

Agriculture

Junior High

Grade 10

Teacher Guide

Standards-Based



Papua New Guinea

Department of Education

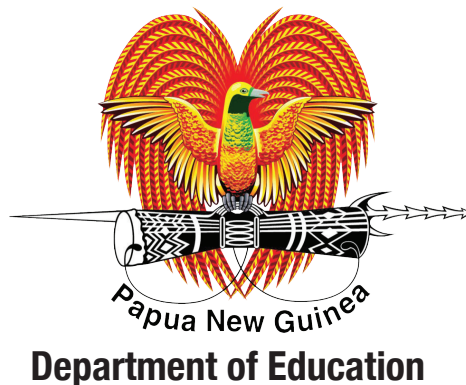
**'FREE ISSUE
NOT FOR SALE'**

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Issued free to schools by the Department of Education

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The department also acknowledges the late Dr Arnold Kukari as a consultant in the realignment and the development of SBC including this Teacher Guide. The Curriculum Panel (CP), Subject Advisory Committee (SAC) and Board of Studies (BOS) are acknowledged for their recommendations and endorsements of this Teacher Guide.

Acronyms

AAL	Assessment AS Learning
AFL	Assessment FOR Learning
AOL	Assessment OF Learning
BoS	Board of Studies
CDD	Curriculum Development Division
CP	Curriculum Panel
DA	Diagnostic Assessment
IHD	Integral Human Development
GoPNG	Government of PNG
OBC	Outcomes-Based Curriculum
OBE	Outcomes-Based Education
PNG	Papua New Guinea
SAC	Subject Advisory Committee
SBC	Standards-Based Curriculum
SBE	Standards-Based Education
SCG	Subject Curriculum Group
STEAM	Science, Technology, Engineering, Arts and Mathematics

Secretary's Message

The ultimate aim of Standards-Based Education in Papua New Guinea (PNG) is to prepare students for careers, higher education, and citizenship. Agriculture will therefore focus on providing students with careers, higher education, and citizenship preparedness knowledge, skills, values, and attitudes that they can use to work, study and live in the 21st Century.

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The Grade 10 Agriculture Teacher Guide has been developed to guide the teachers to use when implementing the Agriculture Syllabus. It expands the broad contents in the syllabus into teachable contents, the strategies for facilitating teaching and learning and how to assess using rubrics. The contents outlined contain essential knowledge, skills, values, and attitudes that are internationally comparable. This will prepare them for careers, higher education, and citizenship

Agriculture embraces STEAM and provides the students the opportunity to integrate Science, Technology, Engineering and Mathematics to equip students with the essential values, attitudes, skills and knowledge. The content captured enables students to acquire relevant knowledge, skills, attitudes and values to make and earn a living and lead productive lives as members of the local, national and international community.

It is therefore, important for Agriculture teachers to be creative, innovative and motivated when teaching Agriculture. The realigned Agriculture curriculum is focused on scientific skills and process, utilizing the analytical and inquiry-based approaches where students will be encouraged to predict, explore, question, test ideas, formulate questions and challenge their own ideas. Agricultural literacy is critically important for Papua New Guinea to participate productively in an increasingly competitive knowledge and technologically based society.

Teachers are encouraged to use the Teachers Guides in conjunction with the Syllabus and other relevant resources to generate creative teaching and learning activities to deliver the Agriculture content. Ensure that safety measures are taken at all times to avoid injuries.

I commend and approve this Agriculture Teachers Guide for Grade 10 to be used in all High and Secondary Schools throughout Papua New Guinea.



.....
UKE W. KOMBRA, PhD, OBE
Secretary for Education

Introduction

PNG shapes and is being shaped by the 21st Century social, economic, political, cultural, religious, and environmental discourses and practices. It is important to provide opportunities for students to learn in-depth and master the 21st Century knowledge, skills, values, and attitudes to prepare them for careers, higher education, and citizenship. There is an increasing demand for knowledge-based workers and workers with qualifications in STEAM globally. PNG children should be equipped with the necessary 21st century and STEAM knowledge, skills, values, and attitudes to ensure that they are marketable globally and can contribute meaningfully to the development of PNG.

Agriculture activity is a feature of everyone's life. Throughout the world people engage in a web of agricultural activities to cultivate, raise, produce, market, deliver and support a range of goods and services. In addition, investors, consumers and employees depend on the agriculture sector for much of their quality of life. The teaching of Agriculture as part of the Standards-Based Curriculum is crucial as it encompasses the theoretical and practical aspects of crop, animal, aquaculture, natural resource management and agribusiness in contexts which students will encounter throughout their lives. Conceptually, it offers learning from the planning of a small-scale agriculture farm to the management of operations, marketing, finance and human resources in large agriculture businesses.

The teaching of Agriculture as part of the Standards Based Curriculum is crucial as it encompasses the theoretical and practical aspects of Agriculture in contexts which students will encounter throughout their lives. Conceptually, it offers learning from crop and animal farming, aqua farming, natural resource management and sustainable practices, marketing, agribusiness.

These skills enhance their confidence and ability to participate effectively, not only as members of the agriculture world, but also as citizens dealing with issues arising from farming activity. Agriculture fosters intellectual, social and moral development and in-demand proficiencies so that students can make a meaningful contribution towards improving the material and social welfare of people. Thus, creating and living sustainable and resilient livelihoods, and sustaining an acceptable quality of life through the sustainable use of natural resources and creative and innovative farming and production methods to meet people's needs.

Students' employability will be enhanced through the study and application of STEAM principles. STEAM is an integral component of the core curriculum. It is envisioned that the study of STEAM will motivate students to pursue and take up academic programs and careers in STEAM related fields. Equal opportunities should be provided for all students to learn, apply and master STEAM principles and skills when integrated into the Agriculture study.

Time allocation for Agriculture is 200 minutes per week. Teachers are urged to fully utilise the allocated time for programming and timetabling

Structure of the Teacher Guide

There are four main parts to this teacher guide. They provide essential information on what all teachers should know and do to effectively implement the Agriculture.

Part 1 provides generic information to help the teachers to effectively use the teacher guide and the syllabus to plan, teach and assess students' performance and proficiency on the national content standards and grade-level benchmarks. The purpose of the teacher guide, syllabus and teacher guide alignment, and the four pillars of PNG SBC, that is, morals and values education, cognitive and high level thinking, and 21st Century thinking skills, STEAM, and core curriculum are explained to inform as well as guide the teachers so that they align SBE/SBC aims and goals, overarching and SBC principles, content standards, grade-level benchmarks, learning objectives and best practice when planning lessons, teaching, and assessing students.

Part 2 provides information on the strands, units, topics and learning objectives. How topics and learning objectives are derived is explained to the teachers to guide them to use the learning objectives provided for planning, instruction and assessment. And to develop additional topics and learning objectives to meet the learning needs of their students and communities where necessary.

Part 3 provides information on SBC planning to help guide the teachers when planning SBC lessons. Elements and standards for SBC lesson plans are described as well as how to plan for underachievers, use evidence to plan lessons, and use differentiated instruction, amongst other teaching and learning strategies.

Part 4 provides information on standards-based assessment, inclusive of performance assessment and standards, standards-based evaluation, standards-based reporting, and standards-based monitoring. This information should help the teachers to effectively assess, evaluate, report and monitor demonstration of significant aspects of a benchmark.

The above components are linked and closely aligned. They should be connected to ensure that the intended learning outcomes and the expected quality of education standards are achieved. The close alignment of planning, instruction and assessment is critical to the attainment of learning standards.

Purpose of the Teacher Guide

This teacher guide describes what all teachers should know and do to effectively plan, teach, and assess Grade 10 Agriculture content to enable all students to attain the required learning and proficiency standards.

The overarching purpose of this teacher guide is to help teachers to effectively plan, teach, assess, evaluate, report and monitor students' learning and mastery of national and grade-level expectations. That is, the essential knowledge, skills, values and attitudes (KSVAs) described in the content standards and grade-level benchmarks, and their achievement of the national and grade-level proficiency standards.

Ample information with thorough guidelines is provided for the teacher to use to achieve the essential KSAV embedded in the set national content standards and grade level benchmarks.

Thus, the teacher is expected to:

- understand the significance of aligning all the elements of Standards-Based Curriculum (SBC) as the basis for achieving the expected level of education quality;
- effectively align all the components of SBC when planning, teaching, and assessing students' learning and levels of proficiency;
- effectively translate and align the Agriculture syllabi and teacher guide to plan, teach and assess different Agriculture units and topics, and the KSVAs described in the grade-level benchmarks;
- understand the Agriculture national content standards, grade-level benchmarks, and evidence outcomes;
- effectively make sense of the content (KSVAs) described in the Agriculture national content standards and the essential components of the content described in the grade-level benchmarks;
- effectively guide students to progressively learn and demonstrate proficiency on a range of Agriculture skills, processes, concepts, ideas, principles, practices, values and attitudes;
- confidently interpret, translate and use Agriculture content standards and benchmarks to determine the learning objectives and performance standards, and plan appropriately to enable all students to achieve these standards;
- embed the core curriculum in their Agriculture lesson planning, instruction, and assessment to permit all students to learn and master the core KSVAs required of all students;
- provide opportunities for all students to understand how STEAM has and continues to shape the social, political, economic, cultural, and environment contexts and the consequences, and use STEAM principles, skills, processes, ideas and concepts to inquire into and solve problems relating to both the natural and physical (man-made) worlds as well as problems created by STEAM;
- integrate cognitive skills (critical, creative, reasoning, decision-making, and

problem-solving skills), high level thinking skills (analysis, synthesis and evaluation skills), values (personal, social, work, health, peace, relationship, sustaining values), and attitudes in lesson planning, instruction and assessment;

- meaningfully connect what students learn in Agriculture with what is learnt in other subjects to add value and enhance students' learning so that they can integrate what they learn and develop in-depth vertical and horizontal understanding of subject content;
- formulate effective SBC lesson plans using learning objectives identified for each of the topics;
- employ SBC assessment approaches to develop performance assessments to assess students' proficiency on a content standard or a component of the content standard described in the grade-level benchmark;
- effectively score and evaluate students' performance in relation to a core set of learning standards or criteria, and make sense of the data to ascertain students' status of progress towards meeting grade-level and nationally expected proficiency standards, and use evidence from the assessment of students' performance to develop effective evidence-based intervention strategies to help students' making inadequate or slow progress towards meeting the grade-level and national expectations to improve their learning and performance.

How to use the Teacher Guide

Teacher Guide provides essential information about what the teacher needs to know and do to effectively plan, teach and assess students learning and proficiency on learning and performance standards. The different components of the teacher guide are closely aligned with SBC principles and practice, and all the other components of PNG SBC. It should be read in conjunction with the syllabus in order to understand what is expected of teachers and students to achieve the envisaged quality of education outcomes.

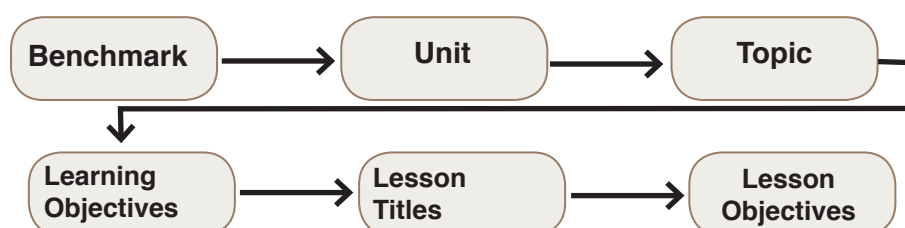
The first thing teachers should do is to read and understand each of the sections of the teacher guide to help them understand the key SBC concepts and ideas, alignment of PNG SBC components, alignment of the syllabus and teacher guide, setting of content standards and grade-level benchmarks, core curriculum, STEAM, curriculum integration, essential knowledge, skills, values and attitudes, strands, units and topics, learning objectives, SBC lesson planning, and SBC assessment. A thorough understanding of these components will help teachers meet the teacher expectations for implementing the SBC curriculum, and therefore the effective implementation of Agriculture Curriculum. Based on this understanding, teachers should be able to effectively use the teacher guide to do the following:

A thorough understanding of these components will help teachers meet the teacher expectations for implementing the SBC curriculum, and therefore the effective implementation of Grade 10 Agriculture Curriculum. Based on this understanding, teachers should be able to effectively use the teacher guide to do the following:

Determine Learning Objectives and Lesson Topics

Topics and learning objectives have been identified and described in the Teacher Guide. Learning objectives are derived from topics that are extracted from the grade-level benchmarks. Lesson topics are deduced from the learning objectives.

Teachers should familiarize themselves with this process as it is essential for lesson planning, instruction and assessment. However, depending on the context and students' learning abilities, teachers would be required to determine additional learning objectives and lesson titles. Teachers should use the examples provided in this teacher guide to formulate additional learning objectives and lesson titles to meet the educational or learning needs of their students,



Identify and Teach Grade Appropriate Content

Grade appropriate content has been identified and scoped and sequenced using appropriate content organisation principles. The content is sequenced using the spiraling sequence principles. This sequencing of content will enable students to progressively learn the essential knowledge, skills, values and attitudes as they progress further into their schooling. What students learn in previous grades is reinforced and deepens in scope with an increase in the level of complexity and difficulty in the content and learning activities.

It is important to understand how the content is organised so that grade appropriate content and learning activities can be selected, if not already embedded in the benchmarks and learning objectives, to not only help students learn and master the content, but ensure that what is taught is rigorous, challenging, and comparable.

Integrate the Core Curriculum in Lesson Planning, Instruction and Assessment

Teachers should use this teacher guide to help them integrate the core curriculum values, cognitive and high level skills, 21st Century skills, STEAM principles and skills, and reading, writing, and communication skills in their lesson planning, instruction and assessment. All students in all subjects are required to learn and master these skills progressively through the education system.

Integrate Cognitive, High Level, and 21st Century Skills in Lesson Planning, Instruction and Assessment

Teachers should integrate the cognitive, high level and 21st century skills in their annual teaching programs, and give prominence to these skills in their lesson preparation, teaching and learning activities, performance assessment, and performance standards for measuring students' proficiency on these skills. Agriculture addresses skills, processes and competencies in the study of Crops, Animals, Aquaculture, Natural Resource Management and Agribusiness. Thus, students will be able to make informed decisions in a variety of Agriculture contexts. This enables them to function effectively in the work place and higher education environments as productive and useful citizens of a culturally diverse and democratic society in an interdependent world.

In addition, it envisaged all students attaining expected proficiency levels in these skills and will be ready to pursue careers and higher education academic programs that demand these skills, and use them in their everyday life after they leave school at the end of Grade 12. Teachers should use the teacher guide to help them to effectively embed these skills, particularly in their lesson planning and in the teaching and learning activities as well as in the assessment of students' application of the skills.

Ingrate Agriculture values and attitudes in Lesson Planning, Instruction and Assessment

In Agriculture, students are expected to learn, promote and use work, relationship, peace, health, social, personal, family, community, national and global values in the work and study environments as well as in their conduct as community, national and global citizens. Teachers should draw from the information and suggestions provided in the syllabus and teacher guide to integrate values and attitudes in their lesson planning, instruction, and assessment. They should report on students' progression towards internalizing different values and attitudes and provide additional support to students who are yet to reach the internalization stage to make positive progress towards this level.

Integrate Science, Technology, Engineering, Arts and Mathematics (STEAM) Principles and Skills in Lesson Planning, Instruction and Assessment

Teachers should draw from both the syllabus and teacher guide in order to help them integrate STEAM principles and skills, and methodologies in their lesson planning, instruction and assessment. STEAM teaching and learning happens both inside and outside of the classroom. Effective STEAM teaching and learning requires both the teacher and the student to participate as core investigators and learners, and to work in partnership and collaboration with relevant stakeholders to achieve maximum results. Teachers should use the syllabus, teacher guides and other resources to guide them to plan and implement this and other innovative and creative approaches to STEAM teaching and learning to make STEAM principles and skills learning fun and enjoyable and, at the same time, attain the intended quality of learning outcomes.

Identify and Use Grade and Context Appropriate, Innovative, Differentiated and Creative Teaching and Learning Methodologies

SBC is an eclectic curriculum model. It is an amalgam of strengths of different curriculum types, including behavioural objectives, outcomes, and competency. Its emphasis is on students attaining clearly defined, measurable, observable and attainable learning standards, i.e., the expected level of education quality. Proficiency (competency) standards are expressed as performance standards/criteria and evidence outcomes, that is, what all students are expected to know (content) and do (application of content in real life or related situations) to indicate that they are meeting, have met or exceeded the learning standards.

The selection of grade and contextually appropriate teaching and learning methodologies is critical to enabling all students to achieve the expected standard or quality of education. Teaching and learning methodologies must be aligned to the content, learning objective, and performance standard in order for the teacher to effectively teach and guide students towards meeting the performance standard for the lesson. They should be equitable and socially inclusive, differentiate, student-centred, and lifelong. They should

enable STEAM principles and skills to be effectively taught and learned by students. Teachers should use the teacher guide to help them make informed decisions when selecting the types of teaching and learning methodologies to use in their teaching of the subject content, including STEAM principles and skills.

Plan Standards-Based Lessons

SBC lesson planning is quite difficult to do. However, this will be easier with more practice and experience over time. Effective SBC lesson plans must meet the required standards or criteria so that the learning objectives and performance standards are closely aligned to attain the expected learning outcomes. Teachers should use the guidelines and standards for SBC lesson planning and examples of SBC lesson plans provided in the teacher guide to plan their lessons. When planning lessons, it is important for teachers to ensure that all SBC lesson planning standards or criteria are met. If standards are not met, instruction will not lead to the attainment of intended performance and proficiency standards. Therefore, students will not attain the national content standards and grade-level benchmarks.

Use Standards-Based Assessment

Standards-Based Assessment has a number of components. These components are intertwined and serve to measure evaluate, report, and monitor students' achievement of the national and grade-level expectations, i.e., the essential knowledge, skills, values and attitudes they are expected to master and demonstrate proficiency on. Teachers should use the information and examples on standards-based assessment to plan, assess, record, evaluate, report and monitor students' performance in relation to the learning standards.

Make informed Judgments About Students' Learning and Progress Towards Meeting Learning Standards

Teachers should use the teacher-guide to effectively evaluate students' performance and use the evidence to help students to continuously improve their learning as well as their classroom practice.

It is important that teachers evaluate the performance of students in relation to the performance standards and progressively the grade-level benchmarks and content standards to make informed judgments and decisions about the quality of their work and their progress towards meeting the content standards or components of the standards. Evaluation should not focus on only one aspect of students' performance. It should aim to provide a complete picture of each student's performance. The context, inputs, processes, including teaching and learning processes, and the outcomes should be evaluated to make an informed judgment about each student's performance; Teachers should identify the causal factors for poor performance, gaps in students learning, gaps in teaching, teaching and learning resource constraints, and general attitude towards learning. Evidence-based decisions can then be made regarding the interventions for closing the gaps to allow students to make the required progress towards meeting grade-level and national expectations.

Prepare Students' Performance Reports

Reporting of students' performance and progress towards the attainment of learning standards is an essential part of SBC assessment. Results of students' performance should be communicated to particularly the students and their parents to keep them informed of students' academic achievements and learning challenges as well as what needs to be done to enable the students' make positive progress towards meeting the proficiency standards and achieve the desired level of education quality. Teachers should use the information on the reporting of students' assessment results and the templates provided to report the results of students' learning.

Monitor Students' Progress Towards Meeting the National Content Standards and Grade-Level Benchmarks

Monitoring of student's progress towards the attainment of learning standards is an essential component of standards-based assessment. It is an evidence-based process that involves the use of data from students' performance assessments to make informed judgements about students' learning and proficiency on the learning standards or their components, identify gaps in students' learning and the causal factors, set clear learning improvement targets, and develop effective evidence-based strategies (including preplanning and re-teaching of topics), set clear timeframes, and identify measures for measuring students' progress towards achieving the learning targets.

Teachers should use the teacher guide to help them use data from students' performance assessments to identify individual students' learning weaknesses and develop interventions, in collaboration with each student and his/her parents or guardians, to address the weaknesses and monitor their progress towards meeting the agreed learning goals.

Develop additional Benchmarks

Teachers can develop additional benchmarks using the examples in the teacher guide to meet the learning needs of their students and local communities. However, these benchmarks will not be nationally assessed as these are not comparable. They are not allowed to set their own content standards or manipulate the existing ones. The setting of national content standards is done at the national level to ensure that required learning standards are maintained and monitored to sustain the required level of education quality.

Avoid Standardisation

The implementation of Agriculture curriculum must not be standardised. SBC does not mean that the content, lesson objectives, teaching and learning strategies, and assessment are standardised. This is a misconception and any attempt to standardise the components of curriculum without due consideration of the teaching and learning contexts, children's backgrounds and experiences, and different abilities and learning styles of children will be counterproductive. It will hinder students from achieving the expected proficiency standards and hence, high academic standards and the desired level of education quality. That is, they should not be applied across all

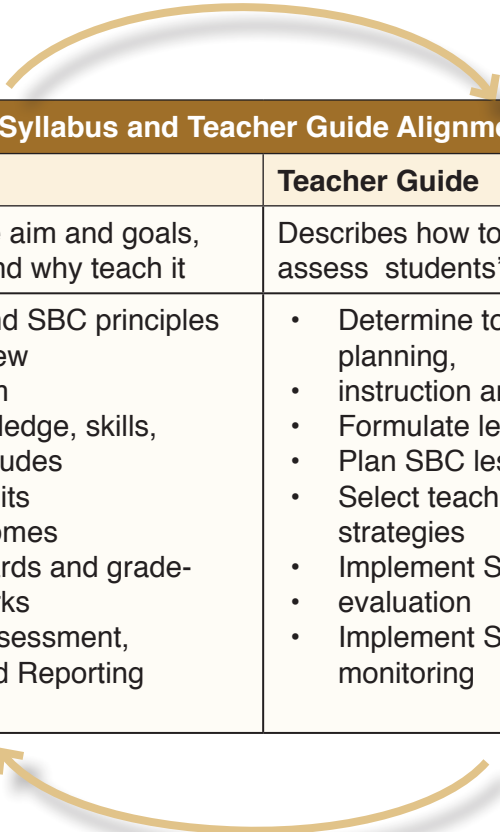
contexts and with all students, without considering the educational needs and the characteristics of each context. Teachers must use innovative, creative, culturally relevant, and differentiated or varied the teaching and learning approaches to teach the curriculum to enable their students to achieve the national content standards and grade-level benchmarks. This will enable all students to experience success in learning the curriculum and achieve high academic standards.

What is provided in the syllabus and teacher guide are not fixed and can be changed. Teachers should use the information and examples provided in the syllabus and the teacher guide to guide them to develop, select, and use grade, context, and learner appropriate content, learning objectives, teaching and learning strategies, and performance assessment and standards. SBC is evidence-based hence decisions about the content, learning outcomes, teaching and learning strategies, students' performance, and learning interventions should be based on evidence. Teaching and learning should be continuously improved and effectively targeted using evidence from students' assessment and other sources.

Syllabus and Teacher Guide Alignment

A teacher guide is a framework that describes how to translate the content standards and benchmarks (learning standards) outlined in the syllabus into units and topics, learning objectives, lesson plans, teaching and learning strategies, performance assessment, and measures for measuring students' performance (performance standards). It expands the content overview and describes how this content identified in the content standards and their components (essential KSVAs) can be translated into meaningful and evidence-based teaching topics and learning objectives for lesson planning, instruction and assessment. It also describes and provides examples of how to evaluate and report on students' attainment of the learning standards, and use evidence from the assessment of students' performance to develop evidence-based interventions to assist students who are making slow progress towards meeting the expected proficiency levels to improve their performance.

Grade 10 Agriculture comprises of the Syllabus and Teacher Guide. These two documents are closely aligned, complimentary and mutually beneficial. They are the essential focal points for teaching and learning the essential Social Science knowledge, skills, values and attitudes.



Syllabus and Teacher Guide Alignment	
Syllabus	Teacher Guide
Outlines the ultimate aim and goals, and what to teach and why teach it • Overarching and SBC principles • Content overview • Core curriculum • Essential knowledge, skills, values and attitudes • Strands and units • Evidence outcomes • Content standards and grade-level benchmarks • Overview of assessment, evaluation, and Reporting	Describes how to plan, teach, and assess students' performance • Determine topics for lesson planning, • instruction and assessment • Formulate learning objectives • Plan SBC lesson plans • Select teaching and learning strategies • Implement SBC assessment and evaluation • Implement SBC reporting and monitoring

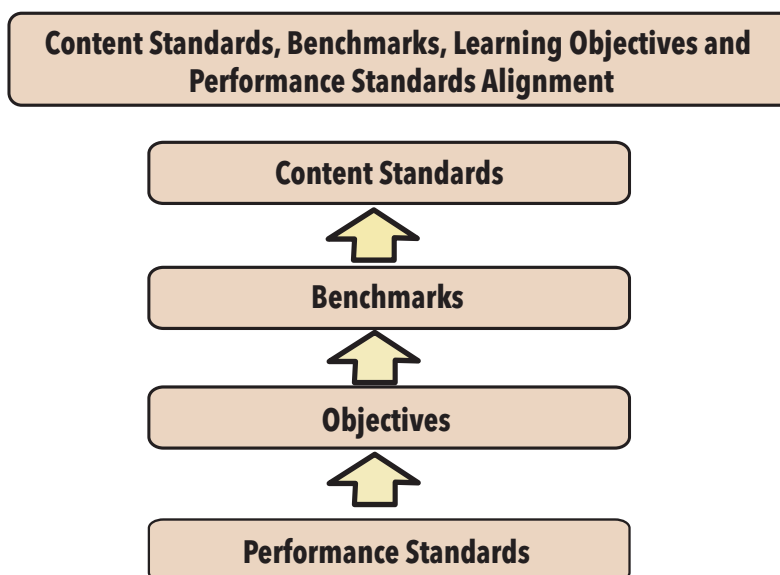
The syllabus outlines the ultimate aim and goals of SBE and SBC, what is to be taught and why it should be learned by students, the underlying principles and articulates the learning and proficiency standards that all students are expected to attain. On the other hand, the teacher guide expands on what is outlined in the syllabus by describing the approaches or the how of planning, teaching, learning, and assessing the content so that the intended learning outcomes are achieved.

This teacher guide should be used in conjunction with the syllabus. Teachers should use these documents when planning, teaching and assessing Grade 10 Agriculture content.

Teachers will extract information from the syllabus (e.g., content standards and grade-level benchmarks) for lesson planning, instruction and is for measuring students' attainment a content standard as well as progress to the next grade of schooling.

Learning and Performance Standards Alignment

Content Standards, Benchmarks, Learning Objectives, and Performance Standards are very closely linked and aligned (see figure 3). There is a close linear relationship between these standards. Students' performance on a significant aspect of a benchmark (KSVA) is measured against a set of performance standards or criteria to determine their level of proficiency using performance assessment. Using the evidence from the performance assessment, individual student's proficiency on the aspect of the benchmark assessed and progression towards meeting the benchmark and hence the content standard are then determined.



Effective alignment of these learning standards and all the other components of PNG SBE and SBC (ultimate aim and goals, overarching, SBC and subject-based principles, core curriculum, STEAM, and cognitive, high level, and 21st Century skills) is not only critical but is also key to the achievement of high academic standards by all students and the intended level of education quality. It is essential that teachers know and can do standards alignment when planning, teaching, and assessing students' performance so that they can effectively guide their students towards meeting the grade-level benchmarks (grade expectations) and subsequently the content standards (national expectations).

Learning and Performance Standards

Standards-Based Education (SBE) are underpinned by the notion of quality. Standards define the expected level of education quality that all students should achieve at a particular point in their schooling. Students' progression and achievement of education standard (s) are measured using performance standards or criteria to determine their demonstration or performance on significant aspects of the standards to determine their levels of proficiency or competency. When they are judged to have attained proficiency on a content standard or benchmark or components of these standards, they are then deemed to have met the standard(s) that is, achieved the intended level of education quality.

Content standards, benchmarks, and learning objectives are called learning standards while performance and proficiency standards (evidence outcomes) can be categorised as performance standards. These standards are used to measure students' performance, proficiency, progression and achievement of the desired level of education quality. Teachers are expected to understand and use these standards for lesson planning, instruction and assessment

Content Standards

Content standards are evidence-based, rigorous and comparable regionally and globally. They have been formulated to target critical social, economic, political, cultural, environment, and employable skills gaps identified from a situational analysis. They were developed using examples and experiences from other countries and best practice, and contextualised to PNG contexts.

Content standards describe what **(content-knowledge,skills,values, and attitudes)** all students are expected to know and do **(how well students must learn and apply what is set out in the content standards)** at each grade-level before proceeding to the next grade.

- are evidenced-based;
- are rigorous and comparable to regional and global standards;
- are set at the national level;
- state or describe the expected levels of quality or achievement;
- are clear, measurable and attainable;
- are linked to and aligned with the ultimate aim and goals of SBE and SBC and overarching and SBC principles;
- delineate what matters, provide clear expectations of what students should progressively learn and achieve in school, and guide lesson planning, instruction, assessment;
- comprise knowledge, skills, values, and attitudes that are the basis for quality education;
- provide teachers a clear basis for planning, teaching, and assessing lessons;
- provide provinces, districts, and schools with a clear focus on how to develop and organise their instruction and assessment programs as well as the content that they will include in their curriculum.

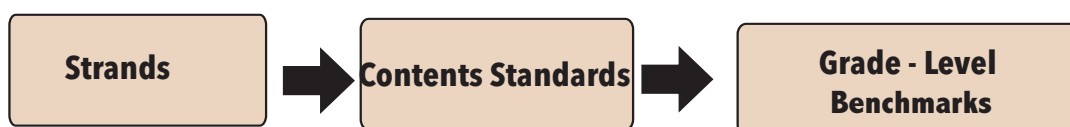
Benchmarks

Benchmarks are derived from the content standards and benchmarked at the grade-level. Benchmarks are specific statements of what students should know (i.e., essential knowledge, skills, values or attitudes) at a specific grade-level or school level. They provide the basis for measuring students' attainment of a content standard as well as progress to the next grade of schooling.

Grade-level benchmarks:

- are evidenced-based;
- are rigorous and comparable to regional and global standards;
- are set at the grade level;
- are linked to the national content standards;
- are clear, measurable, observable and attainable;
- articulate grade level expectations of what students are able to demonstrate to indicate that they are making progress towards attaining the national content standards;
- provide teachers a clear basis for planning, teaching, and assessing lessons;
- state clearly what students should do with what they have learned at the end of each school-level;
- enable students' progress towards the attainment of national content standards to be measured, and
- enable PNG students' performance to be compared with the performance of students in other countries.

Approach for Setting National Content Standards and Grade - Level Benchmarks

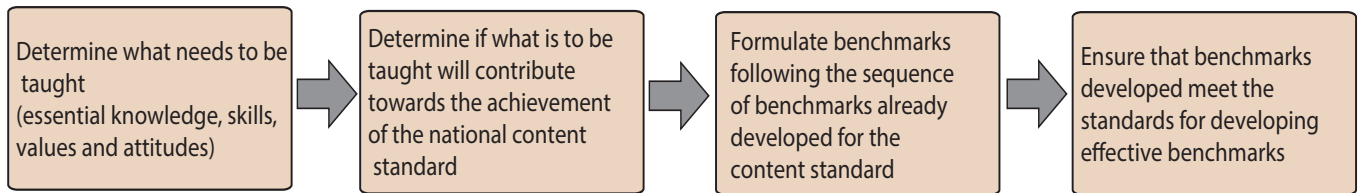


Development of Additional Benchmarks

Teachers should develop additional benchmarks to meet the learning needs of their students. They should engage their students to learn about local, provincial, national and global issues that have not been catered for in the grade-level benchmarks but are important and can enhance students' understanding and application of the content.

However, it is important to note that these benchmarks will not be nationally examined as they are not comparable. Only the benchmarks developed at the national level will be tested. This does not mean that teachers should not develop additional benchmarks. An innovative, reflect, creative and reflexive teacher will continuously reflect on his/her classroom practice and use evidence to provide challenging, relevant, and enjoyable learning opportunities for his/her students to build on the national expectations for students. Teachers should follow the following process when developing additional grade-level benchmark

Benchmark Development Process



Learning Objectives

Learning or Instructional Objectives are precise statements of educational intent. They are formulated using a significant aspect or a topic derived from the benchmark, and is aligned with the educational goals, content standards, benchmarks, and performance standards. Learning objectives are stated in outcomes language that describes the products or behaviours that will be provided by students. They are stated in terms of measurable and observable student behaviour. *For example*, students will be able to identify all the main towns of PNG using a map.

Performance Standards

Performance Standards are concrete statements of how well students must learn what is set out in the content standards, often called the **“be able to do”** of “what students should know and be able to do.” Performance standards are the indicators of quality that specify how competent a students’ demonstration or performance must be. They are explicit definitions of what students **must do to demonstrate proficiency or competency at a specific level on the content standards.**

Performance standards:

- measure students’ performance and proficiency (**using performance indicators**) in the use of a specific knowledge, skill, value, or attitude in real life or related situations
- provide the basis (**performance indicators**) for evaluating, reporting and monitoring students’ level of proficiency in use of a specific knowledge, skills, value, or attitude
- are used to plan for individual instruction to help students not yet meeting expectations (**desired level of mastery and proficiency**) to make adequate progress towards the full attainment of benchmarks and content standards
- are used as the basis for measuring students’ progress towards meeting grade-level benchmarks and content standards

Proficiency Standards

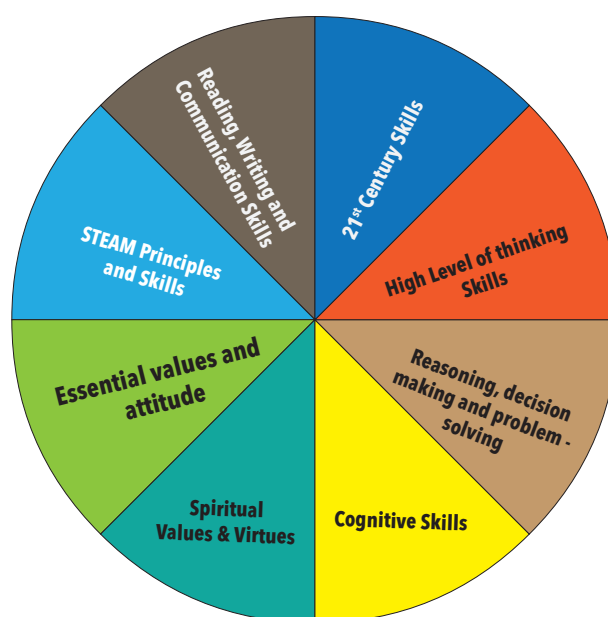
Proficiency standards describe what all students in a particular grade or school level can do” at the end of a strand, or unit. These standards are sometimes called evidence outcomes because they indicate if students can actually apply or use what they have learnt in real life or similar situations. They are also categorized as benchmarks because that is what all students are expected to do before exiting a grade or are deemed ready for the next grade.

Core Curriculum

A core set of common learnings (knowledge, skills, values, and attitudes) are integrated into the content standards and grade-level benchmarks for all subjects. This is to equip all students with the most essential and in-demand knowledge, skills, and dispositions they will need to be successful in modern/postmodern work places, higher-education programs and to be productive, responsible, considerate, and harmonious citizens. Common set of learnings are spirally sequenced from Preparatory - Grade 9 to deepen the scope and increase the level of difficulty in the learning activities so that what is learned is reinforced at different grade levels.

The core curriculum includes:

- cognitive (thinking) skills (Refer to the syllabus for a list of these skills);
- reasoning, decision-making and problem-solving skills
- high level thinking skills (analysis, synthesis and evaluation skills);
- 21st Century skills (Refer to illustrative list in the Appendix);
- reading, writing and communication skills;
- STEAM principles and skills;
- essential values and attitudes (Core personal and social values, and sustaining values), and
- spiritual values and virtues.



The essential knowledge, skills, values and attitudes comprising the core curriculum are interwoven and provide an essential and holistic framework for preparing all students for careers, higher education and citizenship.

All teachers are expected to include the core learnings in their lesson planning, teaching, and assessment of students in all their lessons. They are expected to foster, promote and model the essential values and attitudes as well as the spiritual values and virtues in their conduct, practice, appearance, and their relationships and in their professional and personal lives. In addition, teachers are expected to mentor, mould and shape each student to evolve and possess the qualities envisioned by society.

Core values and attitudes must not be taught in the classroom only; they must also be demonstrated by students in real life or related situations inside and outside of the classroom, at home, and in everyday life. Likewise, they must be promoted, fostered and modeled by the school community and its stakeholders, especially parents. A whole of school approach to values and attitudes teaching, promoting and modeling is critical to students and the whole school community internalising the core values and attitudes and making them habitual in their work and school place, and in everyday life. Be it work values, relationship values, peace values, health values, personal and social values, or religious values, teachers should give equal prominence to all common learnings in their lesson planning, teaching, assessment, and learning interventions. Common learnings must be at the heart of all teaching and extracurricular programs and activities.

Integrating Core Curriculum in the Teaching and Learning

The above knowledge, skills, values and attitudes should be taught and assessed by all teachers from Prep to Grade 12 across subject's fields and subjects through the assessment of evidence outcomes. Teachers must ensure that the core curriculum are reinforced at each school grade and school level to enable students to become proficient in their application in different career, higher education and citizenship contexts. Students' learning is based on their ability to master and demonstrate proficiency in the use of essential knowledge, processes, skills, values, and attitudes in real life or related situations.

A practical example of integrating core curriculum in Teaching and Learning

Teachers can identify a set of core curriculum to teach in one lesson, For example, In Technology and Industrial Arts, Students may be posed with the dilemma to find solutions on how technology can be used to improve food security in their area.

Students will be required to use what they learnt in Social Science about the casual effects of climate change on the livelihood of people. They can use STEAM principles and skills in finding cause and solutions, use high level thinking skills to analyze and evaluate the effects and how to improve food security, use decision making and critical thinking skills to find the solutions for food security, use technology to design the best food security model and be able to confidently and boldly communicate their findings and present intelligent and convincing arguments, then we can conclude that learning of the core curriculum is evident. If students can be able to demonstrate mastery, proficiency and competency of core curriculum in such a manner, then the learning of core curriculum has been achieved.

Science, Technology, Engineering, Arts and Mathematics

STEAM education is an integrated, multidisciplinary approach to learning that uses Science, Technology, Engineering, Arts and Mathematics as the basis for inquiring about how STEAM has and continues to change and impact the social, political, economic, cultural and environmental contexts and identifying and solving authentic (real life) natural and physical environment problems by integrating STEAM-based principles, cognitive, high level and 21st Century skills and processes, and values and attitudes.

Agriculture as a science field is focused on both goals of STEAM rather than just the goal of problem solving. This is to ensure that all students are provided opportunities to learn, integrate, and demonstrate proficiency on all essential STEAM principles, processes, skills, values and attitudes to prepare them for careers, higher education and citizenship.

Objectives

Students will be able to;

- Examine and use evidence to draw conclusions about how STEAM has and continues to change the social, political, economic, cultural and environmental contexts.
- Investigate and draw conclusions on the impact of STEAM solutions to problems on the social, political, economic, cultural and environmental contexts.
- Identify and solve problems using STEAM principles, skills, concepts, ideas and process.
- Identify, analyse and select the best solution to address a problem.
- Build prototypes or models of solutions to problems.
- Replicate a problem solution by building models and explaining how the problem was or could be solved.
- Test and reflect on the best solution chosen to solve a problem.
- Collaborate with others on a problem and provide a report on the process of problem solving used to solve the problem.
- Use skills and processes learnt from lessons to work on and complete STEAM projects.
- Demonstrate STEAM principles, skills, processes, concepts and ideas through simulation and modelling.
- Explain the significance of values and attitudes in problem-solving.

STEAM is a multidisciplinary and integrated approach to understanding how Science, Technology, Engineering, Arts and Mathematics shape and is shaped by our material, intellectual, cultural, economic, social, political and environmental contexts. And for teaching students the essential in demand cognitive, high level and 21st Century skills, values and attitudes, and empower them to effectively use these skills and predispositions to identify and solve problems relating to the natural and physical environments as well as the impact of STEAM-based solutions on human existence and livelihoods, and on the social, political, economic, cultural, and environmental systems.

STEAM disciplines have and continue to shape the way we perceive knowledge and reality, think and act, our values, attitudes, and behaviours, and the way we relate to each other and the environment. Most of the things we enjoy and consume are developed using STEAM principles, skills, process, concepts and ideas. Things humans used and enjoyed in the past and at present are developed by scientists, technologists, engineers, artists and mathematicians to address particular human needs and wants. Overtime, more needs were identified and more products were developed to meet the ever changing and evolving human needs.

What is produced and used is continuously reflected upon, evaluated, redesigned, and improved to make it more advanced, multipurpose, fit for purpose, and targeted towards not only improving the prevailing social, political, economic, cultural and environmental conditions but also to effectively respond to the evolving and changing dynamics of human needs and wants. And, at the same time, solutions to human problems and needs are being investigated and designed to address problems that are yet to be addressed and concurred. This is an evolving and ongoing problem-solving process that integrates cognitive, high level, and 21st Century skills, and appropriate values and attitudes.

STEAM is a significant framework and focal point for teaching and guiding students to learn, master and use a broad range of skills and processes required to meet the skills demands of PNG and the 21st Century. The skills that students will learn will reflect the demands that will be placed upon them in a complex, competitive, knowledge-based, information-age, technology-driven economy and society. These skills include cognitive (critical, synthetic, creative, reasoning, decision-making, and problem-solving) skills, high level (analysis, synthesis and evaluation) skills and 21st Century skills (see Appendix 4). Knowledge-based, information, and technology driven economies require knowledge workers not technicians. Knowledge workers are lifelong learners, are problem solvers, innovators, creators, critical and creative thinkers, reflective practitioners, researchers (knowledge producers rather than knowledge consumers), solutions seekers, outcomes oriented, evidence-based decision makers, and enablers of improved and better outcomes for all.

STEAM focuses on the skills and processes of problem solving. These skills and processes are at the heart of the STEAM movement and approach to not only problem solving and providing evidence-based solutions but also the development and use of other essential cognitive, high level and 21st Century skills. These skills are intertwined and used simultaneously to gain a broader understanding of the problems to enable creative, innovative, contextually relevant, and best solutions to be developed and implemented to solve the problems and attain the desired outcomes. It is assumed that by teaching students STEAM-based problem-solving skills and providing learning opportunities inside and outside the classroom will motivate more of them to pursue careers and academic programs in STEAM related fields thus, closing the skills gaps and providing a pool of cadre of workers required by technology, engineering, science, and mathematics-oriented industries.

Although, STEAM focuses on the development and application of skills in authentic (real life) contexts, for example the use of problem –solving skills to identify and solve problems relating to the natural and physical worlds. It does not take into account the significant influence that values and attitudes have on the entire process of problem solving. Values and attitudes are intertwined with knowledge and skills. Knowledge, skills, values and attitudes are inseparable. Decisions about skills and processes of skills development and application are influenced by values and attitudes (mindset) that people hold. In the same light, the use of STEAM principles, processes and skills to solve problems in order to achieve the outcomes envisaged by society are influenced by values and the mind set of those who have identified and investigated the problem as well as those who are affected by the problem and will benefit from the outcome

STEAM Problem-Solving Processes

Problem-solving involves the use of problem-solving methods and processes to identify and define a problem, gather information to understand its causes, draw conclusions, and use the evidence to design and implement solutions to address it. Even though there are many different problem-solving methods and approaches, they share some of the steps of problem-solving, such as;

- identifying the problem,
- understanding the problem by collecting data,
- analyse and interpret the data,
- draw conclusions,
- use data to consider possible solutions,
- select the best solution,
- test the effectiveness of the solution by trialling and evaluating it, and
- review and improve the solution.

STEAM problem solving processes go from simple and technical to advance and knowledge-based processes. However, regardless of the type of process used, students should be provided opportunities to learn the essential principles and processes of problem solving and, more significantly, to design and create a product that addressed a real problem and meets a human need. The following are some of the STEAM problem solving processes.

1. Engineering and Technology Problem Solving Methods and Approaches

Engineering and technology problem-solving methods are used to identify and solve problems relating to the physical world using the design process. The following are some of the methods and approaches used to solve engineering and technology related problems.

Parts Substitution

It is the most basic of the problem-solving methods. It simply requires the parts to be substituted until the problem is solved.

Diagnostics

After identifying a problem, the technician would run tests to pinpoint the fault. The test results would be used either as a guide for further testing or for replacement of a part, which also need to be tested. This process continues until the solution is found and the device is operating properly.

Troubleshooting

Troubleshooting is a form of problem solving, often applied to repair failed products or processes.

Reverse Engineering

Reverse engineering is the process of discovering the technological principles underlying the design of a device by taking the device apart, or carefully tracing its workings or its circuitry. It is useful when students are attempting to build something for which they have no formal drawings or schematics.

Divide and Conquer

Divide and conquer is the technique of breaking down a problem into sub problems, then breaking the sub-problems down even further until each of them is simple enough to be solved. Divide and conquer may be applied to all groups of students to tackle sub-problems of a larger problem, or when a problem is so large that its solution cannot be visualised without breaking it down into smaller components.

Extreme Cases

Considering “extreme cases”- envisioning the problem in a greatly exaggerated or greatly simplified form, or testing using extreme condition - can often help to pinpoint a problem. An example of the extreme-case method is purposely inputting an extremely high number to test a computer program.

Trial and Error

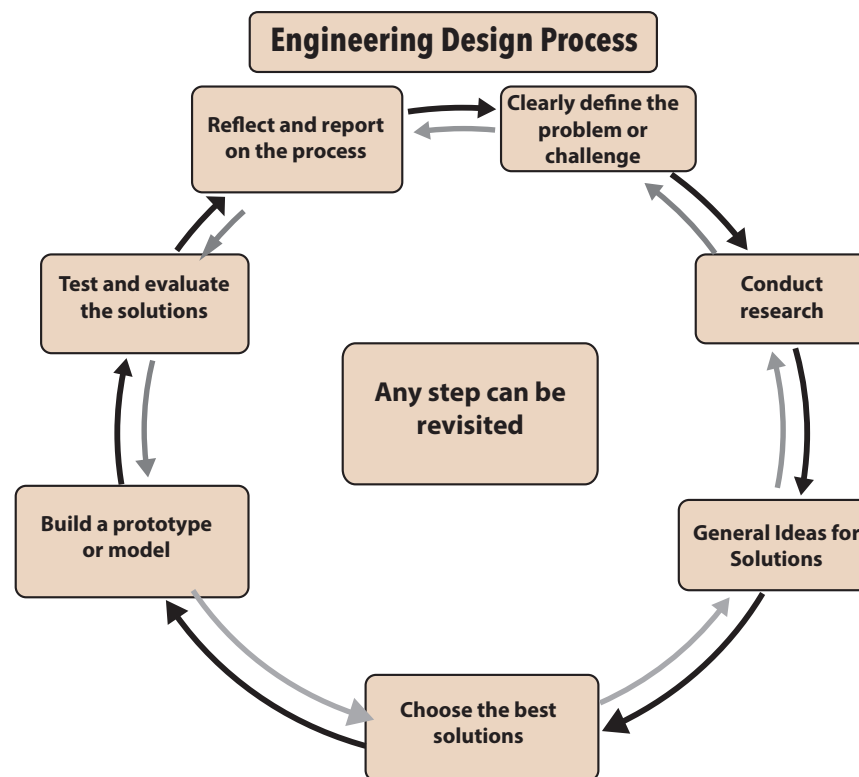
The trial and error method involve trying different approaches until a solution is found. It is often used as a last resort when other methods have been exhausted.

2. Engineering Design Process

Technological fields use the engineering design process to identify and define the problem or challenge, investigate the problem, collect and analyse data, and use the data to formulate potential solutions to the problem, analyse each of the solutions in terms of its strengths and weaknesses, and choose the best solution to solve the problem. It is an open-ended problem-solving process that involves the full planning and development of products or services to meet identified needs. It involves a sequence of steps such as the following;

1. Analyse the context and background, and clearly define the problem.
2. Conduct research to determine design criteria, financial or other constraints, and availability of materials.
3. Generate ideas for potential solutions, using processes such as brainstorming and sketching.

4. Choose the best solution.
5. Build a prototype or model.
6. Test and evaluate the solution.
7. Repeat steps as necessary to modify the design or correct faults.
8. Reflect and report on the process.



3. The Scientific Method and Approach to Problem-Solving

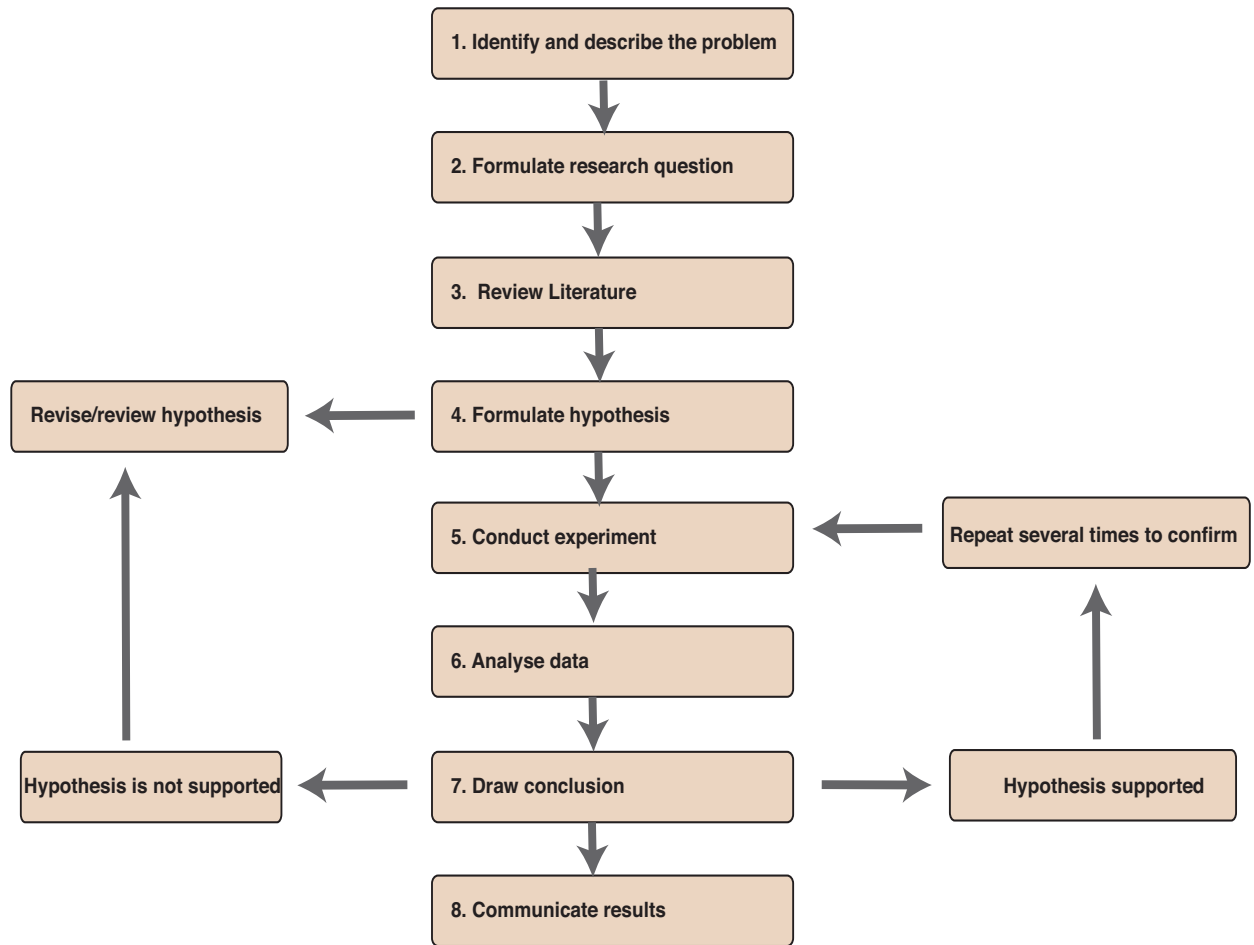
Science uses predominantly the quantitative-scientific inquiry process to investigate, understand, and make informed decisions about problems relating to the natural world. The steps in the process vary, depending on the purpose of the inquiry and the types of questions asked. There are six basic science process skills:

- Observation
- Communication
- Classification
- Measurement
- Inference
- Prediction

These processes are at the heart of the scientific inquiry and problem-solving process.

The steps above should be taught and demonstrated by students separately and jointly before they implement the inquiry process. Students should be guided through every step of the process so that they can explain it and its importance, and use the steps and the whole process proficiently to identify, investigate and solve problems. A brief explanation and examples of each step are provided below to help teachers plan and teach each step.

Students should be provided with opportunities to practice and reflect on each step until they demonstrate the expected level of proficiency before moving on to the next one.



The steps above should be taught and demonstrated by student separately and jointly before they implement the inquiry process. Students should be guided through every step of the process so that they can explain them, their importance and use the steps and the whole process proficiently to identify, investigate and solve problems. A brief explanations and examples of each step are provided below to assist teachers plan and teach each step. Students should be provided with opportunities to practice and reflect on each step until they demonstrate the expected level of proficiency before moving on to the next step.

Step 1: Identify and describe the problem

Problems are identified mainly from observations and the use the five senses – smell, sight, sound, touch and taste. Students should be guided and provided opportunities to identify natural and physical environment problems using their five senses and describe what the problem is and its likely causes.

Example: Observation

When I turn on a flashlight using the on/off switch, light comes out of one end.

Step 2: Formulate research question

After the problem is identified and described, the question to be answered is then formulated. This question will guide the scientist in conducting research and experiments.

Example: Question

What makes light come out of a flash light when I turn it on?

Step 3: Review literature

It is more likely that the research problem and question have already been investigated and reported by someone. Therefore, after asking the question, the scientist spends some time reading and reviewing papers and books on past research and discussions to learn more about the problem and the question asked to prepare for his or her own research. Conducting literature review helps the scientist to better understand his or her research problem, refine the research question and decide on experiment/research approach before the experiment is conducted.

Example: Literature review

The scientist may look in the flashlight instruction manual for tips or conduct online search on how flashlight work using the Manufacturer's or other relevant websites. Scientist may even analyse information and past experiments or discoveries regarding the relationship between energy and light.

Step 4: Formulate hypothesis

With a question in mind, the researcher decides on what he/she wants to test (The question may have changed as a result of the literature review). The research will clearly state what he/she wants to find out by carrying out the experiment. He or She will make an educated guess that could answer the question or explain the problem. This statement is called a **hypothesis**. A hypothesis guides the experiment and must be testable.

Example: Hypothesis

The batteries inside a flashlight give it energy to produce light when the flashlight is turned on.

Step 5: Conduct experiment

This step involves the design and conduct of experiment to test the hypothesis. Remember, a hypothesis is only an educated guess (a possible explanation), so it cannot be considered valid until an experiment verifies that it is valid.

Example: Experimental Procedure

Remove the batteries from the flashlight, and try to turn it on using the on/off switch.

Result: The flashlight does not produce light

Reinsert the batteries into the flashlight, and try to turn it on using the on/off switch.

Result: The flashlight does produce light.

Write down these results

In general, it is important to design an experiment to measure only one thing at a time. This way, the researcher knows that his/her results are directly related to the one thing he/she changed. If the experiment is not designed carefully, results may be confusing and will not tell the researcher anything about his/her hypothesis. Researchers collect data while carrying out their experiments. Data are pieces of information collected before, during, or after an experiment. To collect data, researchers read the measuring instruments carefully. Researchers record their data in notebooks, journals, or on a computer.

Step 6: Analyse data

Once the experiment is completed, the data is then analyzed to determine the results. In addition, performing the experiment multiple times can be helpful in determining the credibility of the data.

*Example: **Analysis***

Record the results of the experiment in a table.

Review the results that have been written down.

Step 7: Draw conclusions

If the hypothesis was testable and the experiment provided clear data, scientist can make a statement telling whether or not the hypothesis was correct. This statement is known as a **conclusion**. Conclusions must always be backed up by data. Therefore, scientists rely heavily on data so they can make an accurate conclusion.

If the data support the hypothesis, then the hypothesis is considered correct or *valid*.

If the data do not support the hypothesis, the hypothesis is considered incorrect or *invalid*.

*Example: **Valid Hypothesis***

The flashlight did not produce light without batteries. The flashlight did produce light when batteries were inserted. Therefore, the hypothesis that batteries give the flashlight energy to produce light is valid, given that no changes are made to the flashlight during the experiment.

*Example: **Invalid Hypothesis***

The flashlight did NOT produce light when the batteries were inserted. Therefore, the hypothesis that batteries give the flashlight energy to produce light is invalid. In this case, the hypothesis would have to be modified to say something like, “The batteries inside a flashlight give it energy to produce light when the batteries are in the correct order and when the flashlight is turned on.” Then, another experiment would be conducted to test the new hypothesis.

An invalid hypothesis is not a bad thing! Scientists learn something from both valid and invalid hypotheses. If a hypothesis is invalid, it must be rejected or modified. This gives scientists an opportunity to look at the initial observation in a new way. They may start over with a new hypothesis and conduct a new experiment. Doing so is simply the process of scientific inquiry and learning.

Step 8: Communicate findings

Scientists generally tell others what they have learned. Communication is a very important component of scientific process and problem solving. It gives other people a chance to learn more and improve their own thinking and experiments. Many scientists’ greatest breakthroughs would not have been possible without published communication or results from previous experimentation.

Every experiment yields new findings and conclusions. By documenting both the successes and failures of scientific inquiry in journals, speeches, or other documents, scientists are contributing information that will serve as a basis for future research and for solving problems relating to both the natural and physical worlds. Therefore, communication of investigative findings is an important step in future scientific discovery and in solving social, political, economic, cultural, and environmental problems.

*Example: **Communication of findings***

Write your findings in a report or an article and share it with others, or present your findings to a group of people. **Your work may guide someone else’s research on creating alternative energy sources to generate light, additional uses for battery power, etc.**

Artistic Design Process

Science uses predominantly the quantitative-scientific inquiry process to investigate, understand, and make informed decisions about problems. The steps in the process vary, depending on the purpose of the inquiry and the types of questions asked. There are six basic science process skills:

The equipping and enabling of students to become proficient in a broad range of STEAM skills, processes and predispositions can also lead to the attainment of many other societal goals, including national and global development goals and aspirations. These goals include:

- sustainability goals;
- peaceful related goals;

- work related goals;
- academic goals;
- relationship goals;
- health goals;
- adoption and internalization of values and attitudes accepted by society, and
- improved social, political, economic outcomes.

Even though the original purpose and the drive of STEAM was to develop a pathway to engage students in learning about, experiencing, and applying STEAM skills in real life situations to motivate and hopefully get them to pursue careers in STEAM related fields and undertake STEAM related higher education programs to meet the demand for STEAM workers, STEAM education can also be used to teach and engage students in study more broadly the impact of STEAM on the social, economic, political, intellectual, cultural and environmental contexts. This line of inquiry is more enriching, exciting, empowering and transformative.

STEAM-Based Lesson Planning

Effective STEAM lesson planning is the key to the achievement of the expected outcomes. STEAM Skills can be planned and taught using separate STEAM-based lesson plans or integrated into the standards- based lesson plans. To effectively do this, teachers should know how to write effective standards and STEAM-based lesson plans.

Developing STEAM-based Lesson Plans

An example of a standards- based lesson is provided in the **Appendix**. Teachers should use this to guide them to integrate STEAM content and teaching, learning and assessment strategies into their standards-based lesson plans.

Integration of STEAM problem-solving skills into standards-based lesson plans

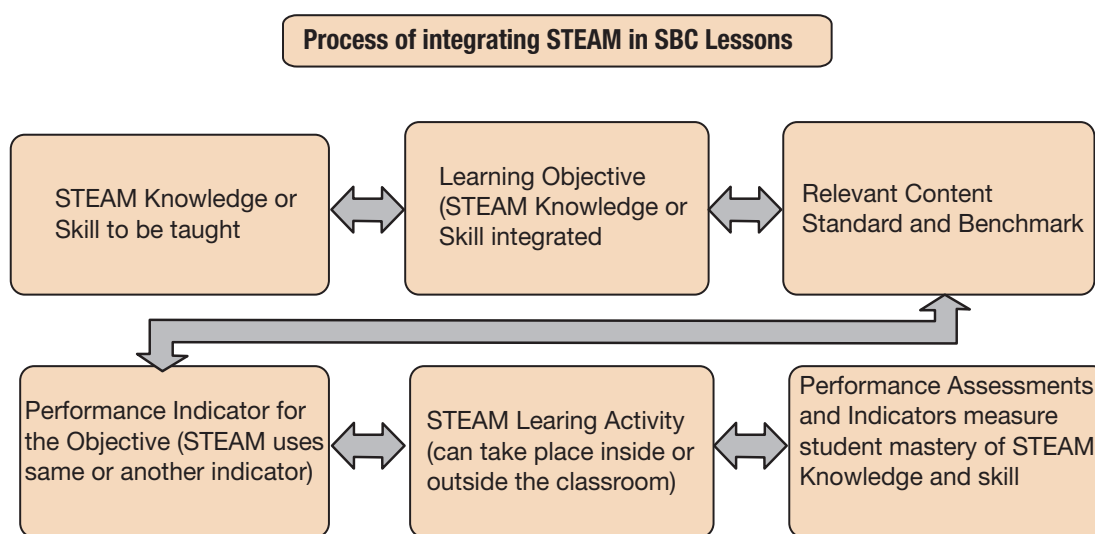
Knowing about how to integrate STEAM problem- solving skills, principles, values and attitudes as well as STEAM teaching, learning, and assessment strategies into standards-based lesson plans is essential for achieving the desired STEAM learning outcomes. When integrating STEAM problem-solving skills into the standards- based lesson plans, teachers should ensure that these skills are not only effectively aligned to the learning objectives and performance standards, they must also be effectively taught and assessed.

STEAM principles and problem-solving skills are integrated into the content standards and grade level benchmarks. A list of these skills, including 21st Century skills is provided in the Agriculture syllabus. Teachers should ensure that these skills are integrated in their standards- based lesson plans, taught and assessed to determine student's level of proficiency on each skill or specific components of the skill. Teachers should use the following process

as a guide to integrate STEAM principles and problem-solving skills into the standards-based lesson plans.

Teachers are expected to integrate the essential STEAM principles, processes, skills, values and attitudes described in the Agriculture benchmarks when formulating their standards-based lesson plans. Opportunities should be provided inside and outside of the classroom for students to learn, explore, model and apply what they learn in real life or related situations. These learning experiences will enable students to develop a deeper understanding of STEAM principles, processes, skills, values and attitudes and appreciate their application in real life to solve problems.

Process for Integrating STEAM Principles and Problem-Solving Skills into Standards-Based Lessons



Teachers should follow the steps given below when integrating STEAM problem-solving principles and skills into their standards-based lesson plans.

Step 1: Identify the STEAM knowledge or skill to be taught (From the table of KSVAs for each content standard and benchmark). **This could already be captured in the learning objective stated in the standards-based lesson plan.**

Step 2: Develop and include a performance standard or indicator for measuring student mastery of the STEAM knowledge or skill (e.g. level of acceptable competency or proficiency) **if this is different from the one already stated in the lesson plan.**

Step 3: Develop student learning activity (An activity that will provide students the opportunity to apply the STEAM knowledge or skill specified by the learning objective and appropriate statement of the standards). Activity can take place inside or outside of the classroom, and during or after school hours.

Step 4: Develop and use performance descriptors (standards or indicators) to analyse students' STEAM related behaviours and products (results or outcomes), which provide evidence that the student has acquired and mastered the knowledge or skill of the learning objective specified by the indicator (s) of the standard (s).

STEAM Teaching Strategies

STEAM education takes place in both formal and informal classroom settings. It takes place during and after school hours. It is a continuous process of inquiry, data analysis, making decisions about interventions, and implementing and monitoring interventions for improvements.

There are a variety of STEAM teaching strategies. However, teaching strategies selected must enable teachers to guide students to use the engineering and artistic design processes to identify and solve natural and physical environment problems by designing prototypes and testing and refining them to effectively mitigate the problems identified. The following are some of the strategies that could be used to utilise the STEAM approach to solve problems and coming up with technological solutions.

1. Inquiry-Based Learning
2. Problem-Based Learning
3. Project-based learning
4. Collaborative Learning

Collaborative learning involves individuals from different STEAM disciplines and expertise in a variety of STEAM problem solving approaches working together and sharing their expertise and experiences to inquire into and solve a problem.

Teachers should plan to provide students opportunities to work in collaboration and partnership with experts and practitioners engaged in STEAM related careers or disciplines to learn first-hand about how STEAM related skills, processes, concepts, and ideas are applied in real life to solve problems created by natural and physical environments.

Collaborative learning experiences can be provided after school or during school holidays to enable students to work with STEAM experts and practitioners to inquire and solve problems by developing creative, innovative and sustainable solutions. Providing real life experiences and lessons, e.g., by involving students to actually solve a scientific, technological, engineering, mathematical, or Arts problem, would probably spark their interest in a STEAM career path.

Developing STEAM partnerships with external stakeholders e.g. high education institutions, private sector, research and development institutions, and volunteer and community development organizations can enhance students' learning and application of STEAM problem solving principles and skills.

Some examples of STEAM-related partnership experiences may include:

- Participatory Learning
- Group-Based Learning
- Task Oriented Learning
- Action Learning
- Experiential Learning
- Modelling
- Simulation

STEAM Learning Strategies

Teachers should include in their lesson plans STEAM learning activities. These activities should be aligned to principle or a skill planned for students to learn and demonstrate proficiency at the end of the lesson to expose students to STEAM and giving them opportunities to explore STEAM-related concepts, they will develop a passion for it and, hopefully, pursue a job in a STEAM field. Providing real life experiences and lessons, *e.g.*, by involving students to actually solve a scientific, technological, engineering, or mathematical, or arts problem, would probably spark their interest in a STEAM career path. This is the theory behind STEAM education.

STEAM-Based Assessment

STEAM-based assessment is closely linked to standards-based assessment where assessment is used to assess students' level of competency or proficiency of a specific knowledge, skill, value, or attitude taught using a set of performance standards (indicators or descriptors). The link also includes the main components such as the purpose, the assessment principles and assessment strategies and tools.

In STEAM-based assessment, assessments are designed for what students should know and be able to do. In STEAM learning, students are assessed in a variety of ways including portfolios, project/problem-based assessments, backwards design, authentic assessments, or other student-centered approaches. When planning and designing the assessment, teachers should consider the authenticity of the assessment by designing an assessment that relates to a real world task or discipline specific attributes such as simulation, role play, placement assessment, live projects and debates. These tasks should make the activity meaningful to the student, and therefore be motivating as well as developing employability skills and discipline specific attributes.

Effective STEAM-Based Assessment Strategies

The following are the six assessment tools and strategies shown to impact teaching and learning as well as help teachers foster a 21st Century learning environment in their classrooms.

1. Rubrics
2. Performance-Based Assessments (PBAs)
3. Portfolios
4. Student self-assessment
5. Peer-assessment
6. Student Response Systems (SRS).

Although the list does not include all innovative assessment strategies, it includes what we think are the most common strategies, and ones that may be particularly relevant to the educational context of developing countries in this 21st Century. Many of the assessment strategies currently in use fit under one or more of the categories discussed. Furthermore, it is important to note that these strategies also connect in a variety of ways.

1. Rubrics

Rubrics are both a tool to measure students' knowledge and ability as well as an assessment strategy. A rubric allows teachers to measure certain skills and abilities not measurable by standardized testing systems that assess discrete knowledge at a fixed moment in time. Rubrics are also frequently used as part of other assessment strategies including; portfolios, performances, projects, peer-review and self-assessment which are also elaborated in this section.

2. Performance-Based Assessments

Performance-Based Assessments (PBA), also known as project-based or authentic assessments, are generally used as a summative evaluation strategy to capture not only what students know about a topic, but if they have the skills to apply that knowledge in a “real-world” situation. By asking them to create an end product. PBA pushes students to synthesize their knowledge and apply their skills to a potentially unfamiliar set of circumstances that is likely to occur beyond the confines of a controlled classroom setting. The implementation of performance-based assessment strategies can also impact other instructional strategies in the classroom.

3. Portfolio Assessment

Portfolios are a collection of student work gathered over time that is primarily used as a summative evaluation method. The most salient characteristic of the portfolio assessment is that rather than being a snapshot of a student's knowledge at one point in time (like a single standardized test), it highlights student effort, development, and achievement over a period of time; portfolios measure a student's ability to apply knowledge rather than simply regurgitate. They are considered both student-centred and authentic assessments of learning.

4. Self-assessment

While the previous assessment tools and strategies listed in this report generally function as summative approaches, self-assessment is generally viewed as a formative strategy, rather than one used to determine a

student's final grade. Its main purpose is for students to identify their own strengths and weakness and to work to make improvements to meet specific criteria. Self-assessment occurs when students judge their own work to improve performance as they identify discrepancies between current and desired performance". In this way, self-assessment aligns well with standards-based education because it provides clear targets and specific criteria against which students or teachers can measure learning.

Self-assessment is used to promote self-regulation, to help students reflect on their progress and to inform revisions and improvements on a project or paper. In order for self-assessment to be truly effective four conditions must be in place: the self-assessment criteria is negotiated between teachers and students, students are taught how to apply the criteria, students receive feedback on their self-assessments and teachers help students use assessment data to develop an action plan.

5. Peer assessment

Peer assessment, much like self-assessment, is a formative assessment strategy that gives students a key role in evaluating learning. Peer assessment approaches can vary greatly but, essentially, it is a process for learners to consider and give feedback to other learners about the quality or value of their work. Peer assessments can be used for variety of products like papers, presentations, projects, or other skilled behaviours.

Peer assessment is understood as more than only a grading procedure and is also envisioned as teaching strategy since engaging in the process develops both the assessor and assessee's skills and knowledge.

6. Student Response System

Student response system (SRS), also known as classroom response (CRS), audience response system (ARS) is a general term that refers to a variety of technology-based formative assessment tools that can be used to gather student-level data instantly in the classroom. Through the combination of hardware, (voice recorders, PC, internet connection, projector and screen) and software.

Teachers can ask students a wide range of questions (both closed and open ended), where students can respond quickly and anonymously, and the teacher can display the data immediately and graphically. The use of technology also includes a use of video which examines how a range of strategies can be used to assess students' understanding.

The value of SRS comes from teachers analysing information quickly and then devising real-time instructional solutions to maximize student learning. This includes a suggested approach to help teachers and trainers assess learning.

Curriculum Integration

Curriculum integration is making connections in learning across the curriculum. The ultimate aim of curriculum integration is to act as a bridge to increase students' achievement and engage in relevant curriculum. (Susan M. Drake and Rebecca C. Burns)

Teachers must develop intriguing curriculum by going beyond the traditional teaching of content based or fragmented teaching to one who is knowledge based and who should be perceived as a 21st Century innovative educator. Curriculum integration is a holistic approach to learning thus curriculum integration in PNG SBC will have to equip students with the essential knowledge, skills, values and attitudes that are deemed 21st Century.

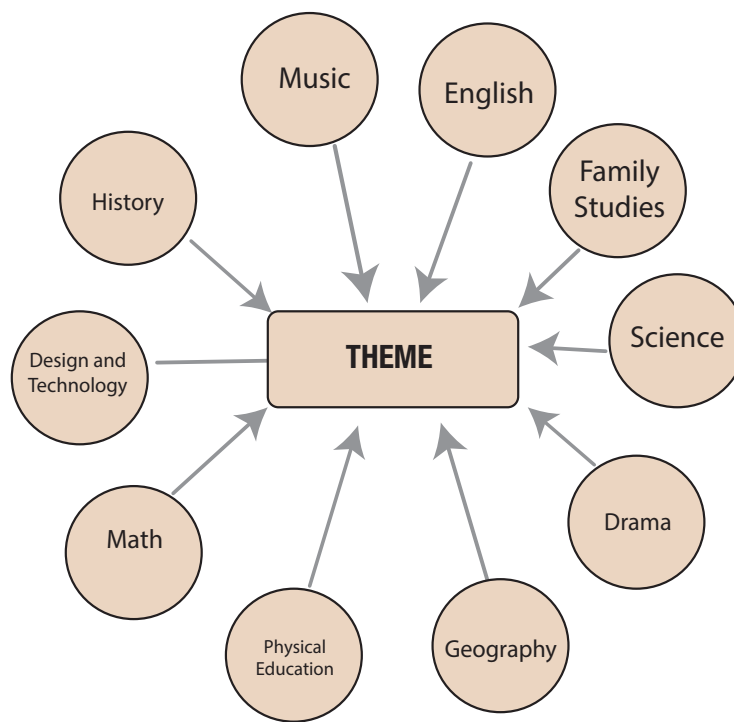
There are three approaches that PNG SBC will engage to foster conducive learning for all its children whereby they all can demonstrate proficiency at any point of exit. Adapting these approaches will have an immense impact on the lives of these children thus they can be able to see themselves as catalyst of change for a competitive PNG. Not only that but they will be comparable to the world standards and as global citizens.

Engaging these three approaches in our curriculum will surely sharpen the knowledge and ability of each child who will foresee themselves as assets through their achievements thus contribute meaningfully to their country. They themselves are the agents of change. Integrated learning will bear forth a generation of knowledge based populace who can solve problems and make proper decisions based on evidence.

Thus, PNG can achieve its goals like the Medium Term Development Goals (MTDG) and aims such as the Vision 2050 for a happy, healthy and wealthy society whereby, all its citizens should have access and fair distribution to income, shelter, health, education and general good and services improving the general standard of living for PNG in the long run.

1. Multidisciplinary Approach

In this approach learning involves a theme or concept that will be taught right across all subject area of study by students. That is, content of a particular theme will be taught right across all subjects as shown in the diagram below. For instance, if the theme is global warming, subject areas create lessons or assessment as per their subjects around this theme. Social Science will address this issue, Science and all other subject likewise.



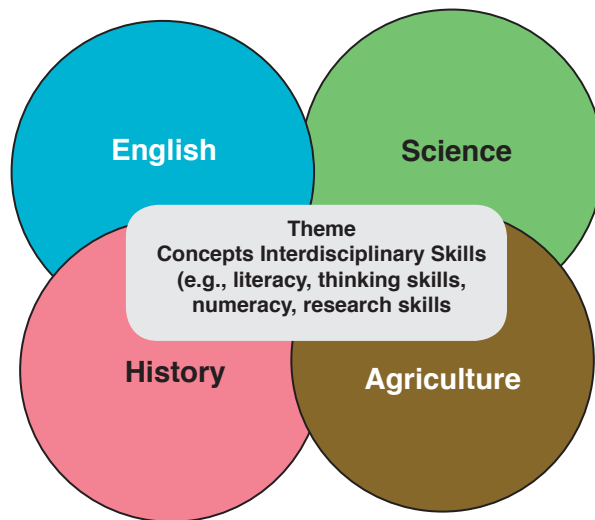
2. Interdisciplinary Approach

This approach addresses learning similarly to the multidisciplinary approach of integrated learning whereby learning takes place within the subject area.

However, it is termed interdisciplinary in that the core curriculum of learning is interwoven into each subject under study by the students. For instance; in Social Science under the strand of geography students write essay on internal migration however, apart from addressing the issues of this topic, they are to apply the skill of writing text types in their essay such as argumentative essay, informative, explanatory, descriptive, expository and narrative essay while writing their essay.

They must be able to capture the mechanics of English skills such as grammar, punctuation and so forth. Though these skills are studied under English they are considered as core skills that cut across all subjects under study. For example; if Science students were to write about human development in biology then the application of writing skills has to be captured by the students in their writing. It is not seen as an English skill but a standard essential skill all students must know and do regardless.

Therefore, essential knowledge, skills, values and attitudes comprising the core curriculum are interwoven and provide an essential and holistic framework for preparing all students for careers, higher education and citizenship in this learning.



3. Interdisciplinary Approach

This approach involves teachers integrate sub disciplines within a subject area. For instance, within the subject Social Science, the strands (disciplines) of geography, environment, history, political science and environment will all be captured studying a particular content for Social Science. For example, under global warming, students will study the geographical aspects of global warming, environmental aspect of global warming and likewise for history, political science and economics. Thus, students are well aware of the issues surrounding global warming and can address it confidently at each level of learning.

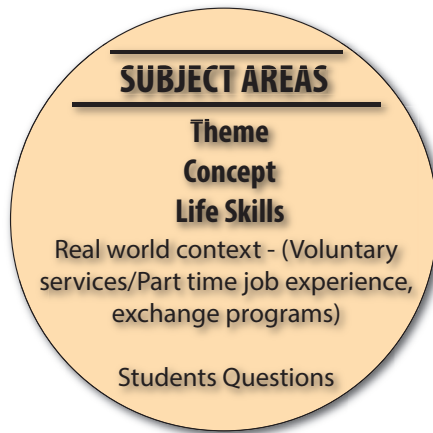
4. Trans disciplinary Approach

In this approach learning goes beyond the subject area of study. Learning is organized around students' questions and concerns. That is, where there is a need for change to improve lives, students develop their own curriculum to affect these needs. The trans-disciplinary approach addresses real-life situations thus giving the opportunity to students to attain real life skills. This learning approach is more to do with Project-Based Learning also referred to as problem-based learning or place-based learning.

Below are the three steps to planning project based curriculum.

1. Teachers and students select a topic of study based on student interests, curriculum standards, and local resources.
2. The teacher finds out what the students already know and helps them generate questions to explore. The teacher also provides resources for students and opportunities to work in the field
3. Students share their work with others in a culminating activity. Students display the results of their exploration and review and evaluate the project. For instance; students may come up with slogans for school programs such as 'Our culture – Keep our city clean for a healthier PNG'. The main aim could be to curb betel nut chewing in public areas especially around bus stops and local markets. Here, students draw up their own instructions and criteria for assessment which is; they have to clean the nearest bus stop or local market once a week throughout the

year. They also design and create posters to educate the general public as their program continues. They can also involve the town council and media to assist them especially to carry out awareness.



These integrated learning approaches will demand for teachers to be proactive in order to improve students learning and achievements. In order for PNG Standards-Based Curriculum to serve its purpose fully, these three approaches must be engaged for better learning for the children of Papua New Guinea now and in the future.

Studies have proven that Project based-programs have led to the following:

- Students go far beyond the minimum effort
- Make connections among different subject areas to answer open-ended questions
- Retain what they have learnt
- Apply learning to real-life problems
- Have fewer discipline problems
- Lower absenteeism

Essential Knowledge, Skills, Values, and Attitudes

Students' level of proficiency and progression towards the attainment of content standards will depend on their mastery and application of essential knowledge, skills, values, and attitudes in real life or related situations. Provided here are examples of different types of knowledge, processes, skills, values, and attitudes that all students are expected to learn and master as they progress through the grades. These are expanded and deepen in scope and the level of difficulty and complexity are increased to enable students to study in-depth the subject content as they progress from one grade to the next.

These knowledge, skills, values and attitudes have been integrated into the content standards and benchmarks. They will also be integrated into the performance standards. Teachers are expected to plan and teach essential knowledge, skills, values and attitudes in their lessons, and assess students' performance and proficiency, and progression towards the attainment of content standards.

Types of Knowledge

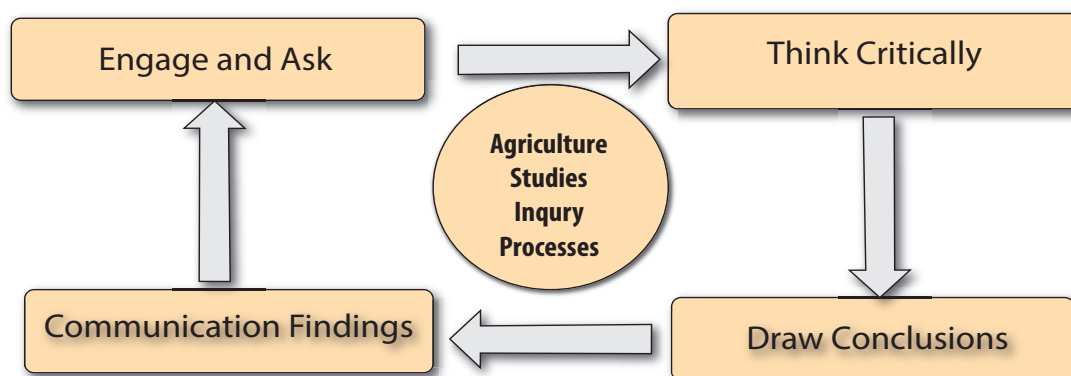
There are different types of knowledge. These include;	
• Public and private (privileged) knowledge • Specialised knowledge • Good and bad knowledge • Concepts, processes, ideas, skills, values, attitudes • Theory and practice • Fiction and non-fiction • Traditional, modern, and postmodern knowledge	• Subject and discipline-based knowledge • Lived experiences • Evidence and assumptions • Ethics and Morales • Belief systems • Facts and opinions • Wisdom • Research evidence and findings • Solutions to problems

Types of Processes

There are different types of processes. These include;	
• Problem-solving • Logical reasoning • Decision-making • Reflection	• Cyclic processes • Mapping (e.g. concept mapping) • Modeling • Simulating
Inquiry processes include: • Gathering information • Analysing information • Evaluating information • Making judgements • Taking actions	

Critical Inquiry Processes

Engage and Ask	How will I engage my students in the topic and prompt them to ask questions? • Determine the enduring understandings about the topic being studied. • Engage your students with the topic by grabbing their interest with a hook connected to the enduring understandings. • Allow students to generate questions based upon the topic and hook. • Determine what questions will be essential to achieving the enduring understandings. (Student generated or teacher determined) • With students, determine what other information is needed in order to fully answer the questions.
Think Critically	How will students access and analyse information about this topic? • Have students think about where they can find answers to the questions posed about the topic. • Gather and organize multiple primary and secondary sources. • Ensure that sources used expose students to different perspectives and viewpoints about the topic. • Students should use sources to collect, analyse, and interpret data. • Ensure students are analysing sources for credibility, bias, and perspective in order to identify gaps in the research.
Draw Conclusion	How will students synthesize ideas to answer the questions posed based on sources used? • Students should engage in civic discussion to answer the questions posed while respecting diverse opinions. • Engage students in evaluating possible courses of action and their consequences. • Students should make and justify an informed decision or choice and/or design an action plan supported by evidence from sources. • Have students evaluate the consequences of a decision or choice. • Allow students to make revisions based on feedback and further study.
Communicate Findings	How will students demonstrate what they have learned and take action on that learning? • Determine how students will apply what they have learned and share their findings with others. • Explore appropriate audiences for students to present conclusions. • Determine if there is an opportunity for students to take action and influence others to make more informed decisions. • Have students develop strategies to persuade others, including policy makers when applicable. • Prepare students to defend their analysis against alternative.



Below is how the Agriculture will be taught in the classroom. Be specific as you make notes of the activities or prompts you will use to ensure students will have the opportunity to practice these skills as a requirement in the Agriculturer content standards.

Types of Skills

There are different types of skills. These include:

1. Cognitive (Thinking) Skills

Thinking skills can be categorized into **critical thinking** and **creative thinking** skills.

i. Critical Thinking Skills

A person who thinks critically always evaluates an idea in a systematic manner before accepting or rejecting it. Critical thinking skills include;

- | | |
|---|---|
| <ul style="list-style-type: none"> • Attributing • Comparing and contrasting • Grouping and classifying • Sequencing • Prioritising • Analysing | <ul style="list-style-type: none"> • Detecting bias • Evaluating • Metacognition (Thinking about thinking) • Making informed conclusions. |
|---|---|

ii. Creative Thinking Skills

A person who thinks creatively has a high level of imagination, able to generate original and innovative ideas, and able to modify ideas and products. Creative thinking skills include;

- | | |
|---|--|
| <ul style="list-style-type: none"> • Generating ideas • Deconstruction and reconstruction • Relating • Making inferences • Predicting • Making generalisations • Visualizing | <ul style="list-style-type: none"> • Synthesising • Making hypothesis • Making analogies • Invention • Transformation • Modeling • Simulating |
|---|--|

2. **Reasoning Skills** - Reason is a skill used in making a logical, just, and rational judgment.
3. **Decision-Making Skills** - Decision-making involves selection of the best solution from various alternatives based on specific criteria and evidence to achieve a specific aim.
4. **Problem Solving Skills** – These skills involve finding solutions to challenges or unfamiliar situations or unanticipated difficulties in a systematic manner.
5. **Literacy Skills**

A strong emphasis must be placed on various types of literacy, from financial to technological, from media to mathematical, from content to cultural. Literacy may be defined as the ability of an individual to use information to function in society, to achieve goals and to develop her or his knowledge and potential. Teachers emphasize certain aspects of literacy over others, depending on the nature of the content and skills they want students to learn.

The following literacy skills are intended to be exemplary rather than definitive

• Listens, read, write, and speak with comprehension and clarity • Define and apply discipline-based conceptual vocabulary • Describe people, places, and events, and the connections between and among them • Arrange events in chronological sequence • Differentiate fact from opinion • Determine an author's purpose • Determine and analyse similarities and differences • Analyse cause and effect relationships • Explore complex patterns, interactions and relationships • Differentiate between and among various options	• Listens, read, write, and speak with comprehension and clarity • Define and apply discipline-based conceptual vocabulary • Describe people, places, and events, and the connections between and among them • Arrange events in chronological sequence • Differentiate fact from opinion • Determine an author's purpose • Determine and analyse similarities and differences • Analyse cause and effect relationships • Develop an ability to use and apply abstract principals • Explore and/or observe, identify, and analyse how individuals and/or societies relate to one another
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6. **High Level Thinking Skills** - These skills include analysis, synthesis, and evaluation skills.
- i. Analysis Skills* – Analysis skills involve examining in detail and breaking information into parts by identifying motives or causes, underlying

assumptions, hidden messages; making inferences and finding evidence to support generalisations, claims, and conclusions.

Key Words				
Analyse	Differences	Find	List	Similar to
Appraise	Discover	Focus	Motivate	Simplify
Arrange	Discriminate	Function	Omit	Take part in
Assumption	Discussion	Group	Order	Test for
Breakdown	Distinction	Highlight	Organize	Theme
Categorize	Distinguish	In-depth	Point out	
Cause & effect	Dissect	Inference	Research	
Choose	Divide	Inspect	See	
Classify	Establish	Isolate	Select	
Comparing	Examine	Investigate	Separate	

ii. Synthesis Skills - Synthesis skills involve changing or creating something new, compiling information together in a different way by combining elements in a new pattern proposing alternative solutions.

iii. Evaluation Skills - Evaluation skills involve justifying and presenting and defending opinions by making judgments about information, validity of ideas or quality of work based on set criteria.

Types of Values

Personal engagement and civic engagement strategies help young people to acquire and apply skills and dispositions that will prepare them to become competent and responsible citizens.

1. Personal Values (importance, worth, usefulness, etc.)

Core values	Sustaining values
• Sanctity of life • Truth • Aesthetics • Honesty • Human • Dignity • Rationality • Creativity • Courage • Liberty • Affectivity • Individuality	• Self-esteem • Self-reflection • Self-discipline • Self-cultivation • Principal morality • Self-determination • Openness • Independence • Simplicity • Integrity • Enterprise • Sensitivity • Modesty • Perseverance

2. Social Values

Core values	Sustaining values
• Equality • Kindness • Benevolence • Love • Freedom • Common good • Mutuality • Justice • Trust • Interdependence • Sustainability • Betterment of human kind • Empowerment	• Plurality • Due process of law • Democracy • Freedom and liberty • Common will • Patriotism • Tolerance • Gender equity and social inclusion • Equal opportunities • Culture and civilisation • Heritage • Human rights and responsibilities • Rationality • Sense of belonging • Solidarity • Peace and harmony • Safe and peaceful communities

Types of Attitudes

Attitudes - Ways of thinking and behaving, points of view	
• Optimistic • Participatory • Critical • Creative • Appreciative • Empathetic • Caring and concern • Positive • Confident • Cooperative	• Responsible • Adaptable to change • Open-minded • Diligent • With a desire to learn • With respect for self, life, equality and excellence, evidence, fair play, rule of law, different ways of life, beliefs and opinions, and the environment.

Teaching and Learning Strategies

Agriculture emphasises and embraces the use of cognitive, reasoning, decision-making, problem solving and higher-level thinking skills to teach to enhance students' understanding of inter-disciplinary concepts and issues in relation to environment, geography, history, politics and economic within PNG and globally.

It aims to provide a meaningful pedagogical framework for teaching and learning essential and in demand knowledge, skills, values, and attitudes that are required for the preparation of students for careers, higher education and citizenship in the 21st century. Students must be prepared to gather and understand information, analyse issues critically, learn independently or collaboratively, organise and communicate information, draw and justify conclusions, create new knowledge, and act ethically.

These teaching and learning strategies will help teachers to;

- familiarise themselves with different methods of teaching indoors and outdoors.
- develop an understanding of the role of a teacher for application of various methods in and out of the classroom.

Successful teachers always keep in view that teaching must “be dynamic, challenging and in accordance with the learner’s comprehension. He/she does not depend on any single method

Please find a list of the different teaching and learning strategies in Appendices (Appendix 2)

The strategies utilised in teaching;

- make learning more engaging
- make learning more effective
- make learning fun
- encourage higher motivational level
- improve attention spans
- develop higher order thinking and reflective skills
- improve communication skills
- develop the spirit of teamwork /collaboration
- develop leadership skills and qualities
- encourage discovery learning

Strands, Units and Topics

The table below outlines the contents of Grade 10 Agriculture in Strands, Units and suggested Lesson Titles to be taught in an academic year.

Content Overview

Strands	Units	Topics	Lesson Titles
Crops	Unit 1: Soil	Soil improvement practices	Natural soil improvement techniques
			Artificial soil improvement techniques
		Strategies and processes for sustaining soil fertility	Strategies to sustain soil fertility
			Processes for sustaining soil fertility
	Unit 2: Types of Crops	Purposes and benefits of different crops	Purposes of different crops
			Benefits of different crops
		Crop classification	Crop classification by growing cycle, species and varieties
			Crop classification by season, land type and crop use
			Crop classification by cultivation, type of product and processing methods
	Unit 3: Crop Farming Practices and Management Systems	Crop management systems and practices used in different contexts	Crop managing systems practiced in different contexts
		Crop cultivation and management principles	Methods of crop cultivation
			Principles of crop management
	Unit 4: Crop Farming and Technology	How technology could be used to improve plant propagation	Types of plant propagation
			Using technology to improve plant propagation
		Impact of propagation technology on plant physiology and anatomy	Impact of technology in plant anatomy.
			Impact technology on plant physiology.
	Unit 5: Types of Plants	Types of agricultural plants	Benefits and functions of planation crops
			Benefits and functions of ornamental plants
			Benefits and functions of bedding plants
		Classification of agricultural plants	Classification of crop species, functions, purpose and benefits
			Classification of ornamental plant species, functions, purpose and benefits
			Classification of bedding plant species, functions, purpose and benefits
		Cultivation of ornamental and bedding plants	Cultivating and processing ornamental plants
			Cultivating and processing bedding plants
		Production processes of different plant products	Processing and preservation of various plant products in different contexts
			Marketing strategies of different plant products in different contexts
	Unit 6: Plant Farming Practices and Management Systems	Horticulture cultivation and production principles	Cultivation methods of horticultural plants in different environments.
			Management and production systems of horticulture in different environments.
		Cultivation and management practices used in different contexts	Benefits and challenges of cultivation practices in different contexts
			Benefits and challenges of management practices in different contexts
	Unit 7: Plant Farming and Technology	Impact of technology in production of horticultural plants in different contexts	Post-harvest technology in horticulture
			Processing and packaging of horticultural plants
			Transportation and marketing technology
		Advantages and disadvantages of technology used in horticulture production	Advantages of technology in production of agricultural plants
			Disadvantages of technology in production of agricultural plants

Animals	Unit 1: Types of Animals	Characteristics of monogastric and polygastric animals	General classification of pig breeds
			General classification of goat breeds
			General classification of sheep breeds
			General classification of cattle breeds
		Monogastric and polygastric animals' physiology systems and functions	Digestive system and functions of monogastrics animals
			Digestive system and functions of polygastric animals
			Animal reproductive system and functions
			Estrous cycle and functions
	Unit 2: Animal Farming Practices and Management Systems	Procedures and practices involved in monogastric and polygastric animal husbandry and management practices	Extensive animal management system
			Semi- intensive animal management system
			Intensive animal management system
		Approaches and Strategies use to Manage Animals	Animal nutrition
			Animal handling
			Animal feeding/Grazing land
			Animal health and housing
	Unit 3: Animal Farming and Technology	Post-Harvest Technology used for Processing and Preserving Animal Products	Post-Harvest processing and post processing technology
			Technology used in packaging
			Preservation methods of animal products
		Technological innovations use to enhance mass production of animal products	Technological innovations use for mass production of pork
			Technology used for mass production of lamb
			Technology use for mass production of beef
			Technology use for mass production of honey
		Technology that enables online Marketing of Animal products	Ways of marketing animal products using technology (e.g. radio,
			Introduction to online marketing
			Types of technology used for online marketing
	Unit 4: Types of Birds	Breeds of Domesticated Birds	Breeds of domesticated birds
			Characteristics of domesticated birds
			Purposes of domesticated birds.
			Functions of domesticated birds.
		Breeds and characteristics of Farmed Birds	Breeds of farmed birds
	Unit 5: Bird Farming Practices and Management Systems	Principles and Factors of poultry production	Principles of Poultry Production in different context
			Factors involved in poultry production in different context
		Poultry Productions systems in different environments	Poultry production systems in different environment
			Advantages of Poultry production systems in different environment
			Poultry production systems in different environment
		Poultry management principles, systems, and practices	Poultry management principles and systems
			Types of Poultry management practices used in various climatic and environmental conditions
	Unit 6: Bird Farming and Technology	Impact of technology used in poultry farming	Impact of technology in poultry farming
			Impact of technology used in poultry farming on different environment and people
			Impact of technology used in poultry farming on different environment and people
		Technology used in harvesting, processing and preserving poultry products and impact on the environment	Technologies used in harvesting poultry products
			Technologies used in processing poultry products
			Technologies in preserving poultry products

Aquaculture	Unit 1: Types of Aqua farming Plants, Animals, and Fish	The cultivation of different fresh, brackish and salt-water animals	The cultivation of fresh water animals
		Different brackish, and salt water animal and plants characteristics species, functions and purposes	The cultivation of brackish water animals
			The cultivation of salt water animals
			Breeds and species of fresh water animals and plants
			Breeds and species of brackish water animals and plants
			Breeds and species of salt water animals and plants
	Unit 2: Aqua farming Practices and Management Systems	Fish farming management practices and systems	Fish farming systems in freshwater
			Fish farming systems in brackish water
			Fish farming systems in saltwater
		Aquaculture plant farming management systems and practices	Aqua plant farming systems in freshwater
			Aqua plant farming systems in brackish water
			Aqua plant farming systems in saltwater
		Preservation and sustainability of aquatic plants and animal species and their environments	Sustainable ways of preserving plants, animals, fish and in which they are farmed
	Unit 3: Aqua farming and Technology	Technology used in fish farming, harvesting and preservation in different environments	Technology used in fish farming
			Technology used in fish harvesting
			Technology used in fish preservation
		Technology used for producing and processing aqua farming products	Technology used for producing aqua farming products and their effectiveness
			Technology used for processing aqua farming products and their effectiveness

Natural Resource Management	Unit 1: Types of Capture Fishery	Harvesting of different capture fish and other aquatic organisms	Methods of harvesting in different environments
		Characteristics, species, functions and purposes of different capture fish and other aquatic organisms	Characteristics of different capture fish and other aquatic organisms
			Functions and purposes of capture fish and other aquatic organisms
	Unit 2: Capture Fishery Harvesting Practices and Management Systems	Capture Fishery management systems used in different places and environments.	Types of management systems
		Capture Fishery regulation and monitoring	Capture Fishery regulation
		Ways of preserving plant, animal, and fish species	Preventive methods of animals, plants and fish species
		Sustainable practices of capture fishery environments	Sustainable practices
	Unit 3: Capture Fishery and Technology	Preservation Technology for capture fishery	Large scale harvesting and preservation technology
		Advantages and disadvantages of the use of technology in capture fishery	Effective technologies used for producing and processing
	Unit 4: Types of Forestry and Forests	Harvesting of tropical forests in different contexts.	Tropical forests
			Harvesting methods used in tropical forests
		Characteristics, elements, functions and purposes of forestry	Farm Forestry
			Agroforestry
			Extension forestry
			Sivi-culture (scientific)
			Community forestry
	Unit 5: Forest Harvesting Practices and Management Systems	Forest management systems	Sustainable Forest Management (SFM)
			Ecosystem approach
		Forest regulation and monitoring systems	Regulations of forestry
			Monitoring systems and practices of forestry
		Ways of preserving and sustaining forests in different environments	How can forests and wildlife be protected
	Unit 6: Forestry and Technology	Forest monitoring and preservation technology	Ways to support sustainable forestry
			Importance of preserving the forests
		Technology used for processing and marketing forestry products.	Forest monitoring technology
			Forest Preservation technology
Agribusiness	Unit 1: Starting Up and Managing an Agribusiness	Managing Risk in Agribusiness	Effectiveness of technology used in Harvesting, Processing and marketing
			Sources of Risk in Agribusiness
			Importance of Risk and Uncertainty in Agribusiness
		Agribusiness communication skills	Risk Management strategies
			Markets related to Agribusiness
			Marketing principles
		Agribusiness start-up	Sales and Marketing strategies
			Components of the sales process
			Processes of obtaining Start-up Capital
			Managing Start-up Capital

Content Expansion

Content expansion is a set of sequenced teaching and learning activities with assessment tasks, designed to help students achieve selected learning outcomes within a specific time frame. Content expansion helps the teacher:

- identify essential knowledge, skills and attitudes that the students need to develop
- write suitable learning activities and assessment tasks for each theme
- make sure that assessment tasks allow students to demonstrate the knowledge, skills and attitudes given in the outcomes
- identify locally relevant resources for the unit of work
- plan the activities to cater for the duration of the unit

This expansion indicates the scope of content outlined with the Knowledge, Skills, Attitudes, Values, (KSAVs) and derived from the Benchmarks. The lesson activities should be developed in line with the KSAVs specified from this table.

This table provides the scope of lesson content based on the Benchmarks to plan your teaching and learning programs. The lesson activities should have the components of relevant Knowledge, Skills, Attitudes and Values that can be assessed in the beginning of the lesson (Input), during the lesson (process) and at the end of the lesson (output). This will lead up to achieving the Content Standards and the Benchmarks in Agriculture subject. Use the tables that follow to help guide you in planning your teaching programs.

The diagram below illustrates how the content in the Teachers Guide is organised. It is arranged into topics, benchmarks together with the essential, knowledge, skills, attitudes and values. Learning objectives are provided for each topic in the units of work for the teacher to utilize in developing their lesson objectives.

Grade 10 Agriculture

Teaching Content

UNITS OF WORK

STRAND 1: CROPS

Strand Overview			
Units	Benchmark	Topics	Lesson Titles
Content Standard 1.1 Students will be able to explain the process of soil formation, examine the nutrients, characteristics, uses and functions of different types of soil, and investigate strategies and processes for improving soil fertility to support crop cultivation and maximize crop production returns in different environments			
Unit 1: Soil	Benchmark: 10.1.1.1. Research different soil improvement practices and explain how they contribute to improving soil fertility.	Soil improvement practices	Natural soil improvement techniques
			Artificial soil improvement techniques
	Benchmark: 10.1.1.2. Investigate and evaluate different strategies and processes for sustaining soil fertility.	Strategies and processes for sustaining soil fertility	Strategies to sustain soil fertility
			Processes for sustaining soil fertility
Content Standard 1.2 Students will be able to identify and examine the characteristics and physiology of different types of crops, categorize them according to their characteristics, purposes and benefits and explore the different environments and places where they are farmed.			
Unit 2: Types of Crops	Benchmark 10.1.2.1 Research and explain the purposes and benefits of different crops.	Purposes and benefits of different crops	Purposes of different crops
			Benefits of different crops
	Benchmark 10.1.2.2 Research and classify crops according to their growing cycle, species, variety, season, land type, crop use, and type of product, how the crop is processed, and cultivation methods.	Crop classification	Crop classification by growing cycle, species and varieties
			Crop classification by season, land type and crop use
Crop classification by cultivation, type of product and processing methods			
Content Standard 1.3. Students will be able to investigate and analyse crop farming, processing, marketing, regulation, and management principles, systems and practices used in different contexts, environments and places			
Unit 3: Crop Farming Practices and Management Systems	Benchmark 10.1.3.1 Investigate and explain crop management systems and practices used in different contexts.	Crop management systems and practices used in different contexts	Crop managing systems practiced in different contexts
			Methods of crop cultivation
	Benchmark 10.1.3.2 Investigate and explain crop cultivation and management principles.	Crop cultivation and management principles	Principles of crop management
Content Standard 1.4. Students will be able to examine how technology is used in the cultivation, regulation, and management of crops in different societies and environments, and analyze their advantages and disadvantages.			

Unit 4: Crop Farming and Technology	Benchmark 10.1.4.1 Investigate and explain how technology could be used to improve plant propagation.	How technology could be used to improve plant propagation	Types of plant propagation
	Benchmark 10.1.4.2. Evaluate the impact of propagation technology on plant physiology and anatomy.	Impact of propagation technology on plant physiology and anatomy	Using technology to improve plant propagation
			Impact of technology in plant anatomy.
			Impact technology on plant physiology.

Content Standard 1.5

Students will be able to identify and examine the characteristics and physiology of different types of plants, categorize them according to their characteristics, purposes, and benefits, and explore the different contexts, environments, and places where they are farmed.

Unit 5: Types of Plants	Benchmark 10.1.5.1 Identify and examine different types of plantation crops, ornamental plants and bedding plants, and analyze their functions, purposes and benefits.	Types of agricultural plants	Benefits and functions of plantation crops
			Benefits and functions of ornamental plants
			Benefits and functions of bedding plants
	Benchmark 10.1.5.2 Research and classify plantation crops, ornamental plants, and bedding plants according to their species, functions, purposes, and benefits	Classification of agricultural plants	Classification of crop species, functions, purpose and benefits
			Classification of ornamental plant species, functions, purpose and benefits
			Classification of bedding plant species, functions, purpose and benefits
	Benchmark 10.1.5.3 Investigate and explain how ornamental and bedding plants are cultivated and processed in different environments and places.	Cultivation of ornamental and bedding plants	Cultivating and processing ornamental plants
			Cultivating and processing bedding plants
	Benchmark 10.1.5.4 Investigate and explain how plantation crops, ornamental plants and bedding plant products are processed, preserved, and marketed in different contexts and environments.	Production processes of different plant products	Processing and preservation of various plant products in different contexts
			Marketing strategies of different plant products in different contexts

Content Standard 1.6

Students will be able to investigate and analyse the different types of horticulture and management principles, systems and practices used in different environments and places to cultivate, process, preserve, market, regulate and consume different types of plants.

Unit 6: Plant Farming Practices and Management Systems	Benchmark 10.1.6.1 Research types of horticulture cultivation and production principles and management systems used in different environments.	Horticulture cultivation and production principles	Cultivation methods of horticultural plants in different environments.
	Benchmark 10.1.6.2 Evaluate horticulture cultivation and management practices used in different environments, contexts, and places.	Cultivation and management practices used in different contexts	Management and production systems of horticulture in different environments.
			Benefits and challenges of cultivation practices in different contexts
			Benefits and challenges of management practices in different contexts
Content Standard 1.7 Students will be able to examine how technology is used in the cultivation, processing, preserving, marketing, regulation, consumption, and management of plants in different types of environments and analyze their advantages and disadvantages.			
Unit 7: Plant Farming and Technology	Benchmark 10.1.7.1 Evaluate the impact of technology in the processing, preservation, transportation, and marketing of horticulture plants in different types of environments, contexts, and places.	Impact of technology in production of horticultural plants in different contexts	Post-harvest technology in horticulture
			Processing and packaging of horticultural plants
			Transportation and marketing technology
	Benchmark 10.1.7.2 Analyse and explain the advantages and disadvantages of using technology in cultivating, processing, preserving, marketing and regulating plants in different types of environments, contexts and places.	Advantages and disadvantages of technology used in horticulture production	Advantages of technology in production of agricultural plants Disadvantages of technology in production of agricultural plants

UNIT 1: SOIL

Content Standard 1.1 Students will be able to explain the process of soil formation, examine the nutrients, characteristics, uses and functions of different types of soil, and investigate strategies and processes for improving soil fertility to support crop cultivation and maximize crop production returns in different environments.

Benchmark: 10.1.1.1. Research different soil improvement practices and explain how they contribute to improving soil fertility.

TOPIC: SOIL IMPROVEMENT PRACTICES

Learning Objectives

By the end of this topic, students will be able to:

- Describe soil improvement practices.
- Explain how soil improvement practices contribute to improve soil fertility.

Essential Questions:

1. What are soil improvement practices?
2. How does soil improvement practice contribute to improve the soil fertility?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Different soil improvement practices to efficiently manage soil fertility.
Skills	• Describe, explain and compare the Different soil improvement practices to efficiently manage soil fertility.
Attitudes & Values	• Appreciate and value the different soil improvement practices.

Content Background

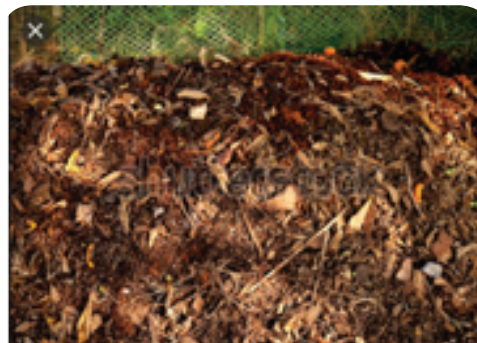
Soil Management practices

Managing soil organic matter is extremely important because organic matter plays a role in almost all aspects of soil quality. Soil organic matter is composed of plant and animal residues, and substances produced by decomposition. Most agricultural soils contain only a small proportion of organic matter, usually less than 5%, but even that small amount strongly influences the vital functions of soil. Soil organic matter releases plant nutrients as it decomposes, thus improving soil fertility. Soil organic matter improves the structure of soils by improving water holding capacity, promoting the aggregation of soil particles, and helping to keep the soil aerated so roots can grow easily. Organic matter feeds the microorganisms and other living organisms in the soil, promoting biological activity and helping to fight pests. Practices such as using cover

crops, applying manure and compost, rotating crops, and controlling erosion for soil conservation, can maintain or increase soil organic matter. Other practices, especially ploughing, tilling and cultivating, can decrease the amount of organic matter in the soil.

Below are some management practices that can be used to retain the soil.

1. The fallow method – leaving the land without any crop planted for a period of time, almost a year or more.
2. Using of legumes – legumes have their root nodules that contain rhizobium bacteria. The bacteria contain the gaseous nitrogen in the soil air which plants cannot access and turn it into a form of nitrogen.
3. Crop rotation – growing of different crops in a sequence in the same area.
4. Using of fertilizers – chemical fertilizers can be used to increase soil nutrients. These fertilizers are sometimes called artificial fertilizers.
5. Using animal manure – most animal manure are known as organic fertilizers. Application can be done 3-4 days before planting.
6. Compost – a compost is done by collecting of kitchen waste, animal manure and some plant remains (leaves, grass) and allowing it to compost



Assessment:

The students divide into five groups and build a compost using local material. Teacher to provide the steps and guidelines to make a compost.

References/Source

1. Agriculture in Melanesia grade 10
2. https://en.wikipedia.org/wiki/Soil_management
3. <https://www.goggle.com/organic-fertiliser/soil>

UNIT 1: SOIL

Benchmark: 10.1.1.2. Investigate and evaluate different strategies and processes for sustaining soil fertility.

TOPIC: STRATEGIES AND PROCESSES FOR SUSTAINING SOIL FERTILITY.

Learning Objectives:

By the end of this topic, students will be able to:

- Explain soil nutrients.
- Describe the four tips in sustainable soil management.

Essential Questions:

- What are soil nutrients?
- What are the four tips in sustainable soil management?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Macro nutrients and micro nutrients • Sustainable soil management
Skills	• Describe macro and micro nutrients. • Identify the four tips to soil management
Essential Attitudes & Values	• Appreciate and value the different types of soil nutrients and four tips to soil management.

Content Background

Soil Nutrients

Soil nutrients are any substances that the plants take in from the soil order to grow and reproduce. Plants also can get their food from the remains of animals and plants. The nutrients are divided into two groups which are macronutrients and micronutrients. Macronutrients are needed in high quantity and micronutrients are needed in small amounts.

So basically, there are seventeen essential plant nutrients, three comes from air and water (carbon, oxygen, and hydrogen) and fourteen comes from the soil.

The table below describes the essential and beneficial elements obtained from the soil.

Macronutrients	Function	Deficiency signs
Carbon (C), hydrogen (H) and oxygen (O).	Obtain from the atmosphere through photosynthesis	These nutrients don't have deficiency signs, they are always available.

Nitrogen (N)	Protein and enzyme component	The older leaves of plants become yellow or light green in colour.
Phosphorus (P)	Membranes, energy, DNA	Older leaves develop purple colour, stunted growth of plants
Potassium (K)	Osmotic balance	Older turn yellow on the leaf margins and stunted growth.
Magnesium (Mg)	Chlorophyll, enzyme activation	Older leaves show yellowing between leaf veins
Calcium (Ca)	Cell structure	Poor growth of roots and shoots of young plants.
Sulphur (S)	Protein and enzyme component	Yellowing in young and old leaves.

micronutrients	Function	Deficiency signs
Boron (B)	Cell wall	Terminal buds die
copper	Enzyme function	Leaves are dark green and stunted growth
iron	Enzyme function, required for chlorophyll production	Yellowing occurs on the vines of leaves.
Manganese (Mn)	Enzyme component	Palm fronds are stunted and deformed. Slow growth of plant parts.
zinc	Enzyme component	Yellowing occurs between the veins of the leaves.

Four tips for sustainable soil management

Planning your sustainable soil management strategies should always be top of mind.

Through seasons of use, soils can become depleted of nutrients and organic matter. If left unattended, this will lead to a decrease in yields for the grower. Additionally, soil depletion is not a phenomenon that is limited to the farmer; the home grower and gardener can face the same issues in their own front or backyards.

Proactive growers work for their soil to ensure that it works for them.

Healthy soil-which is soil that has high organic matter content, a balanced structure and high nutrient availability-provides an excellent basis for plants. It can decrease the amounts of inputs that a grower needs to use, since many of the nutritional requirements of the crops will already be supplied through the soil. This increased nutrient availability can also help plants to develop stronger roots and become naturally more resistant to environmental stressors.

The four tips included below will help increase your soil health in a sustainable way and will lead to noticeable improvements for years to come.

Increase soil organic matter

Between all the animals (like worms and insects) and the millions of microbes that make their homes in the ground, healthy soil is teeming with life. Each of these creatures plays a role in nutrient cycling, which is the process of breaking down crop residue, such as corn stubble, and degrading it into organic matter in the soil. Once the breakdown process is complete, the nutrients then become available for use by the plants. When plants use the nutrients that are available in the soil, growers can begin using more specific additives and fertilizers instead of deploying widespread “just in case” spraying.

Minimize tillage

Tilling can damage the soil environment and should only be used to improve problem areas, including where the soil is compacted or where drainage issues are heavily impacting the fields. Tilling can also increase the number of weeds in a field by bringing them to the surface, where they can germinate and grow. These weeds will compete with the intended crop for nutrients and take over precious field space, potentially decreasing crop yields.

Keep the surface of the soil covered

Using cover crops has become increasingly popular, and for good reason. Not only do cover crops offer another opportunity for growers to improve their soil makeup, since their use increases the availability of nutrients like nitrogen in the soil, but they also significantly reduce the likelihood of soil erosion. When fields are kept uncovered after harvest and during the winter, they become susceptible to erosion from wind and rain, which leaves the grower a step behind in building a healthy foundation for springtime crops.

Rotate crops

The type and amount of nutrients used by different crops will vary depending on which crop is being grown. Different crops also will increase the availability of different nutrients, which can be used by the crops that follow. Crop rotation also plays a part in preventing soil erosion. Not only does the field remain covered, but as each crop’s roots grow to varying lengths, they will hold onto the soil at different depths throughout the seasons, maintaining stability against heavier rains and winds.

While these steps are great ways to improve your soil and ensure that it will continue to be the hardworking first step toward producing a healthy plant and a profitable yield, their results can be maximized when combined with other management tools. Soil testing throughout your fields, for instance, will help you pinpoint areas of concern. Field scouting during the growing season will help the grower catch any areas where there might be a nutrient deficiency or disease pressure before the problem becomes widespread and requires more intervention. By combining all the tools at their disposal, growers can give crops the best possible foundation for seasons to come in a proactive and sustainable way.

Assessment:

Students to go around the farm area and try to identify crops that shows some deficiency signs of nutrient on a particular crop.

Reference/Source

1. Agriculture in Melanesia grade 10
2. Agriculture for Melanesia book 1
3. <https://www.alltech.com/blog/four-tips-sustainable-soil-management>

UNIT 2: TYPES OF CROPS

Content Standard 1.2 Students will be able to identify and examine the characteristics and physiology of different types of crops, categorize them according to their characteristics, purposes and benefits and explore the different environments and places where they are farmed.

Benchmark 10.1.2.1 Research and explain the purposes and benefits of different crops.

TOPIC: PURPOSES AND BENEFITS OF DIFFERENT CROPS

Learning Objectives.

By the end of this topic, students will be able to:

- Identify and examine the purpose and benefits of different crops.

Essential questions

1. Explain the main differences of fibre, oil, and tuber/root crops.
2. What are the main purposes and benefits of different crops

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Purposes and benefits of different crops.
Skills	• Identify and describe the features of fibre, oil, and tuber/root crops.
Attitudes & Values	• Appreciate the purposes and benefits of different crops.

Content Background

Purpose and benefits of different crops

A crop is a plant or plant product that can be grown and harvested for profit or subsistence. By use, crops fall into six categories: food crops, feed crops, fiber crops, oil crops, ornamental crops, and industrial crops.

Food crops, such as fruit and vegetables, are harvested for human consumption. Grains, such as corn, wheat, and rice, are the world's most popular food crops.

Food crops were the first crops to be harvested through agriculture. Agricultural development and the growth of civilizations led to the diversity of other types of crops.

Feed Crops

Feed crops, such as oats and alfalfa, are harvested for livestock consumption. These crops contain nutrients that animals need to develop. They are grown in agricultural fields but can also be found in natural meadows and pastures.

Forage crops are important for livestock farming. Animals feed directly on forages, such as grasses. Forages that are cut and fed to livestock while they are still fresh are called green chop. Alfalfa is a popular crop fed to livestock as green chop.

Some forages are cut, allowed to dry in the field, and stored. These are called hay crops.

Another type of forage crop is silage. Silage crops are harvested, then stored under conditions that allow the forage to break down (ferment) into acids. The wet, acidic silage is fed to livestock such as cattle.

Principle feed crops include corn, barley, wheat, and oats. Each of these crops has different properties that are better suited for some animals' diets over others. Barley, which is harder to digest, is most often fed to beef and dairy cattle because they have a tough, four-chambered stomach. Hull-less barley, which is easier to digest, is fed to swine and poultry.

The production of feed crops has risen dramatically with increased demand for meat worldwide. Increased production of feed crops has changed the agricultural landscape.

The Food and Agriculture Organization (FAO) says 33 percent of arable land on Earth is used to produce food for livestock. This limits the production of crops for human consumption, especially for the world's poorest people. Forests have been cleared to create pastures where livestock can graze. Almost 70 percent of land cleared from the Amazon rainforest, for instance, has been turned over to grazing.

Fiber Crops

Fiber crops, such as cotton and hemp, are harvested for textile and paper products. Textiles, or cloth, are made from the dried and processed fibers of certain plants. Most fibers used to make textiles are taken from the stem or roots of plants such as flax. Flax is used to make linen.

Other parts of a plant can be harvested for fiber. Cotton, the most popular fiber crop in the world, is harvested from the light, fluffy "boll" of fiber that surrounds the plant's seeds. Textiles made from bamboo are manufactured from the pulp of bamboo plants.

Pulp from other fiber crops can be used in a variety of products. Fiber pulp may be used instead of wood pulp to manufacture paper products.

The hemp plant is an interesting and controversial example of a fiber crop. The fibers of the hemp plant are strong and durable, perfect for products such as paper, textiles, ropes, nets, and sailcloth for ships. Hemp advocates see the plant as a versatile and ecological source of fiber.

But some varieties of the hemp plant are used to make marijuana, a psychoactive drug. Marijuana is illegal to grow and use in many parts

of the United States. (The drug is legally grown and sold for medical or recreational use in some places.) Opponents of hemp argue that increased harvesting of hemp crops will lead to increased production and use of marijuana.

Oil Crops

Oil crops, such as canola and corn, are harvested for consumption or industrial uses. Technologies developed in the past century have enabled crops to be processed and broken down into their primary components, including oil. Soybeans, for example, represented 61 percent of world oilseed production and 79 percent of all edible oil consumed in the United States in 2000.

Oil crops are harvested for use in cooking, such as olive oil and corn oil. Oil crops are also harvested for industrial use, such as oil paints, soaps, and lubrication for machinery.

Fuel made from oil crops is called biofuel. The demand for biofuels has grown in recent years. Rising gas prices, concerns about global warming, and a desire for energy self-sufficiency have led governments and businesses to invest in biofuel research.

There are two main types of bio-fuel that use oil crops: bioethanol and biodiesel.

Bioethanol is an alcohol made from fermented materials that come from sugar and starch crops. These crops include sugar cane, corn, and wheat. Bioethanol can be used as a fuel for vehicles, but it is usually used as a gasoline additive to improve vehicle emissions. Bioethanol is used widely in the United States and Brazil, where an abundance of corn and sugar cane crops facilitate its production.

Biodiesel is made by combining vegetable oils with alcohol. Nuts, such as coconuts, macadamias, and pecans, are excellent sources of oil used to manufacture biodiesel. Biodiesel can be used in diesel engines, such as those used by buses. Brazil, the United States, and the European Union (particularly Germany) manufacture and use biodiesel on a large scale. Biofuels provide almost three percent of the world's transport fuel. Many scientists and economists predict that number will rise as oil production decreases in the next century.

Ornamental Crops

Ornamental crops, such as dogwood and azalea, are harvested for landscape gardening. Ornamental crops are most often grown in nurseries, where they are purchased for residential or commercial settings.

Ornamental crop production has deep historical roots. The tulip crop of the Netherlands, for example, has become a symbol of that country.

Today, ornamental crop production is an important economic activity in many developing countries. Kenya, for example, is a major exporter of roses and carnations. Kenyan flower growers have situated their greenhouses near the shores of Lake Naivasha and Lake Victoria, where the soil is fertile and the water is abundant and fresh.

Kenya's huge flower operations, however, are having a negative impact on lake ecosystems. Growers irrigate their flowers with lake water, dramatically lowering supplies of freshwater available for consumption and hygiene. Growers also apply heavy amounts of fertilizers and pesticides so their flowers can maintain their beauty throughout the export process. These chemicals often runoff into the lakes, endangering aquatic animal and plant life.

Industrial Crops

Industrial crops, such as rubber and tobacco, are harvested for their products' use in factories or machines. Industrial crops include all crops used in the production of industrial goods, such as fiber and fuel products.

Rubber is produced naturally from a wide variety of plants, but predominantly from the tree indigenous to the Amazon region. Rubber is harvested for its latex. Latex is an extremely tough fluid found in the inner bark of the tree. Latex is obtained by tapping cutting or shaving the bark with a sharp knife and collecting the latex in cups. When mixed with chemicals, latex creates solid rubber blobs, called curds. Rubber curds are pressed between rollers to remove excess moisture and to form sheets. The sheets are packed and shipped for use in tires, machine belts, shoe soles, and other products.

Rubber has been used by civilizations for thousands of years. One of the earliest uses of rubber was to create balls for use in games in the Olmec Empire in what is today Mexico. Today, rubber is still used to manufacture durable toys, as well as boots, flooring, balloons, and medical supplies.

trees transplanted to southern Asia now produce most of the world's rubber. The countries with the largest rubber crops are Thailand, Indonesia, and Malaysia. Industrialization around the world has increased the global demand for rubber. High demand for natural rubber has increased the environmental degradation of forests in southern Asia.

Harvesting Crops

Methods for growing and harvesting crops have developed over thousands of years. The earliest crops were grown in Mesopotamia around 5500 B.C.E. These crops, indigenous to an agriculturally rich area called the Fertile Crescent, were grown near local sources of freshwater so they could be irrigated relatively easily. Wheat, barley, and figs were among the first crops.

The development of agriculture led to more sophisticated methods of harvesting crops. Crop rotation was the most significant innovation. In crop rotation, one crop is planted one year, then a different crop is planted the next year on the same land. This helps preserve the soil and reduce the chance for disease. Crop rotation and fertilization, which makes soil more productive,

allowed farmers to grow more crops on less land. These innovations also allowed crops to be grown in areas where they might not grow naturally. Improved engineering allowed rivers to be dammed and diverted to provide water for crops. All of these developments increased the abundance of crops, which could be used for trade and industrial use. Today, agriculture is the largest industry in the world. Millions of people harvest crops for subsistence or business purposes. Some tools used to harvest crops have not changed in a thousand years—plows, rakes, sickles. Most of all, harvesting crops still relies on human labor. The tools and machinery used to harvest crops have grown much more complex and expensive, however. Fertilizers, which many farmers need to be economically competitive, cost more than many farmers in the developing world can afford. Machinery, such as tractors and plows, can cost hundreds of thousands of dollars.

GMOs

Genetically modified organisms (GMOs or GM foods) are common throughout the developed world. Biotechnology allows scientists to alter the DNA of microbes, plants, and animals. Businesses sell farmers genetically modified seeds. With these seeds, farmers can use toxic chemicals without harming the crop. Farmers who grow GM foods increase production with less labor and less land. Vegetables and fruits last longer and are less likely to bruise. The heavy reliance on chemicals has disturbed the natural environment, however. Helpful species of animals may be killed along with harmful ones. Chemical use may also pose a health hazard to people, especially through runoff entering local aquifers and other water supplies. Critics argue that GM foods have less nutritional value and decrease biodiversity. Organic and free-range food industries have grown in opposition to industrial farming. Agricultural scientists are looking for safer chemicals to use as fertilizers and pesticides. Some farmers use natural controls and rely less on chemicals.

Seed Banks

In order to preserve biodiversity, seed banks have been created around the world to store seed samples. Seed banks may specialize in a specific crop or in the crops of a region. The International Potato Center, based in Lima, Peru, houses 150 wild potato species and other tubers of Andean origin.

Native Seeds, founded in the southwestern United States, helps Native Americans locate seeds for growing traditional crops, such as orach, or “mountain spinach,” and amaranth, once widely used for food and fiber in Mexico.

The Svalbard Global Seed Vault, the world’s most diverse seed bank, was established in 2008. The Norwegian government built the Seed Vault into the side of a permafrost-covered mountain on the island of Spitsbergen, part of the Svalbard archipelago about 1,030 kilometers (620 miles) from the North Pole. The vault is designed to safely store the seeds of hundreds of thousands of plant varieties from crops grown throughout the globe. The Seed Vault offers “fail-safe” protection for the world’s

agricultural inheritance against any natural, social, or economic disaster. Today, the Seed Vault stores about one million seed samples. It has the capacity to hold 4.5 million samples.

Crops have a wide variety of uses and are an integral part of our existence and development. While advancements in crop science and technology have increased the production of some of our most basic foodstuffs, they also have had wide-ranging impacts on the environment.

The production of crops does not have to harm the environment. By protecting the land, water, and air, and by sharing knowledge and resources, people may find solutions for the problems of world hunger and global energy scarcities through the sustainable use of crops.

Assessment:

- Students do research on the types of ornamental crops and genetically modified crops in PNG.

References/Source:

Robertson, B, Ossom, E, (2009) Agriculture in Melanesia, Grade 9 Student's Book, Pearson, Australia

<https://aggie-horticulture.tamu.edu/wildseed/growing/annual.html>

https://en.wikipedia.org/wiki/Biennial_plant

<https://www.nationalgeographic.org/encyclopedia/crop/>

UNIT 2: TYPES OF CROPS

Benchmark 10.1.2.2 Research and classify crops according to their growing cycle, species, variety, season, land type, crop use, and type of product, how the crop is processed, and cultivation methods.

TOPIC: CROP CLASSIFICATION

Learning Objectives

By the end of this topic, students will be able to:

- Classify crops according to their characteristics (growing cycle, species, variety, season, land type, crop use, and type of product)
- List examples of crops according to their classifications.

Essential questions

1. How can we classify crops?
2. What are the examples of crops according to their classifications?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Classification of crops according to their characteristics.
Skills	• Classifying crops based on their characteristics.
Attitudes & Values	• Appreciate that crops vary according to their characteristics.

Content Background

Based on the uses of crops, they can be classified into several groups such as cereals, grain legumes, vegetables, fruits, spices and drugs and so on. Apart from their botanical classification, they can be further classified on the basis of their life span, (how long they live) seasons.

Classification of crops according to;

A. Mode of Reproduction

Sexual-plants that develop from a seed or spore after undergoing union of male and female gametes. Examples: palms and ferns.

Asexual-plants which reproduce by any vegetative means without the union of the sexual gametes. Examples: breadfruit, mangosteen.

B. Mode of Pollination

Naturally self-pollinated crops. The predominant mode of pollination in these plants is self-pollination in which both pollen and embryo sac are produced in the same floral structure or in different flowers but within the same plant. Examples: rice, most pulses, okra, tobacco, tomato.

Naturally cross-pollinated crops. Pollen transfer in these plants is from the anther of one flower to the stigma of another flower in a separate plant, although self-pollination may reach 5 percent or more. Examples: corn and many grasses, avocado, grape, mango, many plants with unisexual or imperfect flowers.

C. Life Span

Annual-a plant which live within a short period of time, for a few weeks or months, perpetuated by seed, and which die soon after producing seeds; a plant which germinate, grow, flower, produce seed, and die all in one season. Examples: rice, corn, cowpea.

Biennial-a plant which requires two growing seasons to complete its life cycle, the first for vegetative growth and accumulation of food reserves, and the second for the production of reproductive parts. It grows from a seed, produces flower and seed and then dies in two growing seasons.

Examples: bulb onion, cabbage, carrot, celery

Perennial-a plant that lives indefinitely, including all trees and shrubs and many herbaceous plants with underground stems (e.g. corm, rhizome, tuber) like banana and clump-forming grasses. Perennial plants continue growing and produce seeds year after year.

D. Growth Habit

Herbs- succulent plants with self-supporting stems. Examples: banana, sugarcane, tomato.

Vines- climbing or twining plants without self-supporting stems. Examples: cucumber, yam.

Lianas- woody climbing or twining plants which depend on other plants for vertical support to climb up to the top of the canopy. These climbers often form bridges between the forest canopy. Examples: Climbing bamboo, grape, Jade vine, passion fruit.

Shrubs- small trees or tree-like plants, generally less than 5 meters in height but by other authorities it is restricted to small, erect, woody plants which produce several trunks from the base.

Trees- plants having erect and continuous growth with a large development of woody tissue, with a single distinct stem or trunk, reaching a height of 5 meters or more. Examples: mango

E. Leaf Retention

Evergreen – plants that maintain their leaves throughout the year. Abscised leaves are continually replaced by new flushes. • Examples: pines, banana, papaya, palms and most tropical plants.

Deciduous – plants which naturally shed off or lose leaves annually for extended periods. Natural leaf shedding is pronounced in deciduous trees of temperate regions.

F. Ecological Adaptation or Habitat

1. **Aquatic, hydrophyte or hydrophytic plant** — a plant adapted to growing in water or waterlogged soil. It may grow entirely submerged, partly submerged or floating, or anchored to the ground in bogs, swamps, or beside the edges of ponds, lakes or streams. Examples: azolla, kangkong (*Ipomea aquatica*), bulrush (*Cyperus* spp.), lotus (*Nelumbo nucifera*), water lily (*Nymphaea* spp.), mangrove species.

2. **Epiphyte or epiphytic plant** – a plant that grows aboveground on another plant but is not parasitic, usually deriving only physical support from the

host and obtaining nourishment from the air and other sources. Some have roots that take moisture and minerals leached from the canopy of trees and others catch rain and debris in special hollow leaves. –The most common epiphytes belong to the bromeliad, orchid, and fern families; also called air plant or tree dweller.

3. *Halophyte or halophytic plant* – a plant that is able to grow in habitats excessively rich in salts or under saline conditions. – Examples: Mangrove species. Coconut, cashew and tamarind have varying levels of tolerance to saline conditions.
4. *Lithophyte or lithophytic plant* – a plant adapted to growing on rocks or in rocky terrain with little humus, absorbing nutrients from the atmosphere, rain, and decaying matter which accumulate on the rocks. Vanda, Ascocenda, Ascocentrum, and Trudelia orchids can be grown as lithophytes. Dendrobium has also been grown in pots filled with gravel or stone.
5. *Mesophyte or mesophytic plant* – a terrestrial plant which is adapted to moderate conditions for growth, i.e. not too dry and not too wet • (e.g. corn and most commercially-grown crops).
6. *Parasite or parasitic plant* – a plant which grows on another plant from which it takes part or all nourishment Example. Orchids
7. *Saprophyte or saprophytic crop* – grows on decaying organic matter and has no green tissue. • This classification applies to the mushrooms, which are fungi.
8. *Sciophyte or sciophytic plant* – a plant that is adapted to low light intensity or shade, e.g. most ferns and mosses, black pepper, cacao, coffee, lanzones, mangosteen, hot pepper, ginger, and many orchids can tolerate or require shade.
9. *Terrestrial or land plant* – a plant which grows on land, rooting in the soil. It has aerial parts, collectively called shoot, and an underground part called root which absorbs most of its water and nutrient needs from the soil. Most agricultural crops are terrestrial and are further subclassified into various groups such as halophytes, mesophytes, sciophytes and xerophytes depending on climatic and special adaptations.
10. *Xerophyte, xerophytic or xeric plant* – a plant which is adapted to conditions with little or no water. • Examples: cacti and many succulents.

Agricultural Classification of Crops

Crop – In agriculture, plants are classified as either crop or weed. A crop is any useful plant, or a plant which is grown for any purpose. It is utilized by man directly or indirectly, raw or processed.

Direct utilization is exemplified by the use of cereal grains as staple while they are indirectly consumed by man when they are first fed to livestock for

meat, or processed into sugar for human consumption.

These plants are intentionally grown or managed for various uses such as for food, spices, sugar, drinks, fiber, clothing, beverages, medicines, oils, tannins, rubber, ornamentation, fuels, construction materials, soil improvement, organic farming, landscaping and many more.

Weed – a weed is an unintended plant or any plant which grows where it is not wanted. – It competes with the intended crop for space, soil water, nutrients and light or becomes a nuisance in any manner. – Many have allelopathic effect on other plants, both crop and weed, by releasing harmful allelochemicals which are considered plant-produced herbicides. Any plant can be a weed, depending on where it grows and how man is affected.

Agronomic crops – also called “field crops”. – They are mostly annual herbaceous plants that are grown under extensive or large-scale culture. – The usable products are usually in high dry matter form. By tradition, cereals, seed legumes, root and tuber crops, sugar crops, latex and rubber crops, pasture and forage crops, and fiber crops are classified under agronomic crops.

Examples by Category;

1. Cereals: Corn, Rice, Wheat
2. Legumes Cowpea, Beans, Peanut, Soybean
3. Root and tuber crops: Cassava, potato, yam
4. Sugar crop: Sugarcane, Sugar beets
5. Fruits: Avocado, Banana, Mango, Guava, Pomelo – Citrus, Papaya, Sour soup
6. Vegetable (Olericulture): Lettuce, Cabbage, Carrot, Egg-plant, Tomato

Horticultural crops – referred to as “garden crops”. – those grown under any of the fields of horticulture such as olericulture or vegetable crops production, pomology or fruit crops production, and ornamental horticulture (floriculture and landscape horticulture), as well as spices and medicinal plants. – Horticultural products are generally utilized with high moisture content and are therefore highly perishable.

Examples: Flower and ornamental crops

Assessment:

Identify the different types of horticultural crops according to their horticultural classification (olericulture, pomology, ornamental, spices and medicinal plants).

Reference/Source:

Robertson, B, Ossom, E, (2009) Agriculture in Melanesia, Grade 9 Student's Book, Pearson, Australia
https://www.academia.edu/41727492/Classification_of_Agricultural_Crops

UNIT 3: CROP FARMING PRACTICES AND MANAGEMENT SYSTEMS

Content Standard 1.3. Students will be able to investigate and analyse crop farming, processing, marketing, regulation, and management principles, systems and practices used in different contexts, environments and places.

Benchmark 10.1.3.1 Investigate and explain crop management systems and practices used in different contexts.

TOPIC: CROP MANAGEMENT SYSTEMS AND PRACTICES USED IN DIFFERENT CONTEXTS

Learning Objectives

By the end of this topic, students will be able to:

- Describe crop management systems and practices.
- Describe and explain the different management systems.

Essential questions

1. What are crop management systems and practices?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Crop management systems and practices.
Skills	• Identify and describe crop management systems and practices.
Attitudes & Values	• Appreciate crop management systems and practices.

Content Background

Importance of Crop Management

Adoption of best crop management practices improves crop productivity and can contribute to greater yields with improved quality. Crop management is the set of agricultural practices performed to improve the growth, development and yield of crops. It begins with a seedbed preparation, sowing of seeds and crop maintenance; and ends with crop harvest, storage and marketing. The timing and sequence of agricultural practices depend upon several factors, such as winter or spring crops; harvested products such as grain, hay and silage; sowing methods-broadcast and row-crops; and, plants age, soil, climate and weather conditions.

Seedbed Preparation

Seedbed preparation is the first step to improve crop growth and development.

Planting

After the seedbed has been prepared, seed should be sowed 1.5 to 2.0 inches deep to ensure proper moisture availability for good seed germination.

Fertilization

Fertilization may be an important component of crop management. Soils should be tested for available plant nutrients before adding fertilizers to any crop.

Pest Management

Pest management is another important aspect of crop management. Pesticides can be powerful tools for controlling pests in most crops, mainly if used correctly based upon specific pest species.

Irrigation

Irrigation is another critical factor for crop production that influences the final crop yields and quality, especially in our dryland region.

Harvesting

Finally, the yield and quality of crops depend upon the harvest management strategy.

Post-Harvest Storage

The post-harvest storage conditions also influence the crop's forage and grain quality.

Additional Practices

Some additional best practices to increase crop productivity and farm profitability are:

- Increase crop diversity
- Enhance beneficial pollinators population
- Use better weed control measures to increase harvest efficiency, crop quality and yield
- Improve soil quality by following the best soil management practices
- Add nutrients based upon availability from soil and crop needs
- Manage labour and input costs
- Keep track of all expenses and profits
- Keep good records to help manage a profitable farm business
- Engage in creative marketing

The consideration of recommended crop management practices may produce greater yields and an excellent marketable product.

Assessment:

Select five of the above additional management practices and tell the students to divide into five groups to discuss how they can increase crop productivity and farm profitability.

Resource/Source:

<https://extension.unr.edu/publication.aspx?PubID=4103>

UNIT 3: CROP FARMING PRACTICES AND MANAGEMENT SYSTEMS

Benchmark 10.1.3.2 Investigate and explain crop cultivation and management principles.

TOPIC: CROP CULTIVATION AND MANAGEMENT PRINCIPLES

Learning Objectives

By the end of this topic, students will be able to:

- Explain types of crop cultivation and management principles used in cultivation farming.

Essential questions:

1. What are crop cultivation and management principles?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	Techniques in managing of crop cultivation
Skills	Identify and differentiate different crop management principles.
Attitudes & Values	Appreciate and value importance of crop management.

Content Background

Examples of crop management Principles

1. Pest and control disease management: reducing or eliminating different types of unwanted creatures such as cockroaches, ants, wasps, and bees.
2. Watering or Irrigation- An artificial application of water to the soil through various systems of tubes, pumps, and sprays
3. Proper Drainage system: Removal of excess water from farm fields.
4. Pruning: Removal or reduction of parts of plant crops that are not requisite to growth or production. Can also be considered preventive maintenance for both insect and disease damage.
5. Adding manure and fertilizers: soil fertilization is an essential component of crop management to assure nutritional sufficiency for plant growth.

Guiding Principles of Organic Farming

The four principles of organic farming—health, fairness, ecology and care — provide a vision for agriculture that inspires environmentally friendly cultivation and production.

Organic farming aims to produce superior quality products, with high nutritional value and no chemicals, with the purpose of good health. It aims to create a sustainable system that conserves energy, soil and water; while at the same time providing general maintenance of the environment.

Understanding more about the sector itself helps to know what the driving force is behind it. Although not using pesticides and herbicides, growth hormones and antibiotics play a major part in organic production, organic agriculture is much more detailed.

As such, all organic production methods around the world are based on four principles: health, balance, fairness and care. These principles provide a vision for agriculture that inspires environmentally friendly cultivation and production.

Principle of Health

Organic agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible.

The principle of health in organic agriculture refers to the health of ecosystems, as well as the health of people and communities. Healthy soil produces healthy crops, and in turn, healthy produce leads to healthy animals and humans. Good health is imperative to our mental and physical wellbeing; it also increases our immunity and allows our body to regenerate. Organic agriculture aims to provide healthy food that is nutritious and superior quality. By not using fertilisers, pesticides and additives, organic food plays an extra part in aiding good health.

Principle of Fairness

Organic agriculture should build on relationships that ensure fairness with regard to common environment and life opportunities.

The principle of fairness refers to good human relationships and quality of life. Organic agriculture is based on providing a fair and just environment for people to live in. Organic farmers are expected to ensure work completed at their farm is fair to all involved, from the farmers and pickers, through to the distributors and consumers. It aims to provide quality food and other products, and animals are to be housed in conditions that are in accordance with their natural behaviour and wellbeing. Organic agriculture merges human life with animals and plants – and ensures they are all used sensibly now, and into the future.

Principle of Ecological Balance

Organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.

Organic farms are based on an ecological system that balances with the environment and nature, including recycling and taking care of the ecosystem. If you produce and raise organic animals, you need to take care of the farm itself. For crops, take care of the living soil. Ecological balance includes managing conditions and culture; and farmers, producers, traders and consumers should take environmental protection on board. Air, water, biodiversity, climate and land needs to be protected and can be done through the use of high-tech farming systems.

Principle of Care

Organic agriculture should be managed in a precautionary and responsible manner to protect the health and wellbeing of current and future generations and the environment.

When it comes to organic agriculture, it's not just the environment today that matters, but we also need to have consideration for the environment of the future. This is where the principle of care comes in. Many organic farmers aim to increase their production, and while this is great – it must be done with care to ensure the future health of the planet is taken care of. Using organic farming technology is the best way to do this, and its recommended organic producers keep up to date with new methods. Any business can say they are organic, but to be recognised and accepted, organic agriculture needs to be based on these four principles. If you want to find out more, get in touch today.

Assessment:

Group discussion on the types of management principles

Reference/Source:

<https://www.oanz.org/new-blog/4-guiding-principles-for-organic-farming>

UNIT 4: CROP FARMING AND TECHNOLOGY

Content Standard 1.4. Students will be able to examine how technology is used in the cultivation, regulation, and management of crops in different societies and environments, and analyse their advantages and disadvantages.

Benchmark 10.1.4.1 Investigate and explain how technology could be used to improve plant propagation.

Topic: How technology could be used to improve plant propagation.

Learning Objectives

By the end of this topic, students will be able to:

- Explain how technology could be used to improve plant propagation.

Essential questions:

1. What is plant propagation?
2. In what ways can technology be used to improve plant propagation?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Use of technology to improve plant propagation.
Skills	• Research and explain ways technology can improve plant propagation.
Attitudes & Values	• Appreciate and value importance of technology in plant propagation.

Content Background

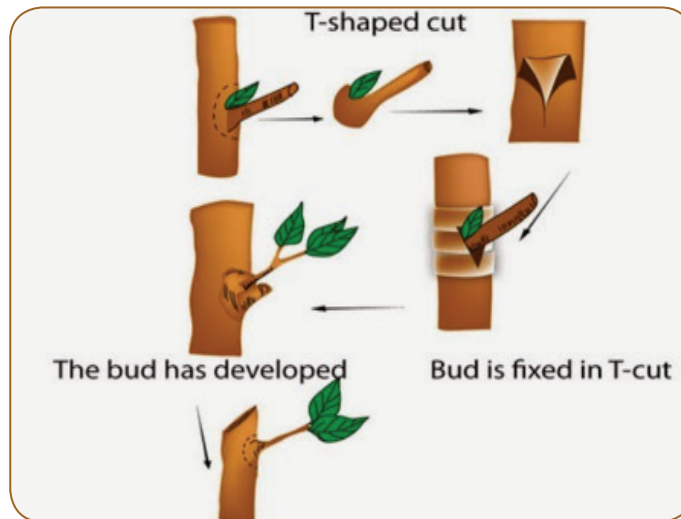
Plant propagation is the process which grows new plants from a variety of sources: seeds, cuttings, and other plant parts. Plant propagation can also refer to the man-made or natural dispersal of seeds.

Sexual Propagation

Sexual propagation of plants involves the union (fertilization) of pollen and egg leading to seed formation. So, it can also be called ‘seed propagation’. It’s an old, easy, simple, and effective technique for ornamentals or flowering plants, vegetables, fruits, and medicinal plants.

Asexual propagation

Asexual propagation of plants can also be called ‘vegetative propagation’ because it involves the use of vegetative parts of plants like leaves, stems, roots, or modified organs. It’s the best method to use to clone your plants, which means to produce plants identical to their parents. It involves methods like cutting, division, layering, grafting, budding, and tissue culture techniques. These techniques are commercially exploited mainly to produce horticulture plants.



Technology has also helped a lot in plant propagation. Some ways technology has improved plant propagation.

1. The use of vegetative crop solutions in fields, greenhouse and laboratory to produce cuttings or transplants.
2. The use of heat propagator plays a significant role in horticulture as it maintains moisture in newly grown plants.
3. Seed Propagation mat: An electric **seed-propagation mat** is a heated rubber mat covered by a metal cage which is used in gardening. The mats are made so that planters containing seedlings can be placed on top of the metal cage without the risk of starting a fire. In extreme cold, gardeners place a loose plastic cover over the planters/mats which create a sort of miniature greenhouse. The constant and predictable heat allows people to garden in the winter months when the weather is generally too cold for seedlings to survive naturally. When combined with a lighting system, many plants can be grown indoors using these mats.
4. The application of tissue culture methods to the propagation of plants has dramatically altered the way many plants are routinely propagated. As tissue culture technology continues to expand and improve, these techniques will be applied to a growing list of plant species. Most of the species that are presently being propagated on a large scale through tissue culture are herbaceous ornamentals and fruits. This technology provides the opportunity to produce uniform, disease-free plants where lack of uniformity and/or virus infestations had previously been a serious problem.



Assessment:

The students do a practical activity on vegetative propagation method (budding). Student should use same crop species, eg; different types of mango trees.

Reference/Source:

1. Baing, S, (2014) Agriculture Grade 10 Student's Book, Oxford University Press, Australia
2. https://en.wikipedia.org/wiki/Plant_propagation
3. <https://www.ratemyfishtank.com/blog/tips-for-rooting-pruning-and-propagating-live-aquarium-plants>
4. <https://www.plantcelltissue.method.org>.

UNIT 4: CROP FARMING AND TECHNOLOGY

Benchmark 10.1.4.2. Evaluate the impact of propagation technology on plant physiology and anatomy.

TOPIC: IMPACT OF PROPAGATION TECHNOLOGY ON PLANT PHYSIOLOGY AND ANATOMY

Learning Objectives

By the end of this topic, students will be able to:

- Identify and evaluate the impacts of propagation technology in plant physiology and anatomy.

Essential questions:

1. What are the impacts of propagation technology in plant physiology and anatomy?

Essential Knowledge, Skills, Attitudes and Values

Essential Knowledge	• Impacts – Advantages and disadvantages of propagation technology in plant physiology and anatomy.
Essential Skills	• Identify and evaluating the impacts of propagation technology in plant physiology and anatomy.
Essential Attitudes & Values	• Appreciate the advantages and disadvantages of propagation technology in plant physiology and anatomy.

Content Background

Basically, the main drive behind the usage of technology in plant propagation is to increase food production to meet the high demand for supply.

SEXUAL OR SEED PROPAGATION

Advantages:

- 1) produces large numbers in a short period of time
- 2) can handle large numbers easily
- 3) produces hybrids

Disadvantages:

- 1) some plants produce no viable seeds
- 2) some seeds are very difficult or slow to germinate
- 3) causes genetic variability (due to production of hybrids)

ASEXUAL OR VEGETATIVE PROPAGATION

Advantages:

1. All off-spring are true-to-type (identical to the parent) and produce a clone - a group of plants, cultivar or variety derived from the same parent plant by asexual (vegetative) propagation.
- 2) for plants that are hard or impossible to propagate from seeds
- 3) decrease time to flowering (esp. grafting & budding); by-passes juvenile phase

Disadvantages:

- 1) can only propagate a few from each parent (except tissue culture).
- 2) requires a lot of labour

TISSUE CULTURE

There are several advantages and disadvantages to using the tissue culture process.

ADVANTAGES OF TISSUE CULTURE

- The new plantlets can be grown in a short amount of time.
- Only a small amount of initial plant tissue is required.
- The new plantlets and plants are more likely to be free of viruses and diseases.
- The process is not dependent on the seasons and can be done throughout the year.

DISADVANTAGES OF TISSUE CULTURE

- Tissue Culture can require more labor and cost more money.
- There is a chance that the propagated plants will be less resilient to diseases due to the type of environment they are grown in.
- It is imperative that, before being cultured, the material is screened; failure to pick up any abnormalities could lead to the new plants being infected.

Assessment:

Students do a short quiz on the topic.

Reference/Source:

<https://www.plantcelltechnology.com/pct-blog/advantages-and-disadvantages-of-plant-tissue-culture/>

UNIT 5: TYPES OF PLANTS

Content Standard 1.5 Students will be able to identify and examine the characteristics and physiology of different types of plants, categorize them according to their characteristics, purposes, and benefits, and explore the different contexts, environments, and places where they are farmed.

Benchmark 10.1.5.1 Identify and examine different types of plantation crops, ornamental plants and bedding plants, and analyse their functions, purposes and benefits.

TOPIC: TYPES OF AGRICULTURAL PLANTS

Learning Objectives

By the end of this topic, students will be able to:

- Describe the functions, purposes and benefits for plantation crops, ornamental and bedding plants in different environments.

Essential questions:

1. What are plantation crops, ornamental and bedding plants?
2. What are the functions, purposes and benefits for plantation crops, ornamental and bedding plants?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Physiology, functions, purposes, and benefits for plantation crops, ornamental plants and bedding plants.
Skills	• Identify, describe, and compare the physiology, functions, purposes, and benefits for plantation crops, ornamental plants and bedding plants.
Attitudes & Values	• Appreciate the purposes, and benefits of plantation crops, ornamental and bedding plants.

Content Background

Plantation crops

Plantation crops are high valued commercial crops which play a vital role in the agricultural economy and trade exports of many countries. Plantation is a large-scale farm that specialises in cash crops. The crops include – tea, coffee, rubber, cocoa, betel nut, betel leaf, oil palm, bamboo, etc.

Characteristics

1. Grown in a vast area of land.
2. Perennial.
3. High-value crops of greater economic importance.
4. Play a vital role in our national economy.
5. Export potential.

6. Must be processed before use.
7. Known as a commercial crop or cash crop.

Importance

1. **High Value Crops**
They are commercial crops grown for their high value products. They have demand in the market and are sold at high prices.
2. **Export Potential**
Many countries in the world export large amount of Plantation Crops Products. These products have high demand in international markets.
3. **Industrial Importance**
Plantation crops means they are consumed after processing. Industry does the job of processing which provides a way for industrial development. For example, Many tea industries are opening to make tea from tea leaves.
4. **Employment Generation**
Production of these crops requires labour for the whole season. This creates job opportunities for many people. For Example – In Kerela, coconut farming provides employment to 78 man per hectare per year. Moreover, Industries required for the processing of these crops also creates employment opportunities for thousands of people.
5. **Prevents Soil Erosion**
These crops grown in hilly and slopes like Tea helps to prevent soil erosion. They also work as cover crops, so – rain can't wash away the soil.

Ornamental plants

Ornamental plants are plants that are grown for decorative purposes in gardens and landscaping design projects. Ornamental plants are used as cut flowers, house plants and specimen display.

Uses of Ornamental Plants

1. Ornamental trees provide shade for pedestrians on hot days, decreasing the use of vehicles. On colder days, the trees bulk up and can reduce frost by retaining heat in the soil.
2. They absorb carbon dioxide from the air and output oxygen; creating cleaner air. This is especially important in cities that are prone to pollution. When used indoors, they help purify the air and create a pleasant atmosphere. The peace of lily may be an example
3. Outdoor ornamentals help beautify the landscape and create an appealing environment. Fallen leaves make good mulch and compost.
4. They are grown for food. Some chilies are grown as ornamental plants. An example is capsicums or Doret Nag, officially the hottest chili in the world.
5. Ornamental Plants and trees planted at the sides of the roads help drivers reduce stress. It also protects drivers from severe car accidents by serving as a barrier to prevent cars from somersaulting or other worse cases.
6. If a person knows how to grow ornamental plants, he or she could earn some money by selling grown ornamentals. Since ornamentals sold at green houses or garden stores can be expensive.

7. Some ornamentals can be used for medicinal purposes. Examples of ornamental herbs are rosemary, Mexican marigold and lemon grass.
8. Ornamental plants can brighten a yard, compliment the style of a house or building. Therefore, increasing its worth by a percentage; making more money for the owner or portraying the owner of a high standards.
9. The foliage of evergreen Ornamental trees brightens winter landscape and affords windbreaks that save money on fuel bills.
10. Ornamental gardens provide a relaxing, protective environment which offers privacy to its users.
11. Ornamentals can be used for decorations during occasions such as weddings and anniversaries. A common example is rose.

Bedding Plants

Bedding plants are generally annual, biennial or tender perennial plant. Bedding in horticulture refers to the temporary planting or fast-growing plants into flower beds to create colourful temporary seasonal display. A bedding plant is any common fast-growing garden plant typically found in a nursery or garden center in mass quantities to plant in flowerbeds, specifically grown for the purpose of decorating and filling in garden spaces. Bedding plants can be annuals, biennials, or perennials and either vegetables or flowers. Because bedding plants are relatively inexpensive, they provide the gardener an opportunity for instant blooms and quick coverage. They are also widely used in pots for decorating patios and decks.

In organic gardening, bedding plants can be grown effortlessly by using seeds from old plants, and are usually discarded after blossoming. Bedding plants may also be known as patio plants.

Assessment:

Students are to identify the types of ornamental and bedding plants around the school area and take pictures if they can.

Reference/Source:

<https://www.maximumyield.com/definition/13/bedding-plant>

UNIT 5: TYPES OF PLANTS

Benchmark 10.1.5.2 Research and classify plantation crops, ornamental plants, and bedding plants according to their species, functions, purposes, and benefits.

TOPIC: CLASSIFICATION OF AGRICULTURAL PLANTS

Learning Objectives

By the end of this topic, students will be able to:

- Identify, compare and classify agricultural plants (Plantation crops, Ornamental and bedding plants) according to their species, purposes and benefits.

Essential questions:

- What are some of the species of plantation crops, ornamental and bedding plants?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	Identify and name different types of species of plantation crops, ornamental and bedding plants.
Skills	Identifying, comparing, differentiating the species of plantation crops, ornamental and bedding plants.
Attitudes & Values	Passionate on the species of plantation crops, ornamental and bedding plants.

Content Background

Plantation crops

Plantation crops constitute a large group of crops. The major plantation crops include coconut, oil palm, cashew, tea, coffee, and rubber; the minor plantation crops include cocoa. Their total coverage is comparatively less and they are mostly confined to small holdings.

Classification

1	Beverage Crops	Tea, coffee, cocoa
2	Oil yielding crops	Coconut, oil palm
3	Nuts	Cashew nut
4	Industrial crops	Rubber
5	Masticatory crops	Arecanut, Beetle vine

- Beverage Crops:** The crops which products are used to make beverage other than water.
- Oil Yielding Crops:** These crops are used to extract oil.
- Nuts:** Nuts are dry single seeded fruits and have high oil content.
- Industrial Crops:** The crops which are used to make industrial products rather than consumption.
- Masticatory Crops:** Masticatory crops are used for chewing purposes.

Ornamental plants

Ornamental plants are often focal points in the landscape. You can find ornamental plants in a variety of cultivars, from roses to grasses and from deciduous to evergreen. Some ornamentals that bloom attract hummingbirds and butterflies, while others simply add colour year-round.

Classification of ornamental plants with examples

The ornamental plants can be divided into two categories, which are;

1. Herbaceous ornamental plants
2. Woody ornamental plants

A) Herbaceous ornamental plants:

1. Annuals

Winter season flowers: Dahlia, Poppy, Dianthus, Calendula, Marigold, Cosmos, Aster etc.

Summer season flowers: Balsam, Cocks comb etc.

Year round / All season flowers: Sunflower, Zinnia etc.

2. Biennial –Holy hock, Sweet William

3. Perennials

- For flowers: Phlox, Gladiolus etc.
- For foliages:

4. Lilies

There are three families which group as [lilies](#). They are

- Amaryllidaceae: Tube rose, Daffodils
- Scitamineae: Dolon chapa, Canna etc.
- Liliaceae: Day lily, Lilium.

5. Aquatic ornamental plants – Lotus, Water lily, Redwater lily, etc.

6. Cactus, Orchid, Ferns –

- Cactus: Star cactus, Rose cactus, Prickly pear, Orchid cactus, etc.
- Orchids: Vanda, Dendrobium, Vanilla, etc.
- Ferns: Bird nest ferns, Sword fern, etc.

B) Woody ornamental plants

- Flowering shrubs: Rose, Jui, Beli, Mollika, Jasmine, Kamini, China rose, etc.
- Non-flowering ornamental shrubs: Croton, Musanda
- Flowering tree – a. Magnoliaceae: Magnolia, Iron wood tree, etc. b. Leguminoseae: Pea cock, Ashok
- Foliage ornamental trees: Rubber, Ashok, Banyan trees, Eucalyptus, etc.
- The palms: Bottle palm, Fishtail palm, Toddy palm, Butterfly palm, Oil palm, Chinese palm, etc.
- Ornamental hedge plants: Duranta, Justicia, Iroxa, etc.
- The conifers: Pine, Thuja, Juniper, etc.

- The creepers and climbers: Madhobi lata, Jhumka lata, Bougainvillea, etc.

Bedding plants

Bedding plants can be categorized into four main groups:

1. Hardy annuals - Grown directly in the early season (e.g., poppy, sunflower, dianthus)
2. Tender annual (perennial) plants - Planted as young plants after the frost melts (e.g., begonia, petunia, chrysanthemum, fuchsia)
3. Hardy biennial plants - discarded after flowering (e.g., daisy, foxglove, cornflower, pansies)
4. Corms or tubers - Planted each year and taken out once the plant naturally dies (e.g., narcissus, hyacinth, gladiolus)

Assessment:

Students are asked to do a case study on a plantation crop that is grown in the community.

Reference/Source:

<https://www.maximumyield.com/definition/13/bedding-plant>

UNIT 5: TYPES OF PLANTS

Benchmark 10.1.5.3 Investigate and explain how ornamental and bedding plants are cultivated and processed in different environments and places.

TOPIC: CULTIVATION OF ORNAMENTAL AND BEDDING PLANTS

Learning Objectives

By the end of this topic, students will be able to:

- Describe and distinguish cultivation of ornamental and bedding plants in different environments.

Essential questions:

1. What are cultivation practices for ornamental and bedding plants in different environment?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Explain cultivation practices for ornamental and bedding plants.
Skills	• Explain, describe, and compare the cultivation practices for ornamental and bedding plants.
Attitudes & Values	• Appreciate that cultivation of ornamental and bedding plants vary in different environments.

Content Background

The cultivation of ornamental plants is called *floriculture*, which forms a major branch of horticulture.

For plants to be considered ornamental, they require specific work and pruning by a gardener. For instance, many plants cultivated for topiary and bonsai would only be considered to be ornamental by virtue of the regular pruning carried out on them by the gardener, and they may rapidly cease to be ornamental if the work was abandoned.

Ornamental plants are plants that are grown for decorative purposes in gardens and landscape design projects, as houseplants, cut flowers and specimen display.

Bedding, in horticulture, refers to the temporary planting of fast-growing plants into flower beds to create colourful, temporary, seasonal displays, during spring, summer or winter. Plants used for bedding are generally annuals, biennials or tender perennials; succulents are gaining in popularity.

Some bedding plants are also referred to as "patio plants" because they are widely used in pots and other containers positioned on patios, terraces, decking and other areas around houses. Larger tender "conservatory plants" may also be moved out from greenhouses or conservatories and planted

out in borders (or stood in their pots in sheltered positions) for the warmer months, then returned to shelter for the winter.

The modern bedding plant industry breeds and produces plants with a neat, dwarf habit, which flower uniformly and reliably. They are bred primarily for use in large-scale bedding schemes where uniformity and predictability is of paramount importance, but this is often achieved by losing the plants' individual character, and has been criticized by such notable plantsmen as the late Christopher Lloyd, who championed an informal style of bedding.

Steps on cultivating ornamental plants

1. What does a household need to start a plant nursery?

- Reliable access to water - enough water and not too salty
- A source of suitable soil
- To be willing to work for more than a year without income while establishing the plants
- Land near their house where a nursery can be set up (about 10 x 10 m)
- To be able to establish a protected nursery area and build a fencing and shade net structure
- To be able to access seeds and cuttings
- To be able to afford operational costs such as water and pesticides.

2. Develop a plan for the nursery

- Identify the plants to be grown (this information is needed for the permit application, and for selling)
- Set targets for the numbers of seedlings and cuttings you will grow
- Plan your operating costs, cash flow etc
- Develop links with other nurseries which are already in the market
- Decide where to take cuttings and collect seeds
- Decide who you want to sell your plants to
- Plan how to transport your plants to the market
- Develop a marketing strategy. For instance, plan to sell some fast-growing plants early on and keep some slow-growing plants to sell later. Some special individual plants should be kept longer so they can grow bigger and sell for higher prices

Assessment:

- The students are to design a project on bedding plant around the school area and plant different types of flowers. This project should be an on-going project.

Reference/Source:

[https://en.wikipedia.org/wiki/Bedding_\(horticulture\)](https://en.wikipedia.org/wiki/Bedding_(horticulture))
https://en.wikipedia.org/wiki/Ornamental_plant#
<https://extension.psu.edu/planting-ornamentals>

UNIT 5: TYPES OF PLANTS

Benchmark 10.1.5.4 Investigate and explain how plantation crops, ornamental plants and bedding plant products are processed, preserved, and marketed in different contexts and environments.

TOPIC: PRODUCTION PROCESSES OF DIFFERENT PLANT PRODUCTS

Learning Objectives

By the end of this topic, students will be able to:

- Identify and describe the production processes of different plants products in different contexts and environment.

Essential Questions:

1. How are plantation crop products processed, preserved and marketed?
2. What are some of the plantation crop products?
3. How are ornamental and bedding plant products processed, preserved and marketed?
4. What are some of the ornamental and bedding plant products?

Essential Knowledge, Skills, Attitudes and Values

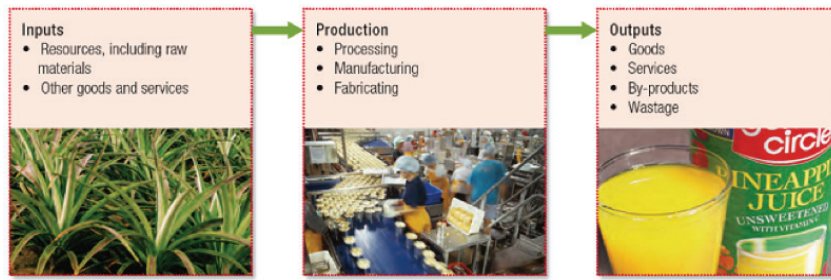
Knowledge	• The production processes of different plant products.
Skills	• Identifying and comparing the production processes of different plants products.
Attitudes & Values	• Be open minded about and appreciate the production processes of different plant products.

Content Background

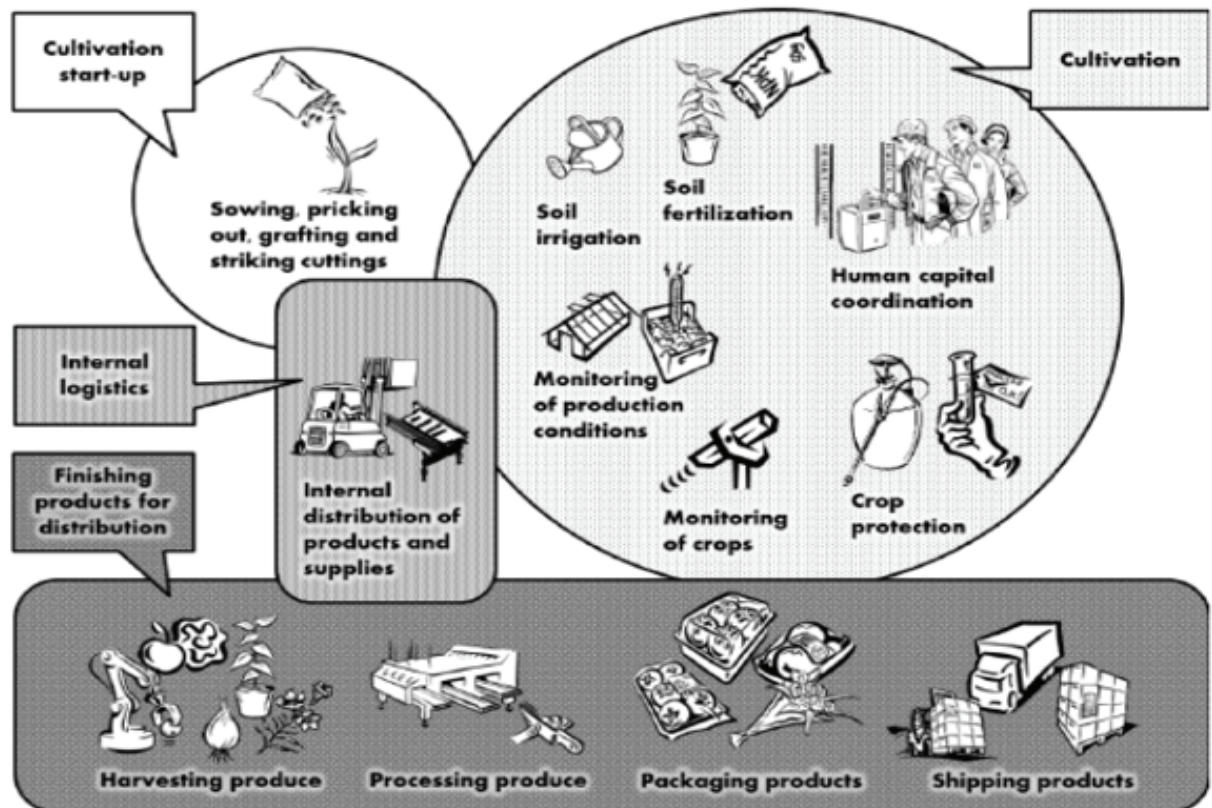
Plant production systems can be characterized by their natural and artificial stability, and natural and artificial controllability. Different plant production systems differing in stability and control ability are needed to maintain the overall sustainability of society under changing climate and social conditions. The plant production system to be chosen depends on its purpose under the given social, environmental, economic, and resource conditions.

The Production Process

The production process involves all activities that require resources and raw materials, mixing and processing them to end up with outputs of goods and services. The simplest view of production is to think about any product as going through three stages: an input stage, a production stage and an output stage.



Main Horticultural Production Proces



Assessment:

In groups, use a chart to do a flow chart of how Queen Emma chocolate is made or processed

Reference/Source:

<https://sites.google.com/a/stmonicas.qld.edu.au/year9business/p>

<https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/plant-production>

UNIT 6: PLANT FARMING PRACTICES AND MANAGEMENT SYSTEMS

Content Standard 1.6 Students will be able to investigate and analyse the different types of horticulture and management principles, systems and practices used in different environments and places to cultivate, process, preserve, market, regulate and consume different types of plants.

Benchmark 10.1.6.1 Research types of horticulture cultivation and production principles and management systems used in different environments.

TOPIC: HORTICULTURE CULTIVATION AND PRODUCTION PRINCIPLES

Learning Objectives

By the end of this topic, students will be able to:

- Examine and evaluate horticulture cultivation and production principles.

Essential questions:

1. What are horticulture cultivation and production principles in different environments?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Horticulture cultivation and production principles in different environments.
Skills	• Examining and evaluating horticulture cultivation and production principles in different environments.
Attitudes & Values	• Appreciate the horticulture cultivation and production principles in different environments.

Content Background

HORTICULTURAL PRODUCTION SYSTEMS

Production systems that take resources, natural and human, and transform them into horticultural products can be classified according to temporal, spatial, economic and social criteria. Within the production systems the particular farming system, the cropping sequence, pattern and management can be further classified according to conformity within specifically defined classes or groups. It must be recognized that no two farms, even if adjacent, would have identical farming systems. This would be even more so for horticultural enterprises than for those producing grain, dairy or meat products, for the diversity of horticultural commodities and their means of production far exceed those of broad-acre and animal-based systems

Types of Production System

The most common basis for classification of horticultural production systems is that based upon the degree of market integration and specialization. The systems can be assembled into four groups as:

- Subsistence
- Home garden
- Semi-intensive mixed commercial
- Very intensive commercial

Other important qualifying considerations for horticultural production systems in the tropics would revolve around altitude and geographic location as they affect crop performance and the agroecological zoning (e.g. spatial correlations, proximity to conurbations), the scale of production, the extent of organic involvement, the degree of disassociation from soil-based growing media and the concordance with principles of sustainability

The specifics of a particular production system at any location will be in response to the needs of the producer and of the consumer (not forgetting that at times the two are the same), and will take into account the biophysical, economic and social contexts within which that system is situated. In terms of sustainability, production will be inherently more sustainable where the necessary inputs for production, nutrients, water, heat and solar radiation are adequately supplied by the environment; deficiencies in any of these will need to be remedied at additional costs and risks to the producer.

Assessment:

The students to discuss the types of production systems. Discuss and do presentation.

Reference/Source:

<https://platform.cabi.org/Uploads/CABI/OpenResources/>

UNIT 6: PLANT FARMING PRACTICES AND MANAGEMENT SYSTEMS

Benchmark 10.1.6.2 Evaluate horticulture cultivation and management practices used in different environments, contexts, and places.

TOPIC: CULTIVATION AND MANAGEMENT PRACTICES USED IN DIFFERENT CONTEXTS

Learning Objectives

By the end of this topic, students will be able to:

- Examine and evaluate cultivation and management practices of horticulture in different contexts

Essential questions

1. What are the cultivation management practices of horticulture in different contexts?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Cultivation management practices of horticulture in different contexts.
Skills	• Examining and evaluating cultivation management practices of horticulture in different contexts.
Attitudes & Values	• Appreciate horticulture cultivation management practices in different contexts.

Content Background

Recommended Horticulture Management Practices

Practices that should always be recommended:

- Test the soil to learn the pH and nutrients already present
- Group plants with similar needs (water, fertilizer, sun...) for easier maintenance
- Fertilize based on a soil test and at the appropriate time of year
- Identify plant problem and severity of damage before choosing a control
- Read and follow all directions on pesticide labels
- Right Plant, Right Place

Assessment:

Research different cultivation and management practices from other countries.

Reference/Resource:

- https://rockingham.ext.vt.edu/content/dam/rockingham_ext_vt_edu/files/horticulture/homeownerMGBMPlink.pdf

UNIT 7: PLANT FARMING AND TECHNOLOGY

Content Standard 1.7 Students will be able to examine how technology is used in the cultivation, processing, preserving, marketing, regulation, consumption, and management of plants in different types of environments and analyse their advantages and disadvantages.

Benchmark 10.1.7.1 Evaluate the impact of technology in the processing, preservation, transportation, and marketing of horticulture plants in different types of environments, contexts, and places.

TOPIC: IMPACT OF TECHNOLOGY IN PRODUCTION OF HORTICULTURAL PLANTS IN DIFFERENT CONTEXTS.

Learning Objectives

By the end of this topic, students will be able to:

- Examine and evaluate the impacts of technology in horticulture cultivation and management practices used in different environments.
- Examine and evaluate the impacts of technology in horticultural plants in different contexts.

Essential questions:

1. What are some of the technology impacts in horticulture cultivation and management systems?
2. What are some of the technology impacts in production of horticultural plants in different contexts?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Impacts of technology in horticulture cultivation and management systems • Impacts of technology in production of horticultural plants in different contexts.
Skills	• Examining, evaluation, identifying and describing impacts of technology in horticulture.
Attitudes & Values	• Appreciate how technology enhances horticulture practices.

Content Background

Innovative technologies for horticulture development

Scientists with horticulture innovation lab are testing and adapting a range of technologies aimed at significantly improving the cultivation of horticulture plants. Given the complexity of horticulture, technologies such as these can reduce constraints that limit the ability of smallholder farmers to achieve maximum profitability with high value horticultural products. Our goal is to develop and test technologies that can overcome common limitations in land, labour, capital and infrastructure.

Generally, technology is in effect in project-oriented activities. Some of the impacts of technology in horticulture are listed below:

- Promoting drip irrigation and climate resilience in Guatemala
- Improving nutrition with African indigenous vegetables in Kenya and Zambia
- Reducing post-harvest losses in Rwanda
- Scaling up seed-drying technology in Bangladesh
- Expanding tomato grafting for entrepreneurship in Guatemala and Honduras

Drip irrigation

Drip irrigation is a type of micro-irrigation system that has the potential to save water and nutrients by allowing water to drip slowly to the roots of plants, either from above the soil surface or buried below the surface. The main idea is to place water directly into the root zone and minimize evaporation.

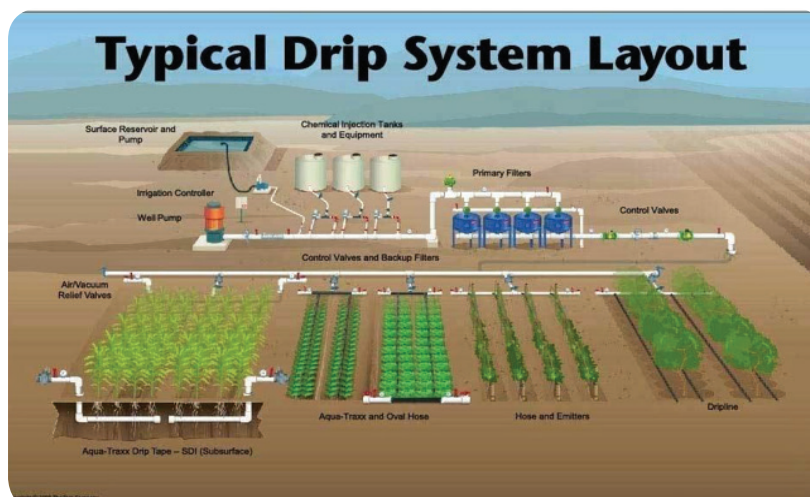


Photo Source: [google.com/search](https://www.google.com/search)

Increasing Plant Nutrition by Technology

Plant nutrition technologies currently offer three products – Power Roc, Bio Roc, and Rock Tea – and has joined the Western Growers for innovation and technology to enhance products. Power Roc and Bio Roc are a blend of several different nutritious mineral- rich rock powders and can be mixed in with a compost pile or added to the soil several times throughout the growing season. Roc Tea is the liquid from a blend of several different nutritious mineral – rich rock powders and waste produce and can be applied directly on mature plants during the growing season.

Assessment:

Students to do an assignment on the plant nutrition technology products

Reference/Source: wginnovation.com

UNIT 7: PLANT FARMING AND TECHNOLOGY

Benchmark 10.1.7.2 Analyze and explain the advantages and disadvantages of using technology in cultivating, processing, preserving, marketing and regulating plants in different types of environments, contexts and places.

TOPIC: ADVANTAGES AND DISADVANTAGES OF TECHNOLOGY USED IN HORTICULTURE PRODUCTION.

Learning Objectives

By the end of this topic, students will be able to:

- Identify and explain the advantages and disadvantages of how technology enhances cultivation, processing, preserving and marketing regulations with horticulture plants.

Essential questions:

1. What are the advantages and disadvantages of technology in horticulture cultivation, processing, preserving and marketing regulations?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Demonstrate an understanding of technology in horticulture cultivation, preserving and marketing regulations. • Advantages and disadvantages of technology used in horticulture production
Skills	• Discover, outline and compare advantages and disadvantages of technology used in horticulture production
Attitudes & Values	• Appreciate how technology enhances horticulture cultivation, processes, preserving and marketing regulations. • Appreciate the advantages and disadvantages of technology used in horticulture production.

Content Background

Advantages of Horticulture Cultivation

- As compared to field crops Horticultural crops will give more returns per unit area (more yield means in terms of weight and money)
- Horticulture crops are very important as their nutrition status is high. Particularly fruits and vegetables give a high amount of vitamins and minerals to us.
- Horticulture is important as it beautifies the surrounding
- Horticultural crops are more suitable for small and marginal farmers.
- Horticultural plants improve the environment by reducing pollution, conserve soil and water and develop the socio-economic status of the farmer.
- You can produce your own fresh oxygen

- Producing own organic fruits and vegetables at low cost in less space.

Disadvantaged of Horticulture Cultivation

- Difficulty in cultivating the crops
- Lack of enough space at home
- Difficulty in the selection of varieties of crops and plants
- Difficulty to grow the crops, in the sense that it requires skills and techniques for proper growth
- May serve as home for predators
- Cost of maintenance is usually high

Technology in enhancing Horticulture

In order to collect and utilise information successfully, it is very important for anyone considering farming to be familiar with the present technological tool available. The vast array of tools includes hardware, software and the best management practices.

Computer and Internet

Computers and internet are the mainly important components in enabling the farming possible as they are the main source of information processing and gathering. The high-speed computer has made faster processing the data gathered through precise management of the land parcel. Internet, which is a system of computers, is the most recent growth among all these technologies. In horticulture, like any new form of business, the internet has the capability to supply timely data about varying conditions.

Global Positioning System (GPS)

The mainly common use of GPS in horticulture is for yield mapping and variable providing location accuracy of 1m. The GPS of high accuracy in future will allow the farmers to do farming operations at night when wind speed is low and more suitable for spraying and use night tillage to reduce the light-induced germination of definite weeds.

Geographical Information System (GIS)

The GIS is a structures collection of computer hardware, software, geographical data, and personnel designed to efficiently capture, store, update, manipulate, analyse and display all forms of Geographical Information System that enable farming. The GIS is the brain of farming. It can assist in agriculture in two ways. One is in linking and integrating GIS data (soil, crop, weather field history) with simulation models. Another is to support the engineering part of designing implements and GPS guided machinery (variable rate applicators) for horticulture and any other agriculture purposes.

Assessment:

List and compare the technologies used in processing and preserving plants and products.

Reference/Source:

<https://aggie-horticulture.tamu.edu/ornamental/safety-publications/safety-first-training-program/>

UNITS OF WORK

STRAND 2: ANIMALS

Strand Overview

Units	Benchmark	Topics	Lesson Titles
Content Standard 2.1 Students will be able to identify and appraise the characteristics of different types of domestic and farm animals, categorize them according to their characteristics, feeding system, purposes and their benefits and investigate the different context, environments, and places where they are farmed.			
Unit 1: Types of Animals	Benchmark: 10.2.1.1 Compare and discuss the characteristics which distinguish monogastric and polygastric animals.	Characteristics of monogastric and polygastric animals	General classification of pig breeds
			General classification of goat breeds
			General classification of sheep breeds
			General classification of cattle breeds
	Benchmark: 10.2.1.2. Analyse and explain monogastric and polygastric animals' physiology systems and functions.	Monogastric and polygastric animals' physiology systems and functions	Digestive system and functions of monogastrics animals
			Digestive system and functions of polygastric animals
			Animal reproductive system and functions
			Estrous cycle and functions
Content Standard 2.2 Students will be able to investigate and analyse the different types of animal husbandry and management principles, systems and practices used in different environments and places to farm animals.			
Unit 2: Animal Farming Practices and Management Systems	Benchmark: 10.2.2.1. Compare and contrast the procedures and practices involved in monogastric and polygastric animal husbandry and management practices.	Procedures and practices involved in monogastric and polygastric animal husbandry and management practices	Extensive animal management system
			Semi- intensive animal management system
			Intensive animal management system
	Benchmark: 10.2.2.2. Identify and evaluate different approaches and strategies used by farmers to manage animals.	Approaches and Strategies use to Manage Animals	Animal nutrition
			Animal handling
			Animal feeding/Grazing land
Animal health and housing			
Content Standard 2.3 Students will be able to explore how technology is used in the farming, processing, preservation, marketing, consumption, regulation, and management of animals in different contexts and environments, and analyze their advantages and disadvantages.			

Unit 3: Animal Farming and Technology	Benchmark: 10.2.3.1. Identify and discuss post-harvest technology used for processing and preserving animal products.	Post-Harvest Technology used for Processing and Preserving Animal Products	Post-Harvest processing and post processing technology	
	Benchmark 10.2.3.2 Analyse and discuss technological innovations that have contributed to the enhancement and mass production of animal products.	Technological innovations use to enhance mass production of animal products	Technology used in packaging	
			Preservation methods of animal products	
			Technological innovations use for mass production of pork	
			Technology used for mass production of lamb	
	Benchmark: 10.2.3.3. Identify and discuss types of technology that enable online marketing of animal products.	Technology that enables online Marketing of Animal products	Technology use for mass production of beef	
			Technology use for mass production of honey	
			Ways of marketing animal products using technology (e.g. radio,	
			Introduction to online marketing	
			Types of technology used for online marketing	
	Content Standard 2.4 Students will be able to identify and evaluate the characteristics of different types of domesticated and farmed Birds, categorize them according to their characteristics, functions, and benefits, and investigate the different contexts, environments, and places where they are farmed.			
	Unit 4: Types of Birds	Benchmark: 10.2.4.1. Identify and categorize breeds of domesticated birds according to their characteristics, functions, and purpose.	Breeds of Domesticated Birds	Breeds of domesticated birds
Characteristics of domesticated birds				
Purposes of domesticated birds.				
Functions of domesticated birds.				
Benchmarks: 10.2.4.2. Identify and categorize breeds of farmed birds according to their characteristics, functions, and purposes		Breeds and characteristics of Farmed Birds	Breeds of farmed birds	
			Purposes and functions of farmed birds	
Content Standard 2.5 Students will be able to investigate and analyse the different types of farm and management principles, systems, and practices used in different environments and places to farm birds.				
Unit 5: Bird Farming Practices and Management Systems	Benchmark: 10.2.5.1. Investigate and explain the principles and factors of poultry production in different contexts.	Principles and Factors of poultry production	Principles of Poultry Production in different context	
			Factors involved in poultry production in different context	
	Benchmark: 10.2.5.2. Research and explain poultry production systems used in different environments and places, and evaluate their advantages and disadvantages.	Poultry Productions systems in different environments	Poultry production systems in different environment	
			Advantages of Poultry production systems in different environment	
			Poultry production systems in different environment	
	Benchmark: 10.2.5.3. Investigate and analyse poultry management principles, systems, and practices used in different climatic and environmental conditions.	Poultry management principles, systems, and practices	Poultry management principles and systems	
			Types of Poultry management practices used in various climatic and environmental conditions	

Content Standard 2.6:

Students will be able to investigate how technology is used for bird farming, processing, preservation, marketing, consumption, regulation, and management in different contents and analyse their strengths and weakness.

Unit 6: Bird Farming and Technology	Benchmarks: 10.2.6.1 Research and evaluate the impact of technology used in poultry farming on different environments and people.	Impact of technology used in poultry farming	Impact of technology in poultry farming
	Benchmark 10.2.6.2. Investigate technology used in harvesting, processing, and preserving poultry products and evaluate their effectiveness and impact on the environment.	Technology used in harvesting, processing and preserving poultry products and impact on the environment	Impact of technology used in poultry farming on different environment and people Impact of technology used in poultry farming on different environment and people
			Technologies used in harvesting poultry products
			Technologies used in processing poultry products
			Technologies in preserving poultry products
			Components of the sales process

UNIT 1: TYPES OF ANIMALS

Content Standard 2.1 Students will be able to identify and appraise the characteristics of different types of domestic and farm animals, categorize them according to their characteristics, feeding system, purposes and their benefits and investigate the different context, environments, and places where they are farmed.

Benchmark 10.2.1.1 Compare and discuss the characteristics which distinguish monogastric and polygastric animals.

TOPIC: CHARACTERISTICS OF MONOGASTRIC AND POLYGASTRIC ANIMALS

Learning Objectives

By the end of this topic, students will be able to:

- Identify and describe characteristics of monogastric and polygastric animal species
- Classify them according to the distinguishing features

Essential Questions

1. What are the main characteristics that distinguish monogastric animals from polygastric animals?
2. How do we distinguish a monogastrics or polygastrics?
3. What are the significant features or characteristics that differentiate a monogastric from polygastric animal?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Characteristics of a monogastric and polygastric animal
Skills	• Comparing and classifying
Attitudes	• Being cooperative in the sustainability and productivity of monogastric and polygastric animals.
Values	• Appreciate the purpose and benefits of raising animals.

Content Background

Characteristics of the monogastric and polygastric depends on the differences they have in their size and their digestive system.

Monogastric animals are animals that have one stomach and many are omnivorous in their feeding behavior; Example

- Pigs – eat both plant matter and animal matter
- Rabbits – eat mainly plant matter

Polygastric animals are animals that have two or more storage compartment stomachs and are herbaceous in their feeding behavior; Example

- Cow – farmed for meat and milk
- Goat – farmed for meat and milk

- Sheep – farmed for meat

Characteristics of monogastric animals

- Monogastric animals have a single stomach compartment
- Omnivores in their eating habits.
- Monogastrics have a single-chambered stomach

Characteristics' of Polygastric animals

- Larger type animals, which commonly graze herbages
- Have four-chambered type stomach
- Rumen is the largest chamber of the digestive system
- Digestive system more efficient

Differences

- Polygastrics are bigger in size compared to monogastric animals
- Polygastrics have a more efficient digestive system compared to monogastric animals
- Polygastrics mainly consume plant matter, compared to monogastric animals which are omnivorous in their feeding behavior

Assessment:

- Describe the characteristics of Monogastric and polygastric animals
- Research and list the breeds of selected monogastric and polygastric animals.

Reference/Source:

Kapari, Michal, W, 1958, Second edition 2000, Longman publishers, Pearson Education Australia, Melbourne, Australia

UNIT 1: TYPES OF ANIMALS

Benchmark 10.2.1.2. Analyse and explain monogastric and polygastric animals' physiology systems and functions.

TOPIC: PHYSIOLOGY SYSTEMS AND FUNCTIONS OF MONOGASTRIC AND POLYGASTRIC ANIMALS

Learning Objectives

By the end of this topic, students will be able to:

- Compare the digestive system and reproductive estrus cycle of monogastric and polygastric animal breeds
- Describe the processes and functions in the digestive and reproductive estrus cycle of monogastric and polygastric animal breeds

Essential Questions:

1. What is the difference between a monogastric and polygastric digestive and reproductive systems?
2. How does the process of digestion and reproduction occur in monogastric and polygastric animals?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Monogastric and polygastric animal digestive systems and reproductive cycle
Skills	• Comparing and contrasting monogastric and polygastric animal digestive systems and reproductive cycle.
Attitudes	• Enjoy learning about the physiology systems and functions of monogastric and polygastric animals.
Values	• Appreciate the physiology systems and functions of monogastric and polygastric animals.

Content Background

Physiology is derived from Greek as the study of nature or normal process or function. Thus, animal physiology is the scientific study of the life-supporting properties, functions and processes of animals or their parts. The study is centered on systems of the body of the animals. In monogastric and polygastric animals the systems may be similar but have differences in the digestive system where a number of chambers are found in the polygastric digestive system. A few of the systems seem to be more important to the farmer and those systems are;

- Skeletal system
- Digestive system
- Reproductive system

Skeletal system

The skeletal system is made of bones and the functions are;

- provides a framework for the animals' body where the muscles are attached
- protects vital organs
- allows movement

Skeletal systems do not differ very much but the functions may vary from animal to animal. For example, wings in birds are used for flying and while many are used for walking.

Digestive System

The digestive systems of polygastric animals are quite different from the monogastric animals. For instance, Sheep have more than one stomach. In fact they have four stomachs. The first stomach is called the rumen. Animals with four stomachs are called ruminants or polygastric animals.

Animals like pigs and poultry cannot live on cellulose because they don't have a rumen.

Reproductive system

Reproduction is necessary for the survival of any species. As we domesticated animals and attempted to make genetic change, it became imperative that we better understand the physiology of reproduction. Through this improved understanding, the development of reproductive technologies like artificial insemination, embryo transfer and sexing semen became possible. By studying developmental biology, a sub-field of reproductive biology, we now better understand crucial developmental periods during gestation and can make appropriate adjustments in how we manage and feed animals.

Assessment:

- Research about the digestive system of monogastric and polygastric animals
- Model the digestive system of monogastric and polygastric animals using appropriate materials on cardboard or charts.

Reference/Source:

ResearchGate_Website, Newspapers, magazines

UNIT 2: ANIMAL FARMING PRACTICES AND MANAGEMENT SYSTEMS

Content Standard 2.2 Students will be able to investigate and analyse the different types of animal husbandry and management principles, systems and practices used in different environments and places to farm animals.

Benchmark 10.2.2.1. Compare and contrast the procedures and practices involved in monogastric and polygastric animal husbandry and management practices.

TOPIC: ANIMAL HUSBANDRY AND MANAGEMENT PRACTICES

Learning Objectives

By the end of this topic, students will be able to:

- Examine different animal husbandry management systems and practices in different environments and places from.
- Explain the procedures and practices involved in animal husbandry of monogastrics and polygastrics

Essential Questions:

1. What is animal husbandry?
2. What procedures and practices of animal husbandry are practiced in monogastrics and polygastrics?
3. Why are the procedures and practices in animal husbandry and management important?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Animal husbandry and management practices
Skills	• Comparing husbandry and management practices involved in a variety of farming systems
Attitudes	• Enthusiastic and self-motivated in animal farming
Values	• Creative and opened minded

Content Background

Animal husbandry refers to livestock raising and selective breeding. It is the management and care of animals in which the genetic qualities and behavior of animals are further developed for profit. A large number of farmers depend upon animal husbandry for their livelihood.

Some husbandry practices that both monogastric and polygastric can go through are;

- Castration
- Dehorning
- Vaccination
- Wearing

- Balanced diet
- Watering
- Disease control and prevention
- Housing

Avoiding overcrowding

Animal husbandry has the following advantages:

1. Animal husbandry helps in the proper management of animals by providing proper food, shelter and protection against diseases to domestic animals.
2. It provides employment to a large number of farmer and thereby increases their living standards.
3. It helps in developing high yielding breeds of animals by crossbreeding. This increases the production of various food products such as milk, eggs, meat, etc.

It involves the proper disposal of animal waste and promotes a healthy environment

Animal husbandry is the type of management practice employed in a farming system. The type of practice takes into account the conditions of the environment and the location of the area. A few of the pig production husbandry practices are discussed below as an example;

- Breeders (Sows and boars)-Parent stock when temperature is high in the hot months, water should be sprinkled on the boars and pregnant sows to help them reduce their temperature. In nature the pig would go into mud.
- Piglets – At night or cold days, heat the pen for baby pigs with a 50-watt electric light bulb
- Housing-The type of pig house constructed should consider; temperature, ventilation, animal space requirement. During a cold weather the animals should be kept warm, while in a hot weather there should be enough ventilation for the animals to be kept cool.

With animals there are principles in which to follow and domesticate. They act as a guide to carefully care and manage animals. These principles are positive attributes for effective animal management. Management Systems for Livestock has been practiced for thousands of years. Several management systems developed in many societies to better adapt to different needs and conditions. Are we raising animals the right way? We hear every day in the news that there are production problems and that food security is not for everybody. Large, sometimes intangible, external factors such as climate changes, political instability, wars they all play a role, but inexperience and lack of knowledge also affects the work farmers do. Furthermore, this is also a consequence of lacking the fundamental tools to monitor the efficiency and to enhance the livestock management systems.

How can we limit the damages and increase farming production

Understanding the different livestock management systems is the first step to develop a good strategy. Management systems have a direct impact on production and diseases, this highlights their relevance. According to FAO there are three main livestock management systems:

1. Mixed production
2. Intensive farming systems “landless”
3. Extensive production system

Mixed livestock production

It includes both agriculture and livestock and it can be either intensive or extensive. Generally, these systems exploit both irrigated and non-irrigated land and they are common in some parts of America, Europe and Asia.

Intensive farming

It applies mainly to livestock. Intensive breeding farms look more like factories to breed *pigs, chickens, laying hens, cattle and even fish*. These farms “landless” are common in north America, Europe and Asia and in heavy populated areas in general, where, for instance, the demand for meat and proteins is very high.

Production systems and animal health management

Extensive livestock production systems

Extensive livestock production systems are systems in which animals are kept free-range for part or all of their production cycle.

Commercial ruminant production

The principal infectious disease threats are vector-borne diseases, reproductive diseases and, in most parts of Africa depending on the area, wildlife/livestock interface diseases. The main challenges for animal health management are:

- Sufficient observation to ensure early diagnosis of problems
- Logistics of rounding up for observation, vaccination and treatment
- Applying the necessary level of biosecurity to prevent uncontrolled access to pastures and animals

Production on communal grazing

In addition to the above diseases and challenges, additional challenges to animal health management are:

- Failure of treatment, e.g. prophylactic treatment against parasites, because not all the animals are treated owing to different levels of commitment amongst owners, resulting in high levels of pasture contamination
- Build-up of pathogens that may affect production and reproduction (*Brucella spp.*, *Mycobacterium bovis*, *Salmonella*) as a result of limited availability of land

- Complete lack of control over access to the land by people, newly introduced animals and sometimes wildlife, resulting in exposure to a wide range of new pathogens including fatal diseases like MCF
- Uncontrolled movement of animal

Extensive pig production

Most extensive pig production occurs in traditional systems in which pigs are never confined, confined only at night or seasonally to protect crops, and find most of their own food.



Scavenging pigs

Pigs kept extensively are free from the majority of infectious diseases that commonly occur in confined pigs, such as PRRS, porcine multisystem wasting syndrome, porcine pleuropneumonia, enzootic pneumonia, swine dysentery, procaine proliferative enteropathy, Glässer's disease to name a few), but are more prone to ASF and CSF because they may be in contact with wild pigs, carcasses of pigs that have died, and pigs from other herds.

Large populations of free-ranging pigs can become a reservoir in which the viruses of those diseases can circulate for long periods of time, probably indefinitely. The main challenges for animal health management in extensively kept pigs are:

- Lack of observation leading to delayed diagnosis of serious diseases
- Lack of investment in pig health by their owners
- Lack of awareness by the owners about diseases like porcine cysticercosis
- Uncontrolled movement of pigs
- Difficulty in applying preventive or control measures

In compliance with consumer demands for pigs to be kept under more natural conditions, pigs in outdoor systems are becoming more frequent in developed countries, for example member states of the European Union, with pressure on other pig-producing countries to follow suit. These systems differ markedly from the traditional extensive systems in that the pigs are fed, the property is fenced and there is likely to be some health management by the owners. Many of the diseases to which confined pigs are prone will be eliminated

because pathogens are less concentrated and may be destroyed by exposure to the elements.

Assessment:

- Investigate the management and husbandry practices in animal husbandry.
- Describe each management system used in animal husbandry using diagrams and create a table of each husbandry practice and their description.

Reference/Source:

ResearchGate_Website, Newspapers, magazines

UNIT 2: ANIMAL FARMING SYSTEMS AND MANAGEMENT PRACTICES

Benchmark: 10.2.2.2. Identify and evaluate different approaches and strategies used by farmers to manage animals.

TOPIC: APPROACHES AND STRATEGIES USED TO MANAGE ANIMALS

Learning Objectives

By the end of this topic, students will be able to;

- Investigate the approaches and strategies used by farmers to manage farmed animals
- Illustrate the approaches and strategies used by farmers to manage farmed animals

Essential Questions:

1. Name some examples of animal husbandry practices used in animal rearing
2. What are some of the approaches and strategies used by farmers to manage farmed animals
3. Why is there a variation in the types of animal husbandry practices in different environments?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Approaches and strategies used by farmers to manage animals
Skills	• Analyse the approaches and strategies used in different environments to farm animals
Attitudes	• Being selective in the types of animal species to farm and conducive environments
Values	• Productivity and profitability in animal production

Content Background

Housing, Husbandry, and Behavioral Requirements

Husbandry may refer to a wide range of animal care aspects, including providing food, water, bedding, housing, and sanitation. Guidelines for housing and husbandry of agricultural research animals can be found in the *Guide for the Care and Use of Agricultural Animals in Research and Teaching*. Because they have been domesticated for millennia, most livestock are capable of adaption to a wide variety of environments, ranging from intensive confinement to extensive pastoral settings. Nevertheless, housing of either livestock or wildlife for research purposes can be highly variable and dependent on the purpose of the research, but should attempt to accommodate the behavioral needs of the study species.

Housing animals used for infectious disease research may require complex bio containment facilities, whereas research on behavior, reproduction, or nutrition may be conducted in outside pens or paddocks with fewer biosecurity concerns. High-level bio containment housing design is driven by requirements to contain the pathogen of interest as well as animals that may be infected with this pathogen.⁹ These bio containment requirements often limit the ability to modify animal housing to reflect a more “normal” environment. This is especially true for wildlife that may vary considerably from livestock species in physiology, body size, or behavior.

The management approaches of livestock depend on the type of resources available and to the farmer’s choice. However, efficient management demands that all aspects of the life cycle will be given appropriate husbandry attention. Attention to all factors call for good management. The following must be considered;

- Always buy and select animals from a reliable source, preferably from a farm which has been known to have minimal disease problems.
- Pay special attention to factors that minimize stress, by good housing, handling and feeding.
- Aim for disease prevention
- Adopt a simple recording system

Modern pig management includes;

- Feeding
- Housing
- Care and control of diseases
- Reproduction cycle and breeding stock

Assessment:

- Research the approaches taken to manage animals in the different management systems and practices.
- Do an oral presentation on the different approaches and strategies of managing animals.

Reference/Source:

ResearchGate_Website, Newspapers, magazines

UNIT 3: ANIMAL FARMING AND TECHNOLOGY

Content Standard 2.3 Students will be able to explore how technology is used in the farming, processing, preservation, marketing, consumption, regulation, and management of animals in different contexts and environments, and analyze their advantages and disadvantages.

Benchmark: 10.2.3.1. Identify and discuss post-harvest technology used for processing and preserving animal products.

TOPIC: POST-HARVEST TECHNOLOGY FOR PROCESSING AND PRESERVING ANIMAL PRODUCTS

Learning Objectives

By the end of this topic, students will be able to:

- Investigate farm technology and describe specific technology used for post-harvesting, processing, and preserving animal products.
- Discuss the advantages and disadvantages of the technology.

Essential Questions:

1. What are the farm technologies used for post harvesting?
2. What specific farm technologies are used in post-harvesting, processing, and preserving certain animal products?
3. What are the technologies that are used to preserve certain breed or species such as sheep, goat etc.?
4. Why do we preserve animal products?
5. What are the advantages and disadvantages of the use of these farm technologies?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Post-harvest technology for processing and preserving animal products
Skills	• Explore and illustrate post-harvest and preservation technology for monogastric and polygastric animal products
Attitudes	• Being creative with farm technologies to process and preserve animal products
Values	• Appreciative of importance of technology

Content Background

Food Processing is the process of transforming food items into a form that can be used. It can cover the processing of raw materials into food via different physical and chemical processes. Various activities covered in this process are mincing, cooking, canning, liquefaction, pickling, macerating and emulsification.

It takes clean, harvested crops, or butchered and slaughtered animal products to produce attractive, marketable, and in several cases, life-long food products. However, food processing can also lower the nutritional value of the food and might include additives that might adversely affect health.

Objectives of Food Processing

Food technology is a very vast domain concerning with the production and processing of food. Food processing has certain objectives, such as:

- It boosts the shelf life of food products.
- Prevent food-contamination.
- Food storage and Transportation.
- Turns raw food materials into attractive, marketable products.
- Provide employment to a large population.

Food processing Methods

There are certain criteria that have to be compiled for the appropriate processing of food, right from the possibility of a pest or [bacteria](#) to invade and multiply on foods to the biological activity of foods. The following methods are applied for the proper processing of food:

- Peeling off the outer layers of the raw materials.
- Chopping or slicing
- Mincing
- Liquefaction
- Fermentation
- Emulsification
- Cooking
- Mixing
- Gasification such as the addition of a gas in bread or soft drinks.
- Proofing
- Spray drying
- Pasteurization
- Packaging

Other Methods of Food Processing

Food preservation is a process involved in food processing employed to prevent the growth of fungi, bacteria, and many other microorganisms. It involves the process of slowing down the oxidation of fats that would lead to rancidity. There are several food preservation methods that are designed specifically to preserve food. Some of the selected few preservation methods are stated below:

Drying

It is one of the traditional techniques that are employed to decompose food products. Exposure of food particles to sunlight to dry them is one such method done naturally. This process would result in the evaporation of moisture content from food, thus preventing microorganisms from invading the food. Moisture from food could also be removed by using hot air

Cooling

It is a technique of preserving food by slowing down the growth of microorganisms and action of an [enzyme](#) that is responsible for the rotting of food. Some of the food products such as meat, dairy products, and fish could be stored in a refrigerator thus increasing the shelf-life of the products.

Freezing

It is one of the regular processes that has been under use domestically and commercially to preserve a wide range of foods. Rapid freezing might have an adverse effect on the texture of food.

Heating

The majority of microorganisms and spores could be destroyed by applying sufficient heat to food items. One of the known examples includes boiling of milk.

Pickling

It is a process of preserving food in an edible and antimicrobial liquid. Pickling could be categorized into two types, namely fermentation and thermal pickling.

In fermentation pickling, bacteria present in a liquid produces organic agents which would act as preservation agents.

In chemical pickling, the food is preserved in an edible liquid that destroys microorganisms and bacteria.

Benefits of Food processing

The important benefits of food processing include:

1. Food processing reduces the number of harmful bacteria in food that can cause diseases. For eg., drying, pickling dehydrates the food product and alters the pH that prevents the growth of harmful microorganisms.
2. It also improves the shelf-life of food products.
3. It reduces health inequalities and major health concerns.

Drawbacks of Food Processing

The important drawbacks of food processing include:

- Processed food contains artificial ingredients.
- A large number of resources are spent in making the food pleasant to the brain that leads to overconsumption.
- Processed foods are the biggest source of added sugar that is very unhealthy.

Assessment:

Plan an excursion to a processing site or factory and research the post-harvest and preservation processes of selected animals.

Present a report on your findings either orally or in a chart.

Reference/Source:

Meat Processing Technology-Gunter Heinz, Peter Hautzinger
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4711421>

UNIT 3: ANIMAL FARMING AND TECHNOLOGY

Benchmark 10.2.3.2 Analyse and discuss technological innovations that have contributed to the enhancement and mass production of animal products.

TOPIC: TECHNOLOGICAL INNOVATIONS THAT HAVE CONTRIBUTED TO THE ENHANCEMENT AND MASS PRODUCTION OF ANIMAL PRODUCTS

Learning Objectives

By the end of this topic, students will be able to:

- Explore and describe technological innovations used for mass production of animal products.

Essential Questions:

1. What are technological innovations and how do they contribute to enhancing of mass production?
2. How has mass production benefit the farmer and society?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Technological innovation and contributions to mass production of animal products
Skills	• Analyze types of technological innovations and its contributions to mass production of animal products
Attitudes	• Being creative and opened minded using technological innovation for mass production.
Values	• Have a sense of creativeness for mass productions of animal products

Content Background

Emerging livestock technologies provide farmers with data-driven insights, allowing them to streamline farm management, improve animal care, and boost productivity.

Here are some of the many innovations redefining livestock farming:

Automated dairy installations milk cows automatically without human intervention, and the milk sensors also help farmers monitor the milk quality. Automated cleaning systems remove waste, enabling cleaner and disease-free environments.

Armenta's non-antibiotic treatment uses acoustic pulse technology (APT) for bovine mastitis, a cow disease responsible for over \$6 billion annual losses in the U.S. and Europe.

Automated feeder systems provide animals with feeding mixtures tailored to their specific needs and in the right amount.

Faromatics employs robotics, A.I., and big data to increase animal welfare and farm productivity.

Assessment:

- Explore the technological innovations and analyse their input to mass production
- Create a table of the impacts and benefits of the technological innovations used

Reference/Source:

Meat Processing Technology-Gunter Heinz, Peter Hautzinger
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4711421>
Assessment:

UNIT 3: ANIMAL FARMING AND TECHNOLOGY

Benchmark 10.2.3.3. Identify and discuss types of technology that enable online marketing of animal products.

TOPIC: TECHNOLOGY THAT ENABLES ONLINE MARKETING OF ANIMAL PRODUCTS

Learning Objectives

By the end of this topic, students will be able to:

- identify types of computer and internet devices and usage that enable the marketing of animal products online
- describe usage of computers and internet devices that enable online marketing of animal products

Essential Questions:

1. What is the difference between traditional and modern marketing methods of animal products?
2. How were animal products marketed traditionally?
3. What is the difference between conventional and online marketing?
4. Which animal products are suitable for online marketing?
5. What are three most suitable technology devices that enable online marketing of animal products

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Traditional and modern marketing methods of animal products
Skills	• Compare and contrast traditional and modern technology for marketing animal products
Attitudes	• Open-minded to ways of online marketing using the internet devices and computers.
Values	• Being appreciative of the use of internet to enable marketing of animal products

Content Background

The livestock industry has become the most dynamic market globally. This is being driven largely by demand due to growth in purchasing power and modern technology. With the constant improvement of the degree of livestock products trade, the market operation and structure of livestock products are also transformed. The survival and development of the livestock industry are dependent on the comprehensive strength of the whole industry chain, therefore, the study of the technology innovation, supply chain risk, and digital marketing towards the business performance of the livestock industry is required. The ability to conceptualize, observe and give due recognition to the possible relation amongst these variables in question by the livestock industry, can bring about an insightful engagement for the betterment of the livestock business performance.

The relationship between technology innovation, supply chain risk, digital marketing, and livestock industry performance improves the whole performance of the livestock industry and enhances competitiveness locally and internationally.

More and more farmers are beginning to use technology and computers by themselves.

Generally, technology and computers have been used by producers with larger farms. Small-scale farmers ignored the technology because of its cost and their lack of knowledge about computer use in farming.

Many computer programs have been designed and described, by which data on dairy herds may be processed. There are computer software designed for timely and direct convenience to farmers. The breeder can evaluate the monthly lots of data using many formulas with high accuracy using this software. It can also be programmed for annual report for detail evaluation of production. In addition to all these, farmers can be able to market their animal products with such technologies, software and websites including social media.

Assessment:

- Research and identify the types of technological devices that enable online marketing of animal products.
- Create a chart of its effectiveness and impacts on the marketing of animal products compared to the manual or traditional marketing methods.

Reference/Source:

ResearchGate, Newspapers, magazines

UNIT 4: TYPES OF BIRDS

Content Standard 2.4 Students will be able to identify and evaluate the characteristics of different types of domesticated and farmed Birds, categorize them according to their characteristics, functions, and benefits, and investigate the different contexts, environments, and places where they are farmed.

Benchmark 10.2.4.1. Identify and categorize breeds of domesticated birds according to their characteristics, functions, and purpose.

TOPIC: BREEDS OF DOMESTICATED BIRDS

Learning Objectives

By the end of this topic, students will be able to:

- Identify the different types of breeds of domesticated birds?
- Describe by what means these breeds of domesticated birds are categorized
- Explain the reasons of domesticating different breeds of birds in the places where they are domesticated

Essential Questions:

1. What are the different types of domesticated birds?
2. How are these breeds of domesticated birds categorized?
3. Why are different breeds of birds domesticated in different contexts?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Differences between a breed and a class of domesticated birds • Purpose and characteristics of domesticated birds
Skills	• Identify, compare and evaluating
Attitude	• Passionate for knowledge on breeds
Values	• Appreciate the purpose of domesticated birds

Content Background

Animal domestication falls into three main groupings: domestication for companionship (dogs, cats and birds), animals farmed for food (sheep, cows, pigs, turkeys, etc.), and working or draft animals (horses, donkeys, camels).

There are about 10,000 living species of birds. Almost all of them can fly, but there are several exceptions.

Birds that are able to fly are divided into 29 orders that differ in their physical traits and behaviors. Table below describes seven of the most common orders. As shown in the table, the majority of flying birds are perching birds, like the honeyeater described in the last row of the table.

Order	Description	Example
Landfowl: turkeys, chickens, pheasants	They are large in size; they spend most of their time on the ground; they usually have a thick neck and short, rounded wings; their flight tends to be brief and close to the ground	turkey 
Waterfowl: ducks, geese, swans	They are large in size; they spend most of their time on the water surface; they have webbed feet and are good swimmers; most are strong flyers.	ducks 
Shorebirds: puffins, gulls, plovers	They range from small to large; most live near the water, and some are sea birds; they have webbed feet and are good swimmers; most are strong flyers.	
Diurnal Raptors: hawks, falcons, eagles	They range from small to large; they are active during the day and sleep during the night; they have a sharp, hooked beak and strong legs with clawed feet; they hunt by sight and have excellent vision.	hawk 
Nocturnal Raptors: burrowing owls, barn owls, horned owls	They range from small to large; they are active during the night and sleep during the day; they have a sharp, hooked beak and strong legs with clawed feet; they have large, forward-facing eyes; they have excellent hearing and can hunt with their sense of hearing alone.	owl 
Parrots: cockatoos, parrots, parakeets	They range from small to large; they are found in tropical regions; they have a strong, curved bill; they stand upright on strong legs with clawed feet; many are brightly colored; they are very intelligent.	cockatoo 

Perching Birds: honeyeaters, sparrows, crows	They are small in size; they perch above the ground in trees and on buildings and wires; they have four toes for grasping a perch; many are songbirds.	
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Many types of birds can make wonderful pets and long-time companions. Popular pet birds come in all different sizes to suit most types of homes. Small pet birds like finches, canaries, parakeets, and lovebirds are friendly low maintenance birds. They are also the best kinds of pet birds for beginners and apartments. Larger pet parrots, cockatiels, and cockatoos also make great household pet birds but take more care and attention.

One of the reasons why birds are excellent pets is that many species are low maintenance. Also, many different types of domestic birds enjoy interacting with humans and they can become loyal pets. Birds can also provide fun entertainment as some mimic household noises or human speech. Some types of pet parrots can be trained to do tricks.

Assessment:

- Describe the characteristics, functions and purposes of domesticated birds
- Research and list the breeds of selected domesticated birds.

Reference/Source:

Britannica_Website, ResearchGate_Website

UNIT 4: TYPES OF BIRDS

Benchmarks: 10.2.4.2. Identify and categorize breeds of farmed birds according to their characteristics, functions, and purposes

TOPIC: BREEDS AND CHARACTERISTICS OF FARMED BIRDS

Learning Objectives

By the end of this topic, students will be able to:

- Identify the different types of breeds of farmed birds?
- Describe by what means these breeds of farmed birds are categorized
- Explain the reasons of farming different breeds of birds in the places where they are farmed

Essential Questions:

1. What are the different types of farmed birds?
2. How are these breeds of farmed birds categorized?
3. Why are different breeds of birds farmed in different context?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Difference between a breed and a class of farmed birds • Purpose and characteristics of farmed birds
Skills	• identify, compare and describe
Attitudes	• Passionate for knowledge on breeds and class birds
Values	• Appreciate the purpose of farmed birds

Content Background

A. Breeds and Varieties of Farmed Birds

Birds or chicken can be identified or classified through designated class, breeds, varieties and strains.

A **class** designates a group of breeds developed in a particular geographical area. The class name themselves indicate the region the breeds originated such as Asiatic, Mediterranean, and American.

Breed refers to a group, each of which possess a given set of physical feature, such as body shape or type, skin color, feathered or nonfeathered shanks. If such individual is mated to one of its own kind, these features should be passed on to their offspring.

A **variety** is a subdivision of a breed. Differentiating characteristics include plumage color, comb type and presence of the beard and muffs.

Strain or lines, are families or breeding population possessing common traits. They may be subdivisions of a breed or variety or may even be systematic crosses. They are developed using breeder programs either for egg production, meat production or color of eggs.

B. Purpose and Characteristics of Farmed Birds.

Different breeds can be classified according their purpose, origin and their characteristics. Some examples are provided below.

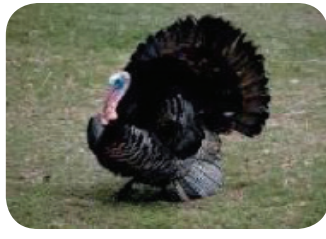
Breed	Jersey Giant
Class	American
Purpose	A very-heavy meat type fowl for heavy roaster and capon production. Fairly good layers.
Origin	Developed in New Jersey in late 1800's
Characteristics	The largest Breed in the American Class. They should be rugged, with an angular shape, single comb and black (with willowish tingle) shanks in the black variety and dark willow shanks in the white variety. The Jersey Giant will go broody but is not the best choice for incubating and brooding because of their s 

Breed	New Hampshire Red
Class	American
Purpose	A dual purpose chicken, selected more for meat production than egg production. Medium heavy in weight, it dresses a nice, plum carcass as either a broiler or a rooster.
Origin	New Hampshire's are relatively new breed, having been admitted to Standards in 1935. They represent a specialized selection out of the Rhode Island breed.
Characteristics	• Fast growing • Usually calm but can be aggressive • Poor at foraging 

Breed	Langshan
Class	Asiatic
Purpose	A general-purpose fowl for the use production of meat and eggs. The general shape of the Langshan makes them better suited to roaster and capon use than as fryers.
Origin	Originated in China and are considered one of the oldest breeds.
Characteristics	• very tall with long legs and tailed carried at a high angle • Active and quick • Many other breeds were created using Langshan blood in the foundation mating. 

Breed	Australorp
Class	English
Purpose	Generally, a very good egg producer with a fairly meaty body of intermediate size.
Origin	Australia
Characteristics	• Medium weight, active bird which lays a tinted egg • Good egg producing bird that does not sacrifice too much meat quality • Popular egg producing bird for backyard flocks 

Breed	Leghorn
Class	Mediterranean
Purpose	An egg-type chicken, Leghorns figured in the development of the most of our modern egg-type strains
Origin	Australia
Characteristics	• Small, spritely, noisy bird with great style and like to move about Good foragers • Relatively large head furnishing (comb and wattles) and is noted for egg production 

Breed	Northfolk black
Purpose	Good for meat and eggs
characteristics	• Medium sized birds, stags 7-8kg • hens are 4-5kg 

Breed	Pekin
Purpose	Meat production
Characteristics	

More than about 8,000 registered breeds, including hundreds of poultry breeds are found around the world. Most of these breeds are kept by smallholder farmers throughout the world, who produce a large part of the world's poultry meat and eggs, and at the same time conserve some of the world's livestock breeds. Many of these breeds are locally adapted, multi-purpose, and indigenous, and suited to various farming enterprises. The current breeds in industrial systems are almost exclusively single purpose breeds, either broilers or layers.

Assessment:

- Describe the characteristics and purposes of farmed birds
- Research and list the breeds of selected farmed birds.

UNIT 5: BIRD FARMING PRACTICES AND MANAGEMENT SYSTEMS

Content Standard 2.5 Students will be able to investigate and analyse the different types of farm and management principles, systems, and practices used in different environments and places to farm birds.

Benchmark 10.2.5.1. Investigate and explain the principles and factors of poultry production in different contexts.

TOPIC: PRINCIPLES AND FACTORS OF POULTRY PRODUCTION

Learning Objectives

By the end of this topic, students will be able to:

- Identify the principles of poultry production in different context
- Examine factors that are required in poultry production in different context

Essential Questions:

1. What are the principles of poultry production in different contexts?
2. What factors are considered in poultry farming in different context?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Principles of poultry management system • Factors of poultry production in different context
Skills	• Identifying, examining and correlating factors of poultry farming in different context
Attitudes	• Enjoy learning about the common poultry management systems in different context.
Values	• Develop a sense of perseverance and self-reflection in the practices of poultry production

Content Background

There are three common management systems used in raising birds;

- i Extensive management system
- ii. Semi-intensive management system
- iii. Intensive management system

All three management systems can be used in any climatic and environmental conditions; however, the management practices may differ. Management practices such as;

- Housing
- Feeding
- Area needed
- Ventilation and temperature
- Care and maintenance

Housing

The housing for birds will depend on the different climatic conditions of Papua New Guinea; one type of housing is suitable for altitudes from sea levels up to about 1000m (hot areas). The other is suitable for altitudes above 1000m or 1500m (cool areas).

Factors to consider in constructing poultry houses;

- Building materials
- Method of building
- Management systems
- Size of project and
- Availability of land space

In selecting the site, take into account factors such as;

- Availability of water
- Nearness of feed or availability of feed
- Nearness to road
- Proper drainage
- Direction of wind
- Nearness to home

Based on the above factors and the climatic conditions in addition to availability of resources according to the environmental region; a temporary house, semi-permanent or permanent house can be constructed.

Area needed (spacing)

This refers to the amount of space available for the birds within their house. It differs in accordance to the climate.

Space requirement for chickens on deep litter.

Age (weeks)	Space per chicken (sq. cm/bird)		Space for 100 chickens (sq. m/100 birds)	
	Highlands	coastal	Highlands	coastal
0-4	900	900	9	9
5-10	1600	1800	16	18

When it is too crowded, the chickens peck and harm each other.

Ventilation and Temperature

Ventilation refers to the providence of fresh air in the chicken house and pushes out ammonia from the chicken droppings. Chickens like any other animals need oxygen to breath so ventilation reduces stuffy, stale air and brings in freshness.

In hot and humid climates, ventilation is very important. Houses should have big windows screened with chicken wire to allow as much ventilation as possible. Ensure the openings are small enough to prevent predators like snake and dogs from entering. The open sides should be covered during rainy

season to prevent rain and wind affecting the chickens and the litters. In the Highlands, less window openings are done to keep out cold draughts and keep in warm air especially at nights. At nights temperature falls below 18 degrees Celsius, therefore the house is constructed in a way that heat is conserved so that the chicks are kept warm. Maximum of two vents are done and covered with chicken wire or suitable material to allow air movement.

Care and Maintenance

Care of poultry buildings and equipment is very important as quality is lost in less time. Poultry equipment and building must be cleaned regularly to minimize health hazards. Cleaning waterers and feeders daily is of paramount importance especially in warmer climates as micro-organisms multiply quicker than in colder climates.

These management practices are mostly done in semi-intensive and intensive poultry systems. Each management system and practice have its advantages and disadvantages depending on how, when and where it is carried out not necessarily in climatic zones. Some advantages and disadvantages will be the same in different climatic and environmental conditions.

Assessment:

- Explore and identify principles and factors of poultry production
- List the principles and factors in poultry farming and provide descriptions for each.

UNIT 5: BIRD FARMING PRACTICES AND MANAGEMENT SYSTEMS

Benchmark: 10.2.5.2. Research and explain poultry production systems used in different environments and places, and evaluate their advantages and disadvantages.

TOPIC: POULTRY PRODUCTIONS SYSTEMS IN DIFFERENT ENVIRONMENTS

Learning objectives

By the end of this topic, students will be able to:

- Identify the types of poultry production systems used in different environments and places
- Describe the importance of the systems used in different environments and places
- Explain the advantages and disadvantages of poultry production systems used.

Essential Questions:

1. What is the poultry production system?
2. What type of systems is used in different environments and places?
3. What are the advantages and disadvantages of the systems in those environments and places?
4. Why are these poultry production systems important in different environment and places?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Types of poultry production systems used in different environments
Skills	• Identifying, describing and explaining
Attitudes	• Being cooperative and creative to sustain and maximize poultry production.
Value	• Appreciate the role of the poultry management systems in in different environment and places

Content Background

A. COMMON TYPES OF PRODUCTION IN DEVELOPING COUNTRIES

Typically, four poultry production systems can be distinguished namely:

- 1. the free-range system or unimproved backyard system:** scavenging, no regular water or feed, little or poor night shelter;
- 2. the improved backyard system:** regular water, supplementary feeding, improved shelter, care of chicks in the first weeks, vaccination against Newcastle disease and other diseases (e.g. fowl pox, fowl cholera, Gumboro disease, coccidiosis), when necessary, and treatment for parasites;

2. the semi-intensive system: as in 2. above, with genetically improved breeds and balanced diets; and

3. the small-scale intensive system: as in 3. above, with further improvements in overall husbandry conditions.

All of these systems are encountered in a small-scale poultry farming, although in the very few cases in which the intensive management system is practiced, it is the small-scale option that is adopted. The choice of system is largely determined by the availability of resources and inputs, i.e. housing, cages, feed, drugs and time/attention. The level of inputs also depends on the keeper's or households socio-economic circumstances. Thus, most farmers adopt the free-range, backyard and semi-intensive husbandry systems, in that order. Also, these management systems frequently overlap; thus, free-range is sometimes coupled with feed supplementation, backyard with night confinement but without feeding; or standard poultry cages in confined space. Under the extensive poultry management systems, there is almost no health care. Thus, small-scale poultry farming in developing countries are often maintained with very low levels of inputs (i.e. land, labour and capital), though there are possible variations between and within regions or countries. On the whole, small-scale poultry farming can be managed by even the poorer social strata of the local communities.

Assessment:

- Investigate and identify the different production systems of poultry in different environments.
- Compare and contrast the production systems practiced in different environments state their advantages and disadvantages.

UNIT 5: BIRD FARMING PRACTICES AND MANAGEMENT SYSTEMS

Benchmark: 10.2.5.3. Investigate and analyse poultry management principles, systems, and practices used in different climatic and environmental conditions.

TOPIC: POULTRY MANAGEMENT PRINCIPLES, SYSTEMS, AND PRACTICES

Learning Objectives

By the end of this topic, students should be able to:

- Identify common types of poultry productions in developing countries
- Identify the causes of poultry diseases and how it occurs.

Essential Questions:

1. What are the common types of poultry production in developing countries?
2. What causes poultry diseases and how does it occur?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Common types of poultry production in developing countries. • Cause of poultry disease • Feeding poultry • Nutrients in a good quality feed
Skills	• Identifying common types of poultry production • Identifying good quality nutrients in feed • Identifying the cause of poultry disease
Attitudes	• Self-determination
Values	• Appreciate the principles and factors of poultry production in different context.

Content Background

COMMON TYPES OF MANAGEMENT SYSTEMS IN DEVELOPING COUNTRIES

Typically, four poultry management systems can be distinguished namely:

1. **the free-range system or unimproved backyard system:** scavenging, no regular water or feed, little or poor night shelter;
2. **the improved backyard system:** regular water, supplementary feeding, improved shelter, care of chicks in the first weeks, vaccination against Newcastle disease and other diseases (e.g. fowl pox, fowl cholera, Gumboro disease, coccidiosis), when necessary, and treatment for parasites;
3. **the semi-intensive system:** as in 2. above, with genetically improved breeds and balanced diets; and
4. **the small-scale intensive system:** as in 3. above, with further improvements in overall husbandry conditions.

All of these systems are encountered in a small-scale poultry farming, although in the very few cases in which the intensive management system is practiced, it is the small-scale option that is adopted. The choice of system is largely determined by the availability of resources and inputs, i.e. housing, cages, feed, drugs and time/attention. The level of inputs also depends on the keeper's or households socio-economic circumstances. Thus, most farmers adopt the free-range, backyard and semi-intensive husbandry systems, in that order. Also, these management systems frequently overlap; thus, free-range is sometimes coupled with feed supplementation, backyard with night confinement but without feeding; or standard poultry cages in confined space. Under the extensive poultry management systems, there is almost no health care. Thus, small-scale poultry farming in developing countries are often maintained with very low levels of inputs (i.e. land, labour and capital), though there are possible variations between and within regions or countries. On the whole, small-scale poultry farming can be managed by even the poorer social strata of the local communities.

Production can be classified by the type of product.

- a. Meat** – Great at producing meat but not efficient at egg production
- b. Eggs** – Good egg production but poor meat production. Do not need males to lay eggs
- c. Dual purpose** – produces both meat and eggs but at lower production rates.

Feeding Poultry

i) Water

Water is the most important part of poultry nutrition. Birds need a constant supply of fresh clean water. Birds cannot lay eggs if they lack water. Use water that you would drink Dirty water can make birds sick. Clean waterers regularly

ii) Good Quality Feed

- Better health
- More eggs
- Birds grow fast

Good quality feed has five nutrients

Nutrients	Source and Purpose
Protein	Protein is one of the most important parts of poultry feed. Protein can be found in Beans –Soy beans, cow-peas, mung beans, Fish meal, Oil seed cakes –sesame cake, soya cake, cottonseed cake, Insects, Leaves of legumes –Leucaena, Cassava, Beans
Carbohydrates (starches)	Carbohydrates (starches) are the largest source of energy for chickens -Rice, Roots crops and starchy fruits and seeds etc...
Fats and Oil	Most grains have some fats and oils in them. Others include oil seeds meals.

Minerals	Minerals are important for proper bone growth and egg production. Sources of minerals include Shells- eggshells, oyster shells, snails shells, Bone meal – made by heating bones then crushing them up Limestone products – lime is good source of calcium.
Vitamins	They are important for body functions. Are found in fresh plant leaves, seeds and fruits.

Poultry Diseases

Poultry diseases can be caused by any condition that results in deviation from the normal function. These diseases occur due to the interaction between 3 main factors;

- i) Agent
- ii) Host
- iii) Environment

Note that not all poultry health and production problems are caused by infectious agents. Many problems can be traced to management factors.

i. Infectious Agents

Bacteria	Bacteria cause many diseases, but can be usually be treated with antibiotics
Viruses	Viruses cause diseases that cannot be treated; therefore, prevention is the only way of protecting your birds. Vaccines are available to help protect your flock
Parasites	Most parasites can be treated with conventional medicine (anthelmintic) as well as traditional remedies
Fungus	No good way to treat fungal infections. Antibiotics may help

(ii) Non –Infectious Agents

Chemical	Birds can come into contact with poisons when farms are not kept clean. - Poisons used to kill rodents - Do not use the chicken house to store farm chemicals
Physical	Injury to the bird
Dietary deficiency	Improper feed formulation or mixing Toxins- Most create toxins that the birds can consume in the feed.

What factors affects the Host?

These factors include; Breed, Age, Sex, and Immune status. The weaker the host it is vulnerable to agents that can cause stress and disease.

Assessment:

- Explore and identify the different production practices and disease that affect production.
- Describe the poultry productions commonly practiced in PNG and the diseases that affect these productions.

UNIT 6: BIRD FARMING AND TECHNOLOGY

Content Standard 2.6: Students will be able to investigate how technology is used for bird farming, processing, preservation, marketing, consumption, regulation, and management in different contents and analyse their strengths and weakness.

Benchmark 10.2.6.1 Research and evaluate the impact of technology used in poultry farming on different environments and people.

TOPIC: IMPACT OF TECHNOLOGY USED IN POULTRY FARMING

Learning Objectives

By the end of this topic, students should be able to:

- Identify the kinds of technologies used in poultry farming on different environment and people
- Distinguish the impact of technologies in poultry farming on different environment and people

Essential Questions:

1. What types of technology are used in poultry farming?
2. How are these technologies used in poultry farming?
3. How does the use of technology affect the environment?
4. How does the use of technology affect the lives of people?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Technologies in poultry farming • Impact of technologies in poultry farming
Skills	• Define technologies used in poultry farming • Identifying technologies used in poultry farming
Attitudes	• Empathetic about the impacts of technologies used
Values	• Appreciate the use of technologies used in poultry farming

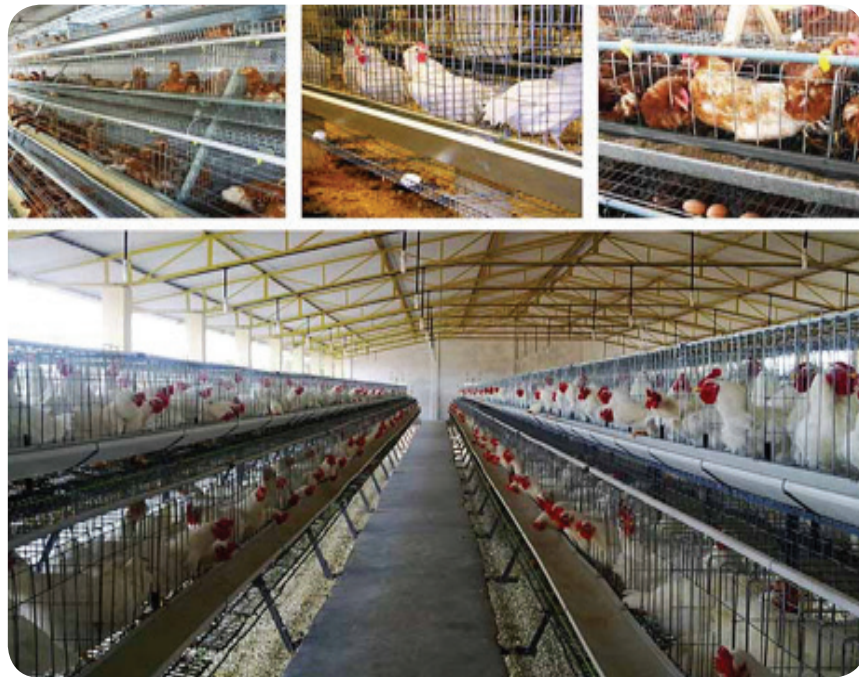
Content Background

Technology is simply the ways and the methods used to help people live productive lives. Farm technology is all of the methods, equipment and machinery used to help people improve farming enterprises. In this context, methods, equipment and machineries used to enhance poultry production. The technologies and innovations used in poultry farming have good and bad impacts on the surrounding environment and people.

Examples of some technologies and innovations used in poultry farming in PNG are:

1. **Hatcheries and incubators-** the two large poultry farming industries in the country (Zenag & Table birds) are using incubators and hatcheries to produce day-old chicks.

2. **Battery cages-** these are cages used for layers to making it efficient to collect eggs.
3. **Feeding and waterers-** this have been improved to rotating and self-refill when low on feed and water
4. **Lighting systems (brooders)-** automatic switch comes on and off depending on the temperature and humidity
5. **Thermal sensitive lights-** lights comes on when intruder approaches as security measure
6. **Feeds-** feeds produced using locally grown crops like kaukau, tapioca etc..



Source: <https://www.agriculture.gov.pg>



Incubator source: <https://www.chinachickencage.com/broiler>

Examples of advanced technologies are used by Zenag and Table Birds which is the production and processing line of poultry products:

- 1. Transporting** – moving the birds from the poultry house to the processing plant. They may also purchase birds from the surrounding small-scale farmers
- 2. Weighing-** weighing the birds before slaughtering using electrical weighing machines
- 3. Starving-** the birds are starved to empty their bowels before being slaughtered
- 4. Slaughtering-** a clean cut is made through the throat by mechanical blades in the production line
- 5. Plucking** – after slaughtering the birds pass through a hot bath to soften the feathers so plucking machines are used to remove feathers
- 6. Cutting and gutting-** the neck and feet are cut and they are gutted removing the internal organs
- 7. Cleaning and inspection-** birds are cleaned and inspected by health inspectors and DAL member
- 8. Chilling-** after inspecting they are stored in chillers
- 9. Packaging-** birds are now packed into trays or packets as pieces or whole
- 10. Weighing and grading-** packaged products are being weighed again to grade and value in terms of prices
- 11. Packing-** packing into cartons ready for wholesalers and retailers
- 12. Transportation and distribution-** transported in chiller trailers to wholesalers and retailers.

Assessment:

- Plan a field trip or excursion to a processing factory or site to research on the technologies used in the production and its impact
- Students present findings in a report write-up.

UNIT 6: BIRD FARMING AND TECHNOLOGY

Benchmark 10.2.6.2. Investigate technology used in harvesting processing, and preserving poultry products and evaluate their effectiveness and impact on the environment.

TOPIC: IMPACT OF TECHNOLOGIES IN POULTRY FARMING IN DIFFERENT CONTEXTS

Learning Objectives

By the end of this topic, students should be able to:

- Identify the types of environments for poultry farming
- Identify long term impact on poultry farming in reference natural and socio-economic environment.

Essential Questions:

1. What are the different types of environments for poultry farming?
2. What are the impacts of technology on the different environment?
3. How will the impacts be addressed?

Essential Knowledge, Skills, Attitude and Values

Knowledge	• Impact of technologies on management and production of poultry farming
Skills	• Identifying the impact of technologies with respect to natural and socio-economic environment.
Attitudes	• Open-mindedness in learning about the impact of technologies
Values	• Respect natural and socio-economic environment.

Content Background

Types of Environments

Environment can be defined differently in various contexts. Environment can be natural; that is all the living things in their habitats and ecosystems and their reactions with each other. The other is the artificial environment that involves the non-living things and the built ones.

An **effect** refers to short term, can be positive or negative; whereas **impact** refers to long term consequences of the effects.

- 1. Natural environment-** technology used in management practices enhances production efficiency, cost efficient etc. on the other hand, it has negative effects that may cause harm to the surrounding environment. For example; emissions from generators or other machineries used in the management or production systems pollute the air and contributes to greenhouse effect. The other is waste disposals and chemicals that are deposited into waterways or rivers that pollute organisms in the river

and human beings as well. The long-term impact is it causes diseases to human.

2. Socio-economic environment- when advanced technology is used to do most of the work it reduces human labor. Social and economic problems arise when technology replaces human power. People are unemployed and find ways of feeding their families which gives rise to social problems or criminal activities.

Assessment:

- Research and identify the impacts of technology used in the harvesting, processing and the preserving of poultry products
- Analyse and categorise the impacts into advantages and disadvantages of each type of technology used in the harvesting, processing and preserving of poultry products.

UNITS OF WORK

STRAND 3: AQUA-CULTURE

Strand Overview

Unit	Benchmark	Topic	Lesson Titles
Content Standard 3.1 Students will be able to define aquaculture, investigate the different types of plants, animals and fish cultivated using this method of farming, categorize them according to their characteristics, purposes and benefits, and investigate the different contexts, environments, and places where they are farmed.			
Unit 1: Types of Aqua farming Plants, Animals, and Fish	Benchmark: 10.3.1.1. Investigate and elaborate on the cultivation of different fresh, brackish, and salt-water animals in different environments.	The cultivation of different fresh, brackish and salt-water animals	The cultivation of fresh water animals
			The cultivation of brackish water animals
			The cultivation of salt water animals
	Benchmark 10.3.1.2. Categorize and examine different fresh, brackish, and salt-water animal characteristics, species, functions, and purposes.	Different brackish, and salt water animal and plants characteristics species, functions and purposes	Breeds and species of fresh water animals and plants
			Breeds and species of brackish water animals and plants
			Breeds and species of salt water animals and plants
Content Standard 3.2 Students will be able to investigate and analyse the different types of aqua farming and management principles, systems and practices used in different environments and places to farm, process, preserve, market, regulate and consume plants, animals and fish.			
Unit 2: Aqua farming Practices and Management Systems	Benchmark 10.3.2.1. Explore and analyse fish farming and management practices and systems used in different places and environments.	Fish farming management practices and systems	Fish farming systems in freshwater
			Fish farming systems in brackish water
			Fish farming systems in saltwater
	Benchmark: 10.3.2.2. Investigate and analyse aqua plant farming and management systems and practices in different places and environments.	Aquaculture plant farming management systems and practices	Aqua plant farming systems in freshwater
			Aqua plant farming systems in brackish water
			Aqua plant farming systems in saltwater
	Benchmark: 10.3.2.3. Discuss different ways of preserving plant, animal, and fish species and sustaining the environments in which they are farmed.	Preservation and sustainability of aquatic plants and animal species and their environments	Sustainable ways of preserving plants, animals, fish and in which they are farmed
Content Standard 3.3 Students will be able to examine how technology is used in aqua farming and the processing, preservation, marketing, consumption, regulation and management of plants, animals and fish in different environment and places and evaluate their strengths and weakness.			

Unit 3: Aqua farming and Technology	Benchmark: 10.3.3.1. Investigate and explain the fish farming, harvesting, and preservation technology used in different environment and places.	Technology used in fish farming, harvesting and preservation in different environments	Technology used in fish farming
			Technology used in fish harvesting
			Technology used in fish preservation
	Benchmark: 10.3.3.2. Investigate and evaluate the effectiveness of different technology used for producing and processing aqua farming	Technology used for producing and processing aqua farming products	Technology used for producing aqua farming products and their effectiveness
			Technology used for processing aqua farming products and their effectiveness

UNIT 1: TYPES OF AQUA FARMING PLANTS, ANIMALS AND FISH

Content Standard 3.1 Students will be able to define aquaculture, investigate the different types of plants, animals and fish cultivated using this method of farming, categorize them according to their characteristics, purposes and benefits, and investigate the different contexts, environments, and places where they are farmed.

Benchmark 10.3.1.1. Investigate and elaborate on the cultivation of different fresh, brackish, and salt-water animals in different environments.

TOPIC: THE CULTIVATION OF DIFFERENT FRESH, BRACKISH AND SALT-WATER ANIMALS

Learning Objectives

By the end of this topic, students will be able to;

- Explore different fresh, brackish, and salt-water animals in different environments.
- Discuss the cultivation of fresh, brackish, and salt-water animals

Essential Questions;

1. What are the different animals found in freshwater, brackish and salt water environments?
2. How are they cultivated in fresh, brackish, and salt-water environments?
3. Are fresh, brackish, and salt-water animals similar or different?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Freshwater aquaculture refers to the raising and breeding of aquatic animals (fish, shrimp, crab, shellfish, etc) and plants for economic purposes by the use of ponds, rivers, lakes and other inland waterways • Saltwater aquaculture is a process that usually involves the rearing, stocking, breeding, protecting and feeding of a variety of different marine life forms.
Skills	• Identify and describe the different types of fish and other organisms that are found in fresh water and saltwater environment • Discuss the cultivation of these animals in various environments
Attitudes	• Appreciate and care about the contributions of freshwater and saltwater environments to mankind
Values	• Conduct self-determination and perseverance in the cultivation of fresh, brackish, and salt-water animals

Content Background

The cultivation of different fresh, brackish and salt-water animals
Aqua culture is the process of rearing, breeding and harvesting of aquatic species, both animals and plants in controlled aquatic environments like the oceans, lakes, rivers, ponds and streams. It serves different purposes including food production

The term 'Aquaculture' means culture of all aquatic forms like fish, prawns, molluscs and sea weeds in fresh, brackish as well as marine waters. The 'Aquaculture' includes:

- The type of culture systems utilized, e.g., pond culture, cage culture, pen culture, etc.
- The type of organisms cultured, e.g., fish, oyster, shrimp or prawns.

The origin of aquaculture dates back to at least three thousand years ago, but unlike agriculture, which has been the most important way of obtaining food on land, aquaculture has until recently contributed very less to mankind due to age old methods in use coupled with lack of proper knowledge. But now the picture is changing rapidly as aquaculture is gaining more importance in the today's' modern world, due to increase in population and shortage of food.

The main objectives of aquaculture are:

- (1) To boost economy of the nation by way of increasing per capita production.
- (2) To generate employment opportunities for the unemployed persons.
- (3) To utilize fully the natural water resources available to the maximum.
- (4) To uplift the socio-economic status of the people of Indian sub-continent.
- (5) To earn foreign exchange revenue by transport of fish to foreign countries.
- (6) To culture ornamental fishes for beautifying aquariums.
- (7) To culture larvicidal fishes for control of mosquito larvae.
- (8) To increase production of food, in the form of fish, and decreasing the pressure on other food items.

Freshwater Animals



Carp – freshwater fish

Saltwater Animals

Saltwater aqua farming is a farming method that utilizes saltwater as opposed to fresh water and usually done in the coastal region. Ocean enclosures can hold many different kinds of fish. Some of the most commonly farmed saltwater fish are salmon. Apart from the fish there are other resources that can be farmed.



Crustaceans

Crustaceans are grown in both the Pacific and Atlantic regions. Shrimp, prawns, crab and lobster are all crustaceans that may be farmed:

- Commercial Shrimp farming
- Pacific white shrimp
- Freshwater prawn farming
- Giant tiger prawn
- Crayfish and crabs
- Chinese river crab



Mollusks

Mollusks like oysters and mussels can also be farmed.

Farmed and bred in fish hatchery;

- Larval, juvenile fish, shellfish, and crustaceans
- Pacific oysters, shrimp, Indian prawns, salmon,
- tilapia and scallops



Assessment:

- Can describe the different types of fish and other organisms that are found in fresh water and saltwater environment.
- Show self-determination and care in cultivation of fish in fresh water and saltwater environment.

Reference/sources

Principles of Aquaculture; Himalaya Publishing House

See also: *Shrimp farming*, *Freshwater prawn farming*, and *Astaciculture*

UNIT 1: TYPES OF AQUA FARMING PLANTS, ANIMALS AND FISH

Benchmark 10.3.1.2. Categorize and examine different fresh, brackish, and salt-water animal characteristics, species, functions, and purposes.

TOPIC: DIFFERENT BRACKISH AND SALT WATER ANIMALS' CHARACTERISTICS, SPECIES, FUNCTIONS AND PURPOSES

Learning Objectives

By the end of this topic, students will be able to;

- Identify common characteristics of animals in freshwater, brackish and saltwater environments
- Examine the species, functions and purposes of aqua farming animals

Essential Questions:

1. What are the common characteristics of freshwater, brackish and saltwater animals?
2. What species of animals are farmed in freshwater, brackish and saltwater?
3. What are their functions and purposes?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Despite the thousands of different species with various adaptations, all fish share some common adaptations that help them thrive in their environment. • Common characteristics of animal species, their functions and purposes – economic and environment benefits
Skills	• Distinguish between freshwater, brackish and saltwater fish according to their physical characteristics. • Analyse and describe the common characteristics of animal species, their functions and purposes in terms of economic and environment benefits
Attitudes	• Show respect and care for the environment in which aqua animals live • Appreciate the contributions of the environment to mankind
Values	• Self-determined and concerned about the contributions of the aqua environment and economic benefits to mankind.

Content Background

Common characteristics of freshwater, brackish and saltwater animals

Common Characteristics of Fish

Despite the thousands of different species with various adaptations, all fish share some common adaptations that help them thrive in their watery domain. While there are some rare exceptions to these rules, below is a list of traits common across these aquatic animals.

1. All fish are cold blooded

All fish are cold –blooded and cannot regulate their body temperature. They rely on the outside environment for temperature regulation. The body temperature changes as the environment's temperature changes.

Many fish species are extremely sensitive to these temperature changes and are only able to exist in a specific water temperature. Other species are able to survive in wider temperature ranges.

2. Water Habitats.

All fish live in water (salt, fresh and brackish water)

3. Gills to breathe

Gills are necessary for underwater life; gills allow the fish to absorb oxygen from water and release carbon dioxide

4. Swim Bladders-

all fish have a swim bladder, which is a specialized organ filled with air that helps ensure fish maintains a stable buoyancy in the water, neither sinking or floating too much. The presence of a swim bladder allows the fish to sleep without sinking to the bottom of its habitat. In some species of fish, air is swallowed and sent to the swim bladder. This adaptation also helps the fish to survive in waters that do not have adequate levels of oxygen.

5. Fins for Movement-

Fins are almost universal characteristics of fish. Many types of fins exist, but the most common are the tall fin, a matching pair of side fins, dorsal fins and anal fin

6. Many fish have excellent vision and can see colors.

They also have nostrils and are able to detect odors in water. Fish may or may not have teeth, depending on the species. Another organ of sense unique to fish is called the lateral line, located along the side of the fish. It contains small sensory hairs that help detect underwater vibrations and determine their sources, enabling fish to navigate even in low light or murky water

Farmed animals in freshwater, brackish and saltwater

On the basis of fish species (number of species stocked for farming)

- Monoculture
- Polyculture

Monoculture

Monoculture is a fish production system in which only one fish species is reared in a culture system. The major fish varieties reared in monoculture system are trout, tilapia, catfishes, carps, shrimp etc. Monoculture of high-value, market-oriented fish species in intensive system is a common practice throughout the world. Supplementary feeding is compulsory to ensure production.

Polyculture

Polyculture is a fish production system in which two or more different fish species are farmed or culture of fish along with some other aquatic animals like shrimp or prawn. In this system of culture species with different habitats and different food preferences are stocked together in such densities that there will be almost no competition for food or space. Polyculture practices give higher yield than monoculture under the same conditions for freshwater carp farming.

Purpose and benefits of aqua farming

(a) Economic Benefits

1. Alternative food source

Fish and other seafood are good sources of protein. They also have more nutritional value like the addition of natural oils into the diet such as omega 3 fatty acids. Also since it offers white meat, it is better for the blood in reducing cholesterol levels as opposed to beef's red meat. Fish is also easier to keep compared to other meat producing animals as they are able to convert more feed into protein. Therefore, its overall conversion of pound of food to pound of protein makes it cheaper to rear fish as they use the food more efficiently.

2. Alternative fuel source

Algae are slowly being developed into alternative fuel sources by having them produce fuels that can replace the contemporary fossil fuels. Algae produce lipids that if harvested can be burn as an alternative fuel source whose only by products would be water when burnt.

Such a breakthrough could ease the dependency of the world on drilled fossil fuels as well as reduce the price of energy by having it grown instead of drilling petroleum. Moreover, algae fuel is cleaner and farmable source of energy, which means it can revolutionize the energy sector and create a more stable economy that avoids the boom-bust nature of oil and replaces it with a more abundant fuel source.

3. Increase Jobs in the market

Aquaculture increases the number of possible jobs in the market as it provides both new products for a market and create job opportunities because of the labor required to maintain the pools and harvest the organisms grown. The increase in jobs is mostly realized in third world countries as aquaculture provides both a food source and an extra source of income to supplement those who live in these regions.

Aquaculture also saves fishermen time as they do not have to spend their days at sea fishing. It allows them free time to pursue other economic activities like engaging in alternative businesses. This increase in entrepreneurship provides more hiring possibilities and more jobs.

4. Reduce Sea Food Trade Deficit

The sea food trade in America is mainly based on trade from Asia and Europe, with most of it being imported. The resultant balance places a trade deficit on the nation. Aquaculture would provide a means for the reduction of this deficit at a lower opportunity cost as local production would mean that the sea food would be fresher. It would also be cheaper due to reduce transport costs.

(b) Environmental Benefits

1. Creates Barrier against pollution with mollusk and sea weed

Mollusks are filter feeders while seaweed acts a lot like the grass of the sea. Both these organisms sift the water that flows through them as brought in by the current and clean the water. This provides a buffer region that protects the rest of the sea from pollution from the land, specifically from activities that disturb the sea bed and raise dust.

Also, the economic benefits of mollusks and sea weed can create more pressure from governments to protect their habitats as they serve an economic importance. The financial benefits realised provides incentive for the government to protect the seas in order to protect sea food revenue.

2. Reduces fishing pressure on wild stock

The practice of aquaculture allows for alternative sources of food instead of fishing the same species in their natural habitats. Population numbers of some wild stocks of some species are in danger of being depleted due to overfishing.

Aquaculture provides an alternative by allowing farmers to breed those same species in captivity and allow the wild populations to revitalize. The incentive of less labor for more gains pushes fishers to convert to fish farmers and make even more profit than before. It also allows them control of the supply of the fish in the market giving them the ability to create surplus stock or reduce their production to reap the best profits available.

It serves different purposes including; food production, restoration of threatened and endangered species populations, wild stock population enhancement, building of aquariums, and fish cultures and habitat restoration.

(c)Health Benefits

All over the world, the demand for seafood has increased because people have learned that seafood's part of regular diets are healthier and help fight cardiovascular disease, cancer, Alzheimer's and many other major illnesses. Aquaculture is currently estimated to account for approximately 13 percent (10.2 million t) of world fish production. Aquaculture will add to wild seafood, and make it cheaper and accessible to all, especially in regions where there depend on imported seafood products.

Assessment:

- Describe the physical characteristics of freshwater, brackish and saltwater fish.
- Show respect and care for the aqua animals and their environment.

Reference/sources.

Ref: <https://sciencing.com>

UNIT 2: AQUA FARMING PRACTICES AND MANAGEMENT SYSTEMS

Content Standard 3.2 Students will be able to investigate and analyse the different types of aqua farming and management principles, systems and practices used in different environments and places to farm, process, preserve, market, regulate and consume plants, animals and fish.

Benchmark 10.3.2.1. Explore and analyse fish farming and management practices and systems used in different places and environments.

TOPIC: FISHING FARMING MANAGEMENT PRACTICES AND SYSTEMS

Learning Objectives

By the end of this topic, students will be able to;

- Explain the common methods used to produce fish.
- Identify good management practices
- Describe the proper fish handling methods
- Explain the consequences of not handling fish correctly

Essential Questions:

1. What are the methods of culturing fish?
2. How do you manage fish farms?
3. What is fish handling?
4. How do you handle a fish?
5. Why is proper handling of fish important?
6. How long should you keep fish out of the water?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Fish farming management and production systems • Pond System • Open Net Pens • Submersible Net Pens • Recirculating Systems • Fish farming management techniques • Fish handling
Skills	• Distinguish between the common methods of fish production • Identify key areas of management and apply appropriate measures to maintain quality • Apply correct techniques when handling fish to maintain freshness of fish. • Assess the freshness of fish by sensory or chemical methods • Formulate checklists to check on the different areas
Attitudes	• Be responsible and caring for properties • Appreciate the importance of proper fish handling techniques
Values	• Affective and concerned about the importance of good management practices • Rational and honest when expressing the importance of proper fish handling techniques

Content Background

Fishing Farming Management Practices and Systems

1. Fish Farming Methods

Pond System

The oldest type of fish farming is the pond system, which originated thousands of years ago. Pond farms include earthen pond, ditch or canal systems, with clay-based soils that can easily be diked to make enclosures

Open Net Pens

Net pens involve a framework made from metal, wood or bamboo which floats on the surface of a body of water and supports a mesh enclosure. They are either anchored to the bottom of the water body, attached to a secure structure nearby, or both.

Fish farmers favor net pens because of their flexibility, versatility and scale. They are able to succeed in whichever type of water body best suits the needs of their stocks. They are designed to allow water to flow freely through, which helps them deal with waste.

Submersible Net Pens

An alternative to open net pens is submersible net pens. Instead of floating on the surface, these are fully underwater and often take the form of a large, closed-off cage.

Since they are beneath the surface, they're also more remote than open pens. This shelters them from the elements and makes it less likely that captive fish stocks will escape.

Recirculating Systems

Some types of fish farming show enormous promise for reducing environmental risk factors. One example is recirculating systems, which are essentially like high-tech pond systems. Fish stocks are reared in a series of interconnected, fully controlled tanks that are indoors and have virtually no chance of contact with wild stocks

2. Fish Management Practices

This topic covers fish farming methods while varying slightly depending on the specific biological requirements of the culture organism, the type of culture system, and the culture environment (freshwater, brackish, and marine) are similar in that they involve the following basic activities:

- I) Pond preparation /conditioning
- II) Stocking
- III) Feeding and or Fertilization (depending on the culture system used)
- IV) Water management
- V) Pond maintenance and
- VI) Harvesting

Variations would consist mainly of differences in application rates of fertilisers, lime, pesticides and feeds: stocking rates and sizes of stocking material; rate of water change and harvesting techniques.

i. Pond preparation

Ponds are totally drained and the pond bottoms dried prior to the application of pesticides. Tobacco dust, derris root/rotenone powder, tea-seed cake/powder, or Gusathion-A are used to eliminate predators and/or wild species that may eventually compete with the cultured organisms for food and space. Tea-seed cake is perhaps the best fish poison to use in brackish water ponds to selectively kill unwanted fish without damaging the shrimps and without affecting rotifers and copepods which are feed for shrimps. On the other hand, rotenone is most effective in fresh water and works better in low-salinity water (ASEAN/SCSP, 1978).

Ponds with acid-sulphate soils are repeatedly dried and flushed, i.e., filled and drained to remove the acids formed by pyrite oxidation. Agricultural lime is then applied to correct soil pH and bring it up to at least 6.5. Brackish water ponds are usually treated by spreading 1.5 t of agricultural lime per ha, followed by another 1.5 t worked into the soil.

To stimulate and maintain the growth of natural plankton, organic (e.g., chicken manure) or inorganic fertilizer (e.g., urea, ammonium phosphate) are applied to the pond bottom. After fertilizer application, water is let in to a depth of about 20-40 cm and gradually increased to 1 m a week after fertilization. Intensively managed ponds or ponds where artificial feeding shall be given, do not need to be fertilized. Extensive ponds need regular fertilization during the culture period to maintain the growth of natural food. Semi-intensive ponds may use a mix of fertilization and supplementary feeding.

Table 8. Variations in pond management techniques commonly used for different species

Species	Stocking Rate	Fertilization	Feed Type	Rate of Water	Pesticides/ Predator Control		Reference
					Type		
MILKFISH	2 000- 5 000/ha	16-20-0 at 50 kg/ha; 45-0-0 at 15 kg/ha; chicken manure at 0.5 t/ha twice weekly	Rice bran and trash fish as supplemental feed	Once every two weeks at high tide	Lime; ammonium sulfate	1 t/ha 10 g/m ²	Bombero-Tuburan & Gerochi, 1988
TILAPIA (O. niloticus; O. mossambicus)	5 000- 20 000/ha	Chicken manure at 500 kg/ha; Inorganic fertilizers at 50 kg/ha	Rice bran, fish meal, ipil-ipil leaf meal				Camacho & Laguna, 1988
CATFISH (Clarias batrachus)	60- 300/m ²		9 parts trash fish and 1 part rice by-products	When necessary			Sirikul et al., 1988

PENAEIDS	From as low as 15 000 to as high as 300 000/ha	Chicken manure at 1-2 t/ha followed by inorganic fertilizer at 75-150 kg/ha mono-ammonium phosphate (16-20-0) and 25-50 kg/ha of urea (46-0-0)	Supplemental feed of rice bran with trash fish, mussels, and clam meat; artificial/formulated diets with 40% CP.	20-30% once every week or every two weeks for low density ponds; 5-20% daily for semi-intensive to intensive ponds			Corre, 1988
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ii. Stocking

After the pond is prepared, fish fingerlings or shrimp post larvae are stocked at the appropriate density depending on the culture strategy, size of pond, and the size of fingerlings, among others.

The fingerlings are properly acclimated and conditioned prior to stocking and weak or diseased fish eliminated. Stocking is usually done in the early morning or late afternoon.

iii. Feeding

Fish/shrimp grown in semi-intensive and intensive culture ponds are given supplementary and full artificial feeds, respectively, the former to augment the natural food in the pond, the latter to totally replace the natural organisms in the water as a source of nutrition.

A wide variety of feed ingredients is used to prepare supplemental/artificial feeds. The simplest fish feeds are prepared at the pond site using locally available raw materials like rice or corn bran, copra meal, and rice mill sweepings as sources of carbohydrates. These are usually mixed with animal protein like trash fish/fish meal, shrimp heads, and snail meat. Supplemental feeds for tilapia are prepared using 80% rice bran and 20% fish meal. Those for shrimps in improved extensive culture (low-density stocking but given dietary supplements for increased growth/production) usually include fresh raw materials like snail/mussel/clam meat or carabao hide and other slaughterhouse leftovers.

Commercial feed preparations are also available now in a wide range of brand names, mostly for semi-intensive and intensive shrimp culture. (Taiwan (PC), Japan, and the USA are the top producers of commercial fish/shrimp feeds.) These commercial diets consist of a number of ingredients like fish meal, blood meal, bone meal, and shrimp head meal (to serve as attractant for the shrimp), together with vitamin and mineral premix and carbohydrate sources like rice/corn bran or wheat. The crude protein (CP) content of these shrimp feeds is generally not lower than 30% to satisfy the high animal protein requirement of shrimps, actually estimated to be about 40% during the earlier stages of growth.

Commercial feeds usually come in various formulations to match the protein requirement of the culture organism, which as a rule, decreases with age. Thus, fish/shrimp feeds come in different forms as starter, grower, and finisher, with starter feeds having the highest CP content of about 40% and finisher feeds having the lowest CP content of about 20%. Starter feeds are usually given on the first month of culture, finisher feeds on the last month, and grower feeds in between.

Some shrimp culturists prefer not to give artificial feeds during the first two weeks of culture when the newly stocked post larvae can subsist on the plankton available in the water.

The feeding rate is computed as a percentage of the estimated animal biomass in the pond, with higher rations given when the animals are small and gradually decreasing as they become bigger. The daily feeding rate usually starts at 5% and 10-15% of estimated biomass of fish and shrimps, respectively, and decreases to a low of 2% and 5%, for fish and shrimps, respectively, toward harvest.

The daily feed rations are given in equal portions during the course of a day. Freshwater fish like tilapia are usually fed twice a day - early morning and late afternoon. Penaeid shrimps are fed more frequently, from three to four to as often as six to seven times a day.

Feeds are broadcast into the water and/or supplied on feeding trays. In semi-intensive and intensive shrimp ponds, small feeding boats are used by caretakers who go around the pond distributing the feed by broadcasting. At certain points along the periphery of the pond, feeding trays (Fig. 12) are submerged into the water after known quantities of feed are put on the surface, to supply feed to the shrimps in the pond as well as to monitor feed consumption and shrimp growth. The feeding tray is lifted two to three hours after the feed was supplied to check how much of it has been consumed and to see if the shrimps are healthy and feeding. Empty feeding trays may indicate that the quantity given is inadequate and may have to be increased. Conversely, full or slightly touched trays indicate excessive feed quantities and/or sluggish shrimps. The feeding ration is subsequently adjusted accordingly to optimize feed utilization.

By monitoring the feeding tray, one can get a good indication of the sizes and quantity of shrimps present in the pond without a need for cast-netting or actual sampling, since shrimps are invariably found on the tray when it is lifted out of the water.

3. Water Management

Water in the pond is kept at certain levels for optimal fish growth. In general, a pond water depth of 1 meter is considered best for culture of tilapia, carps, and shrimps; traditional milkfish ponds can do with just 40-60 cm of water. Pond water is not just maintained at a certain depth; its quality must also be kept high to ensure optimal growth of the culture organism. This is particularly important in semi-intensive and intensive culture systems where large amounts of metabolites are continuously excreted into the pond and where excess,

unconsumed feeds add to the bottom load and serve to pollute the water.

To prevent the deterioration of the pond environment, pond water is continuously freshened by the entry of new water from the river or water source (through the supply canal) while old water is drained through the outlet/drainage gate and through the drainage canal into the sea or river.

A flow-through system of water management that allows the simultaneous entry and exit of water into and out of the pond is essential in any high-density culture system. This is effected by the provision of separate inlets and outlets for all the ponds, each inlet regulating the flow of water from the supply canal to the pond and each outlet controlling the discharge of water out of the pond into the drainage canal. Both the supply and drain gates are so designed as to bring water into and drain water out of the lower levels of the pond, where water quality tends to get poorer faster as a result of the accumulation of wastes and their subsequent decomposition.

The regular replenishment of pond water, independent of natural tidal fluctuations, is made possible by the use of pumps which draw water from the source even at low tide. Although there is no hard-and-fast rule as to the rate of water change necessary for medium- to high density aquaculture, semi-intensive culture systems usually change water at the rate of 10% daily for an equivalent total replacement of water every ten days or three times per month. Intensively managed ponds require greater water exchange in view of the much higher organic load on the pond bottom, especially toward the latter part of the culture cycle when the animals excrete more wastes. Intensive ponds/tanks usually need to provide for aeration facilities/equipment to prevent anoxia that may lead to mass mortalities. Oxygen depletion in high-density ponds results not only from the faster rate of utilization of dissolved oxygen for respiratory activities; it is also caused by the fast rate of decomposition at the pond bottom by aerobic or oxygen-consuming micro-organisms.

Paddlewheels or other types of aerators are thus provided in the ponds to effect the infusion/introduction of greater quantities of oxygen into the water and prevent fish/shrimp mortalities. The aerators are usually operated at regular/periodic intervals for certain fixed durations during the day but especially in the early morning hours when the concentration of dissolved oxygen is known to be lowest (as a result of the absence of photosynthetic, oxygen-producing activity in the pond). Toward the end of the culture period when oxygen demand is highest, aeration may have to be provided continuously and not just sporadically as could be done during the initial stages of rearing. At that time too, water pumps usually need to be run for longer periods to affect greater water exchange.

Pond water is also regularly sampled and measurements taken of basic/essential parameters, particularly dissolved oxygen, pH, and salinity. This is important for the purpose of determining the need for corrective/remedial action to bring water quality to optimum levels and obtain good yields. Dissolved oxygen levels are kept, as much as possible, above 5 ppm by pumping and aeration. Problems of acidity are corrected by liming. Salinity is an important parameter for penaeid culture and has to be maintained within a range of 15-25 ppt for best results. During summer months, high-salinity

water can be diluted by mixing with fresh water from springs or deep wells.

4. Pond Maintenance

i. Fertilization

Aside from feeds and water management, the following pond maintenance procedures are carried out: regular application of fertilizers, lime, and pesticides; prevention of entry of predators; monitoring of the stock for growth rate determination as a basis of feeds and water management; and regular pond upkeep and maintenance.

Extensive ponds are fertilized regularly using either organic fertilizers like chicken, cow, or pig manure, or inorganic fertilizers like urea, ammonium phosphate, or both, to maintain the plankton population in the pond. The fertilizers are either broadcast over the pond water surface or kept in sacks suspended from poles staked at certain portions along the pond periphery. Semi-intensive and intensive culture systems do not require fertilization since they are not natural food-based, except for those which grow plankton-feeders like milkfish whose diet is largely algae dependent.

ii. Liming

In addition to fertilization, ponds also need to be given regular doses of lime to maintain water pH at alkaline or near-alkaline levels (preferably not lower than six). Agricultural lime is broadcast over the pond and applied on the sides of the dikes to correct soil and water acidity.

iii. Elimination of Pests and Predators

Unwanted and predatory species which may have survived the application of pesticides during pond preparation or which were able to enter the pond through the gate screens or through cracks in the dikes, are eliminated by the application of pesticides, preferably organic, into the pond.

Crabs, which are a serious problem in shrimp ponds because they are carnivorous and cause damage to the pond dikes, are not usually affected by known pesticides and are therefore best eliminated by the use of crab traps situated in the pond.

It is also important that the gates are properly screened and the screens kept whole, to prevent the entry of small unwanted fish into the pond. Double screens are usually installed at the main intake to ensure that pests and predators are prevented from entering the pond system.

iv. Stock Monitoring

The culture organisms are monitored closely and regularly to determine their rate of growth and the general condition of the stock. They are regularly sampled for length-weight measurements as a basis for determining/estimating their biomass in the pond and therefore their daily feed rations, as well as for making projections on harvest schedules and procurement of pond inputs.

In the first few months of culture, the feeding tray is a good tool for stock monitoring, as explained in Section 4.3.5.3. As the organisms grow in size, cast-netting is used as a sampling tool, with those caught in the throw of the cast net providing an indication as to sizes and weights of stock. Based on the sampled weights and the daily feed consumption, it is possible to predict the available biomass (i.e., stock surviving after initial mortalities) and make projections on volume of harvest. For this purpose, it is essential that accurate records are kept for analysis at a later time. Data on initial size/weight and number of fry/post larvae stocked, average body weight at each sampling, and feed consumption on a daily basis, are important to have on file.

iv. Regular Upkeep and Maintenance of Facilities

The pond dike and gates are checked regularly for cracks that could lead to seepages and losses of stock. The dikes are best planted with grass or vegetative cover to prevent erosion. The gates and other support infrastructure are properly maintained for efficient operation.

5. Harvesting

Marketable-size fish/shrimps are harvested at the end of the culture period by draining the pond and using harvesting nets to catch the fish or shrimps. The latter are harvested with a bag-net attached to the sluice gate as water is drained out of the pond at low tide. Tilapia are harvested using seine nets after the pond water is drained to half-level the night before.

Harvest of milkfish takes advantage of their behavior of swimming against the current. The method, involves draining 85-90% of the pond water during low tide and allowing in the water at the incoming high tide so that the fish swim against the current through the tertiary gate and into the catching pond, whose gate is closed once a large number of fish is impounded. The fish in the catching pond are then harvested by seining and the rest hand-picked.

6. Fish handling practices

For many farming practices, the capture, handling and transport of fish is an essential requirement, however each of these activities found to be a stressful process.

Due to the need for vaccination, grading and tagging, the movement of fish between facilities, and slaughter; the capture and handling of fish is often unavoidable. However, the removal of fish from water is known to elicit a maximal emergency stress response in the animals, and welfare groups are now advising this should only be completed when absolutely necessary, with animals kept out of the water for no longer than 15 seconds unless anaesthetized (Human Slaughter Association, 2005). Such groups are also releasing a series of recommendations about the best practices to be employed on farms, as well as encouraging the industry as a whole, to continually develop less stressful ways of carrying out these procedures.

i. Capture and Handling

Various methods are used in the capture and movement of fish within farms; ranging from the use of small nets for individual animals to large nets, or seines, for larger fish collection.

Special fish pumps or pipes are also used for the movement of fish between ponds or to separation tanks for treatment.

Each of these methods however, have their associated limitations. The use of nets, for example, can easily cause abrasions and the damage and loss of scales.

Although having the advantage of keeping fish in water, poorly designed pumping systems can also cause fish injury, as fish can often be dropped on to hard surfaces at the point of exit from the pipe.

Once caught, handling is also considered a stressful process, with injuries to eyes, fins and muscle, as well as scale loss are all common, especially in salmon smolts.

Handling is also known to damage the protective mucous coating of the skin, which serves as the primary line of defense against pathogens, thus increasing the vulnerability of fish to disease.

ii.Transport

For certain species, the transport of farmed fish between facilities is a regular and routine part of their production cycle.

Young rainbow trout, for example, are often transported to on-growing farms to be fattened to slaughter weight, and salmon smolts are moved from freshwater sites to seawater cages as they develop; fully grown salmon then often require further transportation to a separate processing plant for their eventual harvest.

Whilst this transport is common and frequent however, the process is extremely stressful for fish and may negatively affect survival rates of the population as a whole. In salmon smolt, for example, it takes more than 48 hours for amounts of the stress hormone, cortisol, to return to pre-transport levels. There are largely three methods employed for the transport of farmed fish; namely the use of well boats, helicopters and water tanks carried on flat-bed trucks. Whilst the practice of water tanks is as appears, fish in helicopters are crowded into highly-oxygenated purpose-built water tanks or buckets carried beneath the vehicle and, due to welfare concerns, are restricted to only very short journeys.

In well boats, fish are kept in a pool of seawater within the boat's hull; the water constantly exchanging with that from the outside by the pressure caused by the motion of the vehicle, or automated pumps when movement ceases. This continual refreshment of the water makes the use of well boats the most preferred method of transport.

However, despite this preference, the transportation of fish by all means causes some form of stress, and injuries are known to be sustained through physical interaction with other animals or concussion with the tank walls. Further poor conditions during transport, caused by overcrowding or inadequate water quality, associated with limited oxygen or the accumulation of carbon dioxide and ammonia, also cause damage and fish mortality. Whilst stress can be reduced by the use of anaesthesia or sedation, neither of the commonly used compounds of metomidate or clove oil are licensed for use within the EU.

For these reasons, welfare charities remain opposed to the transport of live fish over long distances, instead recommending transport to be kept to an absolute minimum at all times.

Assessment:

Explain the common methods of fish production and the correct use of techniques when handling fish to maintain the freshness.

Show responsibility and care when using proper fish handling techniques.

Reference/Source:

Closed Waters: The Welfare of Farmed Atlantic Salmon, Rainbow Trout, Atlantic Cod and Atlantic Halibut. P. Stevenson, 2007, in association with the Compassion in World Farming and World Society for the Protection of Animals.

UNIT 2: AQUA FARMING PRACTICES AND MANAGEMENT SYSTEMS

Benchmark: 10.3.2.2. Investigate and analyze aqua plant farming and management systems and practices in different places and environments.

TOPIC: AQUACULTURE PLANT FARMING MANAGEMENT SYSTEMS AND PRACTICES

Learning Objectives

By the end of this topic, students will be able to;

- Explore aqua plant farming and management systems and practices in different places and environments
- Examine management systems and practices in various environments
- Evaluate management systems and practices in terms of consumption and marketing of the products.

Essential Questions:

1. What are the aspects of Aquaculture plant farming management systems and practices?
2. How are they managed and practiced by the farmers and or the employees?
3. What are the values and products of practicing aqua farming of plants?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Aquaculture plant farming management systems and practices • In various environments
Skills	• Investigate using exploration methods to find out about plant farming, their management systems and practices • Examine the management systems and practices • Evaluate and assess the quality of the management systems and practices
Attitudes	• Collaborate as in teamwork and be diligent in carrying out the assigned activities • Inquisitive and committed to analyzing the management systems and practices
Values	• Is self-esteemed and affectionate about farming management systems and practices

Content Background

Aquaculture plant farming management systems and practices

Management systems of aqua plants in the example of Aquaponics system management.

Aquaponics is the integration of recirculating aquaculture and hydroponics in one production system. Although the production of fish and vegetables is the most visible output of aquaponic units, it is essential to understand that

aquaponics is the management of a complete ecosystem that includes three major groups of organisms: fish, plants and bacteria.

This document provides recommendations on how to keep a balanced system through the proper management of these three organisms. It also lists all the important management phases from starting a unit to production management over an entire growing season.

Description

1. System balance

This technology covers basic principles and recommendations while installing a new aquaponic unit as well as the routine management practices of an established system. Aquaponic systems need to be balanced. The fish (and thus, fish feed) need to supply adequate nutrients for the plants. The plants need to filter the water for the fish. The biofilter needs to be large enough to process all of the fish wastes, and enough water volume is needed to circulate this system. This balance can be tricky to achieve in a new system, but this section provides helpful calculations to estimate the sizes of each of the components. The ratio estimates how much fish feed should be added each day to the system, and it is calculated based on the area available for plant growth. This ratio depends on the type of plant being grown; fruiting vegetables require about one-third more nutrients than leafy greens to support flowers and fruit development. The type of feed also influences the feed rate ratio, and all calculations provided here assume an industry standard fish feed with 32 percent protein (Table 1).

Table 1: Daily fish feed by plant type

Leafy green plants	Fruiting Vegetables
40 to 50 g of fish feed per square meter	50 to 80 g of fish feed per square meter

Leafy green plants Fruiting Vegetables 40 to 50 g of fish feed per square meter 50 to 80 g of fish feed per square meter Source: FAO 2015 On average, plants can be grown at the following planting density. This will ensure that the plants have adequate nutrients. Overly dense planting will lead to deficiencies and too low densities will not adequately filter the water. These figures are only averages, and many variables exist depending on plant type and harvest size, and therefore should only be used as guidelines (Table 2).

Table 2: Planting density by plant type

Leafy green plants	Fruiting Vegetables
40 to 50 g of fish feed per square meter	50 to 80 g of fish feed per square meter

Leafy green plants Fruiting Vegetables 20 to 25 g of fish feed per square meter 4 plants per square meter Source: FAO 2015 On average, the fish will consume 1 to 2 percent of their body weight per day during the grow-out stage. This assumes that the fish are larger than 50 g because small fish eat more than large ones, as a percentage of body weight (Table 3).

Table 3: Fish feeding rate

Fish feeding rate
1 to 2 percent of total body weight per day

Fish feeding rate 1 to 2 percent of total body weight per day Source: FAO 2015 The recommended maximum stocking density is 20 kg of fish for 1 000 litres of water (fish tank). The small-scale units described in this publication have about 1 000 litres of water and should contain 10 to 20 kg of fish. Higher stocking densities require more sophisticated aeration techniques to keep the DO levels stable for fish, as well as a more complex filtration system to deal with the solid waste (Table 4).

Table 4: Fish stocking density

Fish stocking density
10 to 20 kg of fish per 1,000 litre of water

Fish stocking density 10 to 20 kg of fish per 1 000 litre of water Source: FAO 2015 Table 5 summarizes the key figures and ratios for designing small-scale media bed, NFT and DWC units. It is important to be aware that the figures are just guides as other external factors (climate conditions, access to a constant supply of electricity for example) may change the design on the ground. Please note the footnotes below explaining the figures and the applicability of each column per aquaponic method. • The recommended fish density is based on a maximum stocking density of 20 kg per 1 000 litres. Higher densities are possible with further aeration and mechanical filtration, but this is not recommended for beginners. • The recommended feeding rate is 1 percent of body weight per day for fish of more than 100 g of body mass. The feeding rate ratio is 40 to 50 g per m² for Table 5: Practical system design guide for small scale units of leafy greens; and 50 to 80 g per m² for fruiting vegetables.

Fish tank volume (Litre)	Max. fish biomass (kg)	Feed rate (g/day)	Pump flow rate (litre/h)	Filter volume (litre)	Min. volume of biofilter media (litre)		Plant growing area (m ²)
					Volcanic Tuff	Bioballs	
200	5	50	800	20	50	25	1
500	10	100	1 200	20-50	100	50	2
1 000	20	200	2 000	100-200	200	100	4
1 500	30	300	2 500	200-300	300	150	6
2 000	40	400	3 200	300-400	400	200	8
3 000	60	600	4 500	400-500	600	300	12

Source: FAO 2015

- The volumes for mechanical separator and biofilter should be 10 to 30 percent of total fish tank volume. In reality, the choice of containers depends on their size, cost and availability. Biofilters are only needed for NFT and DWC units. Mechanical separators are applicable for NFT, DWC units and media bed units with a fish density of more than 20 kg per 1 000 litres.
- These figures assume the bacteria are in optimal conditions all the time. If not, for a certain period (winter), extra filtration media may need to be added as a buffer. Different values are provided for the two most common biofilter media based on their respective specific surface area.
- Figures for plant growing space include only leafy greens. Fruiting vegetables would have a slightly lower area. In addition, daily health monitoring of the fish and the plants will provide feedback on the balance of the system. Disease, nutritional deficiencies and death are symptoms of an unbalanced system. Water testing will provide information on the balance of the system. High ammonia or nitrite indicates insufficient biofiltration. Low nitrate indicates too many plants or not enough fish. Increasing nitrate is desirable and indicates adequate nutrients for the plants, though water needs to be exchanged when nitrate is greater than 150 mg per litre.

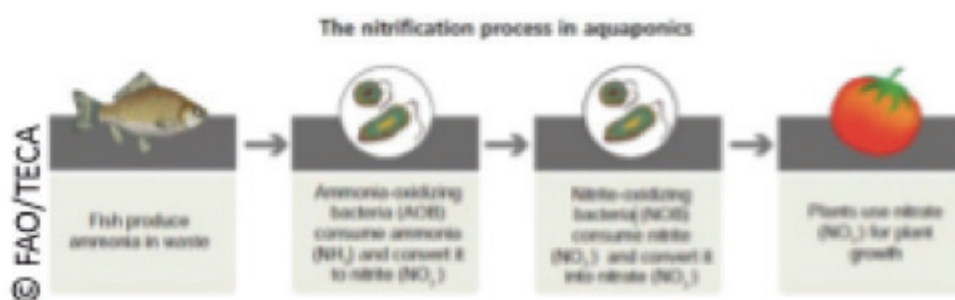
2. System cycling and starting a biofilter colony

Bacteria are a crucial and pivotal aspect of aquaponics, serving as the bridge that connects the fish waste to the plant fertilizer. The nitrifying bacteria convert the fish waste, which enters the system mainly as ammonia, into nitrate, which is fertilizer for the plants. This is a two-step process, and two separate groups of nitrifying bacteria are involved as shown in Figure

1. Therefore, a good establishment of the bacteria colony is crucial for a new aquaponic system. System cycling is a term that describes the initial process of building a bacterial colony when first starting any aquaponic unit. Under normal circumstances this takes three to five weeks as cycling is a slow process that requires patience. Overall, the process involves constantly introducing an ammonia source into the aquaponic unit, feeding the new bacterial colony, and creating a biofilter. The progress is measured by monitoring the nitrogen levels using the nitrate test kit. Once introduced into the unit, the ammonia becomes an initial food source for the ammonia-oxidizing bacteria (AOB), a few of which are naturally occurring and recruit to the system on their own. They can be found on land, in water and in the air. Within five to seven days after the first addition of ammonia, the AOB start forming a colony and begin to oxidize the ammonia into nitrite. Ammonia should be continuously, but cautiously, added to ensure adequate food for the developing colony without becoming toxic. After another five to seven days the nitrite levels in the water will have started to rise, which in turn attracts the NOB. As the Nitrite-oxidizing Bacteria (NOB) populations increase, the nitrite levels in the water will start to decline as nitrite is oxidized into nitrate. The end of the cycling process is defined as when the nitrate level is steadily increasing, the nitrite level is 0 mg per litre and the ammonia level is less than 1 mg per litre. In good conditions, this takes

about 25 to 40 days, but if the water temperature is cool, complete cycling may take up to two months to finish. At this point, a sufficient bacterial colony has formed and is actively converting the ammonia to nitrate. The reason this process is long is because nitrifying bacteria grow relatively slowly, requiring 10 to 15 hours to double in population. However, some heterotrophic bacteria can double in as little as 20 minutes. Alternatively, if another aquaponic system is available, it is extremely helpful to share part of the biofilter as a seed of bacteria for the new system. This greatly decreases the time necessary for cycling the system. It can also be useful to separately start a biofilter medium by continuously trickling a solution containing 2 to 3 mg per litre of ammonia for a few weeks in advance. The media would then function as a primer by simply incorporating it into the new aquaponic biofilter.

Figure 1. The nitrification process in aquaponics



This technology covers basic principles and recommendations while installing a new aquaponic unit as well as the routine management practices of an established system. Aquaponic systems need to be balanced. The fish (and thus, fish feed) need to supply adequate nutrients for the plants. The plants need to filter the water for the fish. The biofilter needs to be large enough to process all of the fish wastes, and enough water volume is needed to circulate this system. This balance can be tricky to achieve in a new system, but this section provides helpful calculations to estimate the sizes of each of the components. The ratio estimates how much fish feed should be added each day to the system, and it is calculated based on the area available for plant growth. This ratio depends on the type of plant being grown; fruiting vegetables require about one-third more nutrients than leafy greens to support flowers and fruit development. The type of feed also influences the feed rate ratio, and all calculations provided here assume an industry standard fish feed with 32 percent protein (Table 1). Table 1: Daily fish feed by plant type Leafy green plants Fruiting Vegetables 40 to 50 g of fish feed per square meter 50 to 80 g of fish feed per square meter Source: FAO 2015 On average, plants can be grown at the following planting density. This will ensure that the plants have adequate nutrients. Overly dense planting will lead to deficiencies and too low densities will not adequately filter the water. These figures are only averages, and many variables exist depending on plant type and harvest size, and therefore should only be used as guidelines (Table 2).

Management practices of aqua plants in Aquaponics

3. Management practices for plants

Seedlings can be planted into the system as soon as nitrates are detected. Expect these first plants to grow slowly and exhibit some temporary deficiencies because the nutrient supply in the water is temporarily small. It is recommended to wait three to four weeks to allow the nutrients to accumulate. In general, aquaponic systems show a slightly lower growth rate than soil or hydroponic production in the first six weeks. However, once a sufficient nutrient base has been built within the unit (one to three months) the plant growth rates become two to three times faster than in soil.

Levels of ammonia, nitrite and nitrate during the first few weeks in a recirculating aquaculture system

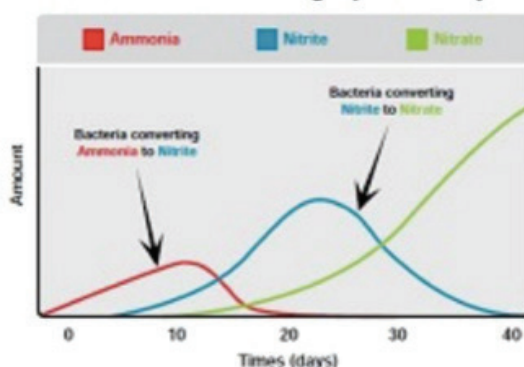


Figure 2. Levels of ammonia, nitrite and nitrate during the first few weeks in a recirculating aquaculture system;

3.1 Establishing a plant nursery

Vegetables are the most important output for small-scale aquaponic production. It is essential that only strong healthy seedlings are planted. Moreover, the planting methods applied must avoid transplant shock as much as possible. Thus, the recommendation is to establish a simple plant nursery to ensure an adequate supply of healthy seedlings ready to be planted into the aquaponic units. It is always best to have an excess of plants ready to go into the system, and often waiting for seedlings is a source of production delay. A simple nursery bed can be constructed using horizontal wood lengths lined with polyethylene liner. Water is pumped into the bed for about half an hour each day (controlled by a simple electric timer), allowing water and moisture to soak into the growing media. The water is then slowly drained down into a tank below. This cycle is repeated daily in order to prevent water logging of the seedlings. Too much moisture increases the threat of fungal infections. Polystyrene propagation trays are placed into the nursery bed and are filled with soil, inert grow media such as rockwool, peat, (need content for the above, on how aqua plants are managed and practiced) coco fibre, vermiculite, perlite or a potting mix with a combination of the various types of growing medium. Simpler alternatives for propagation trays are also possible using recyclable materials such as empty egg boxes. Choose propagation trays that allow adequate distance between seedlings in order to favour good growth without competition for light.

3.2 Direct seeding in media beds

It is possible to sow seeds straight into the media bed. If using a flood-and drain mechanism (e.g. bell siphon) the seeds may be washed around. Therefore, the siphon should be removed while sowing seeds in the bed, and then replaced when the first leaves begin to appear.

3.3 Transplanting seedlings

Transplanting seedlings obtained from soil beds is not recommended. It should only be done if strictly necessary. In this case, all of the soil needs to be washed out from the root system very gently because it may carry plant pathogens. This washing process is very stressful for seedlings and it is possible to lose four to five days of growth as the plant adjusts to new conditions. Thus, it is preferable to start seeds using inert media (rockwool, vermiculite or coco fibre) in propagation trays as explained above. In this way, the seedlings can be transplanted with minimal shock. Larger plants from pots can also be planted, although again the soil needs to be removed. Avoid transplanting in the middle of the day because plant roots are extremely sensitive to direct sun light and leaves can face water stress due to the new growing conditions. It is recommended to plant at dusk so the young seedlings have a night to acclimatize to their new environment before the morning sun.

3.4 During planting

3.4.1 Plant selection

It is best to start a new aquaponic system with fast-growing robust plants with a low nutrient demand. Some examples are leafy green vegetables, such as salads, or nitrogen fixing plants, such as beans or peas. After two to three months, the system is ready for larger fruiting vegetables that demand a greater amount of nutrients. Please see further reading section to find a list of potential plants to be used in aquaponics, “Small-scale aquaponic food production – Integrated fish and plant farming (FAO, 2014)” page 169 - 181.

3.4.2 Plant spacing

Seedlings can be planted using a slightly denser spacing than for most vegetables in soil because in aquaponics the plants do not compete for water and nutrients. Even so, the plants still need enough room to reach their mature size and to avoid reciprocal competition for light, which would depress their marketable quality or favour vegetative growth instead of fruits. In addition, consider shading effects of the full-grown plants, which allows for the contemporary cropping of shade-tolerant species next to taller plants.

3.4.3 Supplementing iron

Some new aquaponic units experience iron deficiencies in the first two to three months of growing as iron is important during the early stages of plant growth and is not abundant in fish feed. Thus, it may be necessary to initially add chelated iron (soluble iron in powder form) to the unit to meet the requirements for plants. The recommendation is to add 1 to 2 mg per litre for the first three months of starting a unit, and again when iron deficiencies are present. Chelated iron can be bought from agricultural suppliers in powder form. Iron can also be supplemented by using aquaponics-safe organic fertilizers such as compost or seaweed tea, as iron is abundant in both.

3.5 *Harvesting plants*

In one to two months, leafy green vegetables should be ready to harvest. After three months, the unit should also have enough of a nutrient base to begin planting larger fruiting vegetables.

The following points detail the final guidelines for growing plants after the initial three-month period.

3.5.1 Staggered planting and harvesting

It is worth staggering the planting over time in order to prevent harvesting the entire crop all at once. If this were to happen, nutrient levels would decrease just before harvest, which might create nutritional problems for the plants, and spike after the harvest, which would stress the fish. Moreover, staggered planting allows for continual harvest and transplant of vegetables and ensures constant nutrient uptake and water filtration.

3.5.2 Harvesting approaches

When harvesting full plants from media beds (e.g. lettuce), make sure the entire root system is removed. In addition, shake the gravel stuck in between the roots and place the gravel back in the media bed. In NFT and DWC pipes / canals also make sure the whole root system is removed. Place the discarded plant roots into a compost bin to recycle the plant waste. Leaving roots and leaves in the system can encourage disease. When harvesting vegetables use a sharp clean knife. To prevent any bacteria contamination, ensure that aquaponic water does not wet the leaves. Place harvested plants into a clean bag and wash and chill the crops as soon as possible to maintain freshness.

3.6 *Managing plants in mature systems*

3.6.1 Stabilizing pH

It is vital for good plant growth to maintain the pH between six and seven, so plants have access to all the nutrients available in the water. Add small amounts of base or buffer whenever the pH approaches 6.0 in order to maintain optimum pH levels. Add rainwater or correct with acid any alkalinity-rich water only if the hardness level in the aquaponic system is too high to prevent nitrifying bacteria from naturally lowering the pH to optimal levels. Treat the water with acid outside the aquaponic system, and pour the water into the system after checking the pH.

3.6.2 Plant nutrition

Successful aquaponic systems are balanced. The feed rate ratio is the main guideline to balance the amount of fish feed to plant growing area, which is measured in grams of daily feed per square metre of plant growing space. The feed rate ratio for leafy vegetables is 20 to 50 g per m² daily; fruiting vegetables require 50 to 80 g per m² daily.

3.6.3 Organic fertilizers

If deficiencies do occur, it is necessary to add outside nutrients. Organic liquid fertilizer can be used as either diluted foliar feed for plant leaves or poured straight into the root zone. Compost tea and seaweed tea are recommended. Deficiencies often occur when there are too many plants for the number of fish, or when feeding is reduced during winter months. Before adding fertilizers, be sure to check pH to make sure there is no nutrient lockout.

3.6.4 Pests and disease

Be sure to try to prevent pests using the integrated production and pest management (IPPM) techniques (e.g. physical barriers, trapping, companion planting, crop rotation, among others). If pests remain a problem, begin by using the mechanical removal techniques before considering sprays. Only use aquaponic-safe remedies, such as plant extracts or repellents, biological insecticides (*Bacillus thuringiensis* and *Beauveria bassiana*), soft soaps, ash, plant oils or extracts of essential oils, chromatic/attractant traps, and external attractant plants treated with insecticides. Regardless, avoid letting the spray enter the water.

3.6.5 Follow seasonal planting advice

To an extent, aquaponic food production methods provide a means to extend planting seasons, particularly if the unit is housed inside a greenhouse. However, it is still strongly recommended to follow local seasonal planting advice. Plants grow better in the season and environmental conditions to which they are adapted.

Assessment:

- Explain the aspects of aquaculture plant farming management systems and practices.
- Is diligent and participates well in the assigned activities for aqua plant farming and management practices.

Resources/Sources

Fisheries and Aquaculture Department (FI) in FAO

Keywords: Aquaculture, aquaponics, fish, hydroponics, soilless culture

UNIT 2: AQUA FARMING PRACTICES AND MANAGEMENT SYSTEMS

Benchmark: 10.3.2.3. Discuss different ways of preserving plant, animal, and fish species and sustaining the environments in which they are farmed.

TOPIC: WAYS OF PRESERVING PLANT, ANIMAL AND FISH SPECIES

Learning Objectives

By the end of this topic, students will be able to;

- Describe the different ways of preserving plants, animals and fish species
- Explain the preservation methods of aqua plants, animals and fish

Essential Questions:

1. What preservation methods used to preserve plants?
2. What preservation methods used to preserve animals and fish?
3. How are plants and fish conserved and protected for sustainability?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Methods on how to preserve plants, animals and fish
Skills	• Apply correct ways of preserving the plants, animals and fish species • Discuss and explain different preservation methods • Practice preservation methods in aqua farming of plants, animals and fish species
Attitudes	• Diligent in learning and practicing the preservation methods on plants, animals and fish species
Values	• Values of Corporation and collaboration in preserving aqua plants, animals and fish species

Content Background

Different Ways of preserving plant, animal, and fish species

Method of Preserving Aquatic Plants

The **preservation of aquatic plants** is a key pillar in biodiversity conservation: inland **aquatic** ecosystems are among those most at risk on a global scale, and **aquatic plants** are one of the most threatened biological groups (Bolpagni, Laini, Stanzani, & Chiarucci, 2018; Dudgeon et al., 2006). Aquatic plants need to be preserved for purpose of consumption, grooming, beautification, medicines etc., for continuous use and business.

Preservation methods go through a process at each of the following stages;

1. Collection of the aquatic plant specimens
 - 1.1 Gathering the specimens
 - 1.2 Recording the data
2. Preservation of specimens
 - 2.1 Pressing
 - 2.2 Drying
3. Processing of specimens

- 3.1 Identification
- 3.2 Label preparation
- 3.3 Mounting
- 3.4 Accessing (Cataloging)
- 4. Storage of Specimens
 - 4.1 Organization
 - 4.2 Handling
 - 4.3 Maintaining

Fish Preservation

1. Ancient methods of preserving fish included;

- drying,
- salting,
- picking and
- smoking.

2. All of these techniques are still used today but the more modern techniques of freezing and caning have taken on a large importance.

Fish curing includes;

- curing fish by drying,
- salting
- smoking and
- picking or by combinations of these processes have been employed since ancient times.
- On sailing vessels fish were usually salted down immediately to prevent spoilage; the swifter boats of today commonly bring in unsalted fish. Modern freezing and methods have largely supplanted older methods of preservation
- Fish to be cured are usually first cleaned, scaled, and eviscerated. Fish are salted by packing them between layers of salt or by immersion in brine.

The fish most extensively salted are;

- Cod, hering, mackerel and hadock.

Smoking preserves fish;

- by drying,
- by deposition of creosote ingredients, and, when the fish are near the source of heat, by heat penetration.
- Herring and haddock (finnan haddie) are commonly smoked.
- Kippers are split herring, and
- bloaters are whole herring, salted and smoked.
- Sardines, pilchard and anchovies and are small fish of the herring family, often salted and smoked and then preserved in oil.
- Fish are dried under controlled conditions of temperature humidity and air velocity
- Since the dried product is relatively unappetizing and rehydrating slow, other preservation methods are common.

Assessment:

- Explain the methods used to preserve plants, animals and fish
- Explain how to conserve and protect plants, animals and fish for sustainability
- Show self-discipline and diligence in working with others to preserve and conserve aqua plants, animals and fish.

Resources/sources

Fish preservation and processing_Nwaigwe Ugochukwu .V.
Department of Food science and Technology Michael Okpara
University of Agriculture, Umudike.

UNIT 3: AQUA FARMING AND TECHNOLOGY

Content Standard 3.3 Students will be able to examine how technology is used in aqua farming and the processing, preservation, marketing, consumption, regulation and management of plants, animals and fish in different environment and places and evaluate their strengths and weakness.

Benchmark: 10.3.3.1. Investigate and explain the fish farming, harvesting, and preservation technology used in different environment and places.

TOPIC: TECHNOLOGY USED IN FISH FARMING, HARVESTING AND PRESERVATION IN DIFFERENT ENVIRONMENT

Learning Objectives

By the end of this topic, students will be able to;

- Examine fish farming, harvesting, and preservation in different environments
- Explore technologies in fish farming, harvesting, and preservation
- Explain the technologies used in fish farming, harvesting, and preservation

Essential Questions:

1. Why is technology very important for fish farming, harvesting, and preservation?
2. What are the processes or steps of using these technologies in fish farming and production?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Technologies used in fish farming, harvesting, and preservation in different environments. • Processes or steps of technologies used and their usefulness to farmers.
Skills	• Explore and discuss the technologies used in fish farming, harvesting, and preservation • Explain the processes and their outputs, how useful to the fish farmers
Attitudes	• Diligent and inquisitive about the technologies used
Values	• High regard for creativity and design of the technologies that help farmers to harvest and preserve the fish for food and future continuity of business.

Content Background

Technology used in fish farming, harvesting and preservation in different environment

Fish Harvest technology

1. Provides employment and economic benefits to large sections of societies
2. It encompasses various processes of catching aquatic organisms
3. Use of fishing methods for different types of fisheries from simple process of gathering organisms to most highly sophisticated fish harvesting systems used to capture large tunas and whales.



Most significant among the technological developments which support the evolutions of fish harvest technology are;

- (i) Developments in craft technology and mechanization of propulsion, gear and catch handling,
- (ii) Introduction of synthetic gear materials,
- (iii) Developments in acoustic fish detection and satellite based remote sensing techniques,
- (iv) Advances in electronic navigation and position fixing equipment, and
- (v) Awareness of the need for responsible fishing to ensure sustainability of the resources, protection of the biodiversity and environmental safety and energy efficiency.

Advances in satellite-based technologies, viz. Global Positioning System (GPS), have positively influenced safety of fishermen, who undertake one of the dangerous occupations in the world, by providing better communication and navigation and Global Maritime Distress and Safety System (GMDSS) based rescue systems which can be activated during emergencies. The mechanization of gear handling has vastly expanded the scale on which fishing operations can take place.

Fish preservation technology

Below are Fish preservation methods used in various environments for;

1. Control of temperature during refrigeration and freezing of fish for consumption
2. Control of water activity when drying, salting, smoking and boiling fish
3. Physical control of microbial loads when canning of fish
4. Chemical control of microbial loads for bio preservation and fermentation
5. Control of the oxygen reduction potential
6. Combined techniques used in hurdle technology

Assessment:

- Discuss and describe the processes of fish farming and production technologies
- Explain the importance of technology in fish farming, harvesting and preservation
- Demonstrates creativity and design of technologies to help farmers harvest and preserve fish for food and business.

Resources/sources

Refrigerating, and Freezing (food), Dried fish, Salted fish, Smoked fish, and Boiled fish,, Fish canning , Biopreservation and Fermented fish

UNIT 3: AQUA FARMING AND TECHNOLOGY

Benchmark 10.3.3.2. Investigate and evaluate the effectiveness of different technology used for producing and processing aqua farming products.

TOPIC: TECHNOLOGY USED FOR PRODUCING AND PROCESSING AQUA FARMING PRODUCTS

Learning Objectives

By the end of this topic, students will be able to;

- Explore the effectiveness of different technology used for producing and processing aqua farming products.
- Evaluate their effectiveness of producing and processing aqua farming products.

Essential Questions:

1. What are the processes involved in using technology to produce and process the aqua farming products?
2. How effective are these technologies in production?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• The effectiveness of technology used for producing and processing aqua farming products
Skills	• Observe and analyses the technology used and its process • Discuss and explain how technology work to produce large quantities of aqua products • Describe its effectiveness and evaluate how useful the technology is to farmers and consumers
Attitudes	• Diligent and critical about the technology used in processing and producing the aqua products
Values	• Is honest and truthful about the usefulness and effectiveness of processing and producing aqua products to farmers and consumers

Content Background

Technology used for producing and processing aqua farming products

PROCESSING OF FISH PRODUCTS

When fish are captured or harvested for commercial purposes, they need some preprocessing so they can be delivered to the next part of the marketing chain in a fresh and undamaged condition. This means, for example, that fish caught by a fishing vessel need handling so they can be stored safely until the boat lands the fish on shore.

There are four preprocessing methods used for commercial purposes and marketing;

1. Handling the catch
2. Removal of the Scales
3. Cutting
4. Filleting of fish

1. Handling the catch

Typical handling processes are (FAO, 2011).

- i. transferring the catch from the fishing gear (such as a trawl, net or fishing line) to the fishing vessel
 - ii. holding the catch before further handling
 - iii. sorting and grading
 - iv. bleeding, gutting and washing
 - v. chilling
 - vi. Storing the chilled fish unloading, or landing the fish when the fishing vessel returns to port
- The number and order in which these operations are undertaken varies with the fish species and the type of fishing gear used to catch it, as well as how large the fishing vessel is and how long it is at sea, and the nature of the market it is supplying (FAO, 2011).
 - Catch processing operations can be manual or automated. The equipment and procedures in modern industrial fisheries are designed to reduce the rough handling of fish, heavy manual lifting and unsuitable working positions which might result in injuries (FAO, 2011).

1.1 Handling live fish

- An alternative and obvious way of keeping fish fresh is to keep them alive until they are delivered to the buyer or ready to be eaten.
- This is a common practice worldwide.
- Typically, the fish are placed in a container with clean water, and dead, damaged or sick fish are removed.
- The water temperature is then lowered and the fish are starved to reduce their metabolic rate.
- This decreases fouling of water with metabolic products (ammonia, nitrite and carbon dioxide) that become toxic and make it difficult for the fish to extract oxygen (FAO, 2011).
- Fish can be kept alive in floating cages, wells and fish ponds.
- In aquaculture, holding basins are used where the water is continuously filtered and its temperature and oxygen level are controlled.
- In China, floating cages are constructed in rivers out of palm woven baskets,

- While in South America simple fish yards are built in the backwaters of rivers (Bremner, 2003).
- Live fish can be transported by methods which range from simple artisanal methods where fish are placed in plastic bags with an oxygenated atmosphere, to sophisticated systems which use trucks that filter and recycle the water, and add oxygen and regulate temperature (FAO, 2011).

1.2. The time lag between catching, transportation and landing encourages fish flesh quality deterioration and short shelf-life for such fish. This could be prevented by observing the following rules:

- Kill the fish immediately after been caught by piercing the head with a needle or any sharp object, this prolongs the period the fish will stiffen.
 - Cut the fish immediately and remove the gills and cut off the head.
 - Wash with clean running water.
 - Put the fish on ice in insulated boxes. In the absence of ice, the fish should be kept in the shade in clean containers away from intense sunlight.
5. Get the fish as fast as possible to the landing area for further preservation and sales

2. Removal of the Scales

For a whole flat fish, wash and cut off the head. Holding the fish by the tail and using a sharp knife, Scale it by scrapping toward the head. Scrap until all the scales are removed (UNDFFW, 2003). Turn the fish and scale the other side.

3. Cutting

- Cutting the removal of the guts (intestines) of the fish.
- Gutting should be carried out on fish no matter what method of preservation is going to be applied.
- After gutting, the fish should be washed thoroughly with clean running water.
- Gutting and washing of the fish helps to prevent bacterial attack before and during processing, preservation and storage (Silva, 2015).

4. Filleting of fish

- The processing industry also adopted freezing of fish in the form of fillets at times when prawns are not available.
- Fillets are nothing but the strips of flesh cut parallel to the backbone of the fish.
- Fishes like milk fish, cat fish, perches, mullets, carps, eel, etc (Bekker-Nielsen, 2005) are suitable for filleting and freezing (Luten et al., 2006).
- Filleting can be done by hand which is economical or by using a filleting machine.
- Fillets may be with or without skin and it fetches a much higher price in the luxury market.
- Fillets are dipped in brine to enhance their appearance and to reduce the amount of drip and it also gives a salty flavor (Bekker-Nielsen, 2005).
- The freezing of fillets can be an individual quick freezing of block

freezing (Zohar et al., 2001).

- After dropping in brine, the fillets wrapped in polythene sheet are frozen in contact plate freezer at -35°C to 400°C. In block freezing the fillets in known weight 500gm, 1Kg, 2Kg. are packed in polythene bags lined with wax and sufficient quantity of glazed water is poured to cover the fillets (Bremner, 2003).
- The fillets are put in a freezer at -35 to 400 °C and stored at -230°C.

Assessment:

- Explain the effectiveness of producing and processing aqua farming products
- Is critical and diligent in discussing the usefulness and effectiveness of processing and producing aqua products to farmers and consumers

Resources/Sources

Fish preservation and processing, Nwaigwe Ugochukwu.V. Department of Food science and Technology Michael Okpara University of Agriculture, Umudike pdf

UNITS OF WORK

STRAND 4: NATURAL RESOURCE MANAGEMENT

Strand Overview			
Unit	Benchmark	Topic	Lesson Titles
Content Standard: 4.1: Students will be able to define capture fishery, investigate the different types of fish and other consumable aquatic organisms and plants harvested using this method of fisheries, categorize them according to their characteristics, purposes and benefits, and investigate the different context, environments and places where they are harvested.			
Unit 1: Types of Capture Fishery	Benchmark: 10.4.1.1 Investigate and elaborate on the harvesting of different capture fish and other aquatic organisms and plants in different environments.	Harvesting of different capture fish and other aquatic organisms	Methods of harvesting in different environments
	Benchmark: 10.4.1.2. Categorize and examine different capture fish and other aquatic organisms and plants according to their characteristics, species, functions, and purposes	Characteristics, species, functions and purposes of different capture fish and other aquatic organisms	Characteristics of different capture fish and other aquatic organisms
			Functions and purposes of capture fish and other aquatic organisms
Content Standard 4.2 Students will be able to investigate and analyse the different types of capture fishery practices and management systems used in different environments and places to capture, process, preserve, market, regulate, and consume fish and other aquatic organisms and plants.			
Unit 2: Capture Fishery Harvesting Practices and Management Systems	Benchmark: 10.4.2.1. Explore and analyze capture fishery management systems used in different places and environments.	Capture Fishery management systems used in different places and environments.	Types of management systems
	Benchmark: 10.4.2.2. Investigate and analyze capture fisheries regulation and monitoring systems and practices in different places and environments.	Capture Fishery regulation and monitoring	Capture Fishery regulation
	Benchmark: 10.4.2.3. Discuss different ways of preserving plant, animal, and fish species and sustaining the environments in which they are caught.	Ways of preserving plant, animal, and fish species	Preventive methods of animals, plants and fish species
		Sustainable practices of capture fishery environments	Sustainable practices
Content Standard 4.3 Students will be able to examine how technology is used in capture fishery and the processing, preservation, marketing, consumption, regulation and management of fish and other aquatic organisms and plants in different environments and places, and evaluate their strengths and weakness.			

Unit 3: Capture Fishery and Technology	Benchmark: 10.4.3.1. Investigate and explain capture fishery and aquatic organisms and plants harvesting and preservation technology used in different environment and places.	Preservation Technology for capture fishery	Large scale harvesting and preservation technology
	Benchmark: 10.4.3.2. Investigate and evaluate the effectiveness of different technology used for producing and processing capture fishery and other aquatic organisms and plants.	Advantages and disadvantages of the use of technology in capture fishery	Effective technologies used for producing and processing
Content Standard 4.4: Students will be able to define forestry, investigate the different types of forestry and forests, categorize them according to their characteristics, purposes and benefits, and investigate the different contexts, environments, and places where they grow and are harvested.			
Unit 4: Types of Forestry and Forests	Benchmark: 10.4.4.1. Investigate and analyze the harvesting of tropical forests in different contexts.	Harvesting of tropical forests in different contexts.	Tropical forests
			Harvesting methods used in tropical forests
	Benchmark: 10.4.4.2. Categorize and examine different types of forestry according to their characteristics, elements, functions, and purposes.	Characteristics, elements, functions and purposes of forestry	Farm Forestry
			Agroforestry
			Extension forestry
			Siviculture (scientific)
			Community forestry
Content Standard 4.5: Students will be able to investigate and analyze the different types of forest harvesting practices and management systems used in different environments and places to harvest, process, preserve, market, regulate, and consume forests.			
Unit 5: Forest Harvesting Practices and Management Systems	Benchmark: 10.4.5.1. Investigate and analyze forest management systems used in different places and environments.	Forest management systems	Sustainable Forest Management (SFM)
			Ecosystem approach
	Benchmark: 10.4.5.2. Investigate and analyze forest regulation and monitoring systems and practices in different places and environments.	Forest regulation and monitoring systems	Regulations of forestry
			Monitoring systems and practices of forestry
	Benchmark: 10.4.5.3. Determine and analyze the different ways of preserving and sustaining forests in different environments.	Ways of preserving and sustaining forests in different environments	How can forests and wildlife be protected
			Ways to support sustainable forestry
			Importance of preserving the forests
Content Standard 4.6: Students will be able to examine how technology is used in the harvesting, processing, preservation, marketing, regulation, consumption, and management of forestry in different environments and places, and evaluate their strengths and weaknesses.			
Unit 6: Forestry and Technology	Benchmark: 10.4.6.1. Investigate and explain forest monitoring and preservation technology used in different environment and places.	Forest monitoring and preservation technology	Forest monitoring technology
			Forest Preservation technology
	Benchmark: 10.4.6.2. Investigate and evaluate the effectiveness of different technology used for processing and marketing forestry products.	Technology used for processing and marketing forestry products.	Effectiveness of technology used in Harvesting,
			Processing and marketing

UNIT 1: TYPES OF CAPTURE FISHERY

Content Standard: 4.1 Students will be able to define capture fishery, investigate the different types of fish and other consumable aquatic organisms and plants harvested using this method of fisheries, categorize them according to their characteristics, purposes and benefits, and investigate the different context, environments and places where they are harvested.

Benchmark 10.4.1.1 Investigate and elaborate on the harvesting of different capture fish and other aquatic organisms and plants in different environments.

TOPIC: HARVESTING OF DIFFERENT CAPTURE FISH AND OTHER AQUATIC ORGANISMS

Learning Objective

By the end of this topic, students will be able to;

- Explain how different capture fish and aquatic organisms are harvested
- Identify the different environments of harvesting capture fish and aquatic organisms

Essential Questions:

1. What methods of harvesting are used to harvest capture fish and aquatic organisms in freshwater?
2. What methods of harvesting are used to harvest capture fish and aquatic organisms in marine water?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Methods of harvesting • Environments used to harvest
Skills	• Identify the methods used to harvest capture fish and aquatic organism • Compare the methods of harvesting in freshwater and marine water
Attitudes	• Appreciate the use of different methods
Values	• Value the methods used in harvesting

Content Background

1. Harvesting of different capture fish and other aquatic organisms in inland waters

Many types of fishing have emerged over the centuries and a vast range of gear now exists to exploit inland waters. The choice of gear is conditioned by many factors including the characteristics of the water to be fished, the target species, the season of the year, the value of the fish caught and the cost of the gear.

Fishing gears fall into three main categories: Passive in which the fish comes to the gear, active, in which the gear engulfs the fish, and other methods. Passive methods include gillnets, setlines and a range of traps with accompanying barriers and fences. Active methods include trawls, seines, lift nets, scoop nets and cast nets. Other methods include rod and line, projectiles, poisons, explosives and fish parks and holes.

The Principal Types of Gear

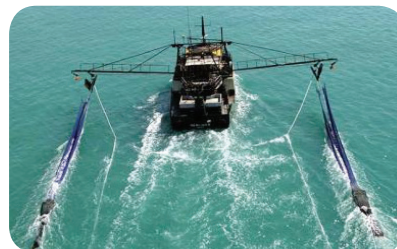
In some case the gear will towed by the vessel, in some it will be used to encircle a spool of fish, in others the gear is static, being left in one place for a while and then retrieved together with its catch. Static and some types of active gears may also be used in dry land without the use of boat. The principle types of gear used in inland water are set out in the table below.

STATIC GEAR	Gill nets, long lines, Traps, Brush parks, Fish holes, Poisons, Lift nets
MOBILE GEAR	Trolling, Harpooning, Pole and line, Cast nets, Dip netting, Electric fishing
TOWED AND DRAGGED GEAR	Trawling
ENCIRCLING GEAR	Purse seining, Beach seine

2. Harvesting of different capture fish and other aquatic organisms in marine waters

In marine fisheries the most important commercially used methods are purse seining, and trawling. Such highly mechanized methods are rare in inland waters where there is a much greater dependence on static gears such as gill nets or barrier traps, and small individually operated active gears such as cast nets.

Types of fishing gears



Choice of fishing gear and method

Many factors enter into the choice of the method and gear used to catch a particular species in a particular area. The choice will depend on:

- 1. The depth of the water-** The various types of fishing gear are designed to operate within particular depths of water: at the surface of deep lakes, on the lake bed in shallow areas, or between surface and bottom where weight is not too great. Depth of water will therefore exert considerable influence on the choice of suitable.
- 2. Characteristics of Lake and River Bed** – Some types of fishing gear, particularly those that rely on their movement over the bottom, are vulnerable to damage from hard, uneven or rough lakebeds, and it is often impossible to use them due to the inappropriateness of the bottom landscape. In many cases static gear can be placed on the bed of lake with little problem.
- 3. Species being fished-** The various species of commercially important aquatic organisms have different habitats, movements, and reaction to stimuli; fresh water shrimps and most mollusks are found living on or in the lake or riverbed as are a wide range of fish species.
- 4. Season of Year and the Flow Regime** – Seasonal migrations are highly significant for fisheries. In rivers the movement of species along the river channels and between the river channels and floodplains provide increased opportunities for capture due to the expectedness of the event and the high concentrations of fish sometimes observed.
- 5. Value** – Fish are recognized by societies as having different characteristics in terms of keeping quality, taste or some cultural criterion that award them with very different values. Furthermore, the same species of fish may be of high, medium, or low value depending on the way in which it is processed and marketed.

Assessment:

- Investigate and differentiate types of harvesting methods used in marine waters and freshwaters.

Reference/Source:

- <http://www.eolss.net> – freshwater Fish Harvest Technology Encyclopedia of Life
- <https://www.goggle.com>,

UNIT 1: TYPES OF CAPTURE FISHERY

Benchmark: 10.4.1.2. Categorize and examine different capture fish and other aquatic organisms and plants according to their characteristics, species, functions, and purposes.

TOPIC: CHARACTERISTICS, SPECIES, FUNCTIONS AND PURPOSES OF DIFFERENT CAPTURE FISH AND OTHER AQUATIC ORGANISMS

Learning Objectives

By the end of this topic, students will be able to;

- Explain the characteristics, species, functions and purposes of different Capture fish.
- Discuss the characteristics, species, functions and purposes of different aquatic organisms

Essential Questions:

1. What are the characteristics of different aquatic organisms?
2. What are the purposes of different aquatic organisms?
3. What are the functions of different aquatic organisms?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Characteristics, species, functions and purposes of different capture fish • Characteristics, species, functions and purposes of different aquatic organisms
Skills	• Identify characteristics, species, functions and purposes of different capture fish • Compare characteristics, species, functions and purposes of different capture fish and aquatic organisms
Attitudes	• Appreciate the use of different methods in harvesting
Values	• Value the methods used in harvesting

Content Background

Characteristics, species, functions and purposes of different capture fish and other aquatic organisms

Examples of marine water capture fish and other aquatic organisms

Species	characteristics	functions	purposes
Tuna (genus Thunnus) 	Tunas are elongated, robust, and streamlined fishes; they have rounded body that tapers to a slender tail base. In color, tunas are generally dark above and silvery below often with an iridescent shine.	It can help stimulate growth and development, lower blood pressure and cholesterol and give the immune system a boost and increase energy levels.	1. Great commercial value as food 2. For local consumption
Seaweed (Kelps) 	It has thick, rubbery stems that protect it from the corrosive ocean water and uses simplified versions of roots and leaves to hold it in place and absorb sunlight.	Sea weed species such as kelps provide essential nursery habitat for fisheries and other marine species and thus protect food sources.	1. Source of food 2. Used to make many products: toothpaste, shampoos and salad dressing
Prawns (Giant tiger) 	They are generally dark coloured, with the carapace and abdomen transversely banded with black and white.	Prawns are a rich source of selenium, one of the most effective antioxidants at maintaining healthy cells. They also contain high levels of Zinc, which is important to develop a healthy immune system. Eating prawns helps build strong bones because they contain phosphorous, copper and magnesium.	1. Source of food 2. Cultivated for commercial marketing

Examples of Freshwater capture fish and other aquatic organisms.

Species	characteristics	functions	purposes
Rainbow trout 	Has a long, skinny body and come in a variety of colors from brown and black to olive and blue- green. It is a carnivore.	Rainbow trout is popular in Western cuisine; both wild-caught and farmed fish are eaten. It has tender flesh and a mild, somewhat nutty flavor. Rainbow trout is sometimes used as a biological indicator for water quality in water purification facilities	1. Harvested for local consumption and for commercial fisheries 2. For commercial fisheries
Mud crabs 	They are large crabs with smooth, broad carapace (outer shell) and possess sizeable claws used for crunching and cutting preys.	The Mud crab is mainly used for food. It is very popular as food throughout its range and also globally.	1. Local consumption 2. For commercial fisheries
Watercress 	Form bushy colonies and root freely from stems. Floats on water and spread over mud surfaces	Commonly used in salads, soups and sandwiches.	1. Cultivated for local consumption

Assessment:

Research on the characteristics, species, functions and purposes of different capture fish and other aquatic organisms

Reference/Source:

<https://www.britannica.com>animal>, <https://www.cookist.com>,
<https://sciencing.com>characteristics>

UNIT 2: CAPTURE FISHERY HARVESTING PRACTICES AND MANAGEMENT SYSTEMS

Content Standard 4.2 Students will be able to investigate and analyse the different types of capture fishery practices and management systems used in different environments and places to capture, process, preserve, market, regulate, and consume fish and other aquatic organisms and plants.

Benchmark 10.4.2.1. Explore and analyse capture fishery management systems used in different places and environments.

TOPIC: CAPTURE FISHERY MANAGEMENT SYSTEMS USED IN DIFFERENT PLACES AND ENVIRONMENTS.

Learning Objectives

By the end of this topic, students will be able to;

- Identify the management systems used in Capture Fishery

Essential Questions:

1. What are Capture Fishery management systems?
2. What types of Capture fishery managements systems are used?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Capture Fishery Management Systems • Types of Capture Fishery Management Systems
Skills	• Discuss types of Management Systems • Differentiate Management Systems
Attitudes	• Appreciate the use of different Capture Fishery Management Systems
Values	• Value the importance of Capture Fishery Management Systems

Content Background

The goal of **Fisheries management** is to produce sustainable biological, social and economic benefits from renewable aquatic resources. Fishery management system aims to achieve the optimal and sustainable utilization of the fishery resource for the benefit of humankind at the same time as safeguarding the ecosystem. Modern fisheries management is based on scientific information that is used to develop the rules under which the fisheries operate.

Management is directed at maintaining a stock size that gives the maximum sustainable yield (or catch) through various management regulations (e.g. total allowable catch), number of boats in the fishery) aimed at controlling, either directly or indirectly, the level of fishing morality. Fishing management involves not only direct regulations but also management of access right, influencing of fisher's attitudes toward the resources and other issues. The scope of fisheries

management has widened in recent years to consider aspects beyond size of the fishery resource, implying an ecosystem approach.

The question of how fisheries can be best managed for both current and future generations has been a subject of debate for many years. When fisheries are assessed, the certification body checks that:

1. An effective legal or customary framework is in place that recognizes the rights of people depend on fishing for food and livelihoods.
2. Management objectives are consistent with Fisheries Standards
3. There are effective consultation and decision-making processes in place
4. There is a system in place to effectively enforce management rules
5. The performance of the management is evaluated

Capture fishery Management in land waters

Environmental Management

- To ensure that the environment and the biodiversity of inland Capture Fisheries are conserved through adopting appropriate ecosystem management rules.

Technical Management

- Establish sustainable management of water bodies and their ecosystems through improved community planning and appropriate management interventions the establishment of preserves, control of fishing effort and habitat restoration measures.

Community based- management

- To promote the empowerment of fishing communities, to take a leading role in making and implementing decisions that ensure the long-term future of their local fisheries.

How are fisheries managed?

- There are many types of fisheries management or fisheries management tools;
 - (a) Total Allowance Catch (TAC) – Is the tool used to establish maximum fishing limits during certain timeframe and for each one of the species controlled by management plans.
 - (b) Fishing effort limits – Is a measure of the amount of fishing. Frequently some is used relating to a given combination of inputs into the fishing activity restrictions on number of trips spent fishing, number of hooks used, kilometers of nets used and restrictions of number of boats.
 - (c) Restrictions on the size of fish that can be caught or retained – There are minimum and maximum legal-size limits for some fish and other aquatic species that are caught with rod and line or other permitted devices.

Size limits let fish:

- Reach maturity
 - Complete their breeding cycle
 - Contribute to sustainable fish stocks
- (d) Gear restrictions – Control the minimum net size of netting in gillnets and trawl. Allow only specific types of gears to be used in particular fisheries.
- (e) Access controls (e.g. licenses and permits) – Commercial fishing licenses and permits are central to fisheries management systems. They are used to;
- Define and allocate harvest rights
 - Places rules and limits upon authorized harvesters in relation to that fishery.

Administer user fees and reporting requirements that support assessment, monitoring and enforcement.

Assessment:

Develop an environmental management system by adopting appropriate ecosystem management rules

Reference/Sources:

<https://www.msc.org>, <https://www.en.m.wikipedia.org>.

UNIT 2: CAPTURE FISHERY HARVESTING PRACTICES AND MANAGEMENT SYSTEMS

Benchmark 10.4.2.2. Investigate and analyse capture fisheries regulation and monitoring systems and practices in different places and environments.

TOPIC: CAPTURE FISHERY REGULATION AND MONITORING

Learning Objectives

By the end of this topic, students will be able to;

- Discuss the regulations and monitoring practices used in Capture Fishery
- Differentiate between regulations and monitoring practices

Essential Questions:

1. What is regulation and monitoring?
2. What are regulations and monitoring practices?
3. What types of regulations and monitoring practices can be used to sustain aquatic organisms?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Regulations and monitoring practices
Skills	• Discuss types of regulations and monitoring practices • Differentiate regulations and monitoring practices
Attitudes	• Critical with decisions for regulations and monitoring practices
Values	• Justice for the importance of regulations and monitoring practices

Content Background

- Fishery regulation** - Is a set of rules and laws governing the exploitation and other practices of fishery resources, especially in the open access water.
- Monitoring practices** – Is the collection, measurement and analysis of fishing activity.

Capture Fishery monitoring, control and surveillance (MSC)

Monitoring, control and surveillance (MSC) is an integral and essential component of fisheries. MSC programs generally include;

- Monitoring** that involves the collection, measurement and analysis of fishing activity, including: catches, species composition, fishing effort, discards, area of operation, etc.
- Control that** involves the specification of terms and conditions under which resources can be harvested, which are normally contained in fisheries legislation and other arrangements (national, sub-regional, regional).

(iii) Surveillance that involves the checking and supervision of fishing activity to ensure that national legislation and terms, conditions of access, and management measures are observed.

MCS programs are required to be effective and efficient within the operational capacity of those charged with their operation. They must also have legality and above all, must be relevant and combined with the fishery being managed.

Monitoring data could include: fish catches, fisheries habitats, number of fishers, survey of gear, verification of fishing vessel registration, catch confirmation and activities that have displaced fisheries activities (e.g. pollution, cages/large fish pens).

Many fisheries management authorities require fisheries to use **at-sea monitoring programs**. These are considered necessary to provide accurate data catch and effort, with vulnerable species and the impact of fishery on the environment. This helps fishery managers establish the status of fish stocks and set sustainable fishing limits.

At-sea monitoring programs can include the installation of video cameras and use GPS technology to track the location of fishing activity, in addition the presence of human observers on fishing trips. The data collected through these methods is used alongside traditional monitoring methods.

Other Monitoring practices

- 1. Register** – All fishing companies and fishing vessels must obtain a commercial fishing license.
- 2. Data collection** – Any licensed holder engaged in commercial fishing is required to keep a logbook and has a duty to keep it on board the vessel at all times. Supply of information on commercial fishing activities is a legal obligation.
- 3. Monitoring** – Regulation on surveillance and monitoring of fishing vessels stipulates the obligation for a satellite-based tracking device on all vessels. The importance of port-to-port vessel tracking as a key instrument for monitoring, control, and surveillance of fishing activities.

In order to ensure rational management and protection of commercial valuable species of fish and other marine organisms these rules have to be empowered:

- Limit the number of commercial fishing licenses that can be issued for waters.
- Restrict the number, size and power of fishing vessels
- Protection of fish and other marine organisms
- Limit the use of certain fishing gears or tools
- Protected species should not be harvested

Assessment:

- Create rules to empower rational management and protection of commercial valuable species of fish and other marine organisms.

Reference/Source:

<https://www.faoadriamed.org>, <https://www.msc.org>>Our approach

UNIT 2: CAPTURE FISHERY HARVESTING PRACTICES AND MANAGEMENT SYSTEMS

Benchmark 10.4.2.3. Discuss different ways of preserving plant, animal, and fish species and sustaining the environments in which they are caught.

TOPIC: WAYS OF PRESERVING PLANT, ANIMAL, AND FISH SPECIES

Learning Objectives

By the end of this topic, students will be able to;

- Identify ways of preserving aquatic organisms and fish species
- Discuss how to conserve aquatic biodiversity

Essential Questions:

1. Why are some aquatic organisms in danger of being extinct?
2. How can we preserve our aquatic organisms and fish species?
3. What is the most important way to conserve aquatic biodiversity?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Preserving aquatic organisms and fish species • Methods of preserving aquatic organisms and fish species
Skills	• Differentiate ways of preserving • Justify their reasons on ways of preserving
Attitudes	• Open-minded with decisions and ways for preserving
Values	• Value the creativeness of preserving

Content Background

Aquatic organisms in danger of being extinct

Overfishing, climate change, pollution and oil spills are all-made issues that are pushing our freshwater and marine organisms to the brink of extinction.

(i) Over fishing - Overfishing is when a particular type of fish is harvested so often and in such great numbers that the population of that fish is severely depleted, resulting in endangerment and potential extinction. This generally is the result of commercial, rather than recreational, fishing. Overfishing has implications well beyond marine life; it affects the human food supply, the fishing industry, and the environment

(ii) Climate change - Marine organisms have disappeared from their habitat due to global warming at twice the rate of wildlife on land. The environment has been polluted with an increase of greenhouse gases. The major consequences are global warming, cyclone, an increase in sea level. It has a clear negative impact on the natural environment including aquatic ones. As a result, production of fish in the aquaculture system and marine system is greatly affected. Marine ecosystems like coral reefs are also destroyed.

(iii) **Pollution** - Aquatic life forms mainly suffer because of water pollution, because of loss of enough amount of fresh dissolved oxygen in water bodies due to raised volume of toxicity in water. Toxicity which is a result of water pollution leads to death of aquatic life forms.

(iv) **Oil spills**- are fatal to most of marine organisms because they drain oxygen from the sea and thus destroys the plant and animal world in it. Many birds and marine organisms are trapped in oil spillages on the shores, and then they die because of their inability to breathe or oil poisoning.

Conservation of fish species and aquatic organisms

Conservation is the proper management of natural resource. Fish conservation measures concerned with protection and preservation of fish and other aquatic life, particularly in sea waters.

1. **Protecting Essential Fishing Habitat**- Essential fish habitat includes all types of aquatic habitat needed for fish spawning, breeding, feeding and growth. It specifies where a certain fish species lives and reproduces. Without these prime locations, these fish would not be able to survive. It is good to work with partners and use the best available science to identify, describe and map Essential Fish Habitat.
2. **Marine Reserve/ Protected Water** – A marine reserve is a define space within the sea in which fishing is banned or other restrictions are placed in an effort to protect plans, animals, and habitats, ultimately conserving biodiversity. Marine reservoirs can be also be used for educational purposes, recreation and tourism as well as potentially increasing fisheries yields by enhancing the declining fish populations.
3. **Threatened or Endangered Species Designations** – Threatened species include organisms likely to become endangered if not properly protected. Endangered fish and aquatic organisms that need protection in order to survive, as they are in danger of becoming extinct. Once spices are listed, they become subject to national recovery programs and will be placed under international protection. Severe penalties can occur if threatened and endangered species regulations are broken, and can even result in jail sentence.
4. **Increase Public Awareness** – Increasing public awareness is one of the most important ways to conserve aquatic biodiversity. This can be accomplished through educational programs, incentive programs and volunteer monitoring programs.

Assessment:

Research on different ways of preserving plant, animal, and fish species and sustaining the environments in which they are caught.

Write an essay on how to conserve aquatic biodiversity.

Reference/Source:

<http://aquafind.com>article>fish>,
<http://www.aquaticlifelab.eu>4-10oilspills>

UNIT 2: CAPTURE FISHERY HARVESTING PRACTICES AND MANAGEMENT SYSTEMS

Benchmark 10.4.2.3. Discuss different ways of preserving plant, animal, and fish species and sustaining the environments in which they are caught.

TOPIC: SUSTAINABLE PRACTICES OF CAPTURE FISHERY ENVIRONMENTS

Learning Objectives

By the end of this topic, students will be able to;

- Identify ways to sustain Capture fishery environments

Essential Questions:

1. What is sustainable fishing?
2. What practices are used to sustain Capture fishery environments?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Types of stainable practices
Skills	• Differentiate ways of sustaining environments • Justify their reasons on ways of sustaining environments
Attitudes	• Desire to learn the practices
Values	• Sustainability of environments

Content Background

Sustainable practices of Capture fishery environments

A) Sustainable fishing means leaving enough fish and aquatic organisms in the ocean and fresh water, respecting the habitats and ensuring people who depend on fishing can maintain their livelihoods. There are ways to fish sustainably, allowing us to enjoy sea food while ensuring that the populations remain for the future. In many indigenous cultures, people have fished sustainably for thousands of years. Today's sustainable fishing practices reflect some lessons learned from these cultures.

Practices used to sustain capture fishery environment

1. Use traditional employed fishing practices that simultaneously harvest and maintain fish populations and does not destroy the habitats.
2. Fish for specify species only during certain times of the year
3. Set aside certain areas, such a coral-reefs, as protected spots in which fishing is prohibited
4. Use hook-and line- and spearing fishing methods, catching only what is needed

Restoring Habitat – Restoring fish habitat is crucial to maintain native species. These aquatic habitats must be restored and enhanced to maintain and grow existing and historical aquatic communities.

B) Large scale fishing

There are many commercial fisheries gather fish in a sustainable way. However there are fishing methods that are destructive to the environment and habitat destruction. Here are 2 major commercial fishing methods being implemented around the world today. Let's see how sustainable practices are imposed.

Types of Methods	Description	Practices
Gillnetting	A massive curtain of net that is suspended using floats or anchored using weights. The netting is invisible so fish swim into the net and get their gills caught. It entangles dolphins, sharks and sea turtles.	This approach is unsustainable and should not be used.
Trolling	A boat has multiple lines being dragged behind a boat. When fish are brought to the boat soon after being caught, are selected and others not intend to catch are released quickly back into the ocean.	This approach is sustainable.

Assessment:

Outline different practices used to sustain capture fishery environments

Reference/Source:

<https://cimioutdoored.org>,

<http://www.msc.orgour-approach>,

UNIT 3: CAPTURE FISHERY AND TECHNOLOGY

Content Standard 4.3 Students will be able to examine how technology is used in capture fishery and the processing, preservation, marketing, consumption, regulation and management of fish and other aquatic organisms and plants in different environments and places, and evaluate their strengths and weakness.

Benchmark 10.4.3.1. Investigate and explain capture fishery and aquatic organisms and plants harvesting and preservation technology used in different environment and places.

TOPIC: PRESERVATION TECHNOLOGY FOR CAPTURE FISHERY

Learning Objectives

By the end of this topic, students will be able to;

- Discuss preservation technology for capture fishery
- Differentiate the different methods of preservation

Essential Questions:

1. Why is fish being preserved?
2. How can fish be preserved?
3. What type of preservation technology is used in fishing industry?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Preservation technology • Methods of preservation technology
Skills	• Categorize different methods of preservation • Justify their reasons for categorizing
Attitudes	• Open-minded with decisions and ways for preserving
Values	• Openness in group discussion

Content Background

Importance of preserving fish and other aquatic organisms

Fish and other aquatic organisms, are more vulnerable to spoilage than certain other animal protein foods, such as meat and eggs. To prevent spoilage, some form of preservation is necessary. **Preservation** means keeping the aquatic organisms, after it has landed, in a condition healthy and fit for human consumption for a short period to few days or for longer periods of over few months. During the period of preservation, this kept as fresh as possible, with minimum losses in flavour, taste, odor, form, nutritive value, weight and digestibility of flesh. This preservation should cover the entire period from the time of capture of fish to its sale at the retailer's counter.

Methods of Preservation

Preservation can be done, both for short and long duration

Preservation for short duration

Chilling- This is obtained by covering the fish with layers of ice. Ice is effective for short term preservation such as is needed to transport landed fish to nearby markets or to canning factories, etc. Here autolytic enzyme activities are checked by lowering the temperature.

Preservation for long time

When the preservation is required for a long period of time, the fish are passed through the cleaning, gutting and conservation and storage.

Cleaning and gutting

During cleaning, the caught fish are washed thoroughly in cold, clean water to remove bacteria, slime, blood, faeces, and mud, etc. from the body surface of the fish. It is being done under proper sanitary conditions. Large fishes are gutted (i.e. all the internal organs or viscera are removed) and the body cavity is washed.

Conservation and Storage

Conservation is necessary to keep the dead fish in fresh condition for quite a long time. This is achieved by employing any one of the methods like freezing, drying, salting, smoking and canning.

Freezing

Freezing means removal of heat from the body. To check the enzyme, bacterial action and putrefaction it is preferred to store the fish under lower temperatures. When fish is intended to be stored for a long period, quick freezing is preferred which inhibits bacterial action. During quick freezing every part of the product comes within the range of 0 to -5°C . Properly frozen fish at -20°C retains its physical properties and nutritive values for a year or more and is almost as good as fresh fish.



Salting

Salting is a process where the common salt, sodium chloride, is used as a preservative which penetrates the tissues, thus checks the bacterial growth and inactivates the enzymes. Some of the factors involved in salting of fish which play an important role are purity of salt, quantify of salt used, method of salting and weather conditions like temperature, etc.



During the process the small fishes are directly salted without being cleaned. In the medium and large sized fish the head and viscera are removed and longitudinal cuts are made with the help of knives in the fleshy area of the body. Then the fish is washed and filled with salt for uniform penetration through flesh. Large fishes like sharks are cut into convenient sized pieces. Generally, sardines, mackerels, seer fishes, cat fishes, sharks and prawns are used for salting.

Smoking

In this method, landed fish is cleaned and brined. It is then exposed to cold or hot smoke treatment. In cold smoking, first a temperature of 38°C is raised from a smokeless fire. After this heating, cold smoke at a temperature below 28°C is allowed to circulate past the fish. In case of hot smoking, first a strong fire produces a temperature around 130°C. This is followed by smoking at a temperature of 40°C. The smoke has to be wet and dense. Good controls are necessary over density, temperature, humidity, speed of circulation, pattern of circulation and time of contact with fish of the smoke. The phenol content of the smoke acts as an antiseptic and it also imparts a characteristic colour and flavour.



Canning

Canning is a method of preservation in which spoilage can be averted by killing micro-organisms through heat. Oily fish are the most suitable for canning. Salmon, tuna, sardine, herring, lobster, shrimp, etc. are canned. Canning is done by putting cleaned dressed and cut fish into a saline solution. The cans holding the fish and the saline are then double sealed under vacuum. Thereafter, sterilization of cans takes place at 121°C for 90min under steam pressure. Sterilization is followed by cooling of the cans under room temperature by running water.



The various preservation methods used in the fish and fishery industry can be classified into three groups; physical, chemical and bio-preservation methods. These methods have different modes of actions and are applied to extend the shelf life of fish and fishery products.

- Physical methods** of fish preservation can be described as three distinct spoil control measures namely, **moist control**, **thermal control** and **non-thermal control** technologies.



Moist control



Thermal control (heat) drying of fish

Chemical methods of fish preservation refer to the addition of salt, sugar, nitrates, seasoning or spices and phosphates to preserve fish. In addition to preservation, this particular processing can result in a characteristic color and flavor of the product.



Assessment:

Research and compare different types of preservation technology for capture fishery

Sources:

<https://medcraveonline.com>, Dreamstime.com,

UNIT 3: CAPTURE FISHERY AND TECHNOLOGY

Benchmark: 10.4.3.2. Investigate and evaluate the effectiveness of different technology used for producing and processing capture fishery and other aquatic organisms and plants.

TOPIC: ADVANTAGES AND DISADVANTAGES OF THE USE OF TECHNOLOGY IN CAPTURE FISHERY

Learning Objectives

By the end of this topic, students will be able to;

- Identify the advantages, disadvantages and effectiveness of technology used in Capture fishery

Essential Questions:

1. What are the advantages and disadvantages of using technology in Capture fishery?
2. What are the effects of using technology in Capture fishery?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Advantages of using Technology • Disadvantages of using Technology
Skills	• Categorize into advantages and disadvantages
Attitudes	• With a desire to learn
Values	• Honesty in solving problems

Content Background

Effects of Technology in Capture fishery

Fishery technology consists of equipment and practices used for finding, harvesting, handling, processing and distributing of aquatic resources and their products. Different fishery technologies will have different effects **on the ecosystem**, the **social structure** of fishing communities, the **safety of fishery workers**, **effectiveness** and **efficiency** of management of the fishery. Fishery technologies produce side effects on the environment and non-target species.

Each fishery technology has advantages and disadvantages that should be balanced in a protective approach and it may be better to have a mixture of technologies. When new technology is introduced, it should be carefully evaluated to assess its potential direct and indirect effects. Responsible fishery technology achieves the specific fishery management objectives with the minimum damaging side effects.

Advantages of using technology

Technical advances have generally led to more;

- efficient and economically fishing operations, example LED lights attached to fishing nets can attract the right catch and guide non-targeted species to safety.
- reduction of the physical labour
- improved access to resources.
- empowers small-scale fishers generating information not just on fisheries, but on markets, which allows them to make better business decisions and demonstrate their commitment to ocean conservation.
- offer an opportunity to improve fisheries management practices and seafood business, while empowering fishers and providing more information to consumers so that they can make more responsible seafood choices.

Disadvantages of using technology

- Over fishing - Improved technology increasing demand and poor management mean that fish populations can come under very heavy fishing pressure and become exhausted or even collapse completely.
- Habitat damage- Fishing gear that is heavy or large can harm the environment while catching fish. Some fishing methods, such as dredging and bottom trawling, impact the sea-floor habitat. In areas with sensitive, bottom-living species, such as deep-sea corals, fishing gear can cause long-term damage.
- Technology used in capture fishery is costly.

Assessment:

- Investigate and report the advantages and disadvantages of technology used for producing and processing capture fishery and other aquatic organisms and plants.

Reference/Source:

<http://www.fao.org>

https://www.sustainweb.org/goodcatch/environmental_impacts

UNIT 4: TYPES OF FORESTRY AND FORESTS

Content Standard 4.4 Students will be able to define forestry, investigate the different types of forestry and forests, categorize them according to their characteristics, purposes and benefits, and investigate the different contexts, environments, and places where they grow and are harvested.

Benchmark 10.4.4.1. Investigate and analyse the harvesting of tropical forests in different contexts.

TOPIC: HARVESTING OF TROPICAL FORESTS IN DIFFERENT CONTEXTS

Learning Objectives

By the end of this topic, students will be able to:

- Examine and discuss the harvesting of tropical forests in different contexts.

Essential Questions:

1. What is a tropical forest?
2. How are tropical forests harvested in different contexts?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Harvesting of tropical forests in different contexts.
Skills	• Define tropical forest. • Discuss and explain the harvesting of tropical forests in different contexts.
Attitudes	• Open-minded and sharing ideas on tropical forest.
Values	• Openness and love for the forest

Content Background

What is a tropical forest?

Tropical forests are closed canopy forests growing within 28 degrees north or south of the equator. They are very wet places, receiving more than 200 cm rainfall per year, either seasonally or throughout the year.



Different categories of tropical forests include:

- **Evergreen:** Evergreen forests receive rain year-round and have no dry season.
- **Seasonal:** They have evergreen vegetation and short dry season.
- **Dry:** These forests have long dry season in which trees lose leaves.
- **Montane:** Known as cloud forests as they receive most of the precipitation from mist or fog that rises from the lowlands.
- **Tropical and subtropical coniferous:** These forests have dry and warm climate with conifers adapted to variable weather.
- **Sub-tropical:** Sub-tropical forests are located at north and south of tropical forests. Trees here are adapted to resist summer drought.

Harvesting of Tropical Forests

Large areas of tropical forest, irrespective of whether protected areas or controlled by communities, are still being harvested unsustainably, if not illegally, through logging, hunting, or collection of non-timber forest products.



In most tropical forests managed for sustainable timber production, harvesting is selective. Between two and 20 stems are removed from each hectare of forest, once every few decades. When done carefully this leaves over 90% of the trees in place.



However, clearcut logging of natural forests in the tropics also occurs when farmers and ranchers are expanding cropland and pastures, and is not used as a means for sustained timber harvesting. With selective logging, only high-value species are felled for timber, but many smaller trees are damaged in the process.

Assessment:

Research and present on the harvesting of tropical forest in different contexts.

Reference/Sources:

Caulfield, Catherine. *In the Rainforest*. Chicago: University of Chicago Press, 1984.

Forsyth, Adrian, and Ken Miyata. *Tropical Nature*. New York: Scribner's and Sons, 1984

<http://www.fao.org/sustainable>

<http://www.bing.com>

UNIT 4: TYPES OF FORESTRY AND FORESTS

Benchmark: 10.4.4.2. Categorize and examine different types of forestry according to their characteristics, elements, functions, and purposes.

TOPIC: CHARACTERISTICS, ELEMENTS, FUNCTIONS AND PURPOSES OF DIFFERENT TYPES OF FORESTRY

Learning Objectives

By the end of this topic, students will be able to:

- Classify the different types of forestry according to their characteristics, elements, functions and purposes.

Essential Questions:

1. What are the different types of forestry?
2. What are the characteristics, elements, functions and purposes of the different types of forestry?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Different types of forestry, their characteristics, elements, functions and purposes.
Skills	• Examine and classify the different types of forestry according to their characteristics, elements, functions and purpose.
Attitudes	• Optimistic about the characteristics, elements, functions and purposes of the different types of forestry.
Values	• Appreciate and Value the different types of forestry.

Content Background

Forestry is the practice of managing forest lands for various uses, including commercial, agricultural, and public. Trees are grown on farms for a variety of commercial and non-commercial purposes, including timber production, shade and shelter, ground water control, prevention of nutrient pollution, erosion prevention, scenic enhancement, and nature conservation. Although some trees are grown for a single purpose, such as timber production, or nature conservation, many are planted to achieve a number of aims simultaneously.

Agroforestry

Agroforestry is a term used to describe a system where through some kind of special arrangement or temporal sequence trees, shrubs etc are grown in the same land management units such as agricultural crops and animals. There are 3 main types of agroforestry systems:

1. Agrisilvicultural system – it is a combination of crops and trees.
2. Silvopastoral system – it is a combination of domesticated animals and forestry.
3. Agrosylvopastoral system – it is a combination of trees, animals and

crops.

Agroforestry has a lot in common with intercropping (the practice of planting two or more crops on the same plot) with both practices placing an emphasis on interaction between different plant species. Generally speaking, both agroforestry and intercropping can result in higher overall yields and reduced operational costs.



Characteristics

While selecting tree species for agroforestry systems, the following desirable characteristics should be taken into consideration. Though all desirable characters are not found in a single species, but their multiple uses are taken care of.

1. Tree species selected should not interfere with soil moisture.
2. Tree species should not compete for plant nutrients.
3. Tree species should not compete for sunlight.
4. Tree species should have high survival rate and easy establishment.
5. Tree species should have fast growing habit and easy management.
6. Agricultural crops should be short duration and quick growing.

Functions

The main environmental service functions that are provided by agroforestry systems (AFS):

- 1) maintenance of soil fertility/reducing erosion via organic matter inputs to the soil, nitrogen fixation and nutrient recycling;
- 2) conservation of water (quantity and quality) via greater infiltration and reduced surface runoff that could contaminate water courses;
- 3) carbon capture, emphasizing the potential of silvopastoral systems; and
- 4) biodiversity conservation in fragmented landscapes.

Purposes

The purpose of agroforestry is to incorporate trees and shrubs into farming systems to gain from their positive interactions with agriculture. Benefits gained from trees and shrubs may be direct (timber), indirect (shade, shelter and fodder), or a mixture of both.

Community Forestry

Community forestry is where local people are involved in a forestry activity. It embraces a spectrum of situations ranging from woodlots in areas which are short of wood and other forest products for local needs, through the growing of trees at the farm level to provide cash crops and the processing of forest products at the household, artisan or small industry level to generate income, to the activities of forest dwelling communities”.

Characteristics

1. Willingness by forestry professionals and forestry agencies to enter into partnership with local people to respond effectively to their needs.
2. A change in the internal culture of forestry agencies, reflecting a shift from a focus on trees to a focus on people to enable forestry agencies to understand what people want and to work in partnership with them to help them achieve their objectives.
3. A shift from centralized, line-command agency management to decentralized management and the sharing of decision-making responsibility with local forest users and local communities.
4. The reorientation of technologies to focus the benefits from forest management on local communities in ways that are desired and supported by these communities. This characteristic also often results in managing forest resources for products other than timber.
5. Cooperation and coordination with community-based organizations that re-present local constituencies and interests. Many of the development components of community forestry may be better managed by NGOs based in the communities.

Elements

Community forestry comprises of three main elements.

1. The provision of fuel and other goods essential to meeting basic needs at the rural household and community level.
2. The provision of food and the environmental necessary for continued food production.
3. The generation of income and employment in the rural community.

Purposes

It was stressed that community forestry must be an integral part of rural development and the “basic precept and that the central purpose of rural development is to help the poor become self-reliant. Forestry for community development must therefore be forestry for the people and involving the people. It must be forestry which starts at the 'grass roots'” (FAO 1978)

Assessment:

Investigate and categorize types of forestry according to their characteristics, elements, functions and purposes.

Reference/Sources

<https://studey.com/academy/lesson/what-is-forestry-definition-types.html>

UNIT 5: FOREST HARVESTING PRACTICES AND MANAGEMENT SYSTEMS

Content Standard 4.5 Students will be able to investigate and analyze the different types of forest harvesting practices and management systems used in different environments and places to harvest, process, preserve, market, regulate, and consume forests.

Benchmark 10.4.5.1. Investigate and analyze forest management systems used in different places and environments.

TOPIC: FOREST MANAGEMENT SYSTEMS

Learning Objectives

By the end of this topic, students will be able to:

- Examine and explain the forest management systems used in different places and environments.

Essential Questions:

1. What is forest management system?
2. What is the forest management systems used in different environments?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	Forest management systems used in different places and environments
Skills	Identify and explain the forest management systems used in different places and environments.
Attitudes	Show responsibility in managing the forest. Be caring and concern in managing the forest.
Values	Kindness and love

Content Background

Forest Management Systems

Forest management is the process of planning and implementing practices for the stewardship and use of forests to meet specific environmental, economic, social and cultural objectives. It deals with the administrative, economic, legal, social, technical and scientific aspects of managing natural and planted forests. It may involve varying degrees of deliberate human interventions, ranging from actions aimed at safeguarding and maintaining forest ecosystems and their functions, to those favouring specific socially or economically valuable species for the improved production of forest goods and services.

Sustainable Forest Management

Sustainable forest management (SFM) is the management of forests according to the principles of sustainable development. Sustainable forest management has to keep the balance between three main pillars: ecological, economic and socio-cultural. Successfully achieving sustainable forest management will provide integrated benefits to all, ranging from safeguarding local livelihoods to protecting the biodiversity and ecosystems

provided by forests, reducing rural poverty and mitigating some of the effects of climate change.



Ecosystem approach

The ecosystem approach is a conceptual framework for resolving ecosystem issues. The idea is to protect and manage the environment through the use of scientific reasoning. Another point of the ecosystem approach is preserving the Earth and its inhabitants from potential harm or permanent damage to the planet itself. With the preservation and management of the planet through an ecosystem approach, the future monetary and planetary gain is the by-product of sustaining and/or increasing the capacity of that particular environment. This is possible as the ecosystem approach incorporates humans, the economy, and ecology to the solution of any given problem.

Agroforestry systems

Agroforestry systems are multifunctional systems that can provide a wide range of economic, sociocultural and environmental benefits. Agroforestry can be particularly important for smallholder farmers because it generates diverse products and services on a limited land area. Agroforestry systems also have limitations, and a careful analysis should be carried out before their introduction.

Economic benefits

Most agroforestry systems aim to increase or maintain the production and productivity of farming systems; reduce agricultural inputs and thus production costs; and diversify production by the use of trees or other woody perennials to produce, for example, food, fodder, lumber, building materials and wood fuel. Agroforestry systems may also create opportunities for small-scale forest-based enterprises. Agroforestry can help reduce rural poverty by increasing on-farm production and household income and by providing employment opportunities, and it can reduce the risk of economic failure by increasing the diversity of production within farming systems.

Social benefits

An increase in production, productivity and product diversity through agroforestry can help improve the health and nutrition of the rural poor. The on-farm production of fuel, fodder and other tree products, otherwise collected from off-farm sources, can reduce the time and effort needed to obtain them (often lessening the burden on women) or save money if the products would otherwise be purchased.

Environmental benefits

Agroforestry systems can provide a range of environmental services. For example, they can improve soil fertility, protect crops and livestock from wind, restore degraded lands, improve water conservation, limit pests and prevent soil erosion

Assessment:

Write an essay on the impact of agroforestry systems on the economy and the environment.

References/Sources

<http://www.fao.org>

http://www.en.wikipedia.org/wiki/Ecosystem_approach

UNIT 5: FOREST HARVESTING PRACTICES AND MANAGEMENT SYSTEMS

Benchmark 10.4.5.2. Investigate and analyze forest regulation and monitoring systems and practices in different places and environments.

TOPIC: FOREST REGULATION AND MONITORING SYSTEMS

Learning Objectives

By the end of this topic, students will be able to:

- Examine and explain the forest regulation and monitoring systems and practices in different places and environments.

Essential Questions:

1. What is forest regulation?
2. What are the forest relations in Papua New Guinea?
3. What is monitoring system?
4. How is monitoring carried out in forestry?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Forest regulation and monitoring systems and practices in different places and environments.
Skills	• Justify and explain the forest regulation and monitoring systems and practices in different places and environments.
Attitudes	• Appreciative and positive of the forest regulation and monitoring systems.
Values	• Justice and trust for the regulation and monitoring systems.

Content Background

Forest Regulation

Forestry laws govern activities in designated forest lands, most commonly with respect to forest management and timber harvesting. Ancillary laws may regulate forest land acquisition and prescribed burn practices.

The Head of State, acting on advice, may make regulations, not inconsistent with this Act, prescribing all matters that by this Act are required or permitted to be prescribed, or that are necessary or convenient to be prescribed for carrying out or giving effect to this Act, and in particular prescribing matters for and in relation to

- (a) The management of National forests; and forests on other Government land and land held under lease from the State; and areas subject to Forest Management Agreements; and forests on customary land, including the regulation of the cutting, removal, hewing and sawing of timber; and the cutting, hewing, stripping, tapping and removal of other forest produce.

- (b) The forms of timber permits, timber authorities and licenses under this Act, and the manner of applying for, granting, issuing, registering and transferring them and the covenants, terms and conditions under which they shall be held, determined, cancelled or withdrawn.
- (c) The procedure for the sale, by auction or by tender, of forest produce and enabling upset prices or minimum royalties to be fixed.
- (d) The assessing of royalty on forest produce and the payment and distribution of royalties.
- (e) The manner of doing or performing anything required by this Act to be done or performed.
- (f) The fees or deposits to be paid with any application or tender; and
- (g) The rate or amounts of rents, fees, dues and charges payable in respect of timber permits, timber authorities, licenses or registration under this Act.

In general, forest industry activities may be carried out by so-called "forest industry participants" under either

- a timber permit,
- a timber authority, or
- a license granted and issued on the basis of the rules and regulations set out in the Forestry Act 1993.

Monitoring System in forestry

Effective monitoring is essential for sustainable forest management (SFM). An important distinction exists between monitoring and auditing, which are complementary components of a monitoring system. Monitoring can be defined as the ongoing assessment of the technical, environmental and social performance and impacts of management. A monitoring system is a way of steering and organizing monitoring so that it is efficient and easy to implement. Monitoring systems vary in sophistication where they may use simple measuring tools and paper-based recording, or they may involve advanced electronic equipment. The most important thing is not how sophisticated a system is, but whether information is collected, reviewed and used efficiently to ensure effective management.

The following may be helpful in keeping monitoring costs under control and achieving understandable results:

1. Keep monitoring focused on forest management that is, on what you really need to know.
2. Whenever possible, use simple and cheap methods.
3. Use resources already available in the company or organization.
4. Wherever appropriate, use easily applied indirect approaches.

Assessment:

Do research and present findings on the different forest regulations and its monitoring systems.

References/Sources

Fry, B. P. (2011). Community forest monitoring in REDD +: the 'M' in MRV? *Environmental Science and Policy*, 14(2), 181–187.

<https://doi.org/10.1016/j.envsci.2010.12.004>

UNIT 5: FOREST HARVESTING PRACTICES AND MANAGEMENT SYSTEMS

Benchmark 10.4.5.3. Determine and analyze the different ways of preserving and sustaining forests in different environments.

TOPIC: WAYS OF PRESERVING AND SUSTAINING FORESTS IN DIFFERENT ENVIRONMENTS

Learning Objectives

By the end of this topic, students will be able to:

- Explain and explore the different ways of preserving and sustaining forests in different environments.

Essential Questions:

1. What are the ways of preserving forests in different environments?
2. How can forests be sustained in different environments?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Ways of preserving forests in different environment. • Ways of sustaining forests in different environments.
Skills	• Justify ways of preserving and sustaining forests in different environments.
Attitudes	• Taking responsibility in preserving and sustaining the forests.
Values	• Sustainability of the forest

Content Background

Conservation of Forests

Conservation of the forest means saving the forest environment from destruction. Forest conservation as the name suggests is the preservation and the protection of forests. It also involves the reversal of deforestation and environmental pollution. The preservation of all natural resources is absolutely essential for the balance of our ecosystem.

Controlled Deforestation

While deforestation cannot be avoided completely, it must be controlled. Young and immature trees should not be felled as far as possible. Large-scale commercial deforestation must be avoided as well. Adapting practices such as clear-cutting or selective cutting will be beneficial in the long run.

Protect against Forest Fires

Forest fires are the most common and deadly cause of loss of forests. They can start due to natural causes or can be accidents caused by man or even intentional in some cases. Once a fire spreads in a forest it is very difficult to control. Precautions must be taken for such incidents. Making fire lanes, spreading chemicals to control fire, clearing out dry leaves and trees and so on.

Afforestation

This is the process by which we plant more trees in the area. We try to increase the forest cover by manual transplantation, or fresh plantation of trees. It is an attempt to balance our ecosystem to reduce the effects of deforestation and environmental pollutions of all types.

Better Farming Practices

Slash and burn farming, overgrazing by cattle, shifting [agriculture](#) are all farming practices that are harmful to the environment and particularly to forests. All practices must be kept under control.

Assessment:

Identify and discover through research the ways of preserving and sustaining forests in different environments.

References/Sources

<http://www.toppr.com>

Ekpo.S, Micheal.K,1996. Agriculture for Melanesia, Australia,

UNIT 6: FORESTRY AND TECHNOLOGY

Content Standard 4.6 Students will be able to examine how technology is used in the harvesting, processing, preservation, marketing, regulation, consumption, and management of forestry in different environments and places, and evaluate their strengths and weaknesses.

Benchmark: 10.4.6.1. Investigate and explain forest monitoring and preservation technology used in different environment and places.

TOPIC: FOREST MONITORING AND PRESERVATION TECHNOLOGY

Learning Objectives

By the end of this topic, students will be able to:

- Examine and explain forest monitoring and preservation technology used in different environment and places.

Essential Questions:

1. What technologies are used in forest monitoring and preservation?
2. How is technology used in forest monitoring and preservation in different environment and places?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Forest monitoring and preservation technology
Skills	• Clarify and describe the use of technology in forest monitoring and preservation.
Attitudes	• Open minded about the forest monitoring and preservation technology.
Values	• Appreciate and Value the use of technology in forest monitoring and preservation.

Content Background

Forests are part of the important and indispensable resources for human survival and social development that protects the balance of the earth ecology. There is a need to design a smart and efficient Forest Monitoring System.

Forest protection is a branch of forestry which is concerned with the preservation or improvement of a forest and prevention and control of damage to forest by natural or man-made causes. (example - fire, animals, insect, fungi, injurious plants and adverse climatic conditions.)

This forest protection also has a legal status and rather than protection from only people damaging the forests is seen to be broader and include forest pathology too.

In recent years, the prevention and monitoring of Forest Fires has become a global concern in Forest Fire prevention organizations. At present, traditional forest fire monitoring measures include ground patrolling, watching tower, aerial patrolling, long-distance video monitoring and satellite monitoring and so forth. The Existing Conventional forest monitoring system has the basic issues of limited application unsatisfied monitoring results, financial, material and labour resources.

Technology has advanced over the years in terms of forest monitoring and preservation which has introduced a project which presents the prototype of a system for detection of any uncontrolled anthropogenic activities, smoke or fires in forests using sensors. The data from the sensors is processed in the microcontroller and is transmitted to the receiver unit through a wireless network. The abnormalities alert the receiver unit and the pictures taken through camera are mailed.

This Forest Monitoring system prototype is designed and developed in an effort to improve the security level for valuable trees which have high demand in market like teak, Sandalwood, etc. This prototype is tested and demonstrated successfully for its functionality.

1. The prototype of the system can be implemented in places where precious trees are planted, to prevent forest fires and other illegal activities.
2. The transmitter and receiver units are placed at proper places for performing experimental tests.
3. The LCD displays the message indicating the situation to the control station where the receiver unit is placed.
4. This message received at the receiver unit is used by the forest officer to take preventive action.
5. With improvements in hardware and firmware the system can be implemented in a large scale that will help forest officials.

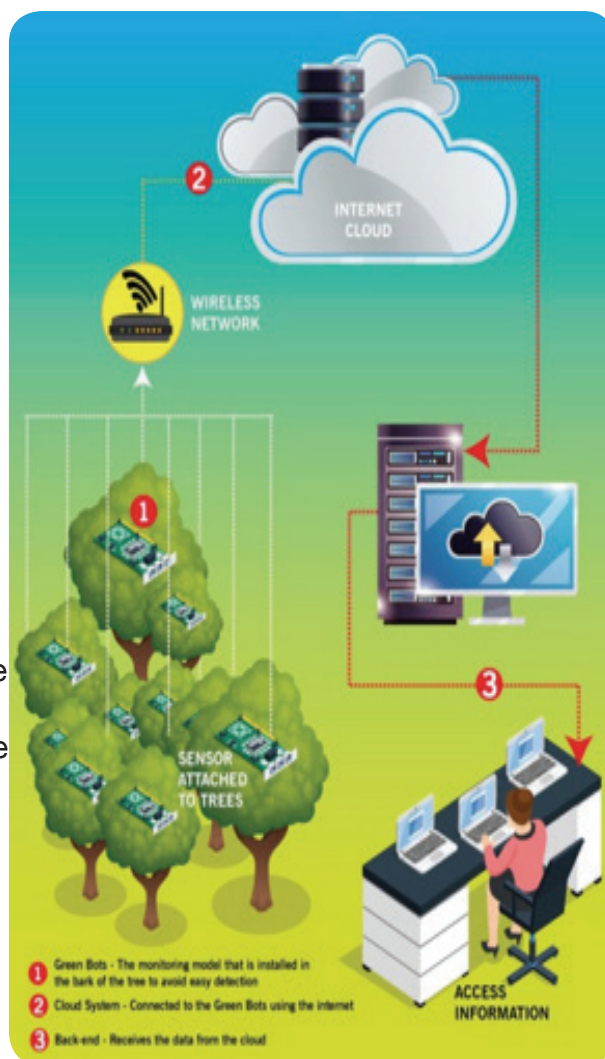
Assessment:

Orally present an awareness on forest monitoring and preservation technology used in different environment and places.

Reference/Sources

<https://www.orfonline.org>

<http://www.kscst.iisc.ernet.in>



UNIT 6: FORESTRY AND TECHNOLOGY

Benchmark 10.4.6.2. Investigate and evaluate the effectiveness of different technology used for processing and marketing forestry products.

TOPIC: TECHNOLOGY USED FOR PROCESSING AND MARKETING FORESTRY PRODUCTS

Learning Objectives

By the end of this topic, students will be able to:

- Examine and explain the effectiveness of different technology used in processing and marketing forestry products.

Essential Questions:

1. How effective is technology used in the processing and marketing of forestry products?

Essential Knowledge, Skills, Attitudes and Values

Knowledge	• Effectiveness of different technology used in processing forestry products. • Effectiveness of different technology used in marketing forestry products.
Skills	• Explore and explain the effectiveness of different technology used in processing and marketing forestry products.
Attitudes	• Critical about the effectiveness of different technology used in processing and marketing forestry products.
Values	• Perseverance of the effectiveness of different technology used in processing and marketing forestry products.

Content Background

Processing of forest products

The major wood product categories are sawn timber, wood-based panels, woodchips, paper and paper products and miscellaneous others including poles and railway sleepers. During the last several decades, forest product processing technologies have undergone extraordinary advances in some of the above categories. Improvements have been achieved in terms of recovery rates, higher qualities in terms of durability and protection, higher utilization of NTFPs such as bagasse, various grain stalks and bamboo, as well as the development of new products such as reconstituted wood-panels. Progress has not been homogenous in all the forest product utilization categories. Even though there is only little information available on the subjects of technology acquisition, adaptation and innovation for the forest-based industrial sector (Contreras-Hermosilla and Gregersen, 1991), it is clear that sawmilling has been far less affected by the spread of innovations than the manufacturing of panel products. There is still a high number of outdated mills in operation which have very low recovery rates, frequently less than 40 percent.

The technological changes that have taken place have not occurred randomly. Many of the technologies that are increasingly adopted and adapted have been developed in industrial countries. Some of them, such as medium density fibreboard (MDF) production technologies had been in use, tested and refined for more than 25 years before they featured more prominently. Most of the machinery is still imported, predominantly, from Europe. Others such as oriented strandboard (OSB) production does not exist yet in most countries and its market is underdeveloped.

The following four reasons account for the contemporary developments in those categories that have experienced changes and those that have remained largely stagnant in terms of modernization:

decreasing raw material supply;
 reduced availability of large-sized timber;
 increasing responsiveness to environmental pressures; and
 government policies to develop domestic wood-based industries.

Marketing

FOREST PRODUCTS IN THE ELECTRONIC MARKET PLACE

1. The Internet, as a new market channel, has the potential to change the traditional way forest products are traded.
2. Electronic marketplaces allow customers to search for suppliers and vice versa.
3. Companies use the Internet to enhance corporate image, improve customer and supplier relations, and to improve competitive advantage.
4. Many forest products companies now have individual homepages on the Internet, however few forest products are currently traded electronically.
5. Concern for security is the primary reason for reluctance to adopt electronic commerce.
6. Extranets offer additional advantages of improved, secure, communication with a company's customers, suppliers, vendors, shippers and other partners.

Assessment:

Compare effectiveness of different technology used in processing and marketing forestry products.

Reference/Source

<http://nationalindustryinsights.aisc.net.au>

<http://www.slideshare.net>

<http://www.fao.org>

<http://www.unece.org>

UNITS OF WORK

STRAND 5: AGRIBUSINESS

Strand Overview			
Unit	Benchmark	Topic	Lesson Titles
Content Standard 5.1 Students will be able to examine the different principles, practices, characteristics, enablers and contexts of business, and explore how agriculture businesses are started and managed in different contexts.			
Unit 1: Starting Up and Managing an Agribusiness	10.5.1.1. Analyse and discuss the best practices of risk management and explain how these practices could be used to manage the risks associated with agribusiness.	Managing Risk in Agribusiness	Sources of Risk in Agribusiness
			Importance of Risk and Uncertainty in Agribusiness
			Risk Management strategies
	10.5.1.2. Explain and practice effective verbal and written communication skills required for agribusiness sales and marketing.	Communication skills in Sales and Marketing	Markets related to Agribusiness
			Marketing principles
			Communication skills in Sales and Marketing
	10.5.1.3. Investigate and explain the processes of obtaining and managing start-up capital, including finance, for an agribusiness and evaluate their strengths and weaknesses.	Agribusiness start-up Capital	Components of the sales process
			Processes of obtaining Start-up Capital
			Managing Start-up Capital

UNIT: STARTING UP AND MANAGING AN AGRIBUSINESS

Content Standard 5.1 Students will be able to examine the different principles, practices, characteristics, enablers and contexts of business, and explore how agriculture businesses are started and managed in different contexts.

Benchmark 10.5.1.1 Analyse and discuss the best practices of risk management and explain how these practices could be used to manage the risks associated with agribusiness.

TOPIC: MANAGING RISKS IN AGRIBUSINESS

Learning Objectives

By the end of this topic, students will be able to:

- Examine risk factors in the management of agriculture businesses and how to address them.
- Research and identify the best practices of risk management

Essential Questions:

1. What types of risks should be considered when planning an agricultural business?
2. How can risks be managed in an agribusiness?

Essential Knowledge, Skills, Attitudes and Values

Essential Knowledge	• Sources of Risks in Agribusiness • Risk Management
Essential Skills	• Examine and discuss the risks involved in an agribusiness. • Investigate and suggest strategies to manage risks.
Essential Attitudes & Values	• Appreciate the value of analysing risks in an agribusiness.

Content Background

Sources of Risk

The most common sources of risk in farming can be divided into five areas: Production 2. Marketing 3. Financial 4. Institutional 5. Human

Production risk

Crop and livestock performance depend on biological processes that are affected by the weather, and by pests and diseases. Low rainfall or drought may lead to low yields. Hail or heavy rains could damage or even wipe out crops. Outbreaks of pests or diseases could also cause major yield losses in crops and livestock.

Marketing risk – prices and costs

Changes in prices are beyond the control of any individual farmer. The price of farm products is affected by the supply of a product, demand for the product, and the cost of production.

Supply of a product is affected by a combination of production decisions made by farmers as a group and by the weather and other factors that influence yields.

Demand for a product is affected by consumer preference, consumers' level of income, the strength of the general economy, and the supply and price of competing products.

Cost of production of a unit of product depends on both input costs and yield. This makes it highly variable. Although input costs tend to be less variable than output prices, when combined with yield variations the cost of production becomes a serious source of risk.

Sometimes price movements follow seasonal or cyclical trends that can be predicted. Many times, however, supply or demand will change unexpectedly and, in turn, affect the market price. When farmers plant crops or commit resources to raising livestock, they do not know for certain what prices they will obtain for their products. In situations of low rainfall, production of crops is often reduced and, as a result, prices rise.

Financial risk

Financial risk occurs when money is borrowed to finance the farm business. This risk can be caused by uncertainty about future interest rates, a lender's willingness and ability to continue to provide funds when needed, and the ability of the farmer to generate the income necessary for loan repayment. Smallholder farmers who borrow money at high interest rates may have particular difficulty making debt repayments. Lower than expected prices, combined with low yields, can make debt repayment difficult and even lead to the sale of the farm.

Institutional risk

Institutional risk refers to unpredictable changes in the provision of services from institutions that support farming. Such institutions can be both formal and informal and include banks, cooperatives, marketing organizations, input dealers and government extension services. Part of institutional risk is the uncertainty of government policy affecting farming, such as price support and subsidies. The risks that farmers face are often a result of decisions taken by policy-makers and managers. Subsidies, food quality regulations for export crops, rules for animal waste disposal and the level of price or income support payments are examples of decisions taken by government that can have a major impact on the farm business.

Human and personal risk

Human risk refers to the risks to the farm business caused by illness or death and the personal situation of the farm family. Accidents, illness and death can disrupt farm performance. In many countries labour migration away from rural areas is a common occurrence. Migration can cause labour shortages for the farm. Political and social unrest can also limit labour availability.

When farmers plant their crop or commit resources to raise live-stock they cannot be certain whether they will have enough labour to manage the farm enterprises.

RISK MANAGEMENT

Decision-making is the principal activity of management.

Early in the cropping season farmers must make decisions about what crops to plant, and what seeding rates and fertilizer levels to use. The yield and prices obtained will not be known with certainty for several months, or even several years in the case of perennial crops and livestock.

In only a few cases are farmers certain of the outcome of their decisions. This usually occurs when the decision is easy and there is only a single outcome.

For example, if farmers decide to take short-term loans, they know what will occur; banks will charge them interest at a specific rate. In this case, farmers know exactly the consequences of their decisions.

In most situations, however, the outcome of a decision cannot be predicted, as there is more than a single possible outcome. Farmers often find that their decisions turn out to be less than perfect because of changes that take place between the time the decision is made and the time the outcome of that decision is finalized. It may be that the outcomes themselves depend on the decisions of others and on future events that lie beyond the control of the farmer.

For effective decisions to be taken, farmers must have all the necessary information regarding input prices, output prices and yields, as well as other technical data.

Assessment Task:

- Do a Research Assignment on the different types of risks in starting up and managing an Agribusiness.

Reference/Source:

- Agribusiness Management and Trade_K.B.Vedamurthy
- AgEcon530 (Agricultural Marketing)_S.K. Srivastava, Scientist (Agril. Economics), NCAP
- Fundamentals of Agribusiness Management_ AgriMoon.com_TNAU, Tamil Nadu

UNIT: STARTING UP AND MANAGING AN AGRIBUSINESS

Benchmark 10.5.1.2 Explain and practice effective verbal and written communication skills required for agribusiness sales and marketing.

TOPIC: COMMUNICATION SKILLS IN SALES AND MARKETING

Learning Objectives

By the end of this topic, students will be able to:

- Identify and examine the concepts of the marketing processes in agribusiness
- Investigate and demonstrate verbal and written communication skills in sales and marketing

Essential Questions:

1. What is the marketing concept?
2. How are communication skills used in sales and marketing?

Essential Knowledge, Skills, Attitudes and Values

Essential Knowledge	• Marketing concept • Communication skills in sales and marketing.
Essential Skills	• Identify and examine the concepts of marketing processes in agribusiness • Investigate and demonstrate communication skills in sales and marketing.
Essential Attitudes & Values	• Value the importance of communication skills in agribusiness sales and marketing.

Content Background

The Marketing concept

Marketing can be defined as the process of anticipating the needs of targeted customers and finding ways to meet those needs profitably. There are several key ideas in this definition. Marketing is about anticipation. Good marketers are always working to anticipate what their customers' needs will be in the future. This may mean anticipating the features farmers will be looking for in a new tractor or it might involve anticipating the type of seasonings consumers will want in a new frozen chicken entrée. Good marketing involves having the right products and services available when the customer is ready to buy them. It follows that good agribusiness marketers know a lot about their customers.

A second key idea is the notion of a target market. Clearly, "one size does not fit all" in the food and agricultural markets. Good marketers understand this and focus their efforts on the unique needs of specific target markets or market segments. They know that the small livestock farmer needs a very different set of products and services than the large operation. Good marketers understand that a high-income, dual-career couple with no children has different needs than a young, middle-income family with two children. While agribusiness

firms may pursue more than one target market, their approach to any single-market segment involves a set of decisions tailored to the unique needs of the segment.

The final key idea in the definition of marketing is that of profitability. After careful study of a particular target market, the agribusiness marketer will likely generate a long list of products and services that the customer might be interested in who is always available for consultation, a website with links to useful information sources, and so on. The challenge for the agribusiness marketer is deciding which of these things the customer will actually pay for. Agribusiness marketers must provide customers with a set of products and services at prices that generate an acceptable rate of return for their firm.

Farmers producing agricultural produce are scattered in remote villages while consumers are in semi-urban and urban areas. This produce has to reach consumers for its final use and consumption. There are different agencies and functionaries through which this produce passes and reaches the consumer. A market channel or channel of distribution is therefore defined as a path traced in the direct or indirect transfer of title of a product as it moves from a producer to an ultimate consumer or industrial user. Thus, a channel of distribution of a product is the route taken by the ownership of goods as they move from the producer to the consumer or industrial user. Factors affecting channels: There are several channels of distribution depending upon type of produce or commodity. Each commodity group has slightly different channel. The factors are:

1. Perishable nature of produce, e.g fruits, vegetables, flowers, milk, meat, etc.
2. Bulk and weight—cotton, fodders are bulky but light in weight.
3. Storage facilities.
4. Weak or strong marketing agency.
5. Distance between producer and consumer. (Whether local market or distant market)

These channels have great influence on marketing costs such as transport, commission charges, etc. and market margins received by the intermediaries such as trader, commission agent, wholesaler and retailer. Finally, this decides the price to be paid by the consumer and share of it received by the farmer producer. That channel is considered as good or efficient which makes the produce available to the consumer at the cheapest price also ensures the highest share to the producer."

Communication Skills in Sales and Marketing

Verbal Communication

Verbal communication is any form of communication that consists of either spoken or written words. In agribusiness sales and marketing, it will form the content of presentation. The sales person must always be sure that the words correctly express the message he or she trying to send. Spoken or written words need to inform the customer about the product or service that the sales person is providing and persuade him or her to purchase it. Verbal

communication is used to supply the customer with technical information, facts about features or benefits, and information about problems or concerns about the product.

A person in sales and marketing will find that spoken communication is used on daily basis to conduct business. It is therefore important to the sales person and the customer that the technical and product-related terms are correctly used and in a manner in which they are used are the foundation of a solid business relationship with customers.

In addition, salespeople must ensure that they do not become too technical and discuss the product at a level the customer cannot understand. They should also avoid discussing it in very simple terms that insult the customer's intelligence. A salesperson can alienate, annoy, or lose the interest of the customer if he/she goes to either extreme.

Effective Listening Skills

Like good spoken communication skills, effective listening is a crucial part of the communication process. A salesperson must not only be able to speak well but also cultivate his/her listening skills, which can be vital to picking up the information needed to make a sale. One key in closing a sale is listening carefully to the customer's needs, concerns, and acceptance of being "sold".

The salesperson must probe for needs, so that he/she can match those needs with appropriate benefit that the product can provide. Customer concerns must be identified and appropriately addressed. Careful listening can give the salesperson signals about when to close the sale.

The salesperson also does not want to extend sales presentation past the point that the customer decides to make a purchase, thus wasting both the customer's and his/her own time and possibly annoying the customer.

A salesperson with effective listening skills is more aware of the customer's listening skills and anything that might cause distraction that might hinder a sale. Any distraction may cause the message to not to be received inaccurately.

A person must develop communication skills to be successful as a sales representative. Verbal and listening skills are the most powerful tools salespersons will use in his/her career. Salespeople must be able to write and speak correctly, listen well and identify any distractions to listening, and recognize and use non-verbal communication.

Written Communication Skills

Written communication skills are used frequently in sales process and can be very effective if utilized properly. Several forms of written communication are used in the sales process.

Written communication skills used in agribusiness takes several forms. The most commonly used forms are letters and memos, sales proposals, reports, product analysis/information sheets, manuals, bulletins and flyers, and demonstration materials.

The reason that written communication skills are important is because written communication is used to support the oral part of the sales presentation. The salesperson should keep in mind that written communication is the most effect way to make a sale with some customers. It also presents information in black and white, which may make it easier for the customer to absorb and retain that information. Another advantage is that customers can often keep them and review the information later, thus allowing them to become familiar with the product or service.

In general, using written communication skills reduces the chances of misunderstanding between the salesperson and the customer.

Assessment Task:

- Students will demonstrate written communication skills to write a proposal for the sale of an agriculture product.
- Research on the Concept of Marketing

Reference/Source:

- Agribusiness Management and Trade_K.B.Vedamurthy
- AgEcon530 (Agricultural Marketing)_S.K. Srivastava, Scientist (Agril. Economics), NCAP
- Fundamentals of Agribusiness Management_ AgriMoon.com_TNAU, Tamil Nadu

UNIT: STARTING UP AND MANAGING AN AGRIBUSINESS

Benchmark 10.5.1.3 Investigate and explain the processes of obtaining and managing start-up capital, including finance, for an agribusiness and evaluate their strengths and weaknesses.

TOPIC: AGRIBUSINESS START-UP CAPITAL

Learning Objectives

By the end of this topic, students will be able to:

- Investigate and discuss the process of obtaining start-up capital for an agribusiness
- Examine the concepts of managing capital
- Research and identify the strengths and weaknesses of obtaining capital.

Essential Questions:

1. What is Capital?
2. How can an agribusiness obtain and manage Start-up Capital?
3. What are the strengths and weaknesses of obtaining capital?

Essential Knowledge, Skills, Attitudes and Values

Essential Knowledge	• Characteristics of Capital • Loans • Equity Capital
Essential Skills	• Investigate and discuss the process of obtaining start-up capital • Examine the concepts of managing capital • Research and identify the strengths and weaknesses of obtaining capital
Essential Attitudes & Values	• Appreciate the importance of institutions that provide capital to new or existing agribusinesses.

Content Background

Capital Management in Agribusiness

Capital is not an original factor like land, but it is the result of man-made efforts. Man makes the capital goods to produce other goods and services, which provides income.

Examples are machinery, raw material, transport equipment, dams, etc.

- Capital is produced means of production.
- Karl Marx in his book “Das Kapital” defined “capital is crystallised labour.”

All capital is necessarily wealth, but all wealth is not necessarily capital. Money if used for the purchase of capital goods, then only it becomes capital. Example, residential buildings are the wealth of the individuals, but these are not considered as capital. However, rent from that building is capital.

Characteristics of Capital

The following are the characteristics of capital:

- Capital is not a free gift of nature. It is the result of the man-made efforts.
- Capital is productive, as it helps in enhancing the overall productivity of all the resources employed in the production process. Invested capital provides interest for its productive capacity. Farm machinery, when used with skilled labourers enhances the productivity of land. Irrigation dam, by providing water can bring out complementary effect on the productivity of other resources like fertilizers, seeds, etc.
- Capital is prospective, as its accumulation rewards income in future. Example, savings and investment in the economy leads to growth and development of the economy due to accumulation of capital over time.
- Capital is highly mobile among factors of production. Example, tractor.
- Capital is supply-elastic, as its supply can be altered according to the need. Based on demand, supply of the capital goods can be changed.

Economists speak of capital as wealth, which is used in the production of additional wealth. Business men frequently use the word capital in the sense of the total assets employed in a business. In law, capital usually means capital stock. A financial manager determines the proper capital structure for his firm. He determines the mix of debt and equity stock. The balancing of the capital expenditures against estimated savings in future requires careful analysis while dealing with the financial aspects of the company's operations. A careful balancing of facilities at each stage of the productive process is necessary to avoid higher operating costs and delay caused by facility bottlenecks and the freezing of capital in idle equipment.

Long-range planning for the capital management/expenditures is essential due to the following reasons:

- It helps in fitting yearly corporate expansion on orderly plan of growth by adopting capital expenditures to anticipated sales requirements.
- It assists in testing the profitability of capital expenditure over a period of time as against in the next following year.
- It facilitates in contracting for plant sites, construction, water or power requirements, etc., in advance.
- Aids to assess the necessary funds provided by internal or external sources.
- Assist in examining the impact of capital expenditures on depreciation, insurance expenses and other fixed expenses in advance in order to make the necessary allowance for them.

Obtaining Capital

Short-term loans are generally defined as loans for one year or less, and they are used whenever the requirement for additional funds is temporary. An important characteristic of short-term loans is that they are usually self-liquidating, that is, they often start a chain reaction process that results in their repayment:

Loan inventories = receivables = cash = repay loan

While short-term loans may be made on an unsecured basis to firms that are well established, there is often a requirement for collateral, or for the loan to be secured by some of the firm's assets. Collateral can take many forms, but for short-term loans it most often takes the form of current assets. Some of the most common kinds of collateral are inventory, accounts receivable, warehouse receipts, and marketable securities. Also, a personal guarantee of the loan is often required by the owners of smaller agribusinesses. In other words, the owner or owners endorse the obligation to repay the debt, and become personally liable if the firm is unable to meet the payment.

Short-term loans may be regular-term loans, with a specific amount due at a specified time, or they may be revolving or line of credit loans. Managers who anticipate a need for short-term funds often apply for a line of credit in advance of their needs. A line of credit is a commitment by the lender to make available a certain sum of money to the firm, usually for a one-year period and at a specified rate of interest, at whatever time the firm needs the loan. Usually, the loan must be repaid during the operating year of the firm.

With a line of credit, a manager is assured of protection in the form of cash that is available as it is needed; there is also the added advantage of not incurring interest on the borrowed funds until they are actually used. Lenders who make a line of credit available to an agribusiness often require that a monthly copy of the firm's financial statements be furnished to them so that they can monitor the financial health of the firm.

Intermediate-term loans are typically used to provide capital for one to five years. Such a loan is almost always amortized; that is, the process in which the amount of a loan is reduced by equal, periodic (i.e., monthly, quarterly, annual, etc.) loan payments. These payments include both interest and principal. The purpose of the intermediate-term loan is to provide the agribusiness with a source of capital that will allow growth or modernization without forcing the owners to surrender control of the business. These loans allow for additional working capital, which can be used to increase revenues and sales; the funds generated by the increased revenues will, in turn, help to retire the loan.

In many respects the intermediate-term loan is similar to the short-term loan. Most require some sort of collateral and/or security against fixed assets, if that is the purpose of the loan. Intermediate-term loans provide permanent increases in capital for the agribusiness whenever larger inventories, larger accounts receivable, new equipment, and/or modernization are essential to the growth and profitability of the firm.

Long-term loans

In general, long-term loans have a duration of more than five years. The time distinctions among these loans are somewhat arbitrary, and there is some overlap in the functions of intermediate- and long-term loans, depending on the philosophies and policies of lender and borrower. But the real difference between intermediate and long-term loans usually rests with the planned use for the funds, as well as with the long-term prospects for the existence of the

firm and its solvency. The purpose of the long-term loan is most often for real estate, that is, for land and buildings. As the lender examines requests for long-term loans, he or she becomes deeply concerned with evaluating the past track record of the firm, the skill and ability of the management team, and the stability of the business enterprise. The collateral for long-term loans is usually a mortgage or claim on the fixed assets of the firm, and the longer the period of the loan, the riskier it becomes for the lender. There is always the chance that an unstable enterprise will be forced to dispose of fixed assets in a forced sale, where these assets may bring only a fraction of their value at the time the loan was closed.

Long-term loans are nearly always amortized over the loan period and secured by a mortgage or claim on a specific fixed asset. Sometimes bonds are used to secure long-term capital, but a small firm seldom has the size or financial strength to sell a bond issue.

Equity capital

If the agribusiness is not in a strong financial position or cannot meet the stiff collateral requirements set by lenders, it may have to turn to equity capital to meet its long-term needs. Equity capital can be used for the same purpose as borrowed funds, but there is an important difference: equity capital does not have to be repaid. It becomes a permanent part of the capital of the business. Equity capital is secured either by reinvesting profits from the business or by finding investors who are willing to invest additional funding in the business.

Lenders pay particular attention to equity when they are making long-term loan commitments, and they may insist that a larger percentage of the owner's money be invested in the capital of the agribusiness than the lenders'. This is particularly true of new businesses, where risks are more difficult to calculate. Some owners do not wish to increase their equity for various reasons, but it may be the only prudent way of securing long-term capital funds.

Assessment Task:

- Investigate the complete process of applying for a loan as start-up capital.
- Practice filling in various loan application forms as start-up capital for an Agribusiness.
- Explain the understanding of Capital.

Reference/Source:

Agribusiness Management and Trade_K.B.Vedamurthy
 AgEcon530 (Agricultural Marketing)_S.K. Srivastava, Scientist (Agril. Economics), NCAP
 Fundamentals of Agribusiness Management_ AgriMoon.com_TNAU, Tamil Nadu

Standards-Based Lesson Planning

What are Standards-Based Lessons?

In a Standards-Based Lesson, the most important or key distinction is that, a student is expected to meet a defined standard for proficiency. When planning a lesson, the teacher ensures that the content and the methods of teaching the content enable students to learn both the skills and the concepts defined in the standard for that grade level and to demonstrate evidence of their learning.

Planning lessons that are built on standards and creating aligned assessments that measure student progress towards standards is the first step teacher must take to help their students reach success. A lesson plan is a step-by-step guide that provides a structure for an essential learning.

When planning a standards-based lesson, teacher instructions are very crucial for your lessons. How teachers instruct the students is what really points out an innovative teacher to an ordinary teacher. Teacher must engage and prepare motivating instructional activities that will provide the students with opportunities to demonstrate the benchmarks. For instance, teacher should at least identify 3-5 teaching strategies in a lesson; teacher lectures, ask questions, put students into groups for discussion and role play what was discussed.

Why is Standards-Based Lesson Planning Important?

There are many important benefits of having a clear and organized set of lesson plans. Good planning allows for more effective teaching and learning. The lesson plan is a guide and map for organizing the materials and the teacher for the purpose of helping the students achieve the standards. Lesson plans also provide a record that allows good, reflective teachers to go back, analyze their own teaching (what went well, what didn't), and then improve on it in the future.

Standards-based lesson planning is vital because the content standards and benchmarks must be comparable, rigorous, measurable and of course evidence based and be applicable in real life that we expect students to achieve. Therefore, teachers must plan effective lessons to teach students to meet these standards. As schools implement new standards, there will be much more evidence that teachers will use to support student learning to help them reach the highest levels of cognitive complexity. That is, students will be developing high-level cognitive skills.

Components of a Standards-Based Lesson Plan

An effective lesson plan has three basic components;

- objectives of the lesson;
- teaching and learning activities;

- assessments to check student understanding of the topic.

Effective teaching demonstrates deep subject knowledge, including key concepts, methodologies, tools and techniques, and meaningful applications.

Planning for under-achievers

Who are underachieving students? Under achievers are students who fail or do not perform as expected. Underachievement may be caused by emotions (low self-esteem) and the environment (cultural influences, unsupportive family)

How can we help underachievement?

Underachievement varies between students. Not all students are in the same category of underachievement.

Given below a suggested strategies teachers may adopt to assist underachievers in the classroom.

- Examine the Problem Individually

It is important that underachieving students are addressed individually by focusing on the student's strengths.

- Create a Teacher-Parent Collaboration

Teachers and parents need to work together and pool their information and experience regarding the child.

Teachers and parents begin by asking questions such as;

- In what areas has the child shown exceptional ability?
- What are the child's preferred learning styles?
- What insights do parents and teachers have about the child's strengths and problem areas?

- Help student to plan every activity in the classroom
- Help students set realistic expectations
- Encourage and promote the student's interests and passions.
- Help children set short and long-term academic goals
- Talk with them about possible goals.
- Ensure that all students are challenged (but not frustrated) by classroom activities
- Always reinforce students

Sample Standards-Based Lesson Plan

The following sample lesson can help teachers to plan effective lessons. Teachers are encouraged to study the layout of the different components of these lessons and follow this design in their preparation and teaching of each lesson. Planning a good lesson helps the teacher in maintaining a standard teaching pattern which should not deviate students learning of the concept from the topic.

Sample Lesson Plan

TOPIC: Agribusiness Communication skills in Sales and Marketing

Lesson Topic: Communication Skills in Sales and Marketing

Grade: 10

Length of Lesson: 40 minutes

National Content Standard: Content Standard 10.5.1 Students will be able to examine the different principles, practices, characteristics, enablers and contexts of business, and explore how agriculture businesses are started and managed in different contexts.

Grade-Level Benchmark

Benchmark 10.5.1.1 Explain and practice effective verbal and written communication skills required for agribusiness sales and marketing.

Essential Knowledge, Skills, Values, and Attitudes

Knowledge: Communication skills in sales and marketing.

Skills: Investigate and demonstrate communication skills in sales and marketing.

Values: Value the importance of communication skills in agribusiness sales and marketing.

Attitudes: Appreciate communication skills in Agribusiness Sales and Marketing

Materials: Handouts on Verbal and Written Communication skills, samples of documents (e.g. sales proposal for an agriculture product)

Lesson Objective: By the end of the lesson, the students will be able to;

- examine and identify verbal and written communication skills in sales and marketing
- demonstrate the use of communication skills in the sales or marketing of an agriculture product.

Essential Questions:

1. Why are communication skills important in sales and marketing?
2. How are communication skills used in sales and marketing?

Sample Lesson Procedure

Teacher Activities	Student Activities
Introduction	
Why is communication important in sales and marketing in Agribusiness?	Refer to handouts and explain the two skills of communication in Sales and Marketing.
Outline objectives and expected standards for this lesson	
Body	
Modelling	
Explain how verbal skills of communication can be applied in sales and marketing. Display and explain samples of written forms of communication in sales and marketing	Take note of the specific communication skills required in Sales and Marketing.
Guided Practice	
Outline the important steps of written communication skills such as letters and memos, sales proposals, reports, product analysis/information sheets, manuals, bulletins and flyers, and demonstration materials.	Make a plan on how to use a specific written form of communication skill to sell or market an agriculture product.
Independent Practice	
Ask students to write up a sample outline of a sales proposal for an agricultural product.	Draw up a plan or written outline of a sales proposal for an agriculture product.
Conclusion	
Assess students understanding of their sales proposals by confirming the outlines of their proposals.	Present their sales proposal outlines to the class of What and How the group intends to sell or market a certain product.
Assessment Task: Write up a <i>sales proposal</i> to business houses or companies to market an Agribusiness Product for the school.	

Sample Assessment

Performance Assessment and Standards (Formative Assessment)

National Content Standard:				
Lesson Topic	Topic	Benchmark	Performance Assessment/ Indicator	
Communication Skills in Sales and Marketing	Agribusiness Communication skills in Sales and Marketing	Benchmark 10.5.1.1 Explain and practice effective verbal and written communication skills required for agribusiness sales and marketing.	Oral Presentation-Demonstrate effective verbal communication skills to market a product.	
			PROFICIENCY RUBRIC -Holistic	
			Advanced	Proficient
			Partially Proficient	Novice
			Demonstrated strong verbal communication skills effectively in marketing an Agribusiness product.	Demonstrated verbal communication skills effectively in marketing an Agribusiness product
			Demonstrated few verbal communication skills in marketing an Agribusiness product	Did not demonstrate effective verbal communication skills in marketing.

Performance Assessment and Standards (Authentic-Summative Assessment)

National Content Standard:				
Lesson Topic	Topic	Benchmark	Performance Assessment/Indicator	
Communication Skills in Sales and Marketing	Agribusiness Communication skills in Sales and Marketing	Benchmark 10.5.1.1 Explain and practice effective verbal and written communication skills required for agribusiness sales and marketing.	Develop and write up a sales proposal to business houses or companies to market an Agribusiness Product from an existing Agriculture Project in the school.	
			PROFICIENCY RUBRIC	
Criteria	Exemplary	Proficient	Partially Proficient	Novice
Effort	Students' proposal is outstanding showing creativity, well organized with great effort.	Students' proposal met most expectations and with satisfactory effort.	Students' proposal shows minimal effort. Has some errors and could have added more.	Students' proposal shows no creativity with very little effort.
Content	Students understood the concepts of marketing their product and did more than what was expected and added more detail to complete the proposal.	Student understood the concepts of marketing their product and completed all the requirements for the proposal.	Students understood the concepts of marketing their product but did not complete all the requirements for the proposal.	Didn't incorporate all the concepts of marketing their product into proposal. Misunderstood the ideas and principles.
Context	Sales proposal is very applicable in the community or school for an Agribusiness.	Sales proposal is satisfactorily applicable in the community or school for an Agribusiness	Sales proposal is less applicable in the community or school for an Agribusiness.	Sales proposal is not applicable in the community or school for an Agribusiness.

Sample Lesson Plan Integrating STEAM

TOPIC: Fish Farming Management Practices and Systems

Lesson Topic: Fish Farming Systems in Freshwater

Grade: 10

Length of Lesson: 40 mins (Theory) and 160 mins During Project Period (Practical)

National Content Standard:

Content Standard 3.2: Students will be able to investigate and analyse the different types of aqua farming and management principles, systems, and practices used in different environments and places to farm, process, preserve, market, regulate, and consume plants, animals and fish.

Grade-Level Benchmark; 10.3.2.1. Explore and analyse fish farming and management practices and systems used in different places and environments.

Essential Knowledge, Skills, Attitudes & Values:

Knowledge	- The four common ways of fish management and production systems. - Pond System - Open Net Pens - Submersible Net Pens - Recirculating Systems - Fish farming management techniques - Fish handling
Skills	- Distinguish between the common methods of fish production - Identify key areas of management and apply appropriate measures to maintain quality - Apply correct techniques when handling fish to maintain freshness of fish. - Assess the freshness of fish by sensory or chemical methods - Formulate checklists to check on the different areas
Attitudes	- Be responsible and caring for properties - Appreciate the importance of proper fish handling techniques
Values	- Affective and concerned about the importance of good management practices - Rational and honest when expressing the importance of proper fish handling techniques

Lesson Knowledge, Skills, Values and Attitudes including STEAM Knowledge and Skills.

Knowledge: Fish farming management systems and practices in different environments such as freshwater, brackish and marine water and their benefits.

Skills: Describe and illustrate freshwater fish farming management systems in different environments.

Values: gratitude for benefits and purposes of freshwater fish farming management systems

Attitudes: Interest and confident in freshwater fish farming using fish farming management systems.

STEAM Knowledge and Skill:

Knowledge: Science, Technology, Engineering, Arts

Skill: Design a Freshwater fish farming system and implement as a project for the school.

Performance Indicator:

Efficiently and effectively designed and implemented a freshwater fish farming system in the school.

- **STEAM Performance Indicator:** (rubrics can be designed to assess the project)
 - Science:
 - Technology used:
 - Design:
 - Mathematics application:
-

Materials: Selected materials specific to the project needs.

Lesson Objective: By the end of the lesson, students will be able to:
Design and implement a Semi-intensive freshwater fish farming system in their school e.g. fish pond

Essential questions:

- What are the benefits and purposes of freshwater fish farming management systems?
 - How are fish farming management practices applied in various environments?
-

Standards-Based Assessment, Monitoring and Reporting

What is Standards-Based Assessment (SBA)?

Standards-Based Assessment is an on-going and a systematic process of **assessing, evaluating, reporting** and **monitoring** students' performance and progression towards meeting grade and national level expectations. It is the measurement of students' proficiency on a learning objective or a specific component of a content standard and progression towards the attainment of a benchmark and content standard.

Purpose of Standards-Based Assessment

Standards-Based Assessment (SBA) serves different purposes. These include instruction and learning purposes. The primary purpose of SBA is to improve student learning so that all students can attain the expected level of proficiency or quality of learning.

Enabling purposes of SBA is to:

- measure students' proficiency on well-defined content standards, benchmarks and learning objectives
- ascertain students' attainment or progress towards the attainment of specific component of a content standard
- ascertain what each student knows and can do and what each student needs to learn to reach the expected level of proficiency
- enable teachers to make informed decisions and plans about how and what they would do to assist weak students to make adequate progress towards meeting the expected level of proficiency
- enable students to know what they can do and help them to develop and implement strategies to improve their learning and proficiency level
- communicate to parents, guardians, and relevant stakeholders the performance and progress towards the attainment of content standards or its components
- compare students' performances and the performances of other students

Principles of Standards-Based Assessment

The principle of SBA is for assessment to be;

- emphasizing on tasks that should encourage deeper learning
- be an integral component of a course, unit or topic and not something to add on afterwards
- a good assessment requires clarity of purpose, goals, standards and criteria
- of practices that should use a range of measures allowing students to demonstrate what they know and can do
- based on an understanding of how students learn
- of practices that promote deeper understanding of learning processes by

- developing students' capacity for self-assessment
- improving performance that involves feedback and reflection
- on-going rather than episodic
- given the required attention to outcomes and processes
- be closely aligned and linked to learning objectives, benchmarks and content standards

Standards-Based Assessment Types

In standards-Based Assessment, there are three broad assessments types.

1. Formative Assessment

Formative assessment includes 'assessment *for* and *as*' and is conducted during the teaching and learning of activities of a topic.

Purposes of assessment for Learning

- On-going assessment that allows teachers to monitor students on a day-to-day basis.
- Provide continuous feedback and evidence to the teachers that should enable them to identify gaps and issues with their teaching, and improve their classroom teaching practice.
- Helps students to continuously evaluate, reflect on, and improve their learning

Purposes of assessment as Learning

- Occurs when students reflect on and monitor their progress to inform their future learning goals
- Helps students to continuously evaluate, reflect, and improve their own learning
- Helps students to understand the purpose of their learning and clarify learning goals

2. Summative Assessment

Summative assessment focuses on 'assessment *of learning*' and is conducted after or at the conclusion of teaching and learning of activities or a topic.

Purposes of assessment of Learning

- Help teachers to determine what each student has achieved and how much progress he/she has made towards meeting national and grade-level expectations
- Help teachers to determine what each student has achieved at the end of a learning sequence or a unit.
- Enable teachers to ascertain each student's development against the unit or topic objectives and to set future directions for learning.
- Help students to evaluate, reflect on, and prepare for next stage of learning

3. Authentic Assessment

- Is performed in a real life context that approximates as much as possible, the use of a skill or concept in the real world.
- Is based on the development of a meaningful *product, performance or process*
- Students develop and demonstrate the application of their knowledge, skills, values and attitudes in real life situations which promote and support the development of deeper levels of understanding.

Authentic assessment refers to assessment that:

- Looks at students actively engaged in completing a task that represents the achievement of a learning objective or standard
- Takes place in real life situations
- Asks students to apply their knowledge, skills, values and attitudes in real life situations
- Students are given the criteria against which they are being assessed

Performance Assessment

Performance assessment is a form of testing that requires students to perform a task rather than select an answer from a ready-made list. For example, a student may be asked to explain historical events, generate scientific hypotheses, solve math problems, converse in a foreign language, or conduct research on an assigned topic. Teachers, then judge the quality of the student's work based on an agreed-upon set of criteria. It is an assessment which requires students to demonstrate that they have mastered specific skills and competencies by performing or producing something.

Types of performance assessment;

i. Products

This refers to concrete tangible items that students create through either the visual, written or auditory media such as;

- Creating a health/physical activity poster
- Video a class game or performance and write a broadcast commentary
- Write a speech to be given at a school council meeting advocating for increased time for health and Agriculture in the curriculum
- Write the skill cues for a series of skill photo's
- Create a brochure to be handed out to parents during education week
- Develop an interview for a favourite sportsperson
- Write a review of a dance performance
- Essays
- Projects

ii. Process Focused Tasks

It shows the thinking processes and learning strategies students use as they work such as;

- Survival scenarios
- Problem solving initiative/adventure/ activities

Decision making such as scenario's related to health issues
 Event tasks such as creating a game, choreographing a dance/gymnastics routine, creating an obstacle course
 Game play analysis
 Peer assessment of skills or performances
 Self-assessment activities
 Goal setting, deciding a strategy and monitoring progress towards achievement

iii. Portfolio

This refers to a collection of student work and additional information gathered over a period of time that demonstrates learning progress.

iv. Performances

It deals with observable affective or psycho-motor behaviours put into action such as;

- Skills check during game play
- Role plays
- Officiating a game
- Debates
- Performing dance/gymnastics routines
- Teaching a skill/game/dance to peers

Performance Standards

Performance Standards are concrete statements of how well students must learn what is set out in the content standards, often called the “be able to do” of “what students should know and be able to do.” Performance standards are the indicators of quality that specify how competent a students’ demonstration or performance must be. They include explanations of how well students must demonstrate the content, explaining how good is good enough.

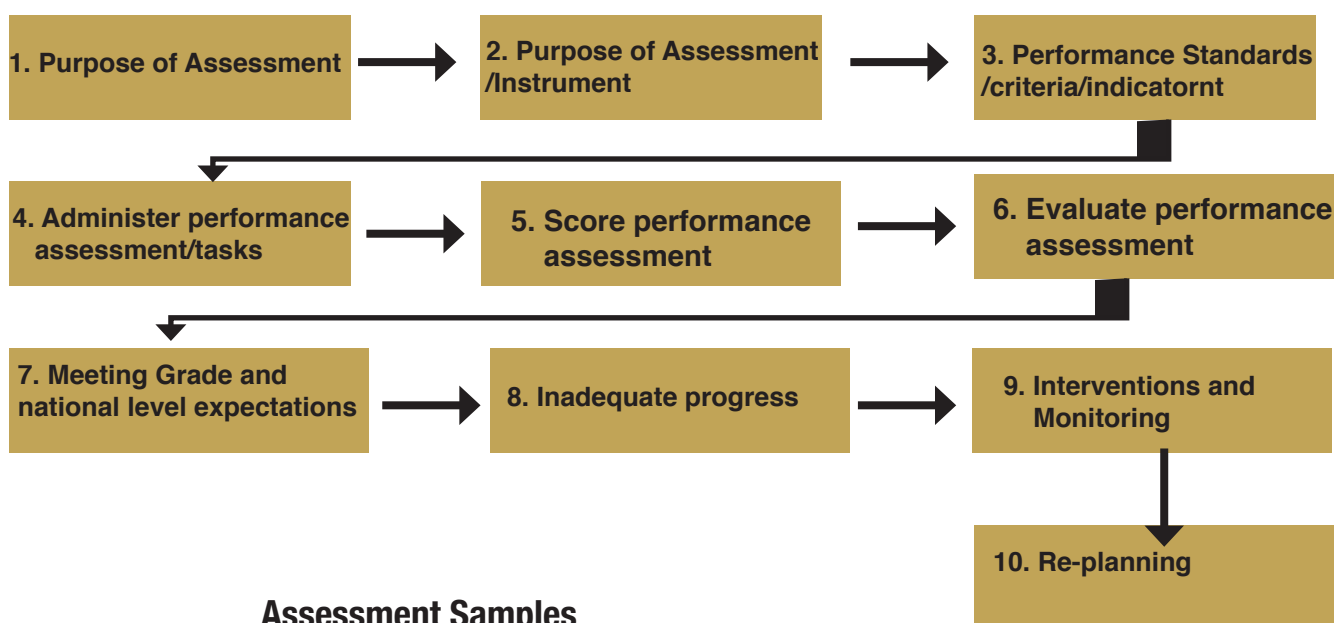
Performance standards:

- measure students’ performance and proficiency (using performance indicators) in the use of a specific knowledge, skill, value, or attitude in real life or related situations
- provide the basis (performance indicators) for evaluating, reporting and monitoring students’ level of proficiency in use of a specific knowledge, skills, value, or attitude
- are used to plan for individual instruction to help students not yet meeting expectations (desired level of mastery and proficiency) to make adequate progress towards the full attainment of benchmarks and content standards
- are used as the basis for measuring students’ progress towards meeting grade-level benchmarks and content standards

Assessment Strategies

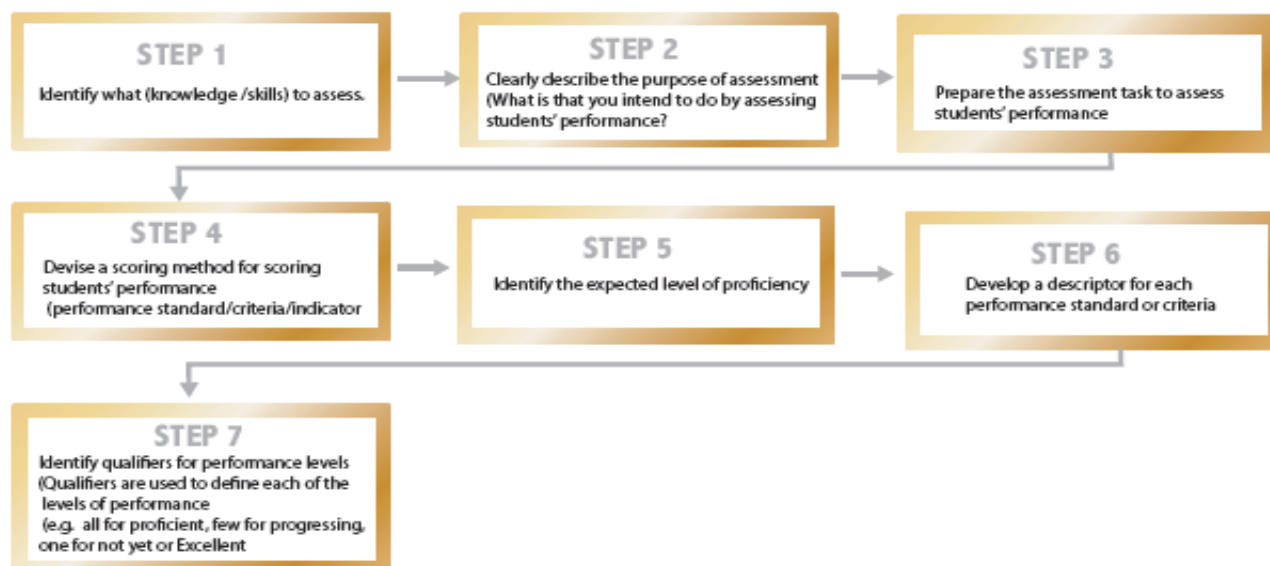
It is important for teachers to know that, assessment is administered in different ways. Assessment does not mean a test only. There are many different ways to find out about student's strengths and weaknesses. Relying on only one method of assessing will not reflect student's achievement. Provided in the appendices is a list of suggested strategies you can use to assess student's performances. These strategies are applicable in all the standards-based assessment types. ***Please refer to the Appendices to see the suggested strategies.***

Standards-Based Assessment Process



Assessment Samples

Teachers are required to use the steps outlined below when planning assessment. These steps will guide you to develop effective assessments to improve student's learning as well as evaluating their progress towards meeting national and grade –level expectations.



Glossary

WORDS/VOCABULARY	DEFINITION/MEANING
Agri silvicultural system	It is a combination of crops and trees
Agroforestry	Is a term used to describe a system where through some kind of special arrangement or temporal sequence trees, shrubs etc. are grown in the same land management units such as agricultural crops and animals
Agronomy	The science of crop and soil management for crop production.
Agrosylvopastoral system	It is a combination of trees, animals and crops.
Animal Husbandry	The science of looking after and breeding farm animals.
Animal Nutrition	The science that studies the quantity and proportions of nutrients needed or found in animal food
Annual crop	Crop that grows, reproduces and dies within one year, eg corn, beans, rice, cabbages, etc
Aqua Plant Organisms	Microalgae, phytoplankton, microphysics or planktonic algae; Gelidium, Pterocladia, Porphyry, and Luminaire – produce agar and carrageenan products.
Aquaculture	Water farming of all aquatic forms like fish, prawns, molluscs and sea weeds in fresh, brackish as well as in marine waters
Aquaponics	The integration of recirculating aquaculture and hydroponics in one production system.
Aviculture	Looking after and breeding birds
Biennial Crop	Crop that requires two years to reach maturity. In the first year, it produces leaves and in the second it flowers and produces seeds and then dies, eg cabbages, onions, leeks
Biofilter	Filter used to filter water for the fish
Biofuel	fuel derived from living matter
Budding	Method of producing new plants in which a piece of bark containing a bud is removed from one plant and attached to another plant through a cut in the bark
Business plan	A detailed plan setting out the objectives of a business over a stated period, often three, five or ten years. For new business it is an essential document for raising capital or loans, for a group of companies the business plan is written is often called a cooperate plan
Cash flow	The total amount of cash being received and paid out by a business
Commercial Farming	Large-scale farming in which many hectares of land are cultivated, usually using machines
Contour Farming	Making ridges and planting beds across hill slopes
Cropping System	Pattern of growing crops in garden, eg mixed cropping or intercropping
Cultivation	Shallow tillage or digging of the soil to loosen it so that water can soak into the soil. It is also for removing weeds
Deep litter system	Method of keeping chickens in which the floor is covered with such materials as sawdust, coffee husks, wood shavings, grass clippings etc
Ecological Control	Changing the environment of the crop or animal so that germs are unable to live. The burning of diseased plant parts animals is a way of controlling further spread of diseases
Ecological System	Group of living things and their surroundings or environment; ecosystem
Entrepreneur	An individual who undertakes to supply a good or service to the market

Farming System	Different methods used to keep animals or grow crops. It includes the various ways of keeping animals in the houses or allowing them to roam, and cropping systems such as shifting cultivation, bush fallow system, continuous cropping, mixed cropping, etc
Feed Conversion Ratio	Amount of feed that an animal eats compared with the amount of weight that it gains, eg 5 kg feed and gains 1 kg weight, its feed conversion ratio is 5:1
Financial report	A document giving a formal account of the revenue and expenses of a business
Fodder	Dried food used for food for animals such as dried grass, hay.
Forage	Leaves and stems, fresh or preserved, collected and fed to animals
Genetic Engineering	Changing genes in an effort to increase or decrease the strength of inherited characteristics, eg increasing fruit yield or resistance to a particular disease
Heterophyte	Plant that depends on dead or living plants or their products as its source of food
Heterotroph	Living things that get their food by breaking down organic matter. Many plants that do not have green colouring matter live in this way, and help to decompose rubbish in the environment
Horticultural crop	Any fruit or vegetable producing plant such as pineapple, banana, orange, cabbage, tomato
Horticulture	The science of growing vegetables, flowers and fruits
Hydrophytic plants	Aquatic plants that have adapted to living in aquatic environments
Industrial crops	Crops which are not sold directly for consumption because they need to be industrially processed.
Inorganic fertilizer	Plant food made up of artificial substances, not from plant and animal matter
Macronutrients	Nutrients that your body needs in large amounts, which include fat, carbohydrates, and protein
Market	A place where people meet to buy and sell goods (Merchandise)
Marketing concept	The process of anticipating the needs of targeted customers and finding ways to meet those needs profitably
Micronutrients	Vitamins and minerals needed by the body in very small amounts.
Micro-organisms	An organism of microscopic size which may exist in its single-celled form or as a colony of cells.
Monoculture	Fish production system in which only one fish species is reared in a culture system
Monogastric Animals	Animals that have one stomach and many are omnivorous in their feeding behavior, like pigs. They eat both plant matter and animal matter.
Mortgage	A loan with security taken to purchase a house, building or shares, etc,
Natural Resource	Any materials provided by nature, eg forest trees and animals, land, rivers, fish, minerals, petroleum
Net profit	Amount of money remaining when all working expenses in a farm enterprise or other projects have been removed
Nutrition	Study of the amounts and proportions of substances that can be used as food
Organic farming	Growing crops with the use of compost, manures and other natural plant food without the use of any artificial fertilisers or commercially produced plant food
Organic fertilizer	Plant food made from the remains of plants and animals

Organic matter	Decayed remains of plants and animals added to the soil to enrich it. Organic matter makes up about 5% of the soil by volume
Ornamental crop	Plants or garden plants that are grown for decorative purposes.
Pastoral farming	Methods of farming in which herdsman or shepherds keep and care for domestic animals
Perennial crop	Crop that grows for many years, eg cocoa trees, coffee trees, oil palm, coconut trees, mangoes and orange trees
Polyculture	Fish production system in which two or more different fish species are farmed or culture of fish along with some other aquatic animals like shrimp or prawn.
Polygastric Animals	Animals that have two more storage compartment stomachs and are herbaceous in their feeding behaviour like cows and sheep.
Quarantine	Separation of sick animals or plants from healthy ones. Such separation ensures that the disease does not spread to healthy animals or plants. When an animal or plants or animal/plant materials is brought into a country from overseas, the animal or plant is normally housed or kept away from others until it is certain that it carries no disease. This is to ensure that no new diseases are introduced into the country. The rules of quarantine are called quarantine laws.
Silage crops	Any crop that is harvested green and preserved in a succulent condition by partial fermentation in a more or less airtight container such as a silo.
Silvopastoral system	It is a combination of domesticated animals and forestry.
System cycling	Term used to describe the initial process of building a bacterial colony when first starting any aquaponic unit

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Appendices

Appendix 1: The Blooms Taxonomy

1. **Creating:** Generating new ideas, products, or ways of viewing things such as designing, constructing, planning, producing and inventing.
2. **Evaluating:** Justifying a decision or course of action Checking, hypothesising, critiquing, experimenting and judging.
3. **Analysing:** Breaking information into parts to explore understandings and relationships. Comparing, organising, deconstructing, interrogating and finding.
4. **Applying:** Using information in another familiar situation. Implementing, carrying out and using and executing.
5. **Understanding:** Explaining ideas or concepts Interpreting, summarising, paraphrasing and classifying, explaining.
6. **Remembering:** Recalling information. Recognising, listing, describing, retrieving, naming, finding.

LEVEL OF UNDERSTANDING	KEY VERBS
CREATING Can the student create a new product or point of view?	Construct, design, and develop, generate, hypothesize, invent, plan, produce, compose, create, make, perform, plan, produce, assemble, formulate,
EVALUATING Can the student justify a stand or decision?	Appraise, argue, assess, choose, conclude, critique, decide, defend, evaluate, judge, justify, predict, prioritize, provoke, rank, rate, select, support, monitor,
ANALYZING Can the student distinguish between the different parts?	Analyzing, characterize, classify, compare, contrast, debate, criticise, deconstruct, deduce, differentiate, discriminate, distinguish, examine, organize, outline, relate, research, separate, experiment, question, test,
APPLYING Can the student use the information in a new way	Apply, change, choose, compute, dramatize, implement, interview, prepare, produce, role play, select, show, transfer, use, demonstrate, illustrate, interpret, operate, sketch, solve, write,
UNDERSTANDING Can the student comprehend ideas or concepts?	Classify, compare, exemplify, conclude, demonstrate, discuss, explain, identify, illustrate, interpret, paraphrase, predict, report, translate, describe, classify,
REMEMBERING Can the student recall or remember the information?	Define, describe, draw, find, identify, label, list, match, name, quote, recall, recite, tell, write, duplicate, memorise, recall, repeat, reproduce, state,

Appendix 2: TEACHING AND LEARNING STRATEGIES

STRATEGY	TEACHER	STUDENTS
CASE STUDY Used to extend students' understanding of real-life issues	Provide students with case studies related to the topic of the lesson and allow them to analyse and evaluate.	Study the case study and identify the problem addressed. They analyse the problem and suggest solutions supported by conceptual justifications and make presentations. This enriches the students' existing knowledge of the topic.
DEBATE A method used to increase students' interest, involvement and participation	Provide the topic or question of debate on current issues affecting a bigger population, clearly outlining the expectations of the debate. Explain the steps involved in debating and set a criteria/ standard to be achieved.	Conduct researches to gather supporting evidence about the selected topic and summarising the points. They are engaged in collaborative learning by delegating and sharing tasks to group members. When debating, they improve their communication skills.
DISCUSSION The purpose of discussion is to educate students about the process of group thinking and collective decision.	The teacher opens a discussion on certain topic by asking essential questions. During the discussion, the teacher reinforces and emphasises on important points from students responses. Teacher guide the direction to motivate students to explore the topic in greater depth and the topic in more detail. Use how and why follow-up questions to guide the discussion toward the objective of helping students understand the subject and summarise main ideas.	Students ponder over the question and answer by providing ideas, experiences and examples. Students participate in the discussion by exchanging ideas with others.
GAMES AND SIMULATIONS Encourages motivation and creates a spirit of competition and challenge to enhance learning	Being creative and select appropriate games for the topic of the lesson. Give clear instructions and guidelines. The game selected must be fun and build a competitive spirit to score more than their peers to win small prizes.	Go into groups and organize. Follow the instructions and play to win

OBSERVATION Method used to allow students to work independently to discover why and how things happen as the way they are. It builds curiosity.	Give instructions and monitor every activity students do	Students possess instinct of curiosity and are curious to see the things for themselves and particularly those things which exist around them. A thing observed and a fact discovered by the child for himself becomes a part of mental life of the child. It is certainly more valuable to him than the same fact or facts learnt from the teacher or a book. Students Observe and ask essential questions Record Interpret
PEER TEACHING & LEARNING <i>(power point presentations, pair learning)</i> Students teach each other using different ways to learn from each other. It encourages; team work, develops confidence, feel free to ask questions, improves communication skills and most importantly develop the spirit of inquiry.	Distribute topics to groups to research and teach others in the classroom. Go through the basics of how to present their peer teaching.	Go into their established working groups. Develop a plan for the topic. Each group member is allocated a task to work on. Research and collect information about the topic allocated to the group. Outline the important points from the research and present their findings in class.
PERFORMANCE-RELATED TASKS (dramatization, song/lyrics, wall magazines) Encourages creativity and take on the overarching ideas of the topic and are able to recall them at a later date	Students are given the opportunity to perform the using the main ideas of a topic. Provide the guidelines, expectations and the set criteria	Go into their established working groups. Being creative and create dramas, songs/lyrics or wall magazines in line with the topic.
PROJECT (individual/group) Helps students complete tasks individually or collectively	Teacher outline the steps and procedures of how to do and the criteria	Students are involved in investigations and finding solutions to problems to real life experiences. They carry out researches to analyse the causes and effects of problems to provide achievable solutions. Students carefully utilise the problem-solving approach to complete projects.
USE MEDIA & TECHNOLOGY to teach and generate engagement depending on the age of the students	Show a full movie, an animated one, a few episodes form documentaries, you tube movies and others depending on the lesson. Provide questions for students to answer before viewing	Viewing can provoke questions, debates, critical thinking, emotion and reaction. After viewing, students engage in critical thinking and debate

Appendix 3: ASSESSMENT STRATEGIES

STRATEGY	DESCRIPTION
ANALOGIES	Students create an analogy between something they are familiar with and the new information they have learned. When asking students to explain the analogy, it will show the depth of their understanding of a topic.
CLASSROOM PRESENTATIONS	A classroom presentation is an assessment strategy that requires students to verbalize their knowledge, select and present samples of finished work, and organize their thoughts about a topic in order to present a summary of their learning. It may provide the basis for assessment upon completion of a student's project or essay.
CONFERENCES	A conference is a formal or informal meeting between the teacher and a student for the purpose of exchanging information or sharing ideas. A conference might be held to explore the student's thinking and suggest next steps; assess the student's level of understanding of a particular concept or procedure; and review, clarify, and extend what the student has already completed
DISCUSSIONS	Having a class discussion on a unit of study provides teachers with valuable information about what the students know about the subject. Focus the discussions on higher level thinking skills and allow students to reflect their learning before the discussion commences.
ESSAYS	An essay is a writing sample in which a student constructs a response to a question, topic, or brief statement, and supplies supporting details or arguments. The essay allows the teacher to assess the student's understanding and/or ability to analyse and synthesize information.
EXHIBITIONS/DEMONSTRATIONS	An exhibition/demonstration is a performance in a public setting, during which a student explains and applies a process, procedure, etc., in concrete ways to show individual achievement of specific skills and knowledge.
INTERVIEWS	An interview is a face-to-face conversation in which teacher and student use inquiry to share their knowledge and understanding of a topic or problem, and can be used by the teacher to explore the student's thinking; assess the student's level of understanding of a concept or procedure and gather information, obtain clarification, determine positions, and probe for motivations.
LEARNING LOGS	A learning log is an ongoing, visible record kept by a student and recording what he or she is doing or thinking while working on a particular task or assignment. It can be used to assess student progress and growth over time.
OBSERVATION	Observation is a process of systematically viewing and recording students while they work, for the purpose of making programming and instruction decisions. Observation can take place at any time and in any setting. It provides information on students' strengths and weaknesses, learning styles, interests, and attitudes.
PEER ASSESSMENT	Assessment by peers is a powerful way to gather information about students and their understanding. Students can use set criteria to assess the work of their classmates.

PERFORMANCE TASKS	During a performance task, students create, produce, perform, or present works on “real world” issues. The performance task may be used to assess a skill or proficiency, and provides useful information on the process as well as the product.
PORTFOLIOS	A portfolio is a collection of samples of a student’s work, and is focused, selective, reflective, and collaborative. It offers a visual demonstration of a student’s achievement, capabilities, strengths, weaknesses, knowledge, and specific skills, over time and in a variety of contexts.
QUESTIONS AND ANSWERS (ORAL)	In the question–and–answer strategy, the teacher poses a question and the student answers verbally, rather than in writing. This strategy helps the teacher to determine whether students understand what is being, or has been, presented, and helps students to extend their thinking, generate ideas, or solve problems.
QUIZZES, TESTS, EXAMINATIONS	A quiz, test, or examination requires students to respond to prompts in order to demonstrate their knowledge (orally or in writing) or their skills (e.g., through performance). Quizzes are usually short; examinations are usually longer. Quizzes, tests, or examinations can be adapted for exceptional students and for re-teaching and retesting.
QUESTIONNAIRES	Questionnaires can be used for a variety of purposes. When used as a formative assessment strategy, they provide teachers with information on student learning that they can use to plan further instruction.
RESPONSE JOURNALS	A response journal is a student’s personal record containing written, reflective responses to material he or she is reading, viewing, listening to, or discussing. The response journal can be used as an assessment tool in all subject areas.
SELECTED RESPONSES	Strictly speaking a part of quizzes, tests, and examinations, selected responses require students to identify the one correct answer. The strategy can take the form of multiple-choice or true/false formats. Selected response is a commonly used formal procedure for gathering objective evidence about student learning, specifically in memory, recall, and comprehension.
STUDENT SELF-ASSESSMENTS	Self-assessment is a process by which the student gathers information about, and reflects on, his or her own learning. It is the student’s own assessment of personal progress in terms of knowledge, skills, processes, or attitudes. Self-assessment leads students to a greater awareness and understanding of themselves as learners.

Appendix 4: The 21st Century Skills

The following list provides a brief illustrative overview of the knowledge, skills, work habits, and character traits commonly associated with the 21st century skills:

- Critical thinking, problem solving, reasoning, analysis, interpretation and synthesizing information.
- Research skills and practices, interrogative and questioning.
- Creativity, artistry, curiosity, imagination, innovation and personal expression.
- Perseverance, self-direction, planning, self-discipline, adaptability and initiative.
- Oral and written communication, public speaking and presenting and listening.
- Leadership, teamwork, collaboration, cooperation and facility in using virtual workspaces.
- Information and communication technology (ICT) literacy, media and internet literacy, data interpretation and analysis, computer programming.
- Civic, ethical, and social-justice literacy.
- Economic and financial literacy, entrepreneurialism.
- Global awareness, multicultural literacy, humanitarianism.
- Scientific literacy and reasoning, the scientific method.
- Environmental and conservation literacy, ecosystems understanding.
- Health and wellness literacy, including nutrition, diet and exercise.

Appendix 5: STEAM or STEM

- By exposing students to STEAM and giving them opportunities to explore STEAM-related concepts, they will develop a passion for it and, hopefully, pursue a job in a STEAM field.
- Providing real life experiences and lessons, e.g., by involving students to actually solve a scientific, technological, engineering, or mathematical, or Arts problem, would probably spark their interest in a STEAM career path. This is the theory behind STEAM education.
- By integrating STEAM content and real life learning experiences at different levels of the curriculum process (e.g., Curriculum frameworks, content standards, benchmarks, syllabi, teachers' guides and students' books, curriculum design and development, annual and term school programs and lesson plans, teaching methodologies.
- Teaching methodologies – Problem and project-based learning, partnerships with external stakeholders e.g., high education institutions, private sector, research and development institutions, and volunteer and community development organizations.
- They underpin STEM education. They are the main enablers of STEM education.
- The 21st century skills movement, which broadly calls on schools to create academic programs and learning experiences that equip students with the most essential and in-demand knowledge, skills, and dispositions they will need to be successful in higher-education programs and modern workplaces.
- The term 21st century skills refers to a broad set of knowledge, skills, work habits, and character traits that are believed—by educators, school reformers, college professors, employers, and others—to be critically important to success in today's world, particularly in collegiate programs and contemporary careers and workplaces.
- Generally speaking, 21st century skills can be applied in all academic subject areas, and in all educational, career, and civic settings throughout a student's life.
- The skills students learn will reflect the specific demands that will be placed upon them in a complex, competitive, knowledge-based, information-age, technology-driven economy and society.

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