (2 marks)

Note

Any other relevant and accurate point not included here should be awarded 2 marks)

Week 22

The candidate's answer should cover:

1. Governance Structure of REDD+ in Ghan**a** – Description of how REDD+ is organised (4 marks)
2. Roles of Key Institutions – Identification and explanation of roles of relevant institutions (6 marks)

A. Governance Structure of REDD+ in Ghana (4 marks)

1. National REDD+ Secretariat (NRS): Coordinates the implementation of REDD+ activities. (1 mark)
2. REDD+ Steering Committee: Provides oversight and strategic direction, made up of government agencies, NGOs, and private sector representatives. (1 mark)
3. REDD+ Working Groups: Thematic or regional groups that provide technical input and stakeholder consultation. (1 mark)
4. Decentralised Implementation Units: Regional/District forest offices that support implementation and monitoring at the local level. (1 mark)

B. Roles of Key Institutions (6 marks)

Expect at least 6 correct institutional roles from the underlisted responses. (1 mark each)

1. Forestry Commission (FC): Leads implementation and policy development; hosts the REDD+ Secretariat.
2. Ministry of Lands and Natural Resources (MLNR): Provides policy direction and oversight, ensures REDD+ aligns with national development goals.
3. Environmental Protection Agency (EPA): Ensures environmental safeguards, monitors and evaluates environmental impacts.
4. Civil Society Organisations (CSOs): Participate in consultations, create awareness, and monitor safeguards.
5. Private Sector: Engages in sustainable land use and investment in REDD+ initiatives.
6. Traditional Authorities/Local Communities: Participate in implementation at the grassroots level, as they are key stakeholders in the use of land and forest resources.
7. Development Partners (eg World Bank, UN-REDD): Provide technical and financial support.

   (Any 6 of the above points = 6 × 1 mark = 6 marks).

   Total marks = (4 + 6 = 10)

Week 23

A. Roles of the Veterinary Services Directorate (VSD) (5 Marks)

The candidate is expected to provide at least **five** of the following roles:

i. Enforces national animal health and welfare policies and regulations.
ii. Conducts inspections of animal farms, abattoirs, and markets to ensure compliance with welfare standards.
iii. Promotes animal welfare through vaccination and disease surveillance programmes.
iv. Issues licenses for animal-based enterprises and ensures they comply with welfare standards.
v. Educates farmers, butchers, and the public on proper animal care and humane handling.
vi. Applies sanctions and penalties for violations of animal welfare laws.
vii. Works with local and international bodies to improve animal welfare.

Any 5 correct responses = 5 x 1 mark = 5 marks

B. Roles of Non-Governmental Organisations (NGOs) (5 marks)

The candidate is expected to provide at least 5 of the following roles:

i. Create advocacy and awareness for humane treatment of animals and champion policy reforms.
ii. Provide training for farmers, veterinarians, and animal handlers on welfare standards.
iii. Monitoring and reporting cases of abuse and neglect to the appropriate authorities.
iv. Offer shelters, rescue services, or veterinary care for abused or stray animals.
v. Collaborate with VSD and other agencies to enforce animal welfare laws.
vi. Research animal welfare issues and provide data to support policy changes.
vii. Access funding and technical support from global animal welfare networks**.**

Any 5 correct responses = 5 x 1 mark = 5 marks

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