

Agriculture

Senior High

Grade 12

Teacher Guide

Standards-Based



Department of Education

**'FREE ISSUE
NOT FOR SALE'**

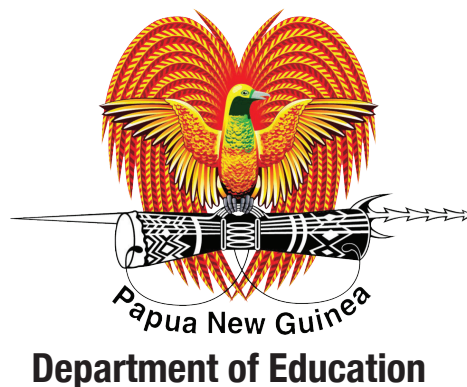
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Issued free to schools by the Department of Education

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The Curriculum Panel (CP), Subject Advisory Committee (SAC) and Board of Studies (BOS) are acknowledged for their recommendations and endorsement 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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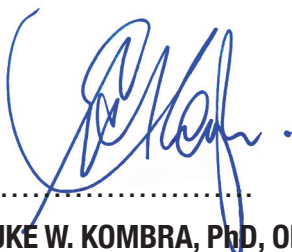
The Grade 10 Agriculture Teacher Guide has been developed to guide the teachers to use when implementing the Agriculture Syllabus. It expands the broad contents in the syllabus into teachable contents, the strategies for facilitating teaching and learning and how to assess using rubrics. The contents 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)

- 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.

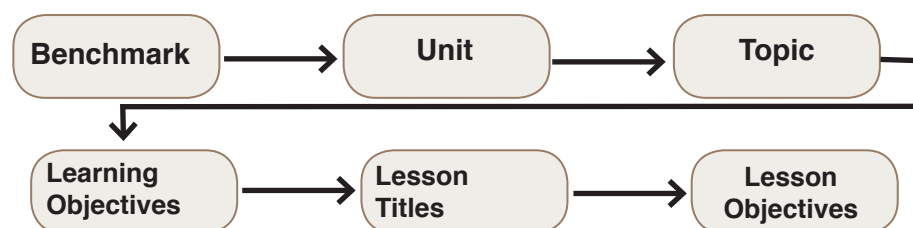
The first thing teachers should do is to read and understand each of the sections of the teacher guide to help them understand the key SBC concepts and ideas, alignment of PNG SBC components, alignment of the syllabus and teacher guide, setting of content standards and grade-level benchmarks, core curriculum, 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.

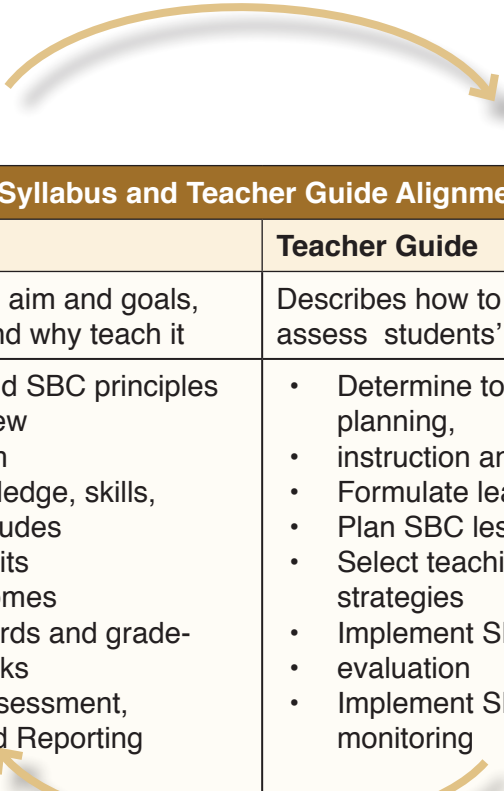
What is provided in the syllabus and teacher guide are not fixed and can be changed. Teachers should use the information and examples provided in the syllabus and the teacher guide to guide them to develop, select, and use grade, context, and learner appropriate content, learning objectives, teaching 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 12 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	Describes how to plan, teach, and assess students' performance
<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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

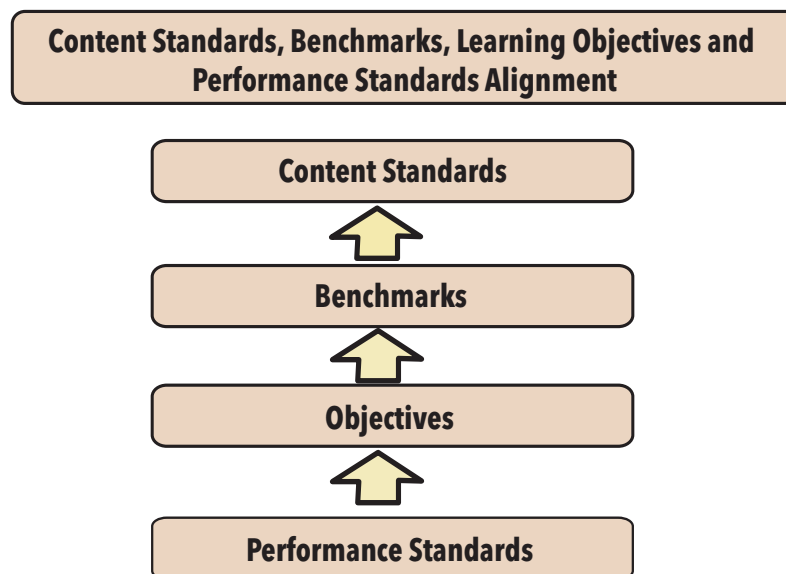
The syllabus outlines the ultimate aim and goals of SBE and SBC, what is to be taught and why it should be learned by students, the underlying principles and articulates the learning and proficiency standards that all students are expected to attain. On the other hand, the teacher guide expands on what 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 12 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

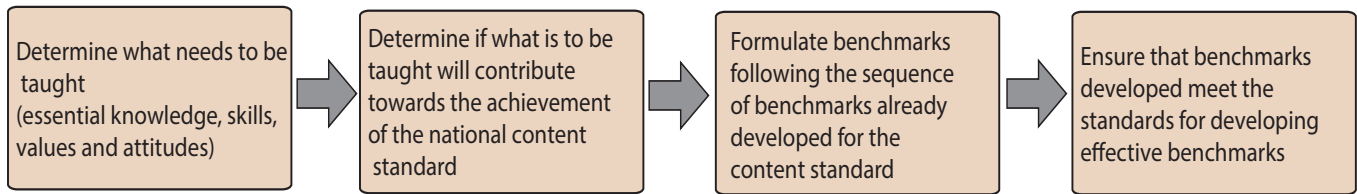


Development of Additional Benchmarks

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

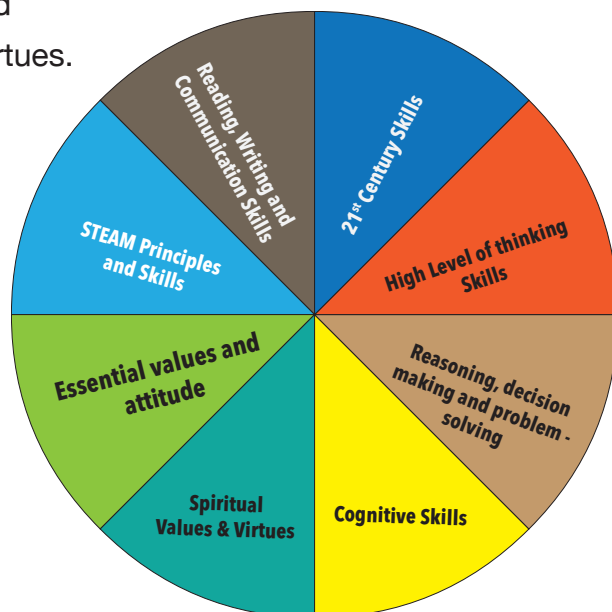
Proficiency standards describe what all students in a particular grade or school level can do” at the end of a strand, or unit. These standards are sometimes called evidence outcomes because they indicate if students can actually apply or use what they have learnt in real life or similar situations. 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

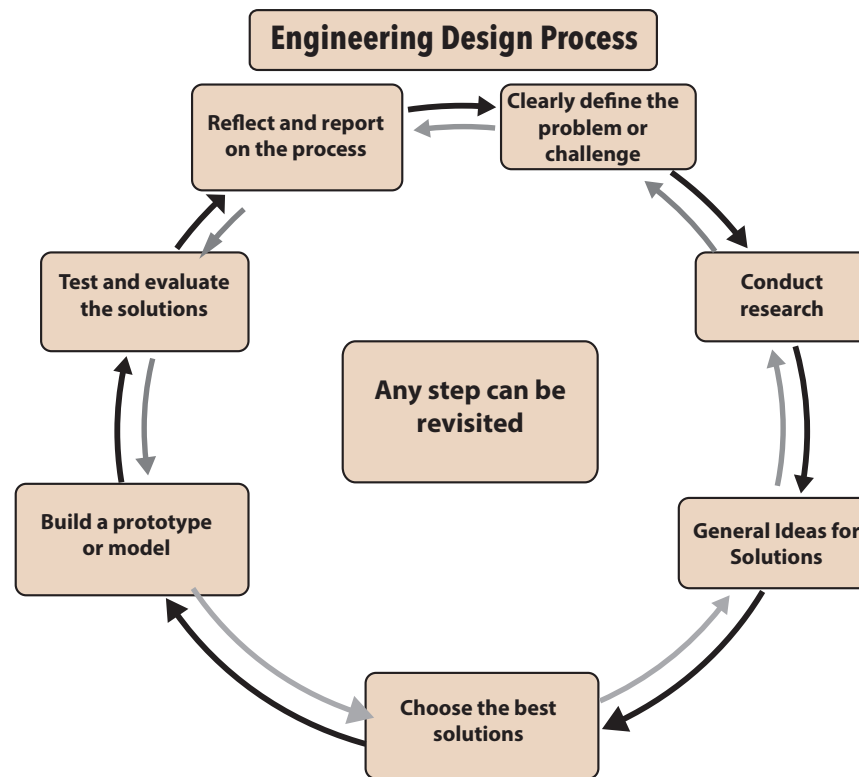
The trial and error method involve trying different approaches until a solution is found. It is often used as a last resort when other methods have been exhausted.

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.

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



3. The Scientific Method and Approach to Problem-Solving

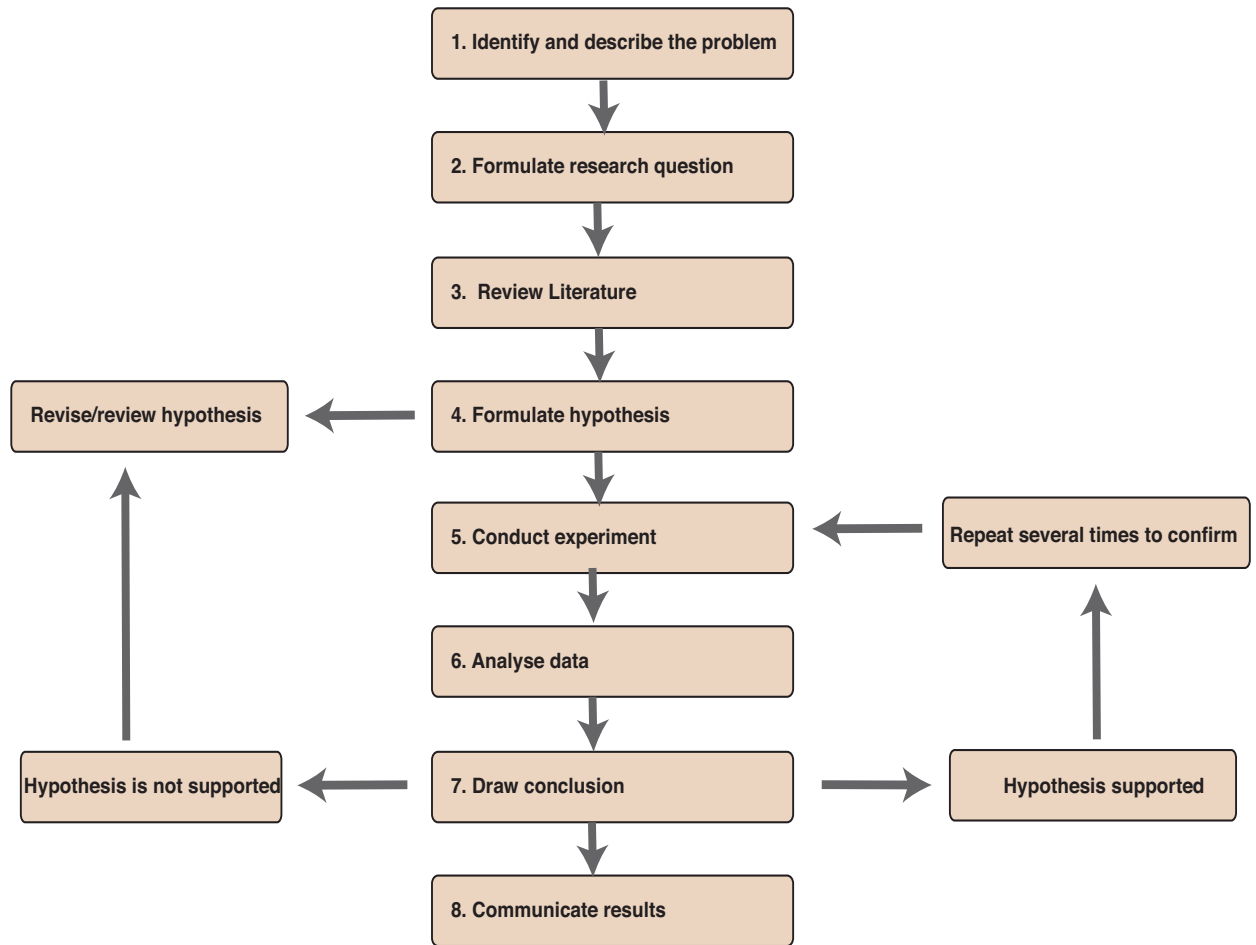
Science uses predominantly the quantitative-scientific inquiry process to investigate, understand, and make informed decisions about problems relating to the natural world. The steps in the process vary, depending on the purpose of the inquiry and the types of questions asked. There are six basic science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

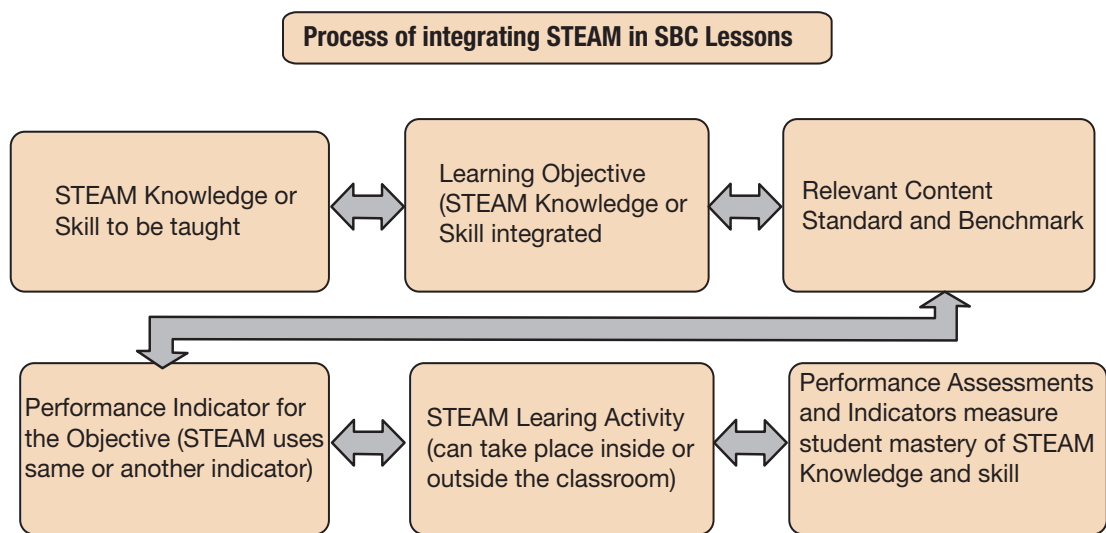
Knowing about how to integrate STEAM problem-solving skills, principles, values and attitudes as well as STEAM teaching, learning, and assessment strategies into standards-based lesson plans is essential for achieving the desired STEAM learning outcomes. When integrating STEAM problem-solving skills 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.

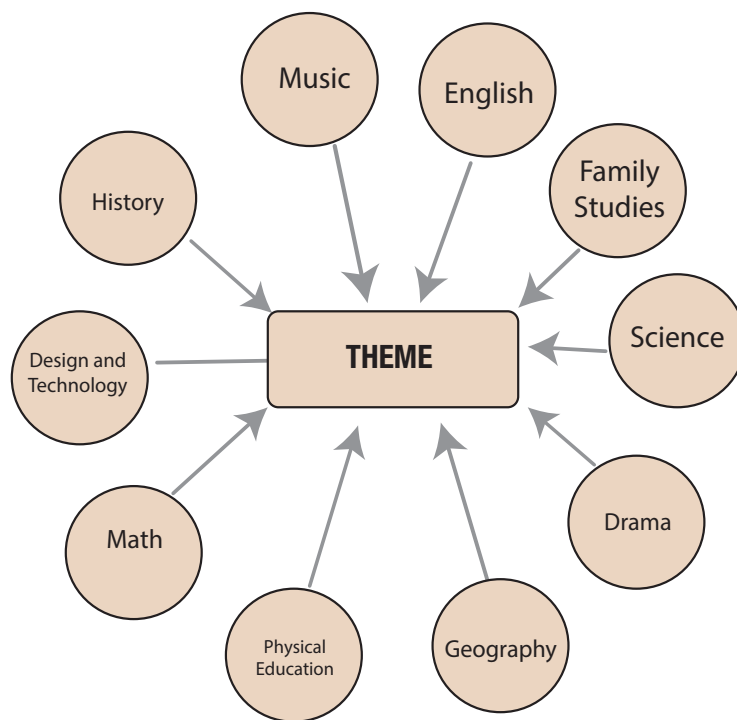
There are three approaches that PNG SBC will engage to foster conducive learning for all its children whereby they all can demonstrate proficiency at any point of exit. Adapting these approaches will have an immense impact on the lives of these children thus they can be able to see themselves as catalyst 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.



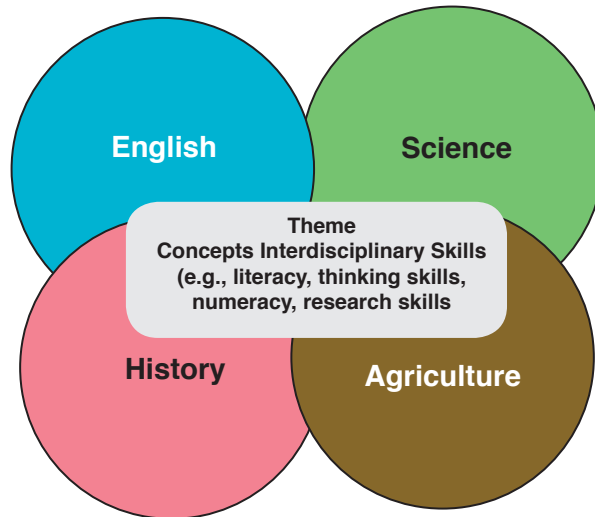
2. Interdisciplinary Approach

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.

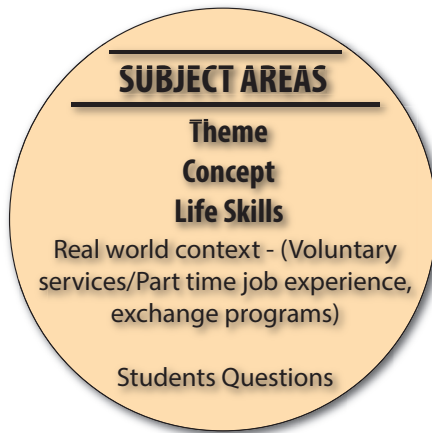
4. Trans disciplinary Approach

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

1. 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

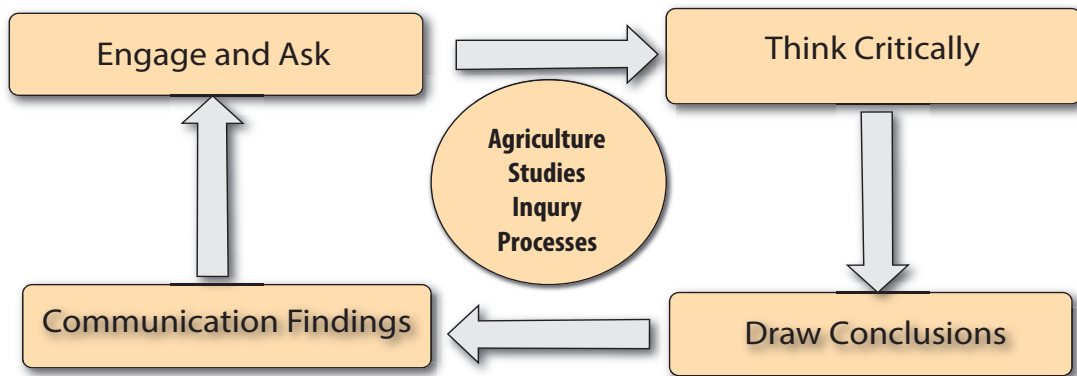
There are different types of knowledge. These include;	
<ul style="list-style-type: none"> • Public and private (privileged) knowledge • Specialised knowledge • Good and bad knowledge • Concepts, processes, ideas, skills, values, attitudes • Theory and practice • Fiction and non-fiction • Traditional, modern, and postmodern knowledge 	<ul style="list-style-type: none"> • 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;	
<ul style="list-style-type: none"> • Problem-solving • Logical reasoning • Decision-making • Reflection 	<ul style="list-style-type: none"> • Cyclic processes • Mapping (e.g. concept mapping) • Modeling • Simulating
<p>Inquiry processes include:</p> <ul style="list-style-type: none"> • Gathering information • Analysing information • Evaluating information • Making judgements • Taking actions 	

Critical Inquiry Processes

<p>Engage and Ask</p>	<p>How will I engage my students in the topic and prompt them to ask questions?</p> <ul style="list-style-type: none"> • 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.
<p>Think Critically</p>	<p>How will students access and analyse information about this topic?</p> <ul style="list-style-type: none"> • 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.
<p>Draw Conclusion</p>	<p>How will students synthesize ideas to answer the questions posed based on sources used?</p> <ul style="list-style-type: none"> • 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.
<p>Communicate Findings</p>	<p>How will students demonstrate what they have learned and take action on that learning?</p> <ul style="list-style-type: none"> • 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

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

<p>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;</p>	
<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

<ul style="list-style-type: none"> • 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 • Analyze cause and effect relationships • Explore complex patterns, interactions and relationships • Differentiate between and among various options 	<ul style="list-style-type: none"> • 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 • Analyze 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
<ul style="list-style-type: none"> • Sanctity of life • Truth • Aesthetics • Honesty • Human • Dignity • Rationality • Creativity • Courage • Liberty • Affectivity • Individuality 	<ul style="list-style-type: none"> • 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
<ul style="list-style-type: none"> • Equality • Kindness • Benevolence • Love • Freedom • Common good • Mutuality • Justice • Trust • Interdependence • Sustainability • Betterment of human kind • Empowerment 	<ul style="list-style-type: none"> • 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	
<ul style="list-style-type: none"> • Optimistic • Participatory • Critical • Creative • Appreciative • Empathetic • Caring and concern • Positive • Confident • Cooperative 	<ul style="list-style-type: none"> • 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

Scientific teaching 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, organize and communicate information, draw and justify conclusions, create new knowledge, and act ethically.

These teaching and learning strategies will help teachers to;

- familiarize themselves with different methods of teaching in the classroom
- develop an understanding of the role of a teacher for application of various methods in 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 for making his/her teaching interesting, inspirational and effective”.

A detailed table of Teaching and Learning Strategies are outlined below:

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.

<p>DISCUSSION The purpose of discussion is to educate students about the process of group thinking and collective decision.</p>	<p>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.</p>	<p>Students ponder over the question and answer by providing ideas, experiences and examples. Students participate in the discussion by exchanging ideas with others.</p>
<p>GAMES AND SIMULATIONS Encourages motivation and creates a spirit of competition and challenge to enhance learning</p>	<p>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.</p>	<p>Go into groups and organize. Follow the instructions and play to win</p>
<p>OBSERVATION Method used to allow students to work independently to discover why and how things happen as the way they are. It builds curiosity.</p>	<p>Give instructions and monitor every activity students do</p>	<p>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</p>

	<p>PEER TEACHING & LEARNING (power point presentations, pair learning) 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.</p>	<p>Distribute topics to groups to research and teach others in the classroom. Go through the basics of how to present their peer teaching.</p>	<p>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.</p>
<p>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</p>	<p>Students are given the opportunity to perform the using the main ideas of a topic. Provide the guidelines, expectations and the set criteria</p>	<p>Go into their established working groups. Being creative and create dramas, songs/lyrics or wall magazines in line with the topic.</p>	
<p>PROJECT (individual/group) Helps students complete tasks individually or collectively</p>	<p>Teacher outline the steps and procedures of how to do and the criteria</p>	<p>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.</p>	
<p>USE MEDIA & TECHNOLOGY to teach and generate engagement depending on the age of the students</p>	<p>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</p>	<p>Viewing can provoke questions, debates, critical thinking, emotion and reaction. After viewing, students engage in critical thinking and debate</p>	

Strands, Units and Topics

The table below outlines the content of Grade 12 Agriculture in strands, units, topics and with the suggested lesson titles to be taught in an academic year. Teachers are provided with what will be taught under each of the five strands in a year. This overview will guide the teachers on how to plan their teaching programs for each term in a school year.

Strands	Units	Topics	Lesson Titles		
Crops	Unit 1: Soil	Topography	Soil analysis Soil topography		
		Returns in crop production	Soil type and cultivation		
		Unit 2: Crop Types	Processes in Crop	Photosynthesis, Respiration, Environmental health, Nutrition, Hormone functions, Photo-morphogenesis,	
	Crop physiology			Crop physiology How crop physiology affects yields	
	Unit 3: Crop Farming Practices and Management Systems			Marketing crops	Processing Storing Transporting
					Crop regulation
			Unit 4: Crop Farming and Technology	Technology and crop yield	GIS software and GPS Agriculture Drones (data from the sky) Farming software
	Constrains	Cultivation Production Marketing			
		Unit 5: Plants			Plant anatomy
	Plant physiology			Fruit trees Flowering trees Spices & Herbal plants Aromatic & ornamental plants	
				Technologies and commercialisation	

	Unit 6: Plant Farming Practices and Management Systems	PNG Laws and Regulations Regarding Uses of Plant Material for Plant Science Enterprises	Laws of Plant Material for Plant Science
			Enterprises
			Regulations of Plant
			Material for Plant Enterprises
		Marketing Systems of Horticultural Crops	Marketing Channels
			Marketing Functions
Animals	Unit 1: Types of Animals	Factors that contribute to the production of quality animal and apiculture products	Mono-gastric animal products
		Benefits of improved animal and apiculture products	Poly-gastric animal products Apiculture products Factors that contribute to quality production Value added mono-gastric and poly-gastric products Value added apiculture products Benefits of Value added products
	Unit 2: Animal Farming Practices and Management Systems	Factors of animal husbandry production	Animal husbandry factors
		Trends in animal agriculture	Current trends of animal production Emerging trends of animal production
	Unit 3: Animal Farming and Technology	Electronic agriculture in animal farming	Types of electronic agriculture Impacts of electronic agriculture on animal farming
		Animal farming technologies	Constrains and solutions
	Unit 4: Types of Birds	Bird anatomy	Anatomy of birds
		Bird physiology	Physiology of birds
	Unit 6: Bird Farming and Technology	Poultry Harvesting Problems	Constrains and solutions in poultry
		Technologies and improved products	Technologies used to improve products

Unit 5: Bird Farming Practices and Management Systems	Planning a Poultry project	Demand and market assessment
		Assess environment and select site
		Design house
		Mobilise and organise materials
		Construct house
		Brooder
		Brooding equipment
		Poultry feed
		Day old chicken
		Feed and nutrition
		Health and care
	Pest and Disease Management	Common poultry pests and diseases
		Pest control and prevention measures
		Disease control and prevention measures

Aquaculture	Unit 1: Types of Aqua farming Plants, Animals, and Fish	Mariculture and Brackish farming	Background and importance of mariculture Background and importance of Brackish farming
		Aquaculture fish species in PNG	Fish farming History in PNG
			Suitable Fish species in PNG – Native and Exotic species
		Principles and Practices of Mariculture	Principles of mariculture
			Practices of mariculture
		Unit 2: Aqua farming Practices and Management Systems	Mariculture Production, Marketing and Management Systems
	Mariculture marketing		
	Mariculture management systems		
	Anatomy and Physiology of Aquaculture Organisms	Anatomy of aqua farming organisms	
		Physiology of aqua farming organisms	
	Unit 3: Aqua farming and Technology	Post-Harvest Technologies	Advantages of mariculture post-harvest technologies
			Disadvantages of mariculture post-harvest technologies
		Aqua and mariculture technology	Ways of improving aqua farming technologies
			Ways of improving mariculture technologies
Trends in aquaculture technology		Trends in aqua farming technologies	
		Ways to improve technologies used in farming, production and marketing	

Natural Resource Management	Unit 1: Types of Capture Fishery	Capture fishery products	Quality production factors
		Improved capture fishery products	Advantages and benefits
	Unit 2: Capture Fishery Harvesting Practices and Management Systems	Capture fishery production	Production factors
		Emerging trends in capture fishery	Improved practices
		Electronic technology	Impact on capture fishery
	Unit 3: Capture Fishery and Technology	Capture fishery technology	Constrains and solution
	Unit 4: Types of Forestry	Properties of common tree species	Common properties of tree
		Physiology of common tree species	Physiology of common trees
	and Forests	Commercialising common tree species	Commercial tree species
		Forest products	Harvesting and processing Preserving and marketing
	Unit 5: Forest Harvesting Practices and Management Systems	Principles of marketing	Marketing forest products Importance of marketing functions
		Forest products	Importance of marketing channels
	Unit 6: Forestry and Technology	Plantation establishment	Common tree species
Clonal forestry		Advantages and benefits	
Agribusiness	Unit 1: Starting Up and Managing an Agribusiness	Inventory Control	Inventory control systems Importance of inventory control
		Accounts receivable and Inventory turnover.	Accounts receivable turnover. Inventory turnover
		Bank reconciliation	Analysing bank reconciliations. Preparing bank reconciliations
		Double entry accounting system	Double entry system of accounting in an agribusiness.
		Accounts receivable and payable.	Accounts receivable and accounts payable in agribusiness.
		Financial Reports	Financial reporting for an agribusiness

Grade 12 Agriculture

Teaching Content

Strand 1: Crops

Content Standard 12.1.1 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 maximise crop production returns in different environments

Units	Benchmark	Topics	Lesson Titles
1. Soils	12.1.1.1 Examine soil topography and analyse soil distribution and uses in different locations.	Topography	Soil analysis
			Soil topography
	12.1.1.2 Research and compare crop production returns to type of soil.	Returns in crop production	Soil type and cultivation

Content Standard 12.1.2 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.

2. Crops Types	12.1.2.1 Investigate and explain the fundamental crop processes	Processes in crops	Photosynthesis
			Respiration
			Environmental health
			Nutrition
			Hormone functions
	12.1.2.2 Analyse different crops and explain their physiology.	Crop physiology	Crop physiology
	How crop physiology affects yields		

Content Standard 12.1.3 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

3. Crop Farming Practises and Management Systems	12.1.3.1 Research and explain how different crops are processed, stored, and transported to markets.	Marketing crops	Processing
			Storing
			Transporting
	12.1.3.2 Investigate and explain how each process of crop cultivation, production, and marketing is regulated.	Crop regulations	Cultivation
			Production
			Marketing
Content Standard 12.1.4 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.			
4. Crop Farming and Technology	12.1.4.1. Research and explain how technologies are being used to increase crop yields and supply to meet demand.	Technology and crop yield	GIS software and GPS agriculture.
			Drones (data from the sky)
			Farming software
	12.1.4.2. Research and identify problems affecting the cultivation, production, and marketing of crops and develop appropriate solutions.	Constrains	Cultivation
			Production
			Marketing
Content Standard 12.1.5 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.			

5. Plants	12.1.5.1. Research and explain the anatomy of fruit trees and flower trees and spice, herbal, aromatic, and ornamental plans.	Plant anatomy	Fruit trees Flowering trees Spices & Herbal plants Aromatic & ornamental plants
	12.1.5.2. Investigate and explain the physiology of fruit trees and flower trees and spice, herbal, aromatic, and ornamental plans.	Plant physiology	Fruit trees Flowering trees Spices & Herbal plants Aromatic & ornamental plants
	12.1.5.3. Discuss how herbal, aromatic, and spice plants in PNG could be grown and commercialised at a large scale.	Technologies and commercialisation	Spices Herbal plants Aromatic plants
Content Standard 12.1.6 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			
6. Plant Farming Practices and Management Systems	12.1.6.1 Explain the principles of marketing and discuss how these can be used for marketing horticulture products.	Principles of marketing	Horticulture products
	12.1.6.2 Investigate and evaluate the importance of horticulture marketing functions and marketing channels for horticulture crops.	Horticulture crops	marketing function marketing channels
Content Standard 12.1.7 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.			
7. Plant Farming and Technology	12.1.7.1 Research and design a system for cultivating horticulture plants at a larger scale.	Horticulture Horticultural technology	How to commercialise Green house
	12.1.7.2 Research and explain genetic engineering and evaluate its implications for horticulture.	Genetic engineering	Implication for horticulture Disadvantages of genetic engineering

Strand 1: Crops

Unit 1: Soil

Content Standard 12.1.1 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 maximise crop production returns in different environments.

Benchmark . 12.1.1.1 Examine soil topography and analyse soil distribution and uses in different locations.

Topic 1: Topography

Learning Objectives:

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

- Explain the importance of soil topography
- Describe soil analysis

Essential questions:

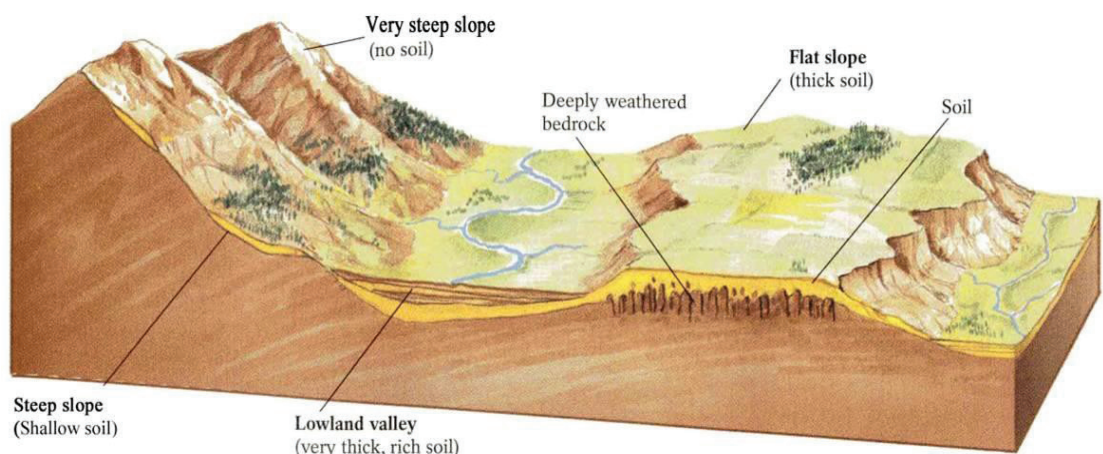
1. What are some features found in soil topography?

Essential Knowledge	Soil topography and soil analysis
Essential Skills	Explain and describe Soil topography and soil analysis
Essential Attitudes & Values	Appreciate

Content Background:

Soil topography – is a detail map shows the surface features of the land. This includes the mountains, hills, creeks and creeks. Topography can affect the soil formation through erosion depending on the shape of the land.

soil that is on the side of the mountains and hills are shallow and not as composed because of erosion that carries soil particles down the side of the steep land.



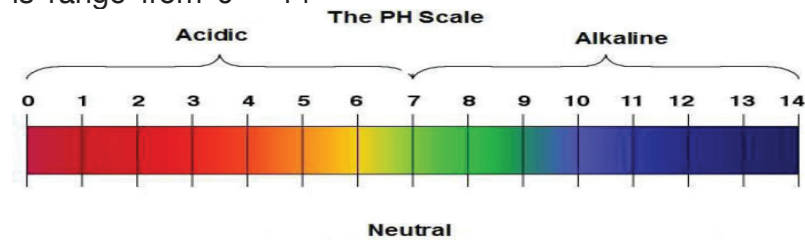
Soil analysis

Soil analysis is a process that is carried to determine the amount of plant nutrients available in the soil.

Soil test – is done to determine the level of major and minor mineral elements

Nutrient balance - is carried out in order to determine the nutritional quality and the ability of crops to cope with both abiotic and biotic stresses.

Soil pH- is design to measure the acidity and alkalinity in soil. The pH level is range from 0 – 14



Assessment task

the students divide into 3 groups and use a pH tester to test a particular soil sample from different locations

Source: https://en.wikipedia.org/wiki/Industrial_crop

References:

NZ soils Basic of soil topography

Strand 1: Crops**Unit 1: Soil**

Content Standard 12.1.1 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 maximise crop production returns in different environments

Benchmark . 12.1.1.2 Research and compare crop production returns to type of soil.

Topic 2: Soil type and crop production**Learning Objectives:**

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

- Describe soil type and cultivation
- Identify the type of soil effect on the yield

Essential questions:

1. What is soil?

Essential Knowledge	Soil type, effect on the yields
Essential Skills	Describe and identify soil type and effect on the yield
Essential Attitudes & Values	Appreciative

Content Background**Soil type and cultivation**

Decision about appropriate cultivation are determine to a large scale by soil type. What may be appropriate for a chalky and clay loam could cause major problems on a silt loam soil. The major soil textural classes and the most appropriate cultivation techniques are outline below.

1. Sandy soils

It's beneficial to minimize ground pressure from machinery to reduce compaction. Use deep tines or sub soiling on a regular basis on a regular basis to loose plough pans deep compaction .

2. Silty soil

Bed system for vegetables is useful to prevent widespread compaction. Reduce tillage is not appropriate in light and medium silts but may be possible on heavy silts.

3. Clay soils

Cultivation should be minimum. Reduce tillage is often appropriate, especially where free lime is present, with deeper loosening every 3- 4 years and mole draining every 4-7 years to ensure good drainage.

4. Loam soil

Where free lime is present on heavier loams, reduced cultivation is suitable. Whereas it is less appropriate on sandy and silty loams. Deep loosening will be required, especially on lighter loams.

5. Peat soils

Avoid excessive cultivations as it can dry out surface layers leaving soil vulnerable to wind erosion. Deep ploughing shallow peats can incorporate silt or clay from below the peat. This can help to stabilize peat and may reduce acidity.

Crop production returns

Crop returns incorporates your own production systems and key variables such as fertilizer prices, fuel prices, expected yields and selling prices. Crop is related to harvested areas, returns per hectare (yields) and quantities produce.

Assessment task

students do a research plot on crop yield by planting three different crops on a particular soil. The research project should take a term.

Sources

<https://www.soilassociation.org/farmers-growers/technicalinformation/min-till-and-no-till/soil-types-and-appropriate-cultivation-techniques/>

Strand 1: Crop**Unit 2: Crop Types**

Content Standard 12.1.2 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: 12.1.2.1 Investigate and explain the fundamental crop processes.

Topic 1: Fundamental crop processes**Learning Objectives:**

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

- Explain the fundamental crop processes.
- Describe the different fundamental crop processes.

Essential questions:

1. What are the types processes?
2. How do they function?

Essential Knowledge	<ul style="list-style-type: none"> • Types of process • How do they function
Essential Skills	Classify, differentiate
Essential Attitudes & Values	Caring and concern

Content Background:

Fundamental Crop Processes

The fundamental crop processes are:

1. Photosynthesis – the process by which plants use sunlight, water and carbon dioxide to create oxygen and energy in the form of sugar.
2. Respiration – using of sugars produced during photosynthesis. It involves two processes which are physical and chemical. The physical process by which organisms take oxygen and emit waste carbon dioxide. The chemical process by which fuel molecules such as sugar and fat are broken down within a cell to liberate energy for cellular life process.
3. Plant nutrition - Plants obtain food in two different ways. Autotrophic plants can make their own food from inorganic raw materials, such as carbon dioxide and water, through photosynthesis in the presence of sunlight. Green plants are included in this group. Some plants, however, are heterotrophic: they are totally parasitic and lacking in chlorophyll. These plants, referred to as holo-parasitic plants, are unable to synthesize organic carbon and draw all of their nutrients from the host plant. chemical elements and compounds necessary

for plant growth and reproduction, plant metabolism and their external supply.

4. Plant hormones – chemical produces by plants that regulate their growth, development, reproductive processes, longevity and even death. The four types of plant hormones are:
 - i. Auxins – It promotes cell enlargement and cell differentiation in plants.
 - ii. Gibberellines – It helps in breaking the dormancy in seeds and buds.
 - iii. Cytokines – It promotes cell division in plants.
 - iv. Abscisic acid – It promotes the dormancy in seeds and buds.
5. Photo morphogenesis – light mediated development where plant growth patterns respond to the light spectrum. Light is important for photosynthesis in plants, few realize that plant sensitivity to light plays a role in the control of plant structural development.

Assessment task

Student do an experiment seed germination on how plant use light in order to grow.

Sources

1. <https://courses.lumenlearning.com/suny-wmopen-biology2/chapter/plant-nutrition/>

Strand 1: Crops**Unit 2: Crop Types**

Benchmark: 12.1.2.2 Analyse different crops and explain their physiology.

Topic: Crop physiology**Learning Objectives:**

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

- Define crop physiology.
- Describe its importance.

Essential questions:

1. What is crop physiology?
2. How crop physiologies affect the yield?

Essential Knowledge	Crop physiology
Essential Skills	Define and describe crop physiology
Essential Attitudes & Values	Caring and concern

Content Background:**Crop physiology**

Crop physiology is the study of the plant processes responsible for the growth, development and production of economic yield by crop plants. This includes how plants are affected by environmental conditions such as temperature, water, and light. This can be quite challenging for farmers who have to look after plants from seed to harvest. The most important is the soil fertility, if the soil is not fertile the plant will be unable to grow. The second most important is the temperature. If the temperature is too high the plants will be more likely to die. The humidity and light must not be too low and or plants will die.

How does crop physiology affects the yield

Crops in general are subjected to a lot of stress. If the plant is not handled properly, it can suffer from stress which can reduce yield. Stress can come in many different forms, such as excessive heat, drought and diseases. No matter what type of stress your plant is subjected to, it is important to understand how crop physiology affect the yield. For the plants to be healthy it needs the proper amount of water and sunlight.

Assessment Task

Conduct a research on how crop physiology affects crop yield.

Sources

<https://www.uaftimes.com/the-importance-of-crop-physiology-in-agriculture/>

Strand 1: Crops

Unit 3: Crop Farming Practices and Management Systems

Content Standard 12.1.3 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 . 12.1.3.1 Research and explain how different crops are processed, stored, and transported to markets.

Topic 1: Marketing crops

Learning Objectives:

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

- Explain marketing
- Describe processing , storage and transporting of crops

Essential questions:

1. What is marketing?
2. How processing, storage and transporting

Essential Knowledge	Marketing, processing
Essential Skills	Expain marketing
Essential Attitudes & Values	sustainability

Content Background:

What is Marketing?

There are many definitions of “marketing.” Here are two particularly relevant to horticultural marketing.

The first is;

Marketing involves finding out what your customers want and supplying it to them at a profit This stresses two important points:

- The marketing process has to be customer oriented.
- Marketing, a commercial process, has to provide farmers, transporters, traders, processors, etc. with a profit or they will be unable to stay in business.

Marketing therefore involves:

- Identifying buyers;
- Understanding what they want in terms of products and how they want to be supplied;
- Operating a production-marketing chain that delivers the right products at the right time;
- Making enough profit to continue to operate.

The second useful definition is:

The series of services involved in moving a product from the point of production to the point of consumption. This definition emphasizes that marketing is a series of inter-connected activities. In the case of horticultural marketing these include:

- Planning production;
- Growing and harvesting;
- Grading of products and their packing, transport, storage, processing, distribution and sale;
- Sending information from production area to market (e.g. products available, volumes) and from market back to producing areas (e.g. prices and supply levels, consumer preferences and changes in taste).

All of these activities are links in the production marketing chain. Like any chain, it is only as good as its weakest link. Marketing systems are dynamic. They are competitive and involve continuous change and improvement. Suppliers, who have lower costs, are more efficient and can deliver quality products are those who survive and prosper. Those who have high costs, do not adapt to changes in market demand and provide poorer quality are often forced out of business.

How can Improved Marketing Help Farmers?

Most farmers see themselves as “pricetakers”, thinking that they have no control over prices and have to accept what is offered. They do not always know how to find new buyers nor how market demand is changing and which products are most profitable to grow. They lack the understanding to improve the prices they receive and the profitability of their production. Your role as an extension advisor should be to help farmers become better informed about the market. They can then start to make decisions on how to improve their marketing. However, you must never tell farmers what they should do or what products to sell. Commercial decisions like these must be made by the farmers themselves.

There are two reasons for this:

1. Farmers need to become owners of new ideas. In this way they become committed and aware that they are responsible for the success or failure of what they do. This increases the chances of a successful outcome.
2. If an extension officer (or NGO specialist) recommends a course of action that fails, he or she will be blamed by the farmers.

When asked about their problems, farmers commonly identify marketing issues as their key constraint. Problems highlighted are usually lack of markets, poor prices, inadequate roads and poor communications. However, while farmers can usually state clearly their problems they often face difficulties in identifying potential solutions. This guide aims to help you to help farmers work out what to do. Farmers are generally highly skilled in agricultural techniques but marketing requires learning new skills, new techniques and new sources

of information. Armed with business and marketing skills farmers will be better able to run their farms profitably. Small-scale farmers face the biggest marketing problems.

Assessment task

The students are asked to do a market survey. Questionnaire to be done by the teacher

Sources

<https://pacificfarmers.com/wp-content/uploads/2014/06/Guide-to-small-holder-marketing.pdf>

http://jnkvv.org/PDF/10042020083748concept%20of%20ag%20markeing_EgEcon530.pdf

Strand 1: Crops

Unit 3: Crop Farming Practices and Management Systems

Content Standard 12.1.3 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 .12.1.3.2 Investigate and explain how each process of crop cultivation, production, and marketing is regulated.

Topic 2: Crop marketing regulations

Learning Objectives:

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

- Identify the types regulation on marketing
- Clarify the business regulations of starting a agribusiness.

Essential questions:

1. What are the types of regulations?
2. What are the factors to consider when starting an agribusiness?

Essential Knowledge	<ul style="list-style-type: none"> • Starting a agribusiness • Regulations
Essential Skills	<ul style="list-style-type: none"> • Research, clarify
Essential Attitudes & Values	<ul style="list-style-type: none"> • Cooperative

Content Background:

Starting an agribusiness in PNG

The scarcity of formal agribusinesses results from many different factors, including access to finance, worker education and training, and perceptions concerning the value of formalization. In addition, it can be ascribed to the restrictions placed upon agricultural investment under the Investment Promotion Act (1992). Under this Act, foreign enterprises cannot conduct business in a range of activities listed under the Cottage Business Activities List (CBAL).

These currently include the following:

- Cultivation and growing of vegetables and other market produce;
- Farming of animals;
- Poultry farming;
- Fishing on a commercial basis; and
- Wholesale and retail sale of wild growing materials.

Other activities are listed, but these are the most relevant to agricultural development. These activities are reserved for the citizens of Papua New Guinea, which may at least in part account for the limited amount of investment in them and the high level of informality at the primary production level in each subsector.

Various types of agribusinesses can be formally established within PNG, but the two forms most commonly found are the limited company, which may be owned privately or publicly, and the cooperative, which is privately owned by shareholders. The concept of agricultural cooperatives linked within a framework of associations has been adopted by PNG's central government as a potential mechanism for rural development and is now being actively pursued. Since 2007, more than 4,500 cooperatives have been registered, although the number productively engaged in business activities is estimated to be substantially less.

The process of starting a business entails two phases. The first involves procedures common to all companies or cooperatives and covers the raising of capital and enterprise registration and identification for the purpose of general taxation. The second varies according to the nature of the business to be undertaken. It may include registration with sector-specific institutions (such as the Coffee Industry Corporation (CIC) or the Kokonas Industri Korporesen (KIK)), which is undertaken through application for and provision of specific licenses.

Business Registration, Regulation and Certification

The Investment Promotion Authority (IPA) through the Companies Office is responsible for the administration of Papua New Guinea's key business laws such as the Companies Act, Business Names Act, Business Groups Incorporation Act and the Associations Incorporation Act.

There are other laws and regulations which will also affect investors. These include laws of the National Government on areas such foreign exchange, taxation and customs, licenses and permits for various activities such as mining and petroleum exploration, agriculture, fisheries, forestry and industrial activities.

Provincial Governments and urban authorities also issue various licenses. It is the responsibility of investors to ensure they comply with the respective laws as well as the Investment Promotion Act 1992.

This reprint of this Statutory Instrument incorporates all amendments, if any, made before 25 November 2006 and in force at 24 October 2004.

.....
Legislative Counsel
Dated 25 November 2006

INDEPENDENT STATE OF PAPUA NEW GUINEA.

No. of 1992.

Investment Promotion Regulation 1992

Assessment task

students are asked to do a research work on a particular agribusiness as an assignment following a criteria set by the teacher.

Reference:

1. INDEPENDENT STATE OF PAPUA NEW GUINEA. No. of 1992. Investment Promotion Regulation 1992
2. http://pdf.usaid.gov/pdf_docs/PA00J9Q9.pdf

Strand 1: Crops**Unit 4: Crop Farming and Technology**

Content Standard 12.1.4 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.

Benchmark . 12.1.4.1. Research and explain how technologies are being used to increase crop yields and supply to meet demand.

Topic 1: Technology**Learning Objectives**

By the end of this top



- describe the dif No. 8 of 1992. on
- compare the dif

Essential questions: *Investment Promotion Act 1992.*

1. What is GIS software?
2. What do you think GPS agriculture means?

Essential Knowledge	<ul style="list-style-type: none"> • GIS software and GPS agriculture, Satelite imagi-nary, Drones • Farming software and online data
Essential Skills	<ul style="list-style-type: none"> • Analyse, discuss
Essential Attitudes & Values	<ul style="list-style-type: none"> • Caring and concern

Content Background:**Tecnologies Used in Crop Yield**

In recent years , the adoption of digital technologies in precision agriculture has been adjusting the ways the farmers treat crops and manage fields . one does not have to be a expect to see how the technology has change the concept of farming making it more profitable, efficient ,safer and simple.

Below are some technologies used:

- GIS software and GPS agriculture
- Satellite imaginary
- Drones
- Farming software and online data
- Merging datasets

As a result modern farms get significant benefits from the ever evolving digital agriculture. This benefits includes reduce consumption of water, nutrients and fertilizer, reduced negative impact on the surrounding ecosystem, reduce chemical runoff into local ground water and rivers, better efficiency, reduced prices and many more. Thereby business becomes cost

effective, smart and sustainable.

GIS Based Agriculture

Since fields are location based, GIS software becomes an incredibly useful tool in terms of precision farming. While using GIS software, farmers are able to map current future changes in precipitation, temperature, crop yield, plant health and others. It also enable the use of GPS application in line with smart machinery to optimize fertilizer and pesticide application, given that the farmer does not have to treat the entire field, but only deal with certain areas, they are able to achieve conservation of money, effort and time.

Satellite derived data

predicting yield as well as conducting almost real time field monitoring, with a view to detect a variety of threats with satellite data in service has never so easy. The sensors are able to give imagery in various spectra allowing for the application of numerous spectral indices.

Drones – data from the sky

With the assistance of the drones farmers has an opportunity to define crops, biomass, plant height, the presence weeds and the water saturation on certain field areas with high precision. They deliver better and more accurate with higher resolutions in comparison to satellites. When they are locally operated, they provide valuable information even faster than scouts. Drones are also considered to be unrivaled aids in the battle against insects; the invasion is prevented by applying the insecticides on the hazard area using drones, all while reducing the likelihood of direct exposure leading to chemical poisoning. Despite the fact the drones are easy to use and are capable of collecting large amounts of data with short time frame.

Farming software and online data

The Farming software helps the farmers plan, monitor and analyse all activities on the farm. An example of farming software is A Farm Management Software (FMS) is a tool that can enable you to control the management aspect of the farm.

Merging remote sensing data

Merging remote sensing data is merging various data sets in order to get meaningful interpretation in the fields. In this case the user of these data sets is able to compare the performance in the field with the average of all fields in the given area.

Assessment task

Give some review questions to students and answer them individually and corrections after the students finish.

Sources: <https://eos.com/blog/top-5-newest-technologies-in-agriculture/>

Strand 1: Crops**Unit 4: Crop farming and Technology**

Content Standard 12.1.4 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 . 12.1.4.2. Research and identify problems affecting the cultivation, production, and marketing of crops and develop appropriate solutions.

Topic 2: Constraints to crop cultivation, production and marketing**Learning Objectives:**

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

- Identify the constraints to crop cultivation, production and marketing
- Describe the solutions and ways of improving crop cultivation, production and marketing

Essential questions:

1. What are the constraints to crop cultivation, production and marketing
2. What are the solutions and ways of improving crop cultivation, production and marketing

Essential Knowledge	constraints to crop cultivation, production and marketing solutions and ways of improving crop cultivation, production and marketing
Essential Skills	Analyse, categorise
Essential Attitudes & Values	appreciative

Content Background:**Constraints to crop cultivation and productions**

Farmers need to deal with many problems, including how to:

- Cope with climate change, soil erosion and biodiversity loss.
- Satisfy consumers' changing tastes and expectations.
- Meet rising demand for more food of higher quality.
- Invest in farm productivity.
- Adopt and learn new technologies.
- Inspire young people to stay in rural areas and become farmers.
- Stay resilient against global economics factors.

Marketing constraints

Marketing constraints or challenges arise due to many factors such as limited knowledge and use of market information, lack of access to high-value reliable markets, high transactional costs, distance from the markets, poor quality

of products, lack of storage facilities, low educational levels of small-scale farmers, ...20 Sept 2014

What Are The Ways To Increase Crop Yield?

1. Quality Of Seeds. Agricultural productivity depends on the quality of seeds with which farmers sow their fields. ...
2. Field Productivity Zoning
3. Monitoring Crops Growth
4. Accurate Weather Prediction
5. Regular Scouting
6. Crop Protection Methods
7. Soil Testing & Its Quality.

1. Gather & analyse reliable market data

The first step to implementing an effective marketing campaign is to know who you're going after. It's more than just "we're going after corn/soy growers." Answer the questions your audience is asking and understand the problems they face. Then, you'll be able to offer the specific products that solve their problems.

The quickest and easiest way to find this out is by analyzing market data. Here are some data points that'll help you understand farmers better:

- Personal & demographic information
- Crop type & rotation pattern
- Relationships with other growers
- Acreage
- Distinction between acres owned vs. operated vs. owned and operated
- Grain bin count & capacity
- Geospatial imagery of the operation

2. Market to specific segments of farmers

After you've gathered the data, it's time to use it to create highly specific messages to farmers. That's where segmentation of your market by the demographics we listed above is going to help.

3. Leverage data-targeted, omnichannel marketing

Some ag companies choose the channel first-be it an ag publisher, radio station or program, or even direct mail and then determine who the audience will be. This marketing approach can be practical to a degree, especially in terms of brand awareness and visibility.

But if you've taken the time to develop segmented audiences of farmers and messages for each of them, then you need to market in such a way that you're reaching them directly. The primary advantage of data-targeted,

omnichannel marketing is that you focus on specific growers, not channels.

Assessment task

In groups of 5 discuss the different ways of improving the different constraints

Sources

- <https://www.richtmann.org › mjss › article › view>
- <https://www.syngenta.com/en/innovation-agriculture/challenges-modern-agriculture>

Strand 1: Crops

Unit 5: Plants

Content Standard 12.1.5 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 . 12.1.5.1. Research and explain the anatomy of fruit trees and flower trees and spice, herbal, aromatic, and ornamental plans.

Topic 1: Plant anatomy

Learning Objectives:

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

- Research and explain the anatomy of fruit and flower trees.
- Investigate and comprehend the anatomy of spices, herbal, aromatic and ornamental plants

Essential questions:

1. What is plant anatomy?
2. How can we explain the anatomy of different types of plants?

Essential Knowledge	Anatomy of fruit trees and flower trees and spice, herbal, aromatic and ornamental plants
Essential Skills	Researching skills
Essential Attitudes & Values	Appreciate the anatomy of fruit and flowering trees, herbal, aromatic and ornamental plants

Content Background:

Fruit Trees

Many of the fruit trees in our area are laden with fruit at this time of year. These fruit are the seed-containing ripened carpels (ovule and ovary) of the fertilized spring flowers. Some fruit, such as the apple, include other flower

parts as well. After the flower is fertilized, the resulting developing seeds emit a growth hormone that causes the fruit to form.

Different species have differing number of carpels in their flowers, which results in the seed configuration within the fruit. The plum flower has one carpel and therefore one seed in the fruit, the apple and pear flower have multiple carpels, and therefore multiple seeds in the fruits. The next time you slice open a fruit, examine the seed configuration for evidence of its floral origins.

The unripe fruit protects the seeds as they develop and the ripe fruit improves the range of seed dispersal after the seeds are mature. Tree fruits have various designs such as fleshy, dry, winged, or barbed, depending on the mode of seed transport (wind, water, or animal). The aroma of the ripe fruit we eat consists of hundreds of volatile compounds, which vary in myriad combinations to create the distinct smells of each fruit type. See our [‘Bounty of the Bough: Fall Harvest’](#) blog entry for when to seek out your favorite ripe fruit this season.

Anatomy of Flowering Plants

Cells with the same structure and functionality constitute a tissue.

Plants tissues are of two types:

1. Meristematic tissue: cells divide actively.
 - Apical meristem– occurs at the tip and produces primary tissues, e.g. dermal, vascular and ground tissues.
 - Intercalary meristem– occurs in grasses between matured tissues.
 - Lateral meristem– produces secondary tissues, e.g. cambium.
2. Permanent tissue: cells, which don’t divide further after attaining their specialised structure and function.
 - Simple tissue: only one type of cells having the same structure and function.
 - Complex tissue: more than one type of cells that work in coordination.

Epidermal Tissue System

- It comprises the outer covering of the plants, such as epidermis, cuticle, stomata, epidermal extensions; trichomes in stem and root hairs
- Stomata regulate gaseous exchange and water loss by transpiration
- Guard cells are bean-shaped in dicots and contain chloroplasts
- Grasses have a dumb-bell shaped guard cells
- Root hairs are unicellular
- Trichomes are multicellular

The ground Tissue System

- They form the major bulk of tissues between epidermal and vascular tissues, e.g. cortex, pericycle, pith
- It contains simple tissues
- Mesophyll of leaves is a ground tissue with chloroplast

The Vascular Tissue System

- It consists of complex tissues of xylem and phloem
- Dicots have cambium present between xylem and phloem of vascular bundle
- Cambium forms secondary vascular tissues
- Dicots have an open vascular bundle
- Monocots have a closed type of vascular bundle, i.e. cambium is absent
- Roots have a radial arrangement of vascular bundles, i.e. xylem and phloem are present alternatively
- Stem and leaves have a conjoint arrangement of vascular bundles, i.e. xylem and phloem are present at the same radius

Dicotyledonous Root

- Epiblema is the outermost layer, which contains root hair
- Several layers of cortex present, that ends with innermost layer endodermis, which contains waxy material called suberin forming Casparian strips
- Next is pericycle, which gives rise to lateral roots and vascular cambium
- Two to six vascular bundles are present
Radial and exarch vascular bundles

Monocotyledonous Root

- The structure is similar to dicot root but polyarch xylem bundles are present
- Pith is large and no secondary growth
- Dicotyledonous Stem
- The outermost layer is the epidermis with cuticle
- Trichomes and stomata may be present on the epidermis
- The cortex consists of three layers; outermost hypodermis (collenchymatous), middle parenchymatous cortical layer and the endodermis containing starch grains
- Below endodermis, pericycle and radially located medullary rays are present
- Vascular bundles are arranged as a ring
- Vascular bundles conjoint, open and with endarch protoxylem

Monocotyledonous Stem

- Hypodermis is sclerenchymatous
- Vascular bundles are scattered, conjoint and closed

Dicotyledonous Leaf

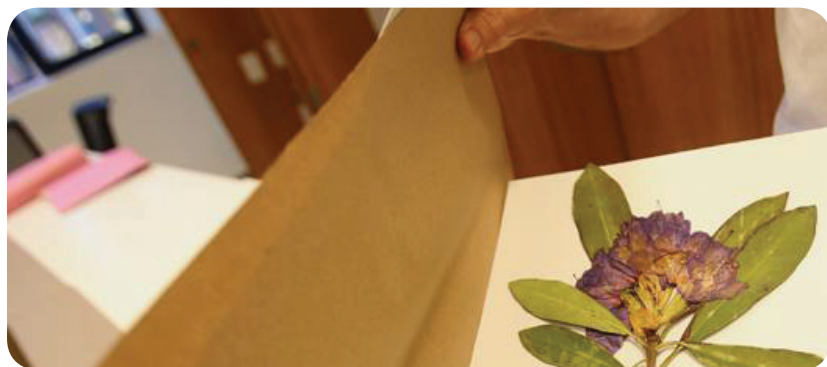
- Also known as dorsiventral leaf due to distinct dorsal and ventral side
- Reticulate venation
- The epidermis covers both the upper and lower surface
- There are more stomata present on the abaxial epidermis
- Mesophyll cells are parenchymatous and perform photosynthesis
- The mesophyll is made up of elongated palisade and oval or round spongy parenchyma cells
- Vascular bundles are surrounded by bundle sheath cells and present on veins and mid-rib

Monocotyledonous Leaf

- Also known as isobilateral as both sides are similar
- Parallel venation
- Stomata are equally distributed on both sides
- The mesophyll is not differentiated between palisade and spongy parenchyma cells
- Some cells of the epidermis are modified into large cells called bulliform cells in grasses, they help in minimising water loss
- Vascular bundles are of the same size

What is Medicinal and Aromatic Plants Program?

Program Description: Biological, ecological, genetic and systematic properties of the Medicinal and Aromatic Plants that have economic value in the food, pharmaceutical, cosmetics and paint industry, culture, collection and protection from nature, chemical contents and analysis methods, supply, production and quality controls, use It is a program that trains auxiliary technical personnel who have basic knowledge and practice in their fields and ethics.



The purpose of the Medicinal and Aromatic Plants Program; is to create trained manpower, which is of great importance in the collection, cultivation, production-processing, marketing and use of plants from nature.

To this end, students are taught to conserve gene resources and to cultivate them as field crops. For the pharmaceutical industry, it is aimed to determine the properties and effective substances of these plants and to increase the effective substances that give these plants therapeutic power.

In addition, students have the opportunity to use the theoretical knowledge they have acquired by making field practices in their regions. Students who know the plants according to their morphological characteristics and determine their properties, also learn to collect them from nature and make them to be stored under suitable conditions.

What are the lessons taken in the Medicinal and Aromatic Plants Program?

Agricultural Botanical, Medicinal and Aromatic Plants Systematics (Bseç), General Chemistry, Basic Mathematics, Environment and Organic Agriculture, Atatürk's Principles and History of Revolution I, University Culture I (Usec), Positive Psychology and Communication Skills (Usec), English I, Turkish Language I, Biochemistry, Medicinal and Aromatic Plants Anatomy, Plant Physiology, Soil Knowledge and Plant Ecology (Bseç), Herbarium Techniques, Turkish Language II *, English II *, Atatürk's Principles and Revolution History II *, University Culture II (Üseç), Drog Preparation Technique (Bseç), Analytical Chemistry, Paint and Perfume Plants Evaluation Technology, Pharmaceutical and Medicinal Plants Evaluation Technology (Bseç), Phytotherapy and Aromatherapy I, Plant Nutrition and Fertilization, Professional Practice I, Medical and Aromatic Plant Growing Technique (Bseç) , Spice and Pleasure Plants Evaluation (Bseç), Medical and Aromatic Plants Conservation and Marketing, Phytotherapy and Aromatherapy II, Medical and Aromatic, Plant Disease and Pests, Summer Practice, Professional Practice II

What are the Fields of Study of Medical and Aromatic Plants Program Graduates?

Students who graduate from the Medicinal and Aromatic Plants Program; Ministry of Agriculture, pharmaceutical factories, pharmacies, cosmetics industry etc. has the opportunity to work in such enterprises.

Students who graduate with the title of "Medicinal and Aromatic Herbal Technician" can also establish their own businesses in the field of medicinal plants.

Assessment Task:

Students do a research on medical and aromatic plants in their local areas and present to the class.

Strand 1: Crops**Unit 5: Plants**

Content Standard 12.1.5 Students will be able to identify and examine the characteristics and physiology of different types of plants, categorise them according to their characteristics, purposes, and benefits and explore the different contexts, environments, and places where they are farmed.

Benchmark . 12.1.5.2. Investigate and explain the physiology of fruit trees and flower trees and spice, herbal, aromatic, and ornamental plants.

Topic 2: Plant physiology**Learning Objectives:**

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

- Research and explain the physiology of fruit and flower trees.
- Investigate and comprehend the physiology of spices, herbal, aromatic and ornamental plants

Essential questions:

1. What is plant physiology?
2. How can we explain the physiology of different types of plants?

Essential Knowledge	Physiology of fruit and flowering plants, spice, herbal, aromatics and ornamental plants.
Essential Skills	Investigative skills
Essential Attitudes & Values	Patient in discovery of physiological properties of plants

Content Background:

Plant physiology is a branch of study in Botany dealing with the physiological processes or functions of plants. Precisely, it is a descriptive study of variation and structure of plants at the molecular and cellular level, resulting in ecological, physiological and biochemistry related aspects of plant exploration.

With terrestrial plants evolving, special techniques and procedures were needed for its survival with a distinction between water and carbon dioxide.

Plant physiology deals with different plant structures and their functioning. It enables analysing processes in plants, namely – photosynthesis, mineral nutrition, respiration, transportation, and ultimately plant development and growth which are traits displayed by living entities.

The description is in the context of cellular activities in molecular parameters. It also gives a brief idea of the role of physiological processes in the environment.

Let us have a detailed look at the plant physiology notes for better conceptual understanding of the topic.

Physiology of Plant Parts

Leaves

Leaves are an important organ of the plant. They can grow in a variety of shapes and sizes. They are the primary centre of photosynthesis.

Stem

The stem provides support and structure to the plant. They perform many important functions such as plant growth, compete and survive in different environments, etc. The structure of the stem differs in different species.

Roots

The roots are an underground part of the plant that absorbs water and nutrients from the soil. That is why they are an important part of the plant.

Xylem and Phloem

These form the vascular tissues of the plant. These are also known as sap. They transport water, sugars and other important substances between the roots, stem and leaves.

Functions of Plant

Transportation In Plants

Plants have a distinct vascular system (xylem and phloem) which helps in transporting nutrients and water from roots to all the parts of the plant through translocation.

Transport of water and nutrients in rooted plants is unidirectional or multi-directional. Modes of transportation can either be passive which occurs through diffusion, facilitated diffusion to be precise or can be through active mode carried out by specific membrane proteins which are called pumps.

Water plays a pivotal role in carrying out physiological activities, hence understanding the importance of plant-water relations is essential.

The concept of water potential helps in comprehending the water movement through terms such as- Solute potential and pressure potential. At the cellular level, osmosis takes place in plants which allows movement of molecules in and out of the cells.

Transpiration is another aspect crucial in the life cycle of plants.

Mineral Nutrition

Plant nutrition is an important aspect instrumental in the growth of plants. It gives an insight into the methods used to identify essential elements for the development of plants, the role of these elements, criteria to identify their essentiality, deficiency symptoms and mechanism of absorption of these elements. It also conveys the importance of nitrogen fixation.

Macro and micronutrients present in plants carry out essential processes such as cell-membrane permeability, osmotic concentration of cell sap and its maintenance, enzyme activity and so on.

Inadequate supply of essential elements can lead to critical concentration in plants. Elements are absorbed through a mechanism which involves isolated cells, tissues and organs.

Apart from other essential elements, nitrogen fixation also takes place in plants.

Photosynthesis in Higher Plants

Plants synthesize their own food through photosynthesis and hence are called autotrophs.

Photosynthesis is important since it is the primary source of food for all living entities on earth and it releases oxygen in the atmosphere which we inhale to breathe.

It takes place in chloroplasts through light and dark reactions using 4 pigments- Chlorophyll a, chlorophyll b, Xanthophyll, carotenoids. Extracting energy from oxidizable substances and storing in the form of bond energy is phosphorylation.

In plants, cyclic and non-cyclic photo-phosphorylations take place. During photosynthesis, the Calvin cycle takes place through a set of 4 chemical reactions.

Respiration in Plants

Food that is required for life processes comes from photosynthesis. Cellular respiration results in the release of energy used for the synthesis of ATP which involves glycolysis.

Aerobic respiration leads to complete oxidation of organic substances in the presence of oxygen, which is common in higher organisms.

To release and utilise the energy stored in molecules, they undergo the following steps: electron transport system and oxidative phosphorylation.

Another important aspect of respiration is the respiratory quotient. The ratio of the volume of carbon dioxide released to the volume of oxygen consumed gives the respiratory quotient.

Plant Growth and Development

The process of plant development starts right from germination under favourable environmental conditions.

Generally, plant growth is indeterminate as they retain their capacity to grow throughout their lives because of the presence of meristems. The growth of plants is, however measurable through parameters such as – dry weight, increase in fresh weight, length, area, volume, cell number etc.

The period of plant growth is categorized into three phases – meristematic, elongation and maturation.

The growth rate can be determined quantitatively in 2 ways – absolute growth rate and relative growth rate.

The growth of plants is controlled by plant growth regulators.

Plants also produce compounds such as phytochromes that are light sensitive and stimulate the growth of the plant in response to environmental signals.

Plant physiology is also an important topic related to fruits, vegetables and other edible parts of the plants. The production of food crops, including the harvest and post-harvest storage of plant products, also hinges on the plant physiology studies.

Strand 1: Crops**Unit 5: Plants**

Content Standard 12.1.5 Students will be able to identify and examine the characteristics and physiology of different types of plants, categorise them according to their characteristics, purposes, and benefits and explore the different contexts, environments, and places where they are farmed.

Benchmark 12.1.5.3. Discuss how herbal, aromatic, and spice plants in PNG could be grown and commercialised at a large scale.

Topic 3: Technologies and commercialisation**Learning Objectives:**

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

- Propose ideas on how to farm and produce herbal, aromatic and spices in PNG

Essential questions:

1. What are some technologies used in commercial production?

Essential Knowledge	Growing herbal, aromatics and spice plants in PNG
Essential Skills	Commercialisation skills
Essential Attitudes & Values	Value commercialisation of plants

Content Background:

Hands-on laboratory science experiences are critical to the learning process across all areas of study, beginning with kindergarten and continuing through post-secondary education. Research has shown that students who engage in well-designed laboratory experiences develop problem-solving and critical-thinking skills, as well as gain exposure to reactions, materials, and equipment in a laboratory setting. Sustained investments in hands-on experiences help inspire students to further their education and prepare them for high-technology careers by fostering skills sought by potential employers.

Hands-on experiences significantly advance learning at all levels of science education when appropriately designed and guided by qualified educators. During hands-on Agricultural activities, students directly and safely investigate chemical properties and reactions, utilizing laboratory apparatus and instruments. These activities are essential for learning Agricultural science and improving science literacy. Web-based and computer-simulated activities may help increase student exposure to agricultural chemistry, reduce costs, and eliminate hazardous

waste and safety concerns; however, these tools cannot be considered as equivalent replacements for hands-on laboratory experiences.

The Education department believes that there is no equivalent substitute for hands-on activities where materials and equipment are used safely and student experiences are guided. The Department supports sustained investments to provide the facilities, equipment, curricula, and professional development needed for effective hands-on laboratory science experiences from kindergarten through post-secondary education.



Photo source: http://www.angop.ao/angola/en_us/noticias/economia/2018/0/3/Biocom-agricultural-laboratory-gets-international-quality-certification,4b0d2afa-aa67-470c-95b7-26a4ae5c3ba2.html

General Safety Rules

1. Listen to or read instructions carefully before attempting to do anything
2. Wear safety gears to protect your eyes from chemicals, heated materials, or things that might be able to shatter
3. Notify your teacher if any spills or accidents occur

Reference:

- Education Bureau of Hong Kong., (2013). Safety in Science Laboratory, cite at: [https://cd1.edb.hkedcity.net/cd/science/laboratory/safety/SafetyHandbook2013_En glish.pdf](https://cd1.edb.hkedcity.net/cd/science/laboratory/safety/SafetyHandbook2013_En%20GLISH.pdf) dated: 09/03/2020. 111 pp
- University of Florida., (2013). Laboratory safety manual, University of Florida, 41pp. Cited at: <https://labsafe%20Univ%20of%20Florida.pdf> on the 09/03/2020
- Virginia State University., (2013). Laboratory Safety manual. 2nd Revision, cited at: <http://www.vsu.edu/files/docs/academics/research/ag-research-safety-plan.pdf> on the 09/03/2020

Strand 1: Crops

Unit 6: Plants Farming Practices and Management Systems

Content Standard 12.1.6 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 . 12.1.6.1 Explain the principles of marketing and discuss how these can be used for marketing horticulture products.

Topic 1: Principles of marketing Horticulture Products

Learning Objectives

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

- Identify and explain the principles of marketing horticultural products

Essential questions

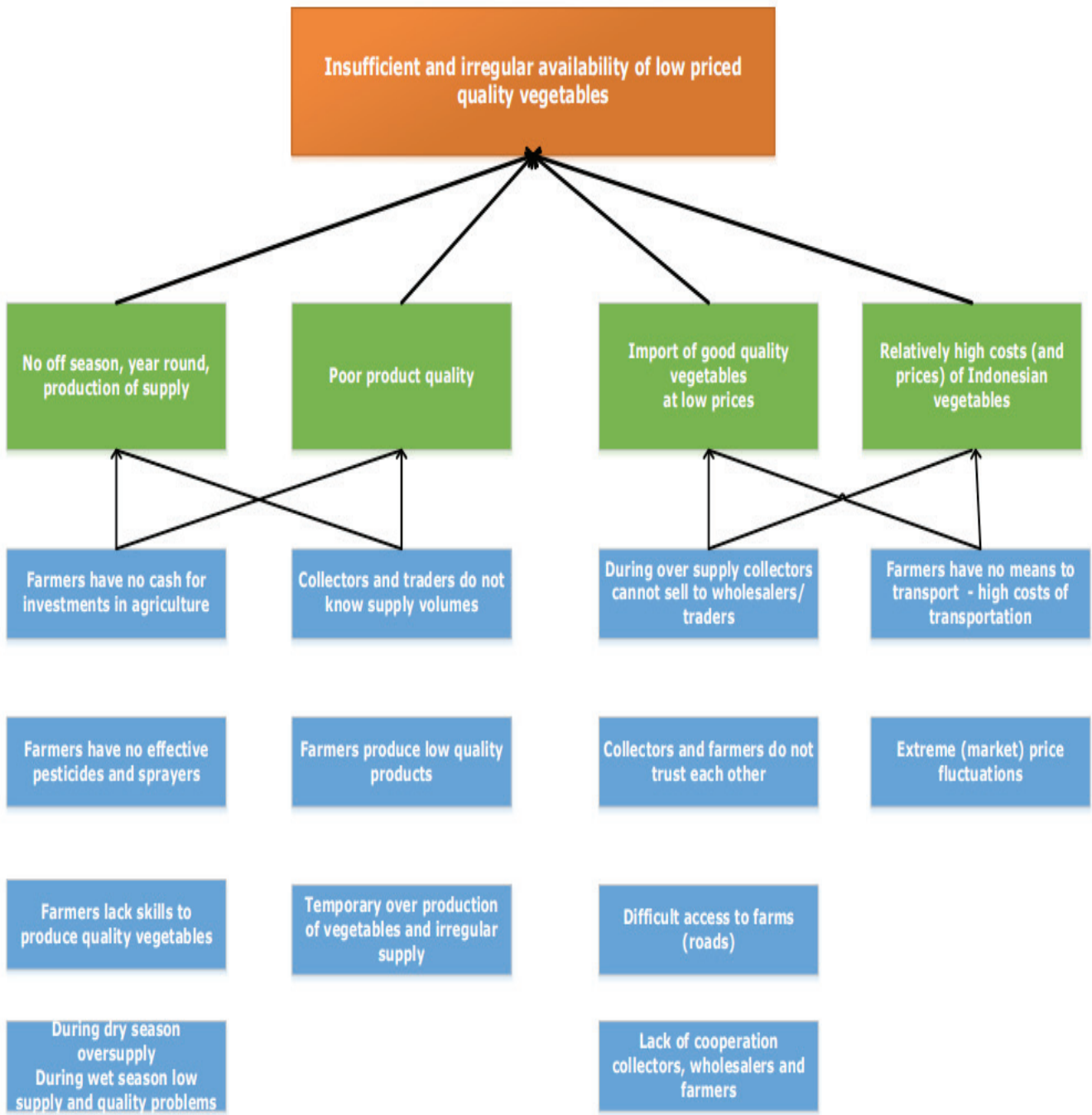
1. Can we market horticultural Plants?
2. Do we have some locals that produce and market horticultural products?
3. How can we market horticultural plants?

Essential Knowledge	Principles marketing horticultural plants
Essential Skills	Critical thinking – in investigating the principles of marketing
Essential Attitudes & Values	Corporative and honest in marketing horticultural plants

Content Background:

Horticulture Marketing

Understanding the needs of supply chain members (such as breeders, producers, market intermediaries, and consumers) is critical for horticultural products' success in the marketplace. Our researcher in horticultural marketing works with researchers from different disciplines and market stakeholders from the United States and around the world to evaluate alternative strategies for addressing statewide, national, and international demand for—and distribution of—horticultural crops through the application of marketing and economic principles and tools.



Strand 1: Crops systems

Unit 6: Plants farming practices and management

Content Standard 12.1.6 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 12.1.6.2 Investigate and evaluate the importance of horticulture marketing functions and marketing channels for horticulture crops.

Topic 2: Horticulture Crops

Learning Objectives:

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

- Propose ideas and justify the essence of horticulture crop marketing

Essential questions:

1. How can horticulture products be marketed?
- 2.

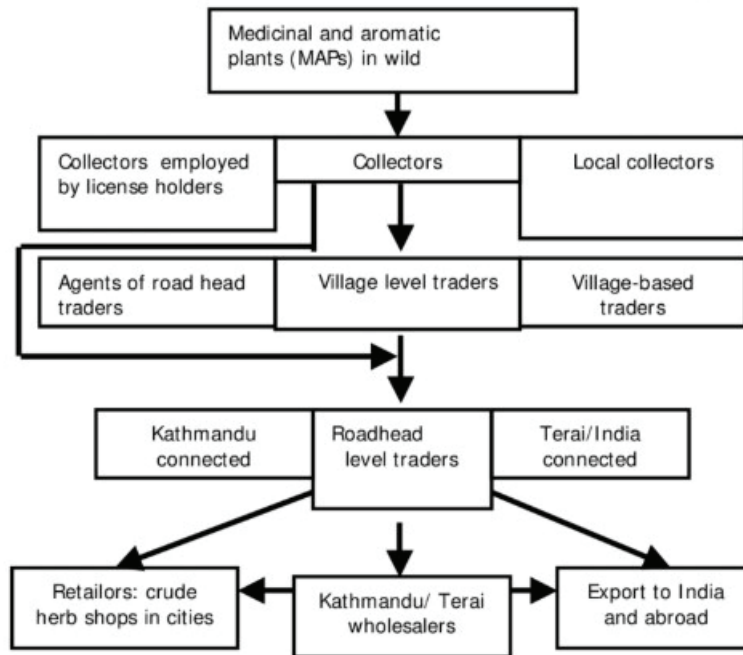
Essential Knowledge	Horticulture marketing functions and channels
Essential Skills	Investigative skills on marketing horticulture
Essential Attitudes & Values	Honesty and value the channels and functions of marketing horticulture crops.

Content Background:

Marketing channels are used to move goods and services to consumers and information and payment back to producers. In developing countries, these channels also serve some additional functions:

1. They encourage production above subsistence level, giving small producers access to the market economy.
2. They create a potential for activities to be built in as services into the final product, thus giving consumers more satisfaction and producers, processors, and traders higher returns.

The marketing functions under three major groups' functions of exchange, functions of physical supply and facilitating functions. Functions of Exchange: It includes buying, assembling and selling. Buying is the first steps of marketing functions. It requires planning of purchases. Intelligent search for probable sellers, assembling of goods in right quantity and quality at the right place and time and at the right price. Assembling is concerned with the collection and concentration of goods of the same type from different sources at a place for further movement. Selling involves demand creation, product planning and development, finding of buyers, negotiations of terms of sale such as price, quantity, quality etc. and sale contract leading to a transfer of title and possession of goods.



(a) The marketing chain for medicinal and aromatic plants harvested in Wild (e.g. from India)

Source: (a) above: https://www.google.com.pg/search?q=marketing+of+medicinal+plants&hl=en&source=Inms&tbm=isch&sa=X&ved=2ahUKEwiiy8THwozoAhUExzgGHUZ5AOEQ_AUoAXoECA0QAw&biw=1366&bih=608#imgrc=6k2NQiRg9uu0hM

Reference:

1. Kotler, P and Keller, K.L., (2012). Marketing Management. 14ed, Prentice Hill, Boston USA, 812 pp
2. Pelton, L.E, Strutton, D and Lumpkin, J.L., (2016). Marketing Channels: A relationship management approach, Edinburg Business School, UK. 50p

Strand 1: Crops**Unit 7: Plant Farming and Technology**

Content Standard 12.1.7 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.

Benchmark 12.1.7.1 Research and design a system for cultivating horticulture plants at a larger scale.

Topic 1: horticulture cultivation**Learning Objectives:**

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

- Describe horticulture cultivation.
- Compare the types of commercial green house.

Essential questions:

1. What is horticultural cultivation?
2. What is an example of commercial horticulture?

Essential Knowledge	Horticulture cultivation, commercial horticulture
Essential Skills	Discover horticulture Compare types of greenhouse
Essential Attitudes & Values	Sustainability and creative

Content Background:**Horticulture cultivation**

Horticulture contributes significantly to society in terms of provision of healthy foods, vitamins and minerals, and recreational activities. Commercial horticulture is very diverse, in terms of crops grown, available cultivars, propagation of planting material, growing media and feed, production systems, crop protection, and post-harvest management and processing; and demands intensive labor input. Increasing labor and land cost has resulted in a decline in horticultural production in many developed countries around the world, shifting the production to countries where the cost of production is competitive. Conversely, availability of affordable technology and sufficient work force with required knowledge is a key challenge facing horticulture in developing economies. Although key challenges facing commercial horticulture are the same globally, the relative importance of these challenges depends greatly on the local economy and climatic conditions.

Commercial Horticulture

Commercial horticulture encompasses the production and management of ornamental plants and turf grass, as well as fruits and vegetables for profit. Extension programs in this area focus on challenges facing these segments

of the industry in marketing, integrated pest management, sustainable cultural practices, environmental and human health risks, invasive species, regulations, and profitability.

Example of commercial horticulture – green house

What Greenhouse Farming Involves?

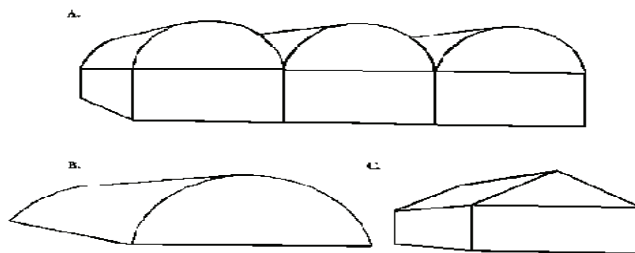
Greenhouse farming is the unique farm practice of growing crops within **sheltered structures** covered by a transparent, or partially transparent, material. The main purpose of greenhouses is to provide **favorable growing conditions** and to protect crops from unfavorable weather and various pests.

Types of Greenhouses

Generally speaking, there are three types of greenhouses: lean-to, detached, and ridge and furrow or gutter connected. Few lean-to greenhouses are used for commercial production because of limitations in size. This type of house is the most popular among hobbyists.



Figure 1. Commercial greenhouse structures: A) gutter connected, B) free standing quonset C) single gable.



Assessment task

Design a model of a greenhouse using local and other improvised materials.

Sources:

<https://www.growerssupply.com/ADAVG>

Strand 1: Crops**Unit 7: Plant Farming and Technology**

Content Standard 12.1.7 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 12.1.7.2 Research and explain genetic engineering and evaluate its implications for horticulture.

Topic 2 : Genetic engineering**Learning Objectives:**

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

- Discover genetic engineering
- Differentiate genetic and conventional plant breeding

Essential questions:

1. What is genetic engineering?
2. How can we differentiate conventional plant breeding?

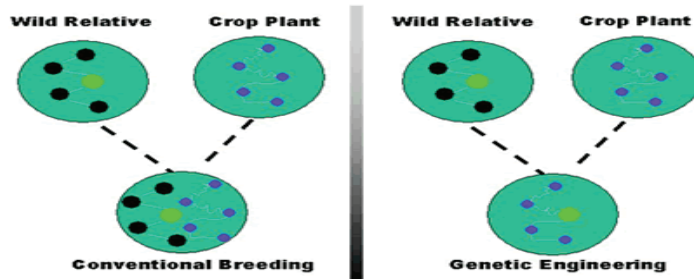
Essential Knowledge	genetic engineering conventional plant breeding
Essential Skills	Compare, differentiate
Essential Attitudes & Values	

Content Background:**Genetic Engineering**

Over the last 50 years, the field of genetic engineering has developed rapidly due to the greater understanding of deoxyribonucleic acid (DNA) as the chemical double helix code from which genes are made. The term genetic engineering is used to describe the process by which the genetic makeup of an organism can be altered using “recombinant DNA technology.” This involves the use of laboratory tools to insert, alter, or cut out pieces of DNA that contain one or more genes of interest. Developing plant varieties expressing good agronomic characteristics is the ultimate goal of plant breeders.

With conventional plant breeding, however, there is little or no guarantee of obtaining any particular gene combination from the millions of crosses generated. Undesirable genes can be transferred along with desirable genes; or, while one desirable gene is gained, another is lost because the genes of both parents are mixed together and re-assorted more or less randomly in the offspring. These problems limit the improvements that plant breeders can achieve.

In contrast, genetic engineering allows the direct transfer of one or just a few genes of interest, between either closely or distantly related organisms to obtain the desired agronomic trait (diagram below). Not all genetic engineering techniques involve inserting DNA from other organisms. Plants may also be modified by removing or switching off their own particular genes.

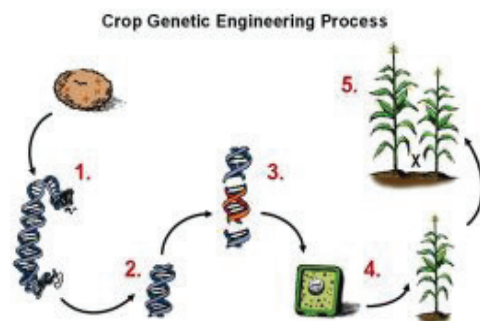


Comparing Conventional Breeding and Genetic Engineering

Conventional Breeding	Genetic Engineering
<ul style="list-style-type: none"> • Limited to exchanges between the same or very closely related species • Little or no guarantee of any particular gene combination from the millions of crosses generated • Undesirable genes can be transferred along with desirable genes • Takes a long time to achieve desired results 	<ul style="list-style-type: none"> • Allows the direct transfer of one or just a few genes, between either closely or distantly related organisms • Crop improvement can be achieved in a shorter time compared to conventional breeding • Allows plants to be modified by removing or switching off particular genes

The five steps in crop genetic engineering process

1. Locating an organism with a specific trait and extracting its DNA.
2. Cloning a gene that controls the trait.
3. Designing a gene to express in a specific way.
4. Transformation, inserting the gene into the cells of a crop plant.
5. Cross the transgene into an elite background.



Assessment task

Students to do a research on genetic engineering steps and interpret them correctly on how they are carried out.

Source

Agricultural Biotechnology (A Lot More than Just GM Crops). https://www.isaaa.org/resources/publications/agricultural_biotechnology/download/.

Strand 2: Animals

Content Overview

Content Standard 2.1: Students will be able to identify and appraise the characteristics of different types of domesticate and farm animals, categorize them according to their characteristics, feeding systems, purposes and their benefits and investigate the different context, environments and places where they are farmed			
UNITS	BENCHMARK	TOPICS	LESSON TITLES
Types of Animals	12.2.1.1 Identify and analyze the factors that contribute to the production of quality monogastric and polygastric animal and apiculture products	Factors that contribute to quality animal products	Monogastric animal products
			Polygastric animal products
			Apiculture products
			Factors that contribute to quality production
	12.2.1.2 Evaluate and discuss the benefits of improved and value added monogastric and	Benefits of improved animal products	Value added monogastric and polygastric products
			Value added apiculture products
Benefits of value added products			
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.			
Animal Farming practices and Management systems	12.2.2.1 Research and explain the factors of husbandry animal production	Factors of animal husbandry production	Animal husbandry factors
	12.2.2.2 Evaluate emerging trends in animal agriculture and justify how it is used to improve current practices	Trends in animal agriculture	Current trends of animal production
			Emerging trends of animal production (can be a research topic)
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 analyse their advantages and disadvantages.			
Animal Farming and technology	12.2.3.1 Explain the advances in electronic agriculture and analyze its impact on animal farming	Electronic agriculture in animal farming	Types of electronic agriculture
			Impacts of electronic agriculture on animal farming (can be a research topic)
	12.2.3.2 Identify a technology problem related to the farming of animals and develop appropriate solution	Animal farming technologies	Constrains and solutions
Content Standard 2.4: Students will be able to identify and evaluate the characteristics of different types of domesticated Birds, categorize them according to their characteristics, functions, and benefits, and investigate the different contexts, environments, and places where they are farmed.			
Units	Benchmark	Topics	Lesson Titles

Types of birds	12.2.4.1 Analyse and explain the anatomy of domesticated and farmed birds.	Bird anatomy	Anatomy of birds
	12.2.4.2 Analyse and explain the physiology of farmed and domesticated birds	Bird physiology	Physiology of birds
Content Standard 2.5: Students will be able to investigate and analyze the different types of farm and management principles, systems, and practices used in different environments and places to farm birds.			
Poultry Farming practices and management systems	12.2.5.1 Explain the process of setting up and managing a poultry project, and evaluate each step.	Poultry project processes	Set up Managing Evaluation
		Planning a poultry project	
	12.2.5.2 Investigate and assess the ability and effectiveness of different poultry pest and disease control and management strategies.	Pest and disease management	Pests Control and prevention measures and
			Common Poultry pest and diseases Disease Control and prevention measures and Control and preventive measures and strategies
Content Standard 2.6: Students will be able to investigate how technology is used in for bird farming, processing, preservation, marketing, consumption, regulation, and management in different contexts and environments and analyze their strengths and weaknesses.			
Bird farming and technology	12.2.6.1 Research and identify poultry harvesting problems and develop appropriate solutions	Poultry harvesting problems	Constrains and solutions in poultry
	12.2.6.2 Research and assess technologies used in different contexts to improve and add value to poultry products to meet the demand for these products.	Technologies and improved products	Technologies used to improve products Field trip to processing sites or give as research topics for assessment

Strand 2: Animals**Unit 1: Types of Animal**

Content Standard 12.2.1: Students will be able to identify and appraise the characteristics of different types of domesticate and farm animals, categorise the according to their characteristics, feeding systems, purposes and their benefits and investigate the different context, environments and places where they are farmed.

Benchmark 12.2.1.1 Identify and analyze the factors that contribute to the production of quality monogastric and polygastric animal and apiculture products

Topic: Factors that contribute to the production of quality animal products

Learning Objectives:

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

- Identify and outline factors that contribute to quality production of monogastric, polygastric, animal and apiculture products

Essential questions:

1. What are some factors to consider before establishing an animal farm?
2. Why do farming systems affect the quality of output of animal products?

Knowledge	Factors that contribute to the production of quality animal products
Skills	Analyze factors that contribute to quality outputs
Attitudes	Creative and visionary learners
Values	Empowerment and sustainability

Content Background:

In the modern world today quality of the animal products produced is very important.

Monogastric livestock are mostly pigs and chickens. Pig products are mostly pork meat in different cuts. Chicken products are both meat and eggs. Polygastric livestock products are mainly cattle, sheep and goats. They all produce meat and milk. Apiculture is the practice of beekeeping and the product is mainly honey.

Some of the factors that may contribute to quality animal product are;

- The desired breed of animal that may give quality and quantity. This can be achieved through selective breeding.
- Type of farming system used
- Feed rations and type used
- Hygiene of the animals farmed
- Processes and procedures involved in slaughtering, packaging and marketing.

Recommended Resources Textbooks, Newspaper Articles, Internet, Android phones, Magazines,

Assessment Task Research and outline factors that contribute to quality production of monogastric, polygastric, and apiculture animal products.

Strand 2: Animals

Unit 1: Types of Animal

Content Standard 12.2.1: Students will be able to identify and appraise the characteristics of different types of domesticate and farm animals, categorize the according to their characteristics, feeding systems, purposes and their benefits and investigate the different context, environments and places where they are farmed.

Benchmark 12.2.1.2 Evaluate and discuss the benefits of improved and value added monogastric and polygastric animal and apiculture products

Topic: Benefits of Improved Animal Products

Learning Objectives: By the end of the topic the students will be able to;

- define value added products and explain the reasons and processes involved in cultivating and improving the quality of animal products

Essential Questions

1. Why are farmers concerned of the quality of outputs of animal products?
2. Give an example of a value added animal product
3. What will the demand be like if there is value added to the products? Or quality output?

Knowledge	Value added meat products are further processed meat products with increasing convenience to consumer through decreasing preparation time, minimizing preparation steps, allowing use of specific parts, taking risks out of kitchen and increasing value of product.
Skills	Evaluate animal products using set of criteria
Attitudes	Being critical thinkers
Values	Empowerment and sustainability

Content Background

What is value added product?

A value added product is a change in the physical state or form of the product. The production of a product in a manner that enhances its value.

Value added meat products are further processed meat products with increasing convenience to consumer through decreasing preparation time, minimizing preparation steps, allowing use of specific parts, taking risks out of kitchen and increasing value of product. These may come to the terms with processed products that is easily used and consumed.

Example;

1. Conned beef – cooked, canned and easily served
2. Lamp flaps – slaughtered, packed and ready for cooking
3. Pork meat – cut into pieces, packed and ready for cooking
4. Honey- collected, strained and packed in bottles or jars ready for use



Value added benefits have the power to drive customer acquisition, Increase member retention and build lasting loyalty. Plus, as the customer has come to expect more value for their loyalty, the right program can help you keep up with that demand.

The difference between profit and added value is that the added value is much easier to quantify. Profit equals the cost of sale minus cost of production, transportation and marketing.

Recommended Resources Textbooks, Newspaper Articles, Internet, Android phones, Magazines, and Other audio- visual media

Assessment Task Research and outline types of value added animal products and explain the reasons and processes involved in cultivating and improving the quality of animal products.

Research topic can be on ‘setbacks or negative outcomes of value added products’

Strand 2: Animals

Unit 2: Animal Farming Practices and Management Systems

Content Standard 12.2.2 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 12.2.2.1 Research and explain the factors of husbandry animal production.

Topic: Factors of Animal Husbandry Production

Learning Objectives: By the end of the topic, students will be able to;

- explore types of animal husbandry practices in each of the livestock management practices

Essential Questions

1. What is animal husbandry?
2. Name a few animal husbandry practices that farmers practice in animal rearing?
3. Why having and applying husbandry practices?

Knowledge	Animal husbandry practices mean the management of animals including their feeding, housing, health care and breeding.
Skills	Research and report on an existing animal farm management systems and husbandry practices
Attitudes	Creative thinkers
Values	Sustainability and empowerment

Content Background

Animal husbandry practices mean the management of animals including their feeding, housing, health care and breeding. Large-scale farming is mostly for commercial purposes so intensive husbandry systems are practiced. Small-scale farming is mostly for consumption and social purposes so the free-range or extensive systems of management are practiced here.

Feeding

Feeding covers the feeds; feed, quality, amount consumed and the frequency. Many polygastric animals are herbaceous and eat a lot of grass.

Housing

This depends on the type of animal looked after and the management practice used. It can also depend on the environment and climatic conditions.

For example;

- In a range or extensive system the animals allowed to find a comfortable shelter they may find within the yard
- In an intensive system, the animals are provided with housing. The houses are constructed to the climatic conditions of the environment.
- In a semi-intensive system, the animal may be allowed to be outside of the house during the day and inside the house during the night.

Health Care

Different types of animals have their pest and diseases. These pests and diseases need to be identified and controlled. Areas that need good understanding by the farmers would be;

- Relationship between climate and diseases
- The cause and nature of the diseases
- Types of diseases
- Defence mechanisms of body against diseases
- Methods of disease control

Breeding

Breeding means to produce young. The more young animals produced; the more income for the farmer. There are number of breeding systems used all around the world

Breeding systems;

1. Outbreeding

- Mating is brought about by pairing animals that possess unlike or dissimilar ancestries or pedigrees
- Tends to produce litters with greater vigour and productivity

2. Cross breeding

- Results in heterozygous individuals in which most pairs of genes contain one of dominant genes that influence vigour

3. Inbreeding

- Mating is brought about in mating by pairing related individuals of those with similar pedigree.
- Similarities of the animals are increased.
- Reduces vigour because it brings together the recessive genes with undesirable effects in the resulting crossbreds.
- Brings out the desired character in a pure form character to retain it.

Animal reproductive cycles need to be understood and monitored.

Example; the **oestrous cycles** of the females, artificial insemination and other practices.

Recommended Resources Textbooks, Newspaper Articles, Internet, Android phones, Magazines, and Other audio-visual media

Assessment Task: Research and discuss animal husbandry practices applied in animal rearing in different farming systems.

Strand 2: Animals

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 12.2.2.2 Evaluate emerging trends in animal agriculture and justify how they are used to improve current practices.

Topic: Emerging Trends in Animal Agriculture

Learning Objectives: By the end of the topic the students will be able to;

- Explore and describe the current and emerging technology trends in animal farming.

Essential Questions

1. What are some of the emerging trends in animal farming?
2. How are these trends beneficial to farmers?
3. What are the impacts of these trends to animal farming?

Knowledge	Current and emerging trends in animal agriculture
	Future production trends
Skills	Describe the Current and emerging trends in animal agriculture
Attitudes	Appreciate current and emerging trends in animal agriculture
Values	Sustainability and creative thinking

Content Background

Current and emerging trends in animal agriculture are evolving in response to rapidly increasing demand for livestock products. Developed countries, demand for livestock is stagnating, production systems are increasing their efficiency and environmental sustainability. Changes in demand for livestock products have been largely driven by:

1. Human population growth
2. Income growth and urbanization

Production response in different livestock systems has been associated with;

1. Science and technology
2. Increases in animal numbers

Future production trends will be affected by;

1. Competition for natural resources
 2. Land and water
 3. Between food and feed
 4. Need to operate in a carbon-constrained economy
2. Developments in; breeding, nutrition and animal health will continue to contribute to increasing potential production and further efficiency and genetic gains.

Livestock products in the future could be heavily moderated by socio-economic factors such as:

- Human health concerns
- Changing socio-cultural values

Recommended Resources Textbooks, Newspaper Articles, Internet, Android phones, Magazines, and Other audio- visual media

Assessment Task: Research and outline the current and emerging trends in animal farming.

Strand 2: Animals and Technology

Unit 3: Animal Farming

Content Standard: 12.2.3. 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 analyse their advantages and disadvantages.

Benchmark 12.2.3.1 Explain the advances in electronic agriculture and analyze its impact on animal farming

Topic: Electronic Agriculture in Animal Farming

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

- Explain and outline how technology has impacted animal farming

Essential Questions

1. How has animal farming advance in animal agriculture?
2. What are some advantages, disadvantages and limitations of electronic technology on animal production?
3. Why advancing to online marketing of animal products?
- 4.

Knowledge	Advances in electronic marketing of animal products
Skills	Explore and outline technology that farmer's requirements are met?
Attitudes	Creative and opened minded learners
Values	Competent and empowerment

Content Background

The main technology that livestock farmer's requirements met is electronic records, milking, heat detection walk-over-weighing, auto-drafting, genetic improvement, feeding, barn environment optimization, and health recording etc. Some sensors are currently available for this purpose, but they do not fulfill all demands. Also, with advances in proteomics and genomics, new biomarkers are being discovered, allowing the disease to be detected at earlier stages. This will lead to assays with higher sensitivity, which can provide additional quantitative information on the level of inflammation 'on-site' and 'on-line' and which is also faster and less expensive. These technologies provide to dairyman many opportunities to make easier and more convenient their decisions about dairy future plans.

Five (5) emerging technologies driving improvements in animal welfare and safety:

1. Remote monitoring technologies
2. Automated dairy installations
3. Pasture and feeding technologies
4. Automated cleaning systems
5. Herd management systems

Students may be given research work on the 5 technologies listed above or on other electronic agriculture in animal farming as practical assessment tasks.

Recommended Resources Textbooks, Newspaper Articles, Internet, Android phones, Magazines, and Other audio- visual media

Assessment Task: Research current and emerging electronic technology use in animal farming and report on how it influences farmers and consumers.

Strand 2: Animals and Technology

Unit 3: Animal Farming

Benchmark 12.2.3.2 Identify a technology problem related to the farming of animals and develop appropriate solution

Topic: Animal Farming Technologies

Learning Objectives: By the end of the topic the students will be able to;

- Identify and explain processes and procedures to follow to solve technological problems associated with animal farming.

Essential Questions

1. What are the limitations that most farmers experience in animal farming?
2. Why are there technology problems in some areas?
3. How would farmers rectify related technology problems and allow for productive and quality output of animal products?

Knowledge	Problems and solutions to technology problems
Skills	Research and report on existing technology related problems and suggest solutions to these problems
Attitudes	Critical thinkers and problem solvers
Values	Empowerment and sustainability

Content background

Pedometers also used for estrus detection attached to the leg of the cow to measure the amount of her activity over a unit time span .Many pedometric systems are commercially available in the market. Also standing activity systems is commercially available in the markets. Standing activity activated by the mounting cow. Radio signal picked up by receiver and relayed to a buffer and a personal computer to analyzing of data. This system record cows number, standing time, date and duration to evaluation on time.

The second one is effective aids for detecting standing estrus is a marker or

teaser animal. Marker animals are worn marking device. When an animal in standing estrus is mounted by the marker animal, the chin-ball marker will rub against the animal in standing estrus, leaving marks on her back and rump. Mounting and standing activity are effective methods for estrus detection. There are many other methods available on the system such as cervical mucus, vaginal characteristics, temperature, blood flow, and hormone changes in blood and milk. But these are methods not applicable on the farm level. Milk progesterone level is a good criteria for stage of the cycle or pregnancy. So it can be used for diagnose problem cows in herd.

The behavior meter continuously records the animal behavior for many purposes (lying time, lying bouts and the activity of the individual cows). The cow-behavior enables animal welfare assessment in different environmental conditions and stress situations, as well as reproductive and health status.

Pregnancy check: Pregnancy diagnosis is one of the most important factors to get ideal calving interval. The most common methods are rectal and trans rectal ultrasonography of the reproductive tract. Both procedures are required training and time. An experienced practitioner using ultrasound can reliably diagnose pregnancy from 30 days gestation whilst an experienced veterinary is able to diagnose pregnancy from 35 days. Enzyme-linked immunosorbent assay

Suggested Research topics for students:

- Identify problems related to application of advanced technology.
- Develop appropriate strategies or solutions to the problems.

Can be done through research alone or after a field trip or excursion to a site or farm that operates on advanced technologies.

Recommended Resources: Textbooks, Newspaper Articles, Internet, Android phones, Magazines, and Other audio- visual media

Assessment Task:

Identify a technology problem related to the farming of animals and develop an action plan to find a solution to the problem.

Strand 2: ANIMALS

Unit 4: Types of Birds

Topic: BIRD ANATOMY

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

Benchmark 12.2.4.1 Analyse and explain the anatomy of domesticated and farmed birds

Essential Question

1. What is the difference between domesticated and farmed birds?
2. Why is it important to know the anatomy of birds?
3. How do these features aid the survival of birds?

Learning Objective

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

- Identify and describe anatomy of birds

Knowledge	Anatomy of birds
Skills	Identify and analyze birds' anatomy
Attitudes & Values	respect for birds
Assessment Task	Research and outline the anatomy of various birds and describe how these specific features aids birds survival.

Content Background

1. Bird Anatomy

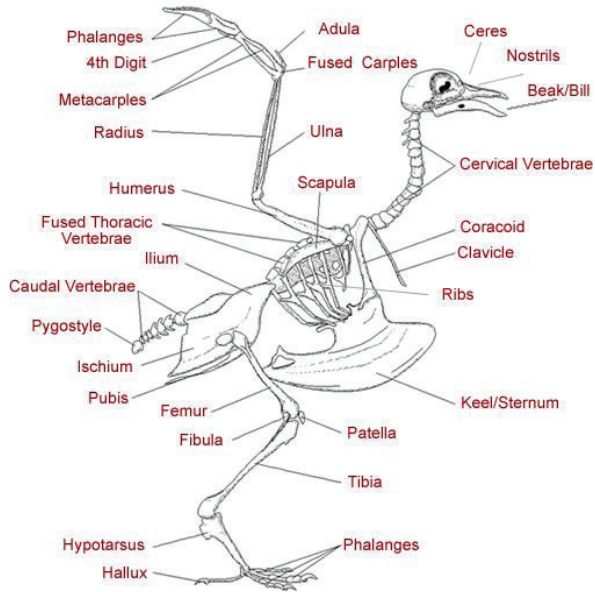
Anatomy refers to the internal and external structures of the body and their physical relationships. (<http://www.sciencedirect.com>)

It is important to know the anatomy of the birds as it provides basic knowledge about the bird's body. It shows many unique adaptations,

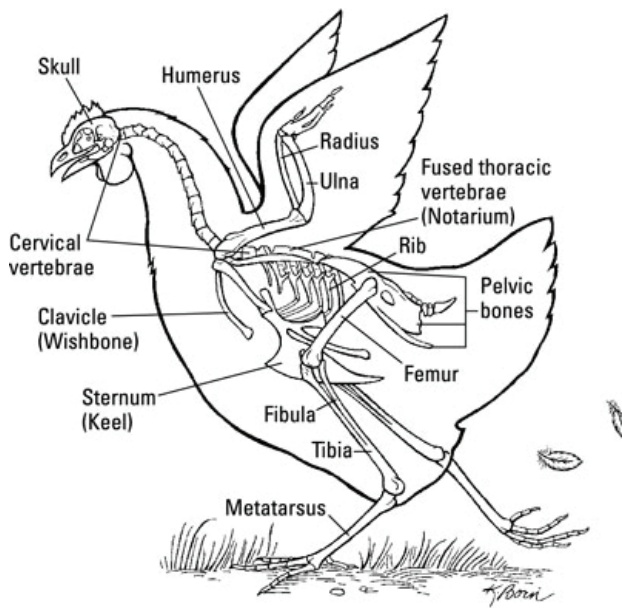
- mostly aiding flight for flight birds
- development of beak which has led to evolution of specially adapted digestive system

All birds have the same basic skeletal structure but with different variations in size and shape depending upon species. A bird skeleton is very unique whether the bird is flightless or adapted to flight (Error! Hyperlink reference not valid.).

External anatomy of birds

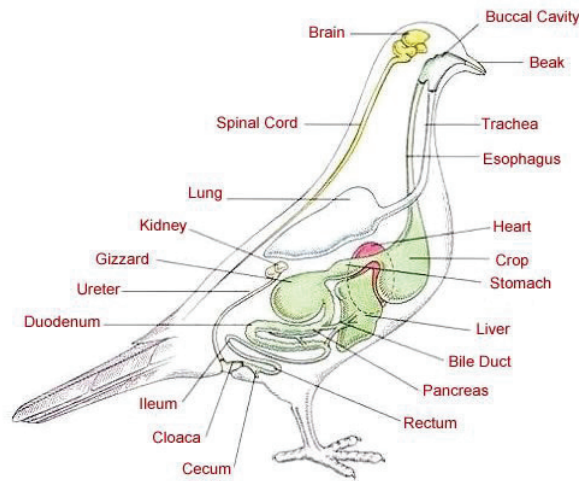
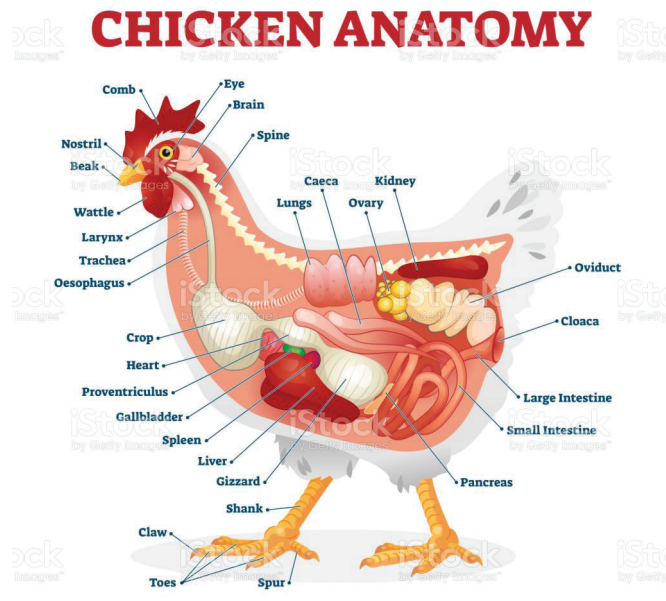


Skeletal system of a flight bird.



Skeletal system of a chicken

Internal anatomy of birds



Teachers can use chicken model to name parts for practical assessment.

Unit: TYPES OF BIRDS	Topic: BIRD PHYSIOLOGY
Content Standard 2.4 : Students will be able to identify and evaluate the characteristics of different types of domesticated Birds, categorize them according to their characteristics, functions, and benefits, and investigate the different contexts, environments, and places where they are farmed.	
Benchmark 12.2.4.2 Analyse and explain the physiology of farmed and domesticated birds	
Essential Question	1. Why is bird physiology important? 2. what are the common physiology of birds?
Learning Objective	By the end of this topic, students will be able to: Explain the physiology of birds
Knowledge	Physiology of birds
Skills	analyze and categorize physiology of birds
Attitudes & Values	appreciate and value variety of bird species
Assessment Task	Research and illustrate physiology of birds

Content Background

Bird Physiology

Physiology is the science of life that aims to understand the mechanisms of living things, from the basis of cell function at the ionic and molecular level to the integrated behavior of the whole body and the influence of the external environment. (Error! Hyperlink reference not valid. is physiology?++)

All birds have the following key features: they are endothermic, have two legs and lay eggs.

Defining characteristics of modern birds also include:

- Feathers
- High metabolism
- A four-chambered heart.
- A beak with no teeth.
- A light weight but strong skeleton
- Production of hard-shelled eggs.

Birds have high metabolism and body temperatures. Their respiratory system is highly adapted to allow efficient oxygen delivery into the body during the flight. A large heart pumps the circulation to deliver oxygen and important compounds around the body. Birds physiology is made up of the following systems:

- Bird respiration
- Circulation
- Metabolism
- Digestion
- Temperature regulation

Students can be given the different systems above to research and identify parts and functions in each system as practical assessment work.

Unit 5: Bird farming practices and management systems

Topic: PLANNING A POULTRY PROJECT

Content Standard 2.5: Students will be able to investigate and analyze the different types of farm and management principles, systems and practices used in different environments and places to farm birds.	
Benchmark 12.2.5.1 Explain the process of setting up and managing a poultry project, and evaluate each step.	
Essential Question	What are the key processes of setting up a poultry project? How is each process managed? Why is it important to evaluate each step?
Learning Objective	By the end of this topic, students will be able to: Identify the processes of setting up a poultry project Evaluate each process and management steps
Knowledge	Explain the process of setting up and managing poultry project
Skills	Evaluate each steps
Attitudes & Values	□patience and perseverance to set up project
Assessment Task	Carry out a research on key processes of setting up a poultry project and outline the management steps

Content Background

Planning a Poultry Project

In order to start up a project or a business, there should always be a plan to follow. Poultry farming is a broad term that basically means you raise different types of domestic birds for the purpose of selling the meat commercially. Chickens are a popular poultry farming birds because they offer a good source of animal protein. (<https://businessdiary.com.ph>)

Planning for poultry production is the act of organizing decisions on a timeline to start and finish the project. The decisions made include the objectives, time required, labour and expertise, finance, materials, and equipment and other factors required to begin and complete the project in a profitable and sustainable manner. Given in Table 1 is a sample of poultry production plan.

Table 1. Sample of a typical poultry production plan

No	Activity	Resource	Time Days	Budget Estimate	Income Estimate	Comments
1	Plan project	Note book, pen, calculator, expertise	1	20		Get advice from poultry experts
2	Inspect site	Camera	1	10		Observe, take photos of land, topography, water etc.

3	Prepare land	Spade, tape measure etc.	2	30		
4	Buy materials to build house	Money and transport	2	500		
5	Build house	Materials, tools, equipment and labour	14	200		
6	Build brooder	Materials and money	3	200		
7	Buy equipment and feeds	Money and transport	2	300		
8	Buy DOC	Money	1	200		100 DOCs
9	Brooding	Money, feed	14	20		Heat, feed & DOCs
10	Management	Money, feed, care	60	500		
11	Harvesting	Slathering and dressing tools	3	100		
12	Dressing of carcass	Tools and equipment	3	100	98 @K30 = 294	2% mortality
13	Marketing and sale	Transport, phone	7	100		
14	Banking	Ledger and financial statement	3			
			116	2380	2940	

Gross margin:

$$K2940 - 2380 = K560.00; \text{GM/Kina input} = 560/2380 =$$

For a profit making project, each step of the planning, processing and management must be evaluated to identify constraints or set-backs so that possible solutions can be drawn out according to the problem at hand and available resources. Improvising and creativity or initiatives may be resorted to, to address some problem or challenges along the way. This is done to minimize loss and maximize profit.

Teachers may give as a research work for students to

- Make evaluation of the project they did
- Identify challenges or constraints encountered
- Develop possible solutions to rectify them

Unit 5: Bird farming practices and management systems

Topic: PEST AND DISEASE MANAGEMENT

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

Benchmark 12.2.5.2 Investigate and assess the ability and effectiveness of different poultry pest and disease control and management strategies.

Essential Question	<ul style="list-style-type: none"> • What are some common pest and disease of poultry? • How can the pests be controlled or rectified? • What are some control or preventive measures or strategies for the diseases?
Learning Objective	By the end of this topic, students will be able to: <ul style="list-style-type: none"> • Investigate and state the control measures of poultry pest and diseases • Assess and evaluate their effectiveness these management strategies
Knowledge	<ul style="list-style-type: none"> • Identifying control and management strategies
Skills	<ul style="list-style-type: none"> • Investigate and assess the ability and effectiveness
Attitudes & Values	<ul style="list-style-type: none"> • Accept challenges (pest & disease) of the project
Assessment Tasks	<ul style="list-style-type: none"> • Describe common pest and disease of poultry and discuss the control or preventative and management measures

Content Background

Pest and Disease Management

The everyday pest of poultry would be lice, fleas, mites and bedbugs. They can be controlled by spraying or dusting the house with recommended chemicals and replacing litter at the end of each crop. These are external parasites while internal parasites such roundworms, tapeworms and gapeworms are found in the intestines and lead to diseases.

Common causes of disease in poultry are usually combination of factors that make birds sick. Environmental conditions like:

- Poisons
- Injury
- Nutritional deficiencies
- Poor air quality
- Temperature extremes
- Physical stress
- Exposure to disease carrying vermin and insects such as rodents and darkling beetles

Common preventive measures include:

- Vaccination
- Parasite control
- Identifying and treating sick birds

- Separating multi-age flocks
- (<http://www.business.qld.gov.au>)

Caring for chickens is one very important management aspect in a chicken project. If not done properly, high mortality can occur thus lower profit.

Some common diseases of chickens their prevention and treatment.

- a) Starvation and chilling
- b) Fowl pox
- c) Coccidiosis
- d) Worms

A) Starvation and chilling

This is not a disease as such, but a management problem. Starvation and chilling is usually caused by low brooding temperature, overcrowding and insufficient feeding space.

Signs and Symptoms.

You will notice that the chicks will huddle together refusing to eat and look tired, wings drooped and feathers ruffled.

Prevention and Treatment.

Provide correct brooding temperature Provide sufficient feeding space
Observe correct floor spacing

B) Fowl Pox

The disease is spread from one bird to another by mosquitoes.

Signs and Symptoms.

Most likely in wet seasons when mosquitoes are around you will see wart like growths on the combs, eyelids and corner of the mouth. Prevention and Treatment.

Prevention is by vaccinating day old chicks. There is little treatment available, but you can separate sick birds form healthy ones. Always buy chicks that have been vaccinated at the hatchery.

C) Coccidiosis

This is a common disease of chickens. It spreads from bird to bird through eating food, water or litter, which contains the parasites. Overcrowding and wet litter are the main cause of the disease.

Signs and Symptoms

Most obvious sign here is blood in the faeces. Birds are not interested in feeding and looked depressed or sleepy.

Prevention and Treatment.

Observe correct floor spacing. Keep the litter in the shed dry at all times. Feed chickens with stock feed which contains chemicals that aid in the control of disease. If there is an outbreak of coccidiosis in the flock, it must be treated with medication in the drinking water. A chemical call TOLTRO or AMPROLMIX

are very effective. See instructions on the containers for instructions to use.

D) Worms

This is an internal parasitic disease. The parasites are obtained by birds eating insects such as grass hoppers, ants and cockroaches, which carry the young form of the worm.

Signs and Symptoms

If you have worm problem in your flock, you will find that your chickens are not gaining weight. They may also show signs of diarrhea. When you cut open a chicken, you will find worms in the intestine.

Prevention and treatment.

Avoid overcrowding and wet litter. You can also use a chemical called Piperazine Citrate or Nilverm Piperazine available from Agricultural stores. See instructions on the containers on how to use them.

NOTE: It is very important to observe safety if you are going to use chemicals to control any of the diseases above.

- Wear protective clothing,
- Read instructions carefully,
- Do not eat or drink when using the chemicals,
- Wash up thoroughly using detergents after use
- And store chemicals way safely.

Student may research on many more pest and disease and their control measures locally especially if a school poultry project does exist and develop or provide solutions to these problems. There are natural or organic ways of preventing pest and diseases that are commonly practiced in the country which is cost efficient. However, as they say;” PREVENTION IS BETTER THAN CURE.”

Unit 6: Bird farming and technology	Topic: POULTRY HARVESTING PROBLEMS
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 contexts and environments, and analyze their strengths and weaknesses.	
Benchmark 12.2.6.1: Research and identify poultry harvesting problems and develop appropriate solutions.	
Essential Question	What are some problems experienced in harvesting poultry? How can these problems be rectified? What are some solutions that can be developed to solve the problems?
Learning Objective	By the end of this topic, students will be able to: <ul style="list-style-type: none"> • identify problems relating to poultry harvesting • Develop appropriate solutions to the problems
Knowledge	<ul style="list-style-type: none"> • identifying the problems
Skills	<ul style="list-style-type: none"> • researching and developing solutions
Attitudes & Values	Accepting and accommodating constraints
Assessment Task	Describe poultry harvesting related problems and suggest possible solutions to the problems

Content Background

Poultry Harvesting Problems

Preslaughter handling

When the birds have reached “harvest” time, they are generally taken off of feed and water. This allows their digestive tracts to empty and reduces the potential for contamination during processing.

At night the birds are caught by specially trained crews and placed into plastic or wooden transport cages. The birds are then transported to the slaughterhouse, where the trucks are often kept between sets of fans to ventilate the cages.

In the next step the birds are removed from the cages and transferred to continuously moving shackles where they are suspended by both legs. The transfer is often done in a dark room illuminated by a red light; the birds are not sensitive to the red light and this helps to keep them calm.

The handling and transfer of birds both on the farm and at the slaughterhouse can be stressful. Stress can have negative effects on the quality of the final meat product, and therefore efforts are constantly being made to improve the preslaughter processes.

(<https://www.cantekgroup.com/>)

Poultry Processing Line Speeds

Most of the discussion around poultry line speeds refers to a specific part of the processing line called the "Evisceration Line."

THE Evisceration LINE IS HIGHLY AUTOMATED. IN A MODERNIZED PLANT, ONLY 2% OF TOTAL PLANT EMPLOYEES WORK ON THE Evisceration LINE.

Evisceration LINE
This section of the plant is where the organs are removed and the carcasses are cleaned and inspected.

SECOND PROCESSING
This next section of the plant is where the product is cut up into parts and then packaged.

THIS PART OF THE LINE OPERATES 40% SLOWER THAN THE OTHER LINE.

SAFETY FIRST

Protecting Processing Plant Workers

Employee safety always has been and will always be a priority for the chicken industry.

THE POULTRY INDUSTRY'S INJURY RATE HAS FALLEN 84 PERCENT.

↓
84%

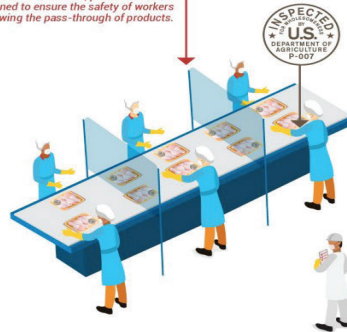
INCREASED LINE SPEEDS OF UP TO 175 BIRDS PER MINUTE HAVE BEEN TESTED AND PROVEN SAFE FOR 25 YEARS.

25
YEARS

POULTRY PLANTS ACROSS THE GLOBE OPERATE THE SAME EQUIPMENT SAFELY AT OVER 200 BIRDS PER MINUTE.

200
BPM

For tasks performed in tandem with workers across from one another, partitions can be positioned to ensure the safety of workers while allowing the pass-through of products.



USDA INSPECTORS are in every plant, monitoring the processing line to ensure the chicken you eat is safe and meets U.S. Department of Agriculture (USDA) safety standards.

WHAT ARE POULTRY PROCESSING LINE SPEEDS?

Poultry line speeds refer to how many birds per minute (BPM) are processed.

LINE SPEEDS ARE DETERMINED BY MANY FACTORS...

- Staffing availability, both of employees and USDA Inspectors, in the plant
- Equipment capacities
- Line layout
- Work space size
- Processing line configuration
- Consumer demand/need
- USDA's Food Safety and Inspection Service (FSIS) regulations, which vary by each plant

ALL OF THESE FACTORS, AND MORE, MUST BE IN PERFECT BALANCE FOR SAFE OPERATING SPEEDS.

<https://www.chickencheck.in/faq/poultry-line-speed/>

All these minimize human labour and production is in mass, however there are still setbacks or disadvantages too.

The use of technology requires skilled and trained (specialized) workers to handle or operate the technologically advanced gadgets to do the work. Unskilled or inexperienced personnel cannot operate the equipment.

If a minor technical error or fault occurs, it affects the production line because it produces in mass or bulk.

Unit 6: Bird farming and technology

Topic: Technologies and Improved Products

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 contexts and environments, and analyze their strengths and weaknesses.

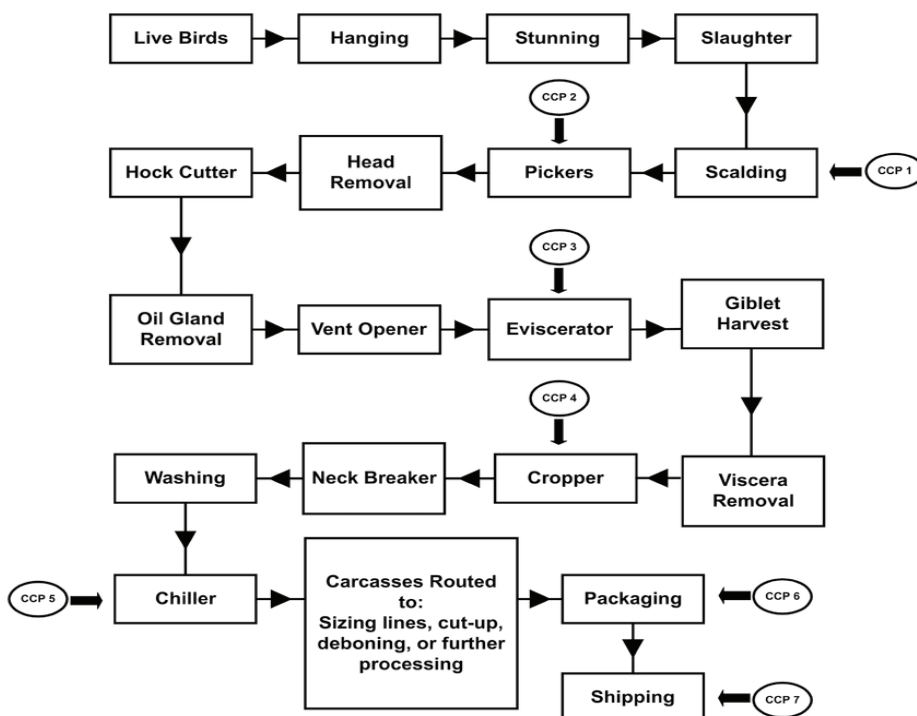
Benchmark 12.2.6.2: Research and assess technologies used in different contexts to improve and add value to poultry products to meet the demand for these products.

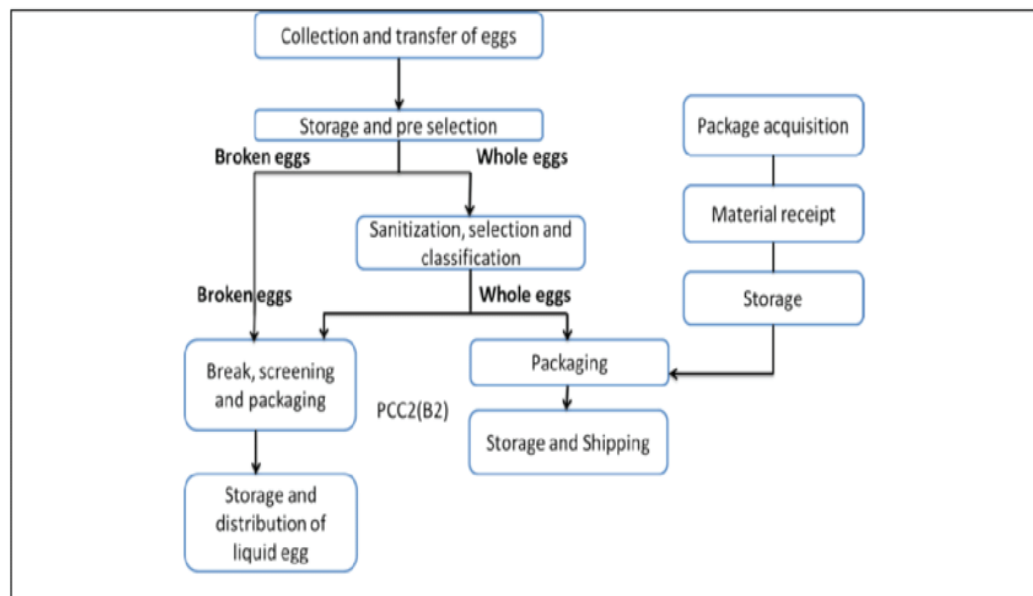
Essential Question	1. What types of technologies are used to improve poultry products? 2. How are poultry products improved?
Learning Objective	By the end of this topic, students will be able to: <ul style="list-style-type: none"> Identify technologies used to improve poultry products
Knowledge	Assess technologies used in different contexts
Skills	Research technologies used to improve poultry products
Attitudes & Values	Accept and tolerate changes
Assessment task	Research and report on types of technologies used to improved poultry products

Content Background

Poultry processing

Processing of poultry involves the steps from the slaughtering to the packaging of the products. All these procedures involve technology in different stages and forms or types.





Researchgate.net/figure

The two main products of poultry are meat and eggs. The production processing stages are shown in the flowchart above. Each stage involves a use of technology and it makes the task at hand more efficient and productive. From the poultry house to the table it reduces preparation time and adds value to the product.

Processing of poultry

Raw poultry products

Whole or individual parts of birds may be packaged raw for direct sale. Most raw turkey is sold frozen, while most chicken is sold fresh.

Fresh poultry

The birds are generally cut into a number of pieces, which are placed on plastic foam trays and covered with a plastic film. A “diaper” (absorbent paper with a plastic backing) is often used to catch any liquid that may be released from the meat. Fresh poultry should be used within 14 to 21 days after slaughter and generally should not be kept in the home refrigerator for more than three days.

Frozen poultry

Most frozen poultry is vacuum-packed in plastic bags and then frozen in high-velocity freezers. The birds are kept in cold storage until needed. Before freezing, poultry may be injected with various salts, flavourings, and oils in order to increase the juiciness of the meat. Injections are usually done with a multi-needle automatic injector, and information about the added ingredients is indicated on the package label.

Frozen storage time (including poultry bought fresh and frozen in a home freezer) depends on the temperature of the freezer, the quality of the packaging, and the cycling of the freezer. For best results poultry should be used within three months. Frozen poultry products can be used directly in the frozen state or thawed first. Thawing should be done in the refrigerator or under running cold water to minimize the potential for microbial contamination.

Processed poultry products

Poultry may be further processed into other products. The number of processed poultry products has increased dramatically since the [1970s](#) because of the low cost of poultry and its versatile, bland flavour.

Battering and breading

Some poultry products are battered (e.g., with beer batter) or battered and breaded (e.g., with cracker meal, bread crumbs, or cornmeal) for frying. The meat may be either cooked or raw prior to coating. For battered and breaded poultry, the pieces are passed through a flour-based batter containing leavening and then through the breading ingredients. Many types of baked breadings have been developed to meet different tastes (e.g., Cajun or Japanese). To hold the breading to the poultry, the product is deep-fried for a short time. If the poultry is fully cooked in this process, the consumer will only have to heat the product before eating it. Chicken nuggets are a battered and breaded product that is marinated before coating.

Tumbling and massaging

In the manufacturing of many poultry products, the meat is mixed with a variety of nonmeat ingredients, including flavourings, spices, and salt. Tumbling and massaging are gentle methods that produce a uniform meat mixture. A tumbler is a slowly rotating drum that works the meat into a smooth mixture. A massager is a large mixing chamber that contains a number of internal paddles. Cured turkey products (i.e., treated with sodium nitrite), such as turkey ham and turkey pastrami, are often tumbled or massaged during processing.

Smoking

Poultry may be smoked. Prior to smoking, the birds must be brined (soaked in a salt solution containing certain flavourings) and then allowed to dry. Smoking can be done using real wood shavings or a smoke flavouring. In the last case this must be labeled in the United States as “natural smoke flavor added.”

Deboning and grinding

Further processed poultry products leave the backs, necks, and bones available for their own processing. These materials are run through a machine called a mechanical deboner or a meat-bone separator. In general, the crushed meat and bones are continuously pressed against a screen and the edible, soft materials pushed through the screen. The resulting minced product is similar in texture to ground beef and has been used for many poultry products such as frankfurters (hot dogs) and bologna. Poultry frankfurters and bologna are made using a process similar to that for beef and pork. The meat is combined with water or ice, salt, and seasonings and chopped to emulsify the materials. The mixture is stuffed into plastic casings and cooked in a smokehouse. The meat is then quickly chilled, peeled, and vacuum-packaged. Bologna is stuffed into a larger casing and is not necessarily peeled. (<https://www.cantekgroup.com/>)

STRAND 3: Aquaculture

Content Overview

Content Standard 12.3.1 Students will be able to define aquaculture, investigate the different types of plants, animals and fish cultivated using this method of farming, categorise them according to their characteristics, purposes and benefits, and investigate the different contexts, environments and places where they are farmed.

Units	Benchmarks	Topics	Lesson Titles
Types of Aqua Farming Plants, Animals and Fish	12.3.1.1 Investigate and discuss the background and importance of mariculture and brackish farming.	Mariculture and Brackish Farming	Background and importance of Mariculture Background and Importance of Brackish Farming
	12.3.1.1. Explore suitable fish species for aquaculture farming in PNG environment	Aquaculture fish species in PNG	Fish Farming History in PNG Suitable Fish Species in PNG – Native and Exotic species

Content Standard 12.3.2 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.

Aqua Farming Practices and Management Systems	12.3.2.1 Examine the principles of mariculture and explain their importance in understanding mariculture practices	Principles and Practices of Mariculture	Principles of Mariculture Practices of Mariculture
	12.3.2.2 Examine mariculture production, marketing and management systems and practices	Mariculture Production, Marketing and Management Systems	Mariculture Production Mariculture Marketing Mariculture Management Systems
	12.3.2.3 Analyse and explain the anatomy and physiology of different aqua farming plants, animals and fish.	Anatomy and Physiology of Aquaculture Organisms	Anatomy of Aqua Farming Organisms Physiology of Aqua Farming Organisms

Content Standard 12.3.3 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.

Aqua Farming and Technology	12.3.3.1 Explain mariculture post-harvest technologies and evaluate their advantages and disadvantages	Post-Harvest Technologies	Advantages of Mariculture post-harvest technologies Disadvantages of Mariculture post-harvest technologies
	12.3.3.2 Research and suggest ways of improving aqua-farming and mariculture technologies.	Aqua and Mariculture Technology	Ways of improving aqua farming technologies Ways of improving mariculture technologies
	12.3.3.3 Investigate and analyse the trend in aqua farming technology and explain how new technology could be used to improve the farming, production and marketing.	Trends in Aqua Culture Technology	Trends in Aqua Farming Technologies Ways to improve Technologies used in farming, production and marketing.

Strand 3: Aquaculture

Unit 1: Types of Aqua Farming Plants, Animals and Fish

Content Standard 11.3.1 Students will be able to define aquaculture, investigate the different types of plants, animals and fish cultivated using this method of farming, categorizing, them according to their characteristics, purposes and benefits, and investigate the different contexts, environments and places where they are formed.

Benchmark 12.3.1.1 Investigate and discuss the background and importance of mariculture and brackish farming

Topic: Mariculture and Brackish Farming

Learning Objectives:

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

- Examine and discuss background and importance of mariculture and brackish farming
- Investigate the contexts and environments of where they are farmed.

Essential Questions:

1. What are the characteristics, purposes and benefits of mariculture and brackish farming?
2. In which different contexts and environments are they farmed?

Essential Knowledge	<ul style="list-style-type: none"> • The history and importance of Mariculture Farming • The history and importance of Brackish Farming
Essential Skills	<ul style="list-style-type: none"> • Be able to explore and examine the history of Mariculture and brackish farming and be able to discuss their importance in terms of their characteristics , purpose and benefits to human consumption and living standards
Essential Attitudes and Values	<ul style="list-style-type: none"> • Confident and critical about their findings and express in their research work; reading, writing and open discussions about Mariculture and brackish farming. • Is Rational and courageous in understanding about the history and importance of Mariculture and Brackish Farming

Assessment Task:

- Can discuss the characteristics, purposes and benefits of Mariculture and brackish farming and explain the contexts and environments in which they are farmed.

Content Background

MARICULTURE AND BRACKISH FARMING

Is a special branch of aquaculture involving the cultivation of marine organisms for food and other products in the open ocean, an enclosed section of the ocean or in tanks, ponds, or raceways which are filled with sea water. An example of the latter is the farming of marine fish, including finfish and shellfish like prawns or oysters and seaweed in salt water ponds. Non-food products produced by mariculture include: fish meal, nutrient agar, jewelry.

TYPES OF OPERATIONS

(i) Fish ponds

Fish are often grown in ponds. The young strip and fish are usually produced in hatcheries, though collection of young animals from nature has been used in some cases. The ponds may be filled with sea water by pumping water depending on the particular species being produced at the size at stocking.

(ii) Pens and cages

In ponds marine fish are being reared in floating pens or cages in protected bays.

(iii) Indoor Facilities

The highest level of technology is associated with indoor facilities in which the animals are grown in raceways or tanks that receive pumped sea water that may be taken directly from the ocean. Water may be flown through the tanks and discarded or it may be recirculated that is reused by passing it through an elaborate water treatment system.

TYPE OF THE SPECIES

Barramundi Farm in Madang province produces barramundi, selected marine fish and crustaceans.

Barramundi (*Lates calcarifer*) is an estuarine species of fish that inhabits coastal and freshwater systems. However, it requires saltwater to reproduce and therefore can be used in controlled restocking of the inland freshwater bodies. Barramundi is a favorite with sports fishers and provides a fillet that is popular with restaurants and hotels. It is farmed widely in Asia and Australia.

The Bismark Barramundi farm was set up in 1998 by Ian Middleton, Managing Director in Dilup Plantation, Madang Province (It has now been shifted to Daru, Western Province). The farm's target for annual production is 200,000 fish at 1.5 kg size (i.e. 250 metric tons/yr). This is more than the entire catch from PNG's wild fishery (170 mt/yr). Incredibly, the annual target will be produced from just 12 female broodstock fish and will require the hatchery to produce about one million fingerlings.

The hatchery, however, has already made single runs of 250,000 fingerlings, so this target can be easily attained. In the grow-out phase the farm has about 120,000 fish (up to 2 kg in size) being raised in pontoons (4 m x 4 m) located in the adjacent bay. The bay is shallow enough to secure mooring lines but is well flushed by nearby oceanic currents. To farm 200,000 fish will require about 20 pontoons, each stocked with 10,000 fish. The Bismark company will give this opportunity for business to the neighbouring villages and special groups through the Family Farmer programme. These communities will acquire their own pontoons and raise the fish and then sell them back to the company.



Figure is Barramundi farming in Madang [Photos: Ben Ponia

BRIEF HISTORY

China was the first country to farm fish. They cultivated carp with fresh water ponds and rice paddles-3500 B.C. Fish farming its mordent form begins when a German farmer successfully gathers trout eggs fertilizes them and then grows the hatched fish to majority-1733. A Ohio trout becomes the first in the USA artificially its fish eggs- 1853. The first commercial trout farm was established in USA established in Idaho-1909.

IMPORTANCE OF MARICULTURE AND BRACKISH FARMING

Both Mariculture and Brackish farming plays an important role, especially in rural areas for food security, economic and social welfare. In heavily populated coastal areas mariculture and brackish farming are in competition with other human activities for space and other resources.

List of pros of mariculture and brackish farming are:

- Source of food for people and marine species
- Source of income
- Flexibility
- Helps waste problems
- Propagation of invasive species
- Threat to coastal ecosystems
- Contaminates water and Threatens Health and Affects wild fish population.

Strand 3: Aquaculture

Unit 1: Types of Aqua Farming Plants, Animals and Fish

Content Standard 12.3.1 Students will be able to define aquaculture, investigate the different types of plants, animals and fish cultivated using this method of farming, categorizing, them according to their characteristics, purposes and benefits, and investigate the different contexts, environments and places where they are formed.

Benchmark 12.3.1.2 Explore suitable fish species for aquaculture farming in PNG environment.

Topic: Aquaculture Fish Species in PNG

Learning Objectives:

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

- Explore and identify commercial species
- Discuss and explain the types of fish species for mariculture and brackish farming in PNG

Essential Questions:

1. What are the commercial species of mariculture and brackish farming in PNG?
2. Which fish species are suitable for mariculture and brackish farming in PNG?

Essential Knowledge	<ul style="list-style-type: none"> • Commercial species and the types of fish species for mariculture and brackish farming
Essential Skills	<ul style="list-style-type: none"> • Explore and Identify the commercial species for marine and brackish farming • Discuss and describe the types of fish species for marine and brackish farming in PNG
Essential Attitudes and Values	<ul style="list-style-type: none"> • Is Confident and Cooperative in learning about commercial species and types of fish species for marine and brackish farming? • Is Courageous and self – determined to use skills and understand about fish species and how used for marine and brackish farming

Assessment Task:

- Discover and identify the suitable fish species for aquaculture farming in various PNG environments

Content Background

Commercial fish species for Mariculture And Brackish farming

1. Background on fresh water fish species in Papua New Guinea

Freshwater fish is much sought after by inland people and there is a real need for improved fisheries resources to meet the existing and future protein requirements of the PNG people. Villagers have traditionally obtained food by agriculture and hunting, and a proportion of villagers regularly fish in inland waters to supplement their diets.

1.1 Native Freshwater Species

Three groups of native freshwater species are favoured by village people:

- eels,
- freshwater prawns and
- catfish.

Relevant information on each group is briefly described below. There are five indigenous species of eel in PNG according to Allen (1991), and they are highly prized.

- (I) The Indian shortfinned eel (*Anguilla bicolor*) is found in the northern rivers, particularly the Sepik and Ramu Rivers, but it is also endemic to other lowland rivers and mountain tributaries.
- (II) The giant long-finned eel (*A. marmorata*) is found in regions in the south-east, near Port Moresby, in lowland rivers and in upland tributaries.
- (III) The Pacific long-finned eel (*A. megastoma*) is found in coastal streams and pools as well as inland from Popondetta and in the north-west around Wewak.
- (IV) The Pacific short-finned eel (*A. obscura*) is found in various types of streams and localities, including Port Moresby, Embi Lake near Popondetta, Madang, Sepik River and near Jayapura.
- (V) The marbled eel (*A. reinhardtii*) is found in a few localities including Dinawa and the Upper Saint Joseph River.

About 18 different species of freshwater crustaceans had been identified in studies of water bodies in PNG. Experience in Australia and other countries with *Macrobrachium* spp. and redclaw suggests that they may be candidates for pond aquaculture in PNG. Native catfish is a delicacy in PNG and farming those species also offers potential.

1.2 Exotic Species

In an attempt to increase fish stocks, more than 25 exotic species of fish have been introduced to PNG since 1949 (Coates 1986). By the early 1990s, some 11 species showed potential for aquaculture or were found in rivers and lakes in PNG.

These include;

- African tilapia (*Oreochromis mossambica*),
- walking catfish (*Clarias batrachus*),
- common carp (*Cyprinus carpio*),
- grass carp (*Ctenopharyngodon idella*),
- bighead carp (*Aristichthys nobilis*),
- climbing perch (*Anaba testudineus*),

- snakehead (*Channa striata*),
- mosquito fish (*Gambusia affinis*),
- guppy (*Poecilia reticulata*),
- brown trout (*Salmo trutta*) and
- rainbow trout (*Oncorhynchus mykiss*).

Of these species, tilapia became an important food source for people along the Sepik and Ramu Rivers (Allen 1991), and common carp, tilapia and trout became common in rivers in the highlands. However, grass carp and bighead carp do not appear to have survived. Local fishermen are able to catch the introduced species, but complain that indigenous species of fish have declined in recent times (Smith and Kia 2000). An ambitious stock enhancement program occurred in PNG during 1993–97 under the Food and Agricultural Organisation of the United Nations (known as FISHAID, FAO). There was also an earlier fish stock enhancement project by FAO (Zwieten 1990) in the Sepik River in 1987–93 (known as SRFSEP, FAO).

The FISHAID project introduced nine new species to the freshwater rivers of PNG (Coates 1997) with the: „immediate objective to improve the naturally poor fish stocks of the Sepik–Ramu basin by stock enhancement“ (FAO 1997). The fish species and numbers that were released into the Ramu–Sepik river system were:

- 173,111 of *Tilapia rendalli* (redbreast tilapia),
- 37 of *Osphronemus goramy* (giant gouramy),
- 27,750 of *Puntius gonionotus* (Java carp),
- 70,309 of *Schizothorax richardsonii* (snow trout),
- 29,827 of *Tor putitora* (golden mahseer),
- 11,224 of *Acrossocheilus hexagonolepis* (chocolate mahseer),
- 14,511 of *Colossoma bidens* (pacu) and
- 160,511 of *Prochilodus margravii* (curimbata).

Another fish, *Barilius bendelesis* (lesser baril), arrived without notice and was not solicited by the project, so the 150 fish of this species were destroyed without stocking.

In 1999 GIFT (also known as „super“ tilapia) were brought in from the Philippines through the GIFT Centre and quarantined at HAQDEC until fingerlings were release to farmers on October 2002. The new fish (GIFT) because of its superior growth rate and ability to breed in their ponds.



Figure 2. The genetically improved farmed tilapia (GIFT) strain of *Oreochromis niloticus* was first

introduced in 2002.

The only significant trout hatchery is the Lake Pindi Yaundo Trout Farm near Mount Wilhelm, which breeds and distributes fingerlings of rainbow trout to smallholder farmers, mainly in Simbu province. Mrs Betty Higgins set up the Pindi Yaundo Trout Farm in 1993, and in 1997 she was able, for the first time in PNG, to successfully produce eyed trout eggs and fingerlings



Figure 3 Rainbow Trout (*Oncorhynchus mykiss*)

1.3 IMPACT OF EXOTIC SPECIES

The current study observed that introduced fish have had a substantial impact on the country's biodiversity and the village people. Anecdotal stories of problems are common. For example,

- snow trout (*S. richardsonii*) causes vomiting when the roe is eaten and there is talk that some children have died. This species is very numerous in the rivers and it cleans stones by scraping the surfaces. As a result, many villagers have complained of injuries suffered as a result of slippery stones as they wade across streams.
- The pacu (*C. bidens*) is a relative of the piranha and it was introduced to eat nuts and berries that float down rivers. It is nicknamed the „ball-cutter“ by the villagers because on occasions it has bitten off the testicles of bathing men.
- At the inland markets, villagers complain that there are no longer any native fish species being sold.

Fishermen believe that introduced species have reduced the numbers of native fish as well as changing the inland fishing industry. For instance, in the Sepik River the once prosperous tilapia fishery has been decimated by predatory fish feeding on tilapia fry. Anecdotal evidence from local people indicates that the introduced “ballcutter” and “rubber-mouth” species are responsible. Further, a common complaint is that the small, intramuscular bones of some introduced fish cause problems when the fish are consumed.

On a positive note, *Tor putitora* (golden mahseer) is breeding in Yonki Reservoir, providing a new fisheries resource for smallholder fishers. A thorough survey of the distribution and abundance of introduced species would be helpful. It should include studies of both benefits for villagers and impacts on biodiversity of native fish stocks.

Strand 3: Aquaculture

Unit 2: Aqua Farming Practices and Management Systems

Content Standard 12.3.2 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 12.3.2.1 Examine the principles of mariculture and explain their importance in understanding mariculture practices.

Topic: Principles and Practices of Mariculture

Learning Objectives:

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

- Evaluate the importance of principles and practices in mariculture.

Essential Questions:

1. What are some of the importance of mariculture?
2. Why do we have to understand the practices and principles of mariculture?

Essential Knowledge	Principles and practices of mariculture
Essential Skills	Investigative skills in evaluating mariculture practices and principles
Essential Attitudes and Values	Appreciate the importance of good management and practices in mariculture.

Assessment Task

Research and draw up a chart to present the principles and practices of mariculture.

Content Background

Mariculture and Brackish Farming

Is a special branch of aquaculture involving the cultivation of marine organisms for food and other products in the open ocean, an enclosed section of the ocean or in tanks, ponds, or raceways which are filled with sea water. An example of the latter is the farming of marine fish, including finfish and shellfish like prawns or oysters and seaweed in salt water ponds. Non-food products produced by mariculture include: fish meal, nutrient agar, jewelry.

Types of Operations

(iv) Fish ponds

Fish are often grown in ponds. The young strip and fish are usually produced in hatcheries, though collection of young animals from nature has been used in some cases. The ponds may be filled with sea water by pumping water. Depending on the particular species being produced at the size at stocking.

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In ponds marine fish are being reared in floating pens or cages in protected bays.

(I) Indoor Facilities

The highest level of technology is associated with indoor facilities in which the animals are grown in raceways or tanks that receive pumped sea water that may be taken directly from the ocean. Water may be flown through the tanks and discarded or it may be recirculated that is reused by passing it through an elaborate water treatment system.

TYPE OF THE SPECIES

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Figure is Barramundi farming in Madang [Photos: Ben Ponia]

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IMPORTANCE OF MARICULTURE AND BRACKISH FARMING

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- Flexibility
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- Propagation of invasive species
 - Threat to coastal ecosystems
 - Contaminates water and Threatens Health and Affects wild fish population.

Strand 3: Aquaculture Unit 2: Aqua Farming Practices and Management Systems

Content Standard 12.3.2 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 12.3.2.2 Examine mariculture production, marketing and management systems and practices

Topic: Mariculture Production, Marketing and Management Systems

Learning Objectives:

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

- Identify and explain Mariculture productions
- Explain and apply maintenance practices

Essential Questions:

1. What is mariculture production and management?
- 2.

Essential Knowledge	Mariculture production, marketing, and management systems
Essential Skills	Investigative skills in evaluating mariculture practices and principles
Essential Attitudes and Values	Appreciate the importance of good management and practices in mariculture.

Assessment Task

Research and draw up a chart to present the principles and practices of mariculture

Content Background

Mariculture Productions

Fingerling production and distribution in Papua New Guinea

A total of 19 hatcheries were surveyed, of which only four had substantial levels of production. HAQDEC at Aiyura in EHP is the major hatchery in PNG for fingerling production of common carp, the GIFT strain and Java carp (*Puntius gonionotus*). It distributes fingerlings throughout the country. The Erap Aquaculture Centre, located in the lowlands near Lae, produces GIFT fingerlings and distributes them to farmers mainly in Morobe province.

The Lake Pindi Yaundo Trout Hatchery in Simbu province, owned and managed by Mrs Betty Higgins, was the major source of trout fingerlings and eyed eggs from the mid 1990s until 2002. After closing down for a while, it is now operational again. Smallholder trout farmers currently rely on obtaining

fingerlings from advanced farmers or catching wild trout fingerlings to stock their ponds. As for coastal aquaculture, Bismark Barramundi Farm in Madang province produces barramundi, selected marine fish and crustaceans.

Most of the small-scale hatcheries had basic facilities and fed brood stock with cooked sweet potato (kaukau). Under these conditions their production was very low. Fish hormones were absent from all inland hatcheries, including HAQDEC, in PNG throughout the period from late 2002 to May 2005, so natural spawning was practiced and production of fingerlings was low.

The cost of fingerlings varied according to size and species of fish. Generally, carp fingerlings sold for 20 toea each (PNG kina 0.20) and GIFT fingerlings for 30 toea. Of the 19 hatcheries surveyed during 2001–03, 68% produced common carp, 21% produced rainbow trout and the remaining 11% produced common carp and either rainbow trout or tilapia. The release of the GIFT strain from quarantine in late 2002 resulted in a reduced reliance of farmers on central hatcheries for fingerlings, with smallholder farmers now being suppliers of GIFT fingerlings.



Figure 1. Pond with Happa set up to hold



Figure 2. Rainbow trout
Hatchery GIFT fingerlings

Limitation to growth of Aquaculture

A major limitation to the growth of aquaculture, and particularly trout farming, in PNG has been the cost of importing processed feed and fishmeal. However, two fish canneries and fish loining plants have recently been established in Lae and Madang, and these now provide a source of local fishmeal and fish oil for incorporation into locally produced diets. Although a cheaper, locally processed diet is now available, it has high fibre content and 10% less protein than the imported pellets. The other set back is availability and supply of good fish fingerlings.

Management Practices

Types of Aquaculture in Papua New Guinea

- Freshwater pond fish farming
- Barramundi Farming

Strand 3: Aquaculture Unit 2: Aqua Farming Practices and Management Systems

Content Standard 12.3.2 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 12.3.2.3 Analyse and explain the anatomy and physiology of different aqua farming plants, animals and fish.

Topic: Anatomy and Physiology of Aquaculture Organisms

Learning Objectives:

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

- Explain the difference between the anatomy and physiology of aquaculture organisms.

Essential Questions:

1. What is the anatomy and physiology of organisms?
2. How can we find the anatomy and physiology of aquaculture organisms?

Essential Knowledge	Anatomy and Physiology of aquaculture organism
Essential Skills	Analysis and Explanation skills
Essential Attitudes and Values	Appreciate the anatomy and physiology of different aqua farming plants, animals and fish

Assessment Task

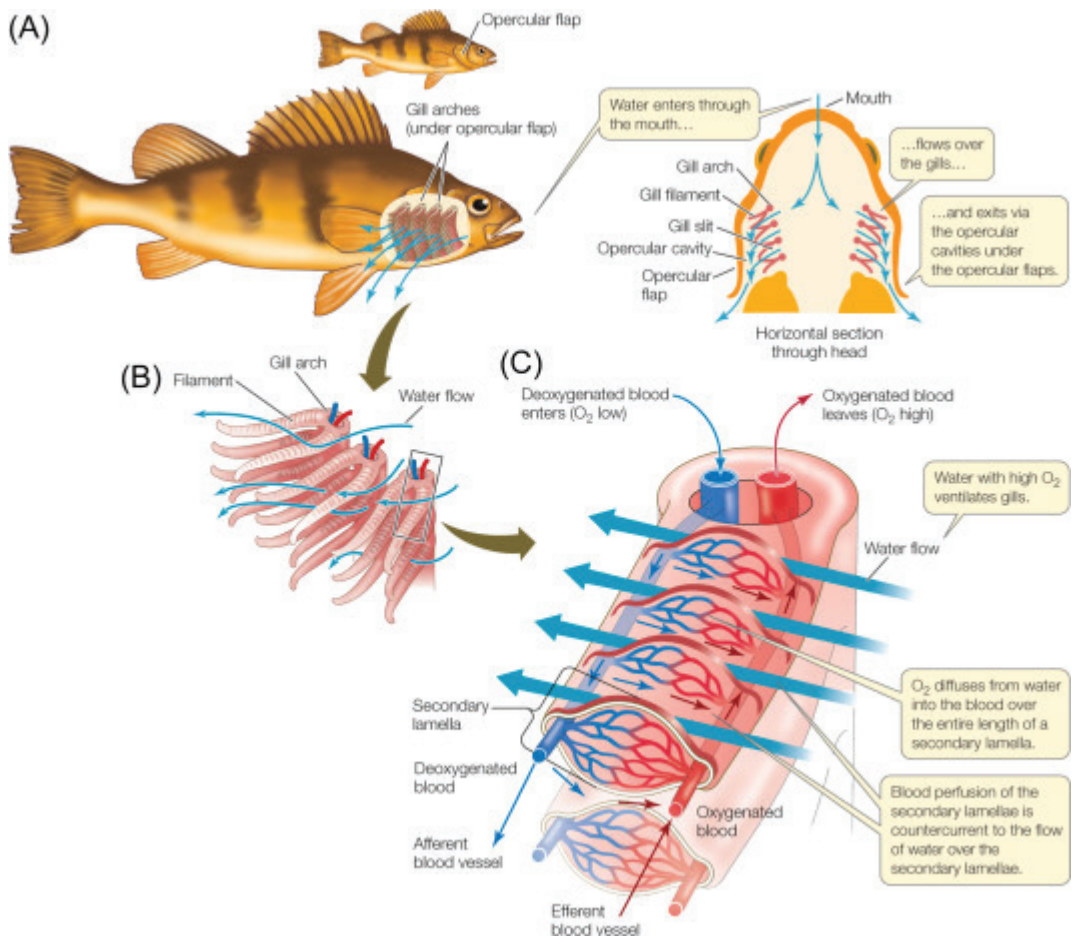
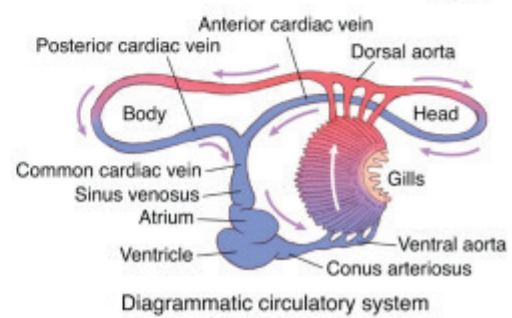
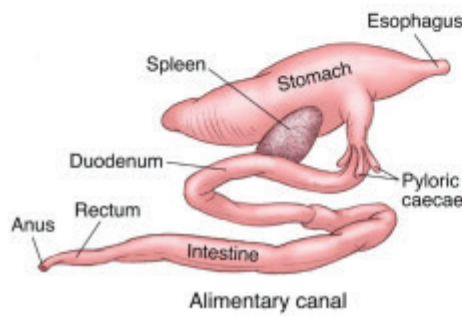
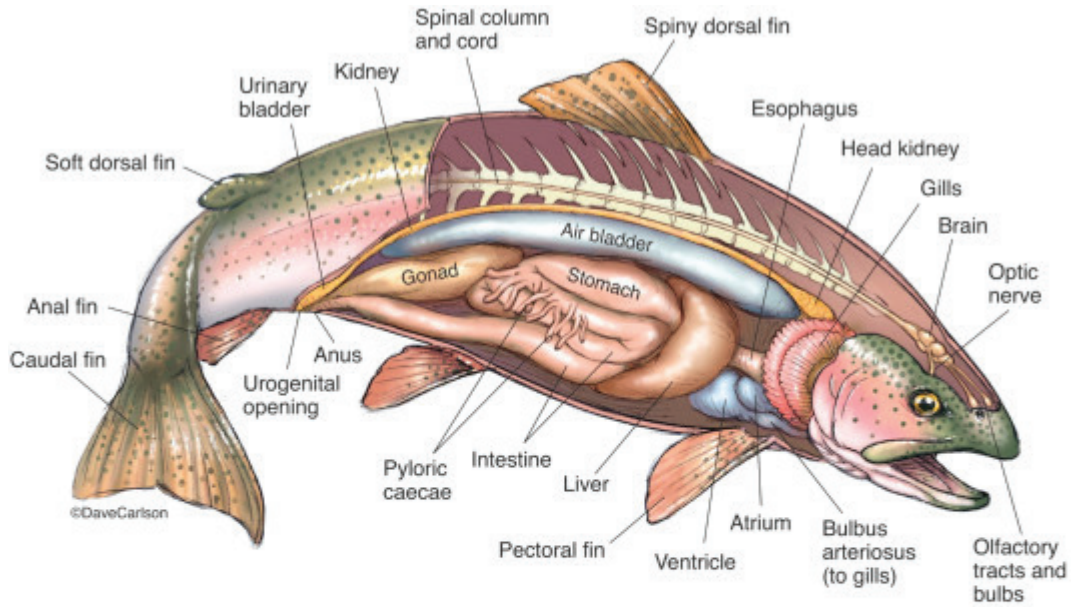
Research and create a chart to show the anatomy and physiology of an aqua farming plant, animal and fish.

Content Background

Anatomy is the study of an organism's structures. Fishes come in a diverse array of forms, many with special modifications. The shape, size, and structure of body parts permit different fishes to live in different environments or in different parts of the same environment. The external anatomy of a fish can reveal a great deal about where and how it lives.

For further concepts and content kindly type the link below to:

<https://manoa.hawaii.edu/exploringourfluidearth/biological/fish/structure-and-function-fish>



Strand 3: Aquaculture Unit 3: Post-Harvest Technologies

Content Standard 12.3.3 Students will be able to examine how technology is used to aqua farming and processing, preservation, marketing, consumption, regulation and management of plants, animals and fish in different environment and places and evaluate their strengths and weakness.

Benchmark 12.3.3.1 Explain mariculture post-harvest technologies and evaluate their advantages and disadvantages

Topic: Post-Harvest Technologies of Mariculture

Learning Objectives:

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

- Research proper post-harvest technologies of mariculture and state their advantages and disadvantages

Essential Questions:

1. What technologies are used in post-harvesting of mariculture?
2. What are the advantages and disadvantages of these post-harvest technologies?

Essential Knowledge	Mariculture post-harvest technologies
Essential Skills	Identify and list the advantages and disadvantages of post-harvest technologies
Essential Attitudes and Values	Appreciate post-harvest technologies

Content Background

MARICULTURE

Mariculture is a special branch of aquaculture involving the cultivation of marine organisms for food and other products in the open ocean, an enclosed section of the ocean or in tanks, ponds, or raceways which are filled with sea water. An example of the latter is the farming of marine fish, including finfish and shellfish like prawns or oysters and seaweed in salt water ponds.

Fish farming is one of the common type of aquacultures. It involves the selective breeding of fish in both sea water and fresh water.in this topic we are going to look at fish farming in sea water.

Fish is one of the most perishable food items in nature and requires careful handling. Fish spoilage is a one-way process; fish loses its freshness and quality after death and eventually becomes unfit for consumption. Proper handling of fish is necessary to control and slow down spoilage so that it reaches the consumer fresh. Due to delicate nature and rapid deterioration of fish muscles, that occurs if treated badly, it is extremely important to handle fish very carefully during all stages of transportation, retail distribution,

processing, preservation and marketing.

Post-Harvest Methods in Mariculture

Post-harvest describes the systems of harvesting, handling, processing, sorting, storing, packaging, transport and marketing of mariculture products.

Handling after harvest

Harvest and handling in mariculture refers to the activities which take place when fish and other saltwater products are removed from the open ocean, an enclosed section of the ocean or in tanks, ponds, or raceways which are filled with sea water or other production unit, and before the products are marketed for human consumption as food. What happens to them during this crucial period has implications for food loss and waste (FLW) at this stage and in the subsequent stages of the value chain.

Handling

The quality of the products depends on how it is handled from the time it is taken out from the water until it reaches the kitchen. In this topic, we will use fish as an example of mariculture.

Consider these three cardinal rules in handling fresh fish;

1. Cleanliness:

- Observe cleanliness throughout the fish handling chain.
- Gut the fish immediately after fish is harvested

2. Care:

- Work on fish as quickly as and as promptly as possible.
- Sort fish properly before packing.
- When fish have to wait on deck or on the fish landing for some time before working on these, cover these to protect them from heat and other elements.
- Drain fish before icing
- Avoid brushing the fish
- Don't throw, trample or kick the fish

3. Cooling: Temperature is the most important single factor affecting the quality of fish.

- Use plenty of ice. Put additional layer of ice it reaches the kitchen. Fish landed is usually subjected to rough handling treatments.
- on top, bottom and side of fish in boxes or shelves.
- Don't over-fill a box or shelf. The next box or shelf on top will smash the fish below.
- Lay the fish belly downward – this prevents entry of dirt water into the fish.
- Don't pack fish so tightly that melted ice cannot flow.
- Fish is cooled more quickly when ice cold water is poured on them. Fish spoils easily when allowed to stay in stagnant water, blood or slime.
- Store fish in ice as quickly as possible. Make sure the fish room is always kept clean.

Causes of fish spoilage

Spoilage refers to food becoming unfit to eat. Like most any other food, sea food must be handled and stored correctly to maintain its quality and ensure its safe to eat.

Sea food not handle correctly goes to changes due to the action of bacteria and enzymes that make it taste bad and eventually becomes dangerous to eat. The food is then said to have gone off or gone bad.

Spoilage by bacteria

Bacteria are usual cause of sea food spoiling. Surface slime, gills and the gut of a living fish contains millions of bacteria. After the fish is caught, the number of bacteria increase dramatically and cause illness and food poisoning. Cooking will kill bacteria but may not degrade the toxins that they are produced.

Enzymes are present in all living things and are important in promoting the building of tissues as well as digesting food. After a sea food species is caught enzymes continue to work and start to break down and soften the fish. Histamine poisoning is one of the common types of non-bacterial fish for poisoning. Histamine occurs naturally in many fish including tuna, marlin and sandiness. If the fish is not chilled immediately after capture and not kept at a temperature less than 16 degree Celsius histamine is converted to histamine. Because histamine is not destroyed by heat, even cooked fish will cause reactions that are often severe. Symptoms include allergic responses facial flushing and dizziness.

Transportation:

- Fresh fish transported to far distances must be packed with ice to ensure freshness when they reach the consumers.
- Proper packing of fresh fish with ice means arranging the fish and ice alternately in the container to maintain chilling temperature.
- It is attained with the ratio of 1 kg of ice to 2 kg of fish.
- The more sophisticated method of the transportation is the refrigerated truck or Insulated Van.
- When transporting fish within the region, wholesalers pack them in ice. Upon reaching their destination, fish are repacked with ice and sold to retailers and eventually to consumers.
- The latest practice of transporting live marketable fish.

Processing:

- Fish spoils very quickly within 12 hours after being harvested.
- This due to the high ambient temperature that is ideal for bacterial growth.
- To prevent contamination of the fish, proper hygiene must be ensured.
- Contamination can come from people, soil, dust, sewage, surface water, manure, or spoiled foods.
- Poorly cleaned equipment
- To prevent spoilage of the harvested fish, either the bacteria present in them must be killed or their growth must be suppressed.

Preserving Mariculture products

Methods of preservation most mariculture products include drying, salting, pickling, and smoking. All of these techniques are still used today but the more modern techniques of freezing and canning have taken on large importance.

1. How to preserve Fish: Salting and Sun-drying

Salting fish is a way of drying the flesh because it draws out moisture and so prevents bacterial. In cooler climates water is removed using dehydrator machines. This can be done in domestic level as well as large industrial size dehydration plants.

When done properly both sun dried and salted fish can remain edible for many months. Before cooking the fish is dehydrated by soaking overnight in portable water.

2. Ways to Preserve Fish: Freezing

Freezing preserves fresh fish by locking any water present into solid form (ice). This makes the water unavailable to bacteria and thus prevents bacteria growth. Unfortunately one of the side effects of freezing fish can be that frozen water crystals pierce the cell walls. This can make the defrosted fish mushy in texture. To limit this type of cell damage fish should be frozen using a process known quick fish drying.

3. Smoking

Smoking is a method of preserving fish which combines three effects:

- Preserving value of the smoke: the smoke produced from burning wood contains a large number of compounds, some of which will kill bacteria
- Drying: the fire which produces the smoke also generates heat and this will dry the fish.
- Cooking: If the fish are smoked at a high temperature, the flesh will be cooked and this will destroy the enzymes and kill bacteria.

The long storage of some smoked fish products is due more to drying and cooking than to the preservative value of the chemical compounds deposited on the fish from the smoke

Measuring Quality of Freshness

Quality is a measurement made by the customer on the suitability of a product (fish) for its purpose or use.

Fish quality Assessment

There are several ways of assessing fish quality and they are categorized as follows;

Sensory method – this is using your 5 senses to determine freshness like; smell, seeing the gill colours, feel the flesh texture, see the body colours and fish eyes

	HIGH QUALITY	MEDIUM QUALITY	POOR QUALITY
Eyes	Eye clear, black stands out from head, surface of eye convex	Eye about 50% cloudy. Surface of eyes slightly concave.	Eye opaque/brown. Severely sunken
Body colour	Body colours bright	Body colours dull	Body colours dark- not visible
Gill colour	Gills bright pink/red	Gills brown, small or medium amount of slime (clear)	Gills brown/putrid.
Smell	No 'fish' smell or slight 'seawater' smell	Definite 'fish' smell.	Pronounced putrid odour
Flesh texture	Firm and elastic (springs back quickly on pressing)	Flesh soft (doesn't spring back fully on pressing).	Flesh falling away from carcass. Very soft texture.

Table 1: Table categorizing different sensory methods with the degree of freshness.

Strand 3: Aquaculture**Unit 3: Aqua and Mariculture Technology**

Content Standard 12.3.3 Students will be able to examine how technology is used to aqua farming and processing, preservation, marketing, consumption, regulation and management of plants, animals and fish in different environment and places and evaluate their strengths and weakness.

Benchmark 12.3.3.2 Research and suggest ways of improving aqua-farming and mariculture technologies.

Topic: Aqua and Mariculture Technology**Learning Objectives:**

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

- Identify ways of improving aqua-farming and mariculture technologies.

Essential Questions:

1. What are some technologies that are being developed in aquaculture?

Essential Knowledge	Aqua-farming and mariculture technology
Essential Skills	Identifying technologies that improve aquaculture and mariculture
Essential Attitudes and Values	Appreciate the influence of technology on aquaculture

Performance Indicator**Content Background**

Technology adoption has played a key role in the global development and increase in the agriculture productivity. However, the decision to adopt a new technology on farms is complex. While the factors that drive the adoption of new technologies have been well studied in agriculture, less attention has been paid to drivers of technology adoption in aquaculture. Aquaculture technologies have developed and advanced rapidly in recent decades, but not all technologies have been adopted by farmers.

The global aquaculture industry in general and mariculture is challenged with the responsibility of feeding a rapidly growing global population. As with other food production industries, aquaculture is finding ways to ensure food security by producing efficiently and sustainably.

Digital agriculture innovations- like drones, satellite images and sensor technology- have allowed new concepts to emerge, such as precision farming, smart farming and digital farming. These terms, despite often being used interchangeably, have different meanings:

- Precision agriculture is a technology-enabled approach to farming management that observes, measures, analysis and optimizes the need of individual fields and crops

- Smart farming is the application of information and communication technologies to optimize complex farm systems
- Digital farming is creating value from data.

Digital farming means to go beyond the mere presence and availability of data to create actionable intelligence and meaningful added value from such data. Digital farming integrates both concepts: precision farming and smart farming.

Dr. Ioannis Nengas, designation research director at Heelenic Centre of Marine, outlines seven digital farming technologies that will impact the present and future of global aquaculture market.

1. Digital Feeding
2. Artificial intelligence
3. Computer vision
4. Smart Sensing
5. Underwater drone data collectors
6. Augmented reality
7. Virtual reality

Follow the link to get more information <https://www.pearselyoncultivator.com> or <https://www.aquamaof.com>

Strand 3: Aquaculture Unit 3: Trends in Aqua Culture Technology

Content Standard 12.3.3 Students will be able to examine how technology is used to aqua farming and processing, preservation, marketing, consumption, regulation and management of plants, animals and fish in different environment and places and evaluate their strengths and weakness.

Benchmark 12.3.3.3 Investigate and analyse the trend in aqua farming technology and explain how new technology could be used to improve the farming, production and marketing.

Topic: Trends in Aqua Culture Technology

Learning Objectives:

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

- Identify trends in aquaculture technology.

Essential Questions:

1. What is the growth trend in aquaculture?
2. What is the most profitable aquaculture?

Essential Knowledge	Trends in aquaculture
Essential Skills	Comparing different types of aquaculture technology
Essential Attitudes and Values	Appreciate the improvements of aquaculture over the years

Performance Indicator

Content Background

From cloud computing to artificial intelligence, new technologies of the 21st century are not only changing the way people communicate, engage and conduct transactions, it is also dramatically transforming industries and making an impact on their growth and development.

Some of these technologies are now widely applied and proving its worth in more mature industries, such as agriculture and transportation. For a young industry like aquaculture, these innovations can have huge implications on its evolution. The transition from manual operations to digital platforms can help significantly improve aquaculture farm production, management and risk mitigation strategies.

Environmental monitoring

Demonstrating the environmental sustainability of the industry through certification programs has served as a catalyst for some of the innovations that are transforming aquaculture. Sediment quality conditions and the

robustness and abundance of marine life and macro-invertebrates beneath marine finfish cage aquaculture sites are indicators of a fish farm's impact on the environment. The traditional method of assessing seabed diversity is time consuming, requires large quantities of formalin to preserve samples and requires an excellent taxonomic expertise.

The recent development of next-generation sequencing (NGS) technologies is moving the industry toward more refined, efficient and effective monitoring. NGS technologies offer the possibility to use environmental DNA (eDNA) or RNA to explore benthic diversity. These methods have cut the benthic monitoring costs incurred by fish farmers and has made monitoring quicker and more accurate.

Genomic selection

Breeding programs for fish and shellfish are aimed at increasing the profitability and sustainability of aquaculture. New hatchery technologies are being developed to enhance broodstock quality that can produce specific pathogen-free and fast-growing seed stock. The recent development of low-cost genomic tools is proving to be a game-changer for small hatcheries.

Computer vision

Image recognition devices are proving to be a friend to breeding and genetics firms – particularly in phenotyping processes for genomic selection. Phenotype refers to the physical characteristics of an animal. It's the sum of genetics and the environment.

Digital image analysis and computer vision systems can do the trick and provide more accurate data collection. These data will enable genetic researchers to find a relationship between genetic components and the final phenotype in a population – allowing them to select genetically superior animals, in whatever trait is of importance.

With precise phenotyping methodologies, researchers will be better able to develop a high-quality population of fish that are, for example, fast-growing, sea-lice-resistant and can perform well in different environmental conditions.

The technology monitors factors as growth, sea lice, disease, lesions and others aspects that affect the health and welfare of the individual fish. According to the company, it is possible to separate the fish that needs treatment, for example, against sea lice. This reduces the extent of sea lice treatments dramatically and “brings fish welfare to a new level by monitoring each fish in the pen,”

Sensors

Innovation in sensing technologies, coupled with computer vision systems, is changing the way farms are being managed. Water quality monitoring in land-based fish farms is one application. When used in conjunction with an online software tool for data management and analysis, the technology could spell the difference between life and death – literally.

Farm management with IoT

Many new industry innovations in recent years are based on the Internet of Things (IoT) platform. Put plainly, IoT is a network of electronic devices – personal gadgets, wearable devices, home appliances, office machines or industrial machinery and equipment – that are connected to the Internet. This Internet connectivity creates a huge network of devices that communicate with each other and with people.

In the aquaculture industry, imagine an interconnected network of devices – sensors, computers, tanks, grading equipment, fish counters, pumps, etc. – within a state-of-the-art fish farm, communicating with each other, sending and uploading critical data to a central command station, providing the operator a complete view of the entire facility. This is the potential for IoT in fish farming.

Devices such as the Osmobot and XpertSea's XpertCount technology, which offers precision inventory assessment and quality analysis of farm species, are both Internet-connected devices that will form part of the larger IoT network. These devices are creating tons of data that can be a goldmine for production analysis and forecasting.

Big data

As more farms go online, more and more devices are spewing out vast amounts of data that are all indicators of the overall health of the facility and the species that live in them. Industry innovators believe big data will become an important component for industry growth and even influence production yields. Predictive analytics, machine learning or artificial intelligence systems all require vast amounts of data to be able to process output and produce key leading indicators for the industry: production forecasting, disease control and management, feed management, environmental controls, energy efficiency, etc.

More information can be obtained from (<https://www.hatcheryinternational.com/digital-disruption-3325/>)

Strand 4: Natural Resource Management

Content Overview

Content Standard 12.4.1 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, categorise them according to their characteristics, purposes and benefits, and investigate the different contexts, environments, and places where they are harvested.			
Units	Benchmarks	Topic/s	Lesson Title/s
1. Types capture fishery	12.4.1.1 Identify and analyse the factors that contribute to the production of quality capture fishery products.	Capture fishery products	Quality production factors
	12.4.1.2 Evaluate and discuss the benefits of improved and value added capture fishery products	Improved capture fishery products	Advantages and Benefits
Content Standard 12.4.2 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.			
2.. Capture fishery harvesting practises and management system	12.4.2.1 .Research and explain the factors of capture fishery production.	Capture fishery production	Production factors
	12.4.2.2 Evaluate emerging trends in capture fishery and justify how it is used to improve current practice	Emerging trends in capture fishery	Improved practices
Content Standard 12.4.3 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 environment and places and evaluate their strengths and weakness.			
3. Capture fishery and technology	12.4.3.1 Explain the advances electronic technology and analyze its impact on capture fishery.	Electronic technology	Impact on capture fishery
	12.4.3.2 Identify a technology problem related to capture fishery and develop appropriate solutions.	Capture fishery technology	Constrains and solution
Content Standard 12.4.4 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 thedifferent contexts, environments, and places where they grow and are harvested.			

4. Types of forestry and forests	12.4.4.1 Research and explain the properties of common trees species in the different types of forestry.	Properties of common trees species	
	12.4.4.2 Investigate and explain the physiology of common trees in the different types of forestry.	Physiology of common tree species	
	12.4.4.3 Discuss how common tree species could be grown and commercialised on a large scale.	Commercialising common tree species	
	12.4.4.4 Examine and explain how forest products are harvested processed, preserved, and marketed in different contexts and environments.	Forest products	Harvesting & Processing Preserving & Marketing
Content Standard 12.4.5 Students will be able to investigate and analyze the different types of forestry practices and management systems used in different environments and places to harvest, process, preserve, market, regulate, and consume forests products.			
5. Forests harvesting (creation) practises and management systems	12.4.5.1 Explain the principles of marketing and discuss how these can be used for marketing forest products.	Principles of Marketing	Marketing forest products
	12.4.5.2 Investigate and evaluate the importance of marketing functions and marketing channels for forest products.	Forest products	Importance of marketing functions Importance of marketing channels
Content Standard 12.4.6 Students will be able to examine how technology is used in the harvesting, processing, preservation, marketing, regulation, consumption, and management of forestry			
6. Forestry and Technology	12.4.6.1 Research and design a system for establishing a plantation for a certain common tree species.	Plantation establishment	Common tree specie
	12.4.6.2 Research and explain clonal forestry and evaluate its benefits	Clonal forestry	Advantages and benefits

Strand 4: Natural Resource Management Unit 1: Types of capture fishery

Content Standard 12. 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, categorise them according to their characteristics, purposes and benefits, and investigate the different contexts, environments, and places where they are harvested.

Benchmark: 12.4.1.1 Identify and analyse the factors that contribute to the production of quality capture fishery products.

Topic: Capture fishery products

Learning Objective: Students will be able to;

- Describe factors that contribute to the production of quality capture fishery products.
- Identify types of quality capture fishery products.

Essential Questions

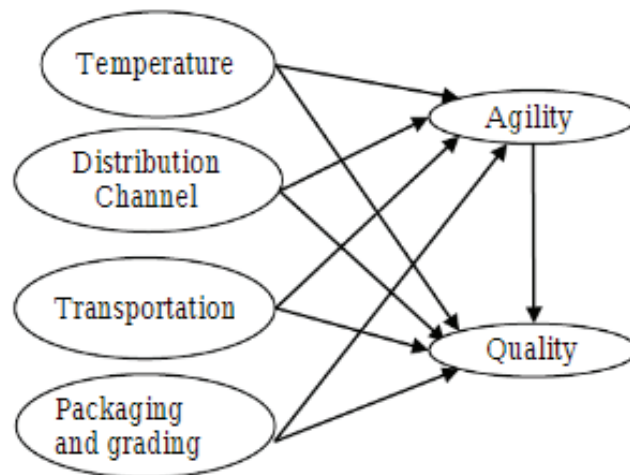
1. What are the factors that contribute to the production of capture fishery products?
2. What are the quality capture fishery products?

Essential Knowledge	Factors that contribute to the production of quality capture fishery products
Essential Skills	Describe types of quality fishery products
Essential Attitudes & Values	Appreciate and value quality production of capture fishery products

Content Background

Factors that contribute to the production of quality capture fishery products

The consumption of fish by humans worldwide is 77%. The demand and consumption of fresh fish has significantly grown during recent years. The supply chain of fish is a network which consists of the fishermen, middlemen, distributors, transporters, storage facilities, suppliers, retailers, delivery and selling the product to the consumer. It is necessary to maintain the quality and safety of fish/fish products till the time of consumption by the consumer. The quality and safety of the fish/ fish products may / depend mainly on the temperature, distribution channel, transportation, packaging and grading. To understand these factors on the quality and safety of the fish/fish products and to propose the implementation of the concept of agility into these factors so that the quality and safety of these products is ensured with minimum losses and wastage.



1. Temperature

The important factor that affects the quality and safety of unpreserved products is temperature mainly for fresh fish. The irregular changes in the temperature leads to the fast development of some specific spoilage organisms and also which cause problems in safety and quality thus leading to economic losses. Generally, the fresh fish is stored and shipped at melting ice temperature (or even below 0 °C, at very low cold temperatures so that the supply chain of fresh fish can be good and be safe for some time period otherwise it may face some danger as far as quality and safety is concerned.

2. Distribution Channel

The major activity of the distribution channel is to perform the distribution process from the fisher, Stage one to consumer, the last stage. The various channel members involved are fisher, wholesaler, distributor, retailer and consumer. The fish is transferred from producers to final consumer. This channel is mostly managed, supported, financed and controlled by the middlemen who are skillful mediators in the supply chain of fisheries. The supply is strategically very important in the supply chain as it is a collective objective of every function in the chain.

This has relevance in the fish supply chain as it is a blend of sequence of functions which are performed by the participants like wholesalers, retailer, exporter and the fisherman in transferring the products to the consumers both domestically and internationally

In order to earn reasonably good profit for the quality of fish, farmer and traders, the entire distribution channel is divided into buying and selling, auctioning, transportation, grading, packaging, storing, financing, market information and pricing. Distribution channel has an influence on the quality of the fish products.

3. Transportation

The mode of transportation for perishable products such as fresh fish is usually by Air as it is faster compared to other modes of transport. There would be changes in the temperature during loading, unloading, storage and holding the product as almost 80% of the time in transport is unprotected. The other mode of transportation of fresh fish is by sea where the product is stored in refrigerated containers so that minimum required temperature for the complete journey is taken care. There should be a trade-off among the various modes of transport based on the quality and safety regarding time, temperature, customer requirement, economic efficiency, efficient packaging.

4. Packaging & Grading

The packaging of food is for preserving the food during storage, transportation and distribution which has to be provided by the manufacturing or production centre and plays a very important role in the package. It is essential to have proper packaging of fish.

Assessment Task

Design a flow chart on factors that contribute to the production of quality capture fishery products.

Source: https://www.researchgate.net/publication/325067596_Agility_in_the_Factors_Effecting_the_Quality_and_Safety_of_Fish_Products

Strand 4: Natural Resource Management capture fishery

Unit 1: Types of

Content Standard 12. 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, categorise them according to their characteristics, purposes and benefits, and investigate the different contexts, environments, and places where they are harvested.

Benchmark: 12.4.1.2 Evaluate and discuss the benefits of improved and value-added capture fishery products.

Topic: Improve capture fishery products

Learning Objective: Students will be able to;

- Explain the benefits of improved and value-added capture fishery products.

Essential Questions

1. What are the benefits of improved and value-added- capture fishery products?

Essential Knowledge	Benefits of improved and value-added capture fishery products
Essential Skills	Discuss the benefits of improved and value-added capture fishery products
Essential Attitudes & Values	Appreciate and value benefits of value-added capture fishery products

Content Background

What is Value addition? Add value means:

Employing processing method
Adding specialized ingredients
Novel packing to enhance the nutrition
Sensory characteristics
Shelf life and
Convenience of food products



Value addition means

– any additional activity that in one way or the other change the nature of a product thus adding to its value at the time of sale.



Value addition is one of the most prominent approaches among the other processing techniques in the fish and seafood industry with tremendous market values as well as employment opportunities. It is a good option for foreign earnings also by exporting of value-added products. Besides the

profitable utilization of low valued fish, it can fulfil the consumers' demands of convenient foods with quality assurance and longer shelf life. With mentioned intention, various diversified fish and seafood products can be prepared. Thus, the nation's economic growth will be gradually increased with production and distribution (through domestic or international trade) of different ready-to-eat or ready to cook or ready to serve products. With the concerns about healthy and balanced diet in our country and in the world, the interest in fishery products is constantly increasing. Fishery products are the sources of good quality protein, vitamins and minerals. They are also rich in calcium and phosphorus. All the nutritional properties of fishery products are the real reason why they are more preferred.

These products range from live fish and shellfish to ready-to-serve convenience products. In general, value additions mean any additional activity that in one way or another changes nature of the product thus adding to its value at the time of sale. As far as the fish-processing industry is concerned value addition is one of the possible approaches to raise profitability since this industry is becoming highly competitive and increasingly expensive. There is a great demand for seafood/seafood-based products in ready to eat convenience form. A number of such diverse products have already invaded western markets. One factor responsible for such a situation is more and more women getting educated and taking up employment. Reasonably good expendable income, education, awareness and consciousness towards hygiene and health and increased emphasis on leisure pursuits are some of the other reasons. Marketing of value-added products is completely different from traditional seafood trade. It is dynamic, sensitive, complex and very expensive.

Most of the market channels currently used is not suitable to trade value-added product. A new appropriate channel would be supermarket chain; which want to procure directly from source of supply. Appearance, packaging and display are all important factors leading to successful marketing of any new value-added product. The retail pack must be clean, crisp and clear and make contents appear attractive to consumer. The consumer must be given confidence to experiment with a new product from, target group, market area, species used and so on. The latest packaging must also keep abreast with latest technology. A large number of value-added and diversified marine products both for export and internal market based on shrimp, lobster, squid cuttlefish, bivalves, certain species of fish and minced meat from low priced fish have been identified. The technology for their production is readily available. Value addition is the most talked about word in food-processing industry, particularly in export-oriented fish processing industry because of the increased realisation of valuable foreign exchange. Value can be added to fish and fishery products according to the requirements of the different markets.

An example, one of these fishery products is trout. Trout is a delicious, healthy and cheap fish that it is alternative to red meat as it is basic protein source. It is also an important instrument for creating job and income in the rural areas. Poverty and unemployment is a major problem in today's world and trout farms provide many people with employment. Trout Farm is an important example in this respect. The farm makes contribution to the well-being of the community, economic growth and the economic vitality of rural areas.

Assessment Task

Write an essay on a type of fishery product and identify the benefits of improved and value-added.

Source:

<https://sifisheriessciences.com/article-1-56-en.html>

<http://aquafind.com/articles/Value-Added-Fish-Process.php>

Strand 4: Natural Resource Management

Unit 2: Capture fishery harvesting practices and management system.

Content Standard 12.4.2 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 12.4.2.1 Research and explain the factors of capture fishery production.

Topic 1: Capture fishery production.

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

- Explore and identify how much is produce in global fishery capture production.
- Distinguish between marine and inland waters production.
- Summarise the top countries for fishery capture production.

Essential questions:

1. What is the global capture fishery production?
2. What is the global capture fishery production in marine and inland waters?
3. What are some of the top countries globally in capture fishery production?

Essential Knowledge, Skills, Attitudes and Values	
Knowledge	Global capture fishery production, capture fishery production in marine and inland waters.
Skills	Explore, compare, differentiate and explain capture fishery productions in different environments.
Attitudes	Open minded with desire to learn.
Values	Appreciate learning knowledge and skills.

Content Background:**CAPTURE FISHERIES PRODUCTION**

In 2020, global capture fisheries production was 90.3 million tonnes— a fall of 4.0 percent compared with the average of the previous three years. The decrease concerned both marine capture fisheries and inland waters (3.9 percent and 4.3 percent, respectively) and is most likely due to both the disruption in fishing operations because of the COVID-19 pandemic and the ongoing reduction in China's catches (10 percent lower in 2020 compared with the average of the previous three years). The 2017–2019 average was high because of the peak experienced in 2018 (96.5 million tonnes) due to relatively high catches of anchoveta (*Engraulis ringens*). Catches have generally fluctuated between 86 million tonnes and 93 million tonnes per year since the late 1980s.

China remains the top capture producer despite the downward revision of its catches for the period 2009–2016 and a decline of around 19.3 percent between 2015 and 2020. The top seven capture producers (China, Indonesia, Peru, India, Russian Federation, United States of America and Viet Nam) accounted for almost 49 percent of total global capture production while the top 20 producers accounted for over 73 percent.

Marine capture production

In 2020, global marine captures were 78.8 million tonnes, a decline of 6.8 percent from the peak of 84.5 million tonnes in 2018, when relatively high catches of anchoveta were reported by Peru and Chile.

Marine captures were severely affected by the disruption to fishing operations caused by the COVID-19 pandemic during 2020. Compared with 2019 (i.e. prior to the COVID-19 pandemic), global marine captures decreased by 1.6 percent in 2020, well within the limits of interannual fluctuations in previous years. Of the top ten producers for global capture production, most reported catches in 2020 were either at the same level as or higher than the catches for 2019 (e.g. Peru, India, Russian Federation and Norway).

Global production of marine capture fisheries continues to be highly concentrated among a small number of producers. In 2020, similar to previous years, the top seven producers accounted for over 50 percent of total marine captures, and China alone accounted for 14.9 percent of the world total, followed by Indonesia (8.2 percent), Peru (7.1 percent), the Russian Federation (6.1 percent), the United States of America (5.4 percent), India (4.7 percent) and Viet Nam (4.2 percent). While China remains the world's top producer of marine captures, its catches declined from 14.4 million tonnes in 2015 to 11.8 million tonnes in 2020, representing a decrease of 18.2 percent from 2015 and 7.2 percent from 2018 (an average annual decrease of 3.9 percent). While total catches for China in the FAO database are generally considered to be complete, improvements are needed to more accurately assign China's distant-water fishery catches by area and disaggregate catches by species.

Inland waters capture production

In 2020, total global catches in inland waters were 11.5 million tonnes, a decrease of 5.1 percent from 2019. As with marine capture production, fishing operations in inland waters were severely impacted by the COVID-19 pandemic during 2020, and this was compounded by the decline in China's catches. Despite the decrease in 2020, inland water catches remain at historically high levels and only marginally below the highest levels of 12.0 million tonnes recorded in 2019.

For the first time since the mid-1980s, China was not the top producer of inland water catches in 2020 and instead the highest catches were reported by India at 1.8 million tonnes. While China continues to be one of the largest producers of inland water capture fisheries, reported catches have decreased by over 33 percent from 2.2 million tonnes in 2017 to 1.5 million tonnes in 2020.

With the exception of China, the increase in inland water catches continues to be driven by several major producing countries – notably India, Bangladesh, Myanmar and Uganda

Inland water captures are more concentrated than marine captures among major producing nations endowed with important waterbodies or river basins. In 2020, 13 countries produced over 75 percent of total inland captures, compared with 20 countries for marine captures.

Three major species groups account for over 75 percent of total inland water catches. The first group, “carps, barbels and other cyprinids”, has shown a continuous increase, rising from about 0.7 million tonnes per year in the mid-2000s to almost 1.9 million tonnes in 2020, and explains most of the increase in catches from inland waters in recent years. Catches of the second-largest group, “tilapias and other cichlids”, have also started to increase in recent years from 0.7 million tonnes to 0.9 million tonnes per year. Catches of the third-largest group,

“freshwater crustaceans”, have generally remained stable at between 0.4 million tonnes and 0.45 million tonnes per year; however, in 2020, catches fell to 0.3 million tonnes, mostly as a result of the decrease in China's inland water catches.

Assessment Task

Do a research about Papua New Guinea's capture fishery productions in marine capture and inland waters capture. State factors that contributes to decrease of production in both environments.

COVID-19 pandemic is a contributing factor to the reduction of capture fishery productions. Do a research on how did it affect the global capture fishery productions.

Analyse global fishery capture production.

Distinguish between marine and inland waters production and list them.

Source: <https://www.fao.org/3/cc0461en/online/sofia/2022/capture-fisheries-production.html>

Strand 4: Natural Resource Management

Unit 2: Capture fishery harvesting practices and management system.

Benchmark 12.4.2.2 Evaluate emerging trends in capture fishery and justify how it is used to improve current practice.

Topic 1: Emerging trends in capture fishery.

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

- Investigate and report on the emerging trends in capture fishery.
- Explain how these trends improve current practices in capture fishery.

Essential questions:

1. What are emerging trends in capture fishery?
2. What are some of the trends that improve the current practices in capture fishery?

Essential Knowledge, Skills, Attitudes and Values	
Knowledge	Emerging trends that improve current practices in capture fishery.
Skills	Investigation and reporting skills .
Attitudes	Open minded with desire to learn.
Values	Appreciate learning knowledge and skills.

Content Background

Technological innovations

Technology has changed the lives of humans and continues to do so with near daily advances in all realms. Natural resource management has also had to adapt to changes in technology that have focused on resource extraction. Often, technology has allowed the more efficient harvest of trees, minerals, and fish—at industrial scales and in increasingly and previously inaccessible water depths.

Key innovations in fisheries include the development of hooks and boats, multifilament nets, echolocation and the diesel engine, to name a few. Fisheries on the high seas are now possible as a result of vessel technology, navigational and echo-sounding equipment, and multiple fishing gear technological innovations, as well as advances in refrigeration technology.

All of this has substantially changed not only stock assessments (through the impact of novel technology on catch rates overtime), but also the way fisheries are managed. In short, as technological innovations creep into a sector, assessment and management have to adapt.

The technology, underwater tools for observing fish have a long history as aids to fishers across sectors. Single and dual frequency sonar technology are common tools for detecting fish, but cameras that capture still images and video are increasingly used to gather details about fish size, species, and location that are more challenging to glean using tools that locate fish indirectly.

Cameras used for fishing include those that are directly developed and marketed as tools to enhance fishing productivity as well as the adaptation of general-purpose underwater cameras for observing fish.

Boat-based electronics- Modern anglers have access to a suite of technologies that enable them to efficiently navigate amongst and within fishing sites while informed by real time data on the structure of the waterbody, current conditions, water temperature, and location of the fish
Hook technology - Early hooks were fashioned from bone or shell, and the use of hooks helped humans access protein and reside in areas that were otherwise resource poor. Since their humble beginnings thousands of years ago, innovation with fish hooks has been remarkable and has largely occurred in three areas: shape, piercing/cutting ability, and materials. Collectively, the goal of these modifications has been to maximize capture rates and minimize fish loss, thereby imparting maximum benefits for anglers.

Fish attractants- The technology attempts to utilise scents to stimulate the well-developed olfactory (smell) and gustatory (taste) organs of fish to increase their catch rates are probably as old as recreational fishing itself
Lure and bait technology- Fishing tackle manufacturers have long attempted to create artificial lures or enhance organic baits that attract the attention of both fish and the angling consumer.

Fishing rod, reel and line technology- Fishing rod technology has focused largely on making rods that are lighter and more sensitive (e.g., with IM8 graphite) than early (e.g., bamboo, fibreglass, and boron models) or less expensive rods while also retaining or increasing strength and reaction characteristics.

Social media and online forums- The popularity of social media accelerated in the first decade of the new millennium. This came as a response to the World Wide Web evolving from a platform hosting mainly static information to one that includes a great deal of user generated content, which is considered the lifeblood of social media.

Assessment Task

- Do a research about other emerging trends that improve current practices in capture fishery.
- Explain the emerging trends in capture fishery and how they improve current practices in capture fishery.

Source: Rev Fish Biol Fisheries (2021) 31:253–288
[https://doi.org/10.1007/s11160-021-09643-1\(0123456789\(\).,-volV\)\(01234567](https://doi.org/10.1007/s11160-021-09643-1(0123456789().,-volV)(01234567)

Strand 4: Natural Resource Management Unit 3: Capture fishery and technology.

Content Standard 12.4.3 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 environment and places and evaluate their strengths and weakness.

Benchmark 12.4.3.1 Explain the advances electronic technology and analyse its impact on capture fishery.

Topic 1: Electronic technology.

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

- Investigate and report on the advances of electronic technology.
- Explain the impacts of electronic technology on capture fishery.

Essential questions:

1. What are the advances of electronic technology in capture fishery?
2. What are some of the impacts of electronic technology in capture fishery?

Essential Knowledge, Skills, Attitudes and Values	
Knowledge	Advances and impacts of electronic technology in capture fishery.
Skills	Investigation and reporting skills .
Attitudes	Open minded with desire to learn.
Values	Appreciate learning knowledge and skills.

Content Background:

Fisheries technology

Harvesting of aquatic resources and production is done either in the wild (capture fisheries) or in controlled environments (aquaculture). Both use a large variety of technologies - from artisanal to highly-industrial - encompassing vessels and equipment as well as fishing gears and methods.

For both capture fisheries and aquaculture, the technological development and widespread use of synthetic fibers, hydraulic equipment for gear and fish handling, electronics for fish finding, satellite-based technology for navigation and communications, onboard conservation and increased use of outboard engines have all contributed to the major expansion of fisheries and aquaculture in recent decades - particularly in small-scale fisheries. Technical advances have generally led to more efficient and economical fishing operations, reduction of the physical labour required per unit of output and improved access to resources.

Where management has been ineffective, the greater efficiency of fishing methods and aquaculture production has sometimes led to overfishing

and environmental degradation. These points to the need to develop more effective fisheries management frameworks, together with safer and more environmentally-friendly methods of production, for example, in developing selective fishing gear and in designing aquaculture systems that reduce their impact on external environments.

Fish capture technology

Fish capture technology encompasses the process of catching any aquatic animal, using any kind of fishing methods, often operated from a vessel. Use of fishing methods varies, depending on the types of fisheries, and can range from a simple and small hook attached to a line to large and sophisticated midwater trawls or purse seines operated by large fishing vessels. The targets of capture fisheries can include aquatic organisms from small invertebrates to large tunas and whales, which might be found anywhere from the ocean surface to 2 000 meters deep.

The large diversity of target species in capture fisheries and their wide distribution requires a variety of fishing gear and methods for efficient harvest. These technologies have developed around the world according to local traditions and, not least, technological advances in various disciplines.

In recent decades major improvements in fiber technology, along with the introduction of other modern materials, have made possible, for example, changes in the design and size of fishing nets. The mechanization of gear handling has vastly expanded the scale on which fishing operations can take place. Improved vessel and gear designs, using computer-aided design methods, have increased the general economics of fishing operations. The development of electronic instruments and fish detection equipment has led to the more rapid location of fish and the lowering of the unit costs of harvesting, particularly as this equipment becomes more widespread. Developments in refrigeration, ice-making and fish processing equipment have contributed to the design of vessels capable of remaining at sea for extended periods.

Although these technologies are largely available, those actually introduced in many small-scale fisheries may amount to no more than motorizing a dugout canoe, use of modern and lighter gear or introducing the use of iceboxes to ensure the quality of the product landed.

The impact of such changes, however, has considerably increased landings and the earnings of fishers, and underlines the need for effective management to prevent excessive fishing effort. The emphasis of much recent technical innovation has been focused on greater and more appropriate selectivity of fishing gear so as to reduce negative impacts on the environment.

Assessment Task

- Explain the advances of electronic technology and its impacts in capture fishery.
- Do a research on the advances of electronic technology and its impacts on capture fishery in Papua New Guinea.

Source: <https://www.fao.org/fishery/en/technology>
<https://www.fao.org/fishery/en/technology/capture>

Strand 4: Natural Resource Management Unit 3: Capture fishery and technology.

Content Standard 12.4.3 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 environment and places and evaluate their strengths and weakness.

Benchmark 12.4.3.2 Identify a technology problem related to capture fishery and develop appropriate solutions.

Topic 1: Capture fishery technology.

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

1. Investigate, identify and explain problem related to capture fishery technology.
2. Discuss and develop appropriate solutions to problems related to capture fishery technology.

Essential questions:

1. What are the problems encountered when using technology in capture fishery?
2. How does technology in capture fishery affect the different environments?
3. What are some solutions to minimize the use of capture fishery technology and its effects on different environments?

Essential Knowledge, Skills, Attitudes and Values	
Knowledge	Problems and solution in use of technology in capture fishery.
Skills	Investigation and reporting skills.
Attitudes	Open minded with desire to learn.
Values	Appreciate learning knowledge and skills.

Content Background

Fishing Technology

Modern fishing technology was built to catch as many fish as possible as efficiently as possible, and it is very effective at doing this. Unfortunately, it achieves this effectiveness at the expense of the health of ocean ecosystems. The three main problems of current fishing technology are: the destruction of the ocean floor and environs, ghost fishing, and bycatch.

Destruction of the ocean floor and environs

The main cause of this part of the problem is a fishing method called bottom trawling. Bottom trawling is usually done by one or two fishing vessels with a large net that is dragged along the bottom for a few hours at a speed of three or four knots.

Unfortunately, bottom trawling is the world's most lucrative fishing method, and so is quickly replacing much more ocean-floor-friendly methods like hook-and-line and trapping.

Bottom trawls can dig up to several inches into the seabed, disrupting the bottom habitat and the animals that live there, including unique structures made by living creatures. Trawls kill marine life, destroy food sources and shelters, and endanger young fish and future generations of ocean fauna (Safina, 5). Lab studies of the relationship between sea floor composition and predation showed that more complex habitats like rocks, rather than simple habitats like sand or mud, gave prey fish like young cod more time to escape their predators.

Dragging metal frames along the ocean floor also kicks up a cloud of sediment. While this does make the nets more efficient, as the dirt helps bring fish into the net, it also causes numerous problems.

The dragging metal frame of bottom trawlers indirectly kills significant quantities of ocean life, including commercial fish such as cod. Is it not, then, in the interest of everyone to find a way to fish without destroying the ocean floor?

Ghost Fishing

Fishing nets and traps today are made of durable polymer fibers, built to last. While this seems great at first, this durability can kill millions of fish and other organisms. When fishing nets or traps are lost due to storms or negligence, they actually continue to catch fish (Gabriel, 2005). And thanks to those polymer fibers, they can keep catching fish or crabs or other life for months or years. To make matters worse, many traps and nets become self-baiting: fish become trapped in the gear and die, other fish come to feed on the dead fish, become trapped themselves, and continue the cycle until the net becomes completely full (Matsuoka, 2005). This is called "ghost fishing," and it is probably the most frustrating problem plaguing the fishing industry today. Hundreds or thousands of fish or crustaceans can be caught in a single net, and the fish aren't even used in any way; they are completely wasted.

Bycatch

Every fishing method has potential to catch and kill non-target fauna, called bycatch. It is by far the most widespread of the technology-related problems (Gabriel, 2005).

Most commercial fishing methods today involve dragging an enormous net through vast amounts of water. Inevitably, these nets will catch fish other than those species the fishermen want. In 2005 alone, 7.3 million tons of commercially viable fish were discarded into the ocean (ICES 2005).

High mortality rates for non-target fish species can change the ecology of an area by changing food web relationships, altering predator-prey interactions, and destroying the environment. In the long term, bycatch can lead to overfishing, decreased productivity, and reduction in the size of the total catch (Turning A Blind Eye, p. 5). Almost 1,000 marine mammals, many of which are from critically endangered species, die every day after becoming tangled in fishing equipment. The largest threat facing marine animals is the possibility of being caught as bycatch, rather than pollution or collisions with ships (Verrengia, p. 4).

Clearly, bycatch is a problem that must be addressed if we are to live in a world of sustainable fisheries.



Photograph from [NOAA](#).
Bycatch includes everything from sand dollars to sea turtles.

Assessment Task

- Explain the problems encountered when using technology in capture fishery.
- Do a research on technology and its impacts on capture fishery in Papua New Guinea in different environments.

Source: <http://web.mit.edu/12.000/www/m2011/finalwebsite/problem/present/tech.shtml>

Strand 4: Natural Resource Management

Unit 4 Types of forests and forestry

Content Standard 12.4.4 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: 12.4.4.1 Research and explain the properties of common trees species in the different types of forestry.

Topic: Common Tree Species

Learning Objective:

- Identify the common trees species in the different types of forestry
- Describe the properties of the common tree species in the different types of forestry

Essential Questions:

1. What trees species are common in the different types of forestry?
2. What are the properties of the common tree species?

Essential Knowledge, Skills, Attitude and Values

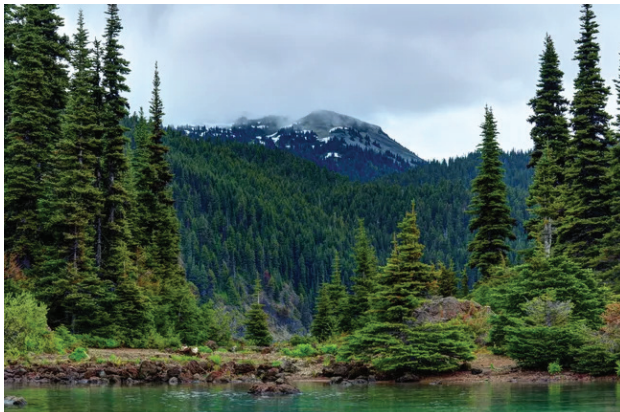
Knowledge	Common species of trees
Skills	researching and describing properties of common trees
Attitudes	Awareness of common species of trees locally
Values	Appreciate role of common species of trees

Content Background

Common in different types of forestry

The forests are shaped by the amount of solar radiation and precipitation, both of which are influenced by latitude. The kind of organisms that survive in such an area are determined by the climatic conditions there and they have shaped the growth of forest millions of years. Based on attitude, there are three types of, forest are boreal forest, temperate forest and tropical forest

Boreal Forest trees



Boreal forest, also known as taiga is one of the world's largest land biomes, found across Siberia, Scandinavia, and North America (Alaska and Canada). Boreal forests play a significant role in removing carbon dioxide from the atmosphere. On average the temperature is below freezing. Needle-leaf plant species such as conifers, spruce, fir, and pine trees are predominant in boreal forests. Large herbivores mammals like moose and deer are just two examples of animals that live in this environment. During the forest harsh winters most native bird to the taiga migrate to find warmer conditions

Temperate Forest



Temperate forests are located in the mid-latitudes and have four distinct seasons. They are inhabited by species that can adapt to the seasonal changes. The temperatures of temperate forests vary throughout the year due to the four distinct seasons at these latitudes.

The soil is fertile with a lot of precipitation that supports the diverse flora like deciduous tree like maples, hickories, oak, birch with many other trees that drop their leaves and become dormant in fall and winter to save energy.

Tropical forest



Tropical forests are common to area near the equator and located between the Tropics of Cancer and Capricorn at 23 degrees north and south. Tropical forests have a warm temperature and are the rainiest forests on Earth and known for the extraordinary biodiversity. Kapok tree in Madre de Dios, Peru, Rubber tree (*Hevea brasiliensis*), Ramón tree (*Brosimum alicastrum*), Xate (*Chamaedorea elegans*, *Chamaedorea ernesti-augustii*, *Chamaedorea oblongata*), Ipê (*Tabebuia* spp) are few species of trees that are common in tropical forests

Assessment

Investigate the properties of common trees species in the different types of forestry.

Source: <https://www.treehugger.com/types-of-forests-definitions-examples-5180645>

<https://education.nationalgeographic.org/resource/forest-biome>

Strand 4: Natural Resource Management

Unit 4 Types of forests and forestry

Content Standard 12.4.4 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: 12.4.4.2 Investigate and explain the physiology of common trees in the different types of forestry.

Topic: Physiology of tree species

Learning objective

- Identify the common physical feature in the physiology of trees
- Explain the physiology of common species of trees of different types of forestry

Essential Questions

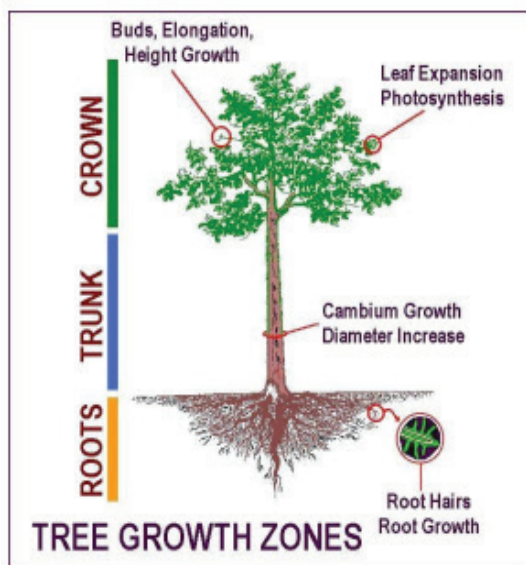
1. What is physiology of tree?
2. What are physiological processes in the physiology of a tree?

Knowledge, skills, attitude and values

Essential Knowledge, skills, attitude and values	
Knowledge	Physiology of trees and the process of physiological process
Skills	Identifying the tree physiology
Attitude	Develop a caring habit for the trees
Values	Being grateful of for roles of tree in the environment

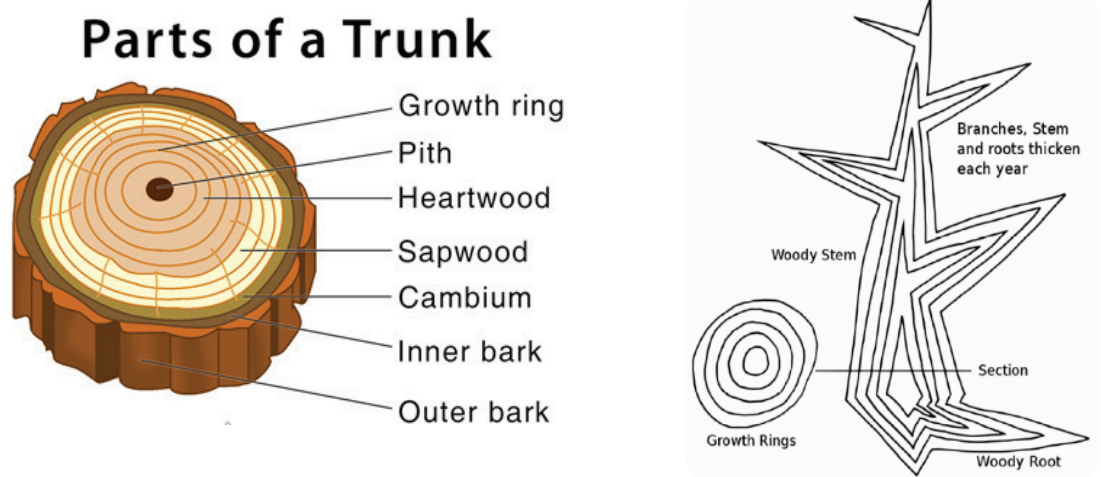
Content background

Tree Physiology



In forestry the role of tree physiology is defined as: first to elucidate the nature of basic physiological processes in the tree itself which controls growth. Secondly to show these processes are individually or collectively affected by both heredity and the environment. Therefore, tree physiology is about the study of how trees grow and develop in regard to its genetics, biochemistry, cells, tissue and organ functions and its interaction with environment factors. The main parts of a tree crown, trunk and branches and the roots. Tree Root Physiology studies the parts of the roots and functions which cover the root parts, root cap, apical meristem, region of elongation, region of root hair, rhizosphere and mycorrhizae. Tree Trunk Physiology concentrates on the functions by the parts of the around the trunk of the tree, which are; outer bark, inner bark or cork cambium, phloem, cambium, xylem, heartwood, symplast, vessel and tracheids and apical dominance. Physiology of Leaves looks at the processing of chlorophyll, process of photosynthesis, respiration, transpiration stomata, glucose and distribution of glucose. The age of tree is calculated by simply counting the annual rings or growth rings that form in its trunk due the wood growth. This growth of a tree or lateral expansion is called the Secondary growth. Growth occurs in plants and trees in two ways: primary growth and secondary growth. Primary growth causes the plant to grow in length, both below and above the ground, due to the apical meristems that are actively dividing into these regions. Secondary growth causes the plant to grow in the width due to the presence of lateral meristems or cambium layer which actively divides to bring about this kind of growth. During each growing season a new layer of wood is added that thickens the stem, existing branches and roots.

The diagram shows secondary growth in a eudicot or coniferous tree showing idealised vertical and horizontal sections



Assessment task

Research types physiological process in a tree and describe the functions of the part that carry out these processes.

Source

- <https://en.wikipedia.org/wiki/Tree>
- <https://gibneyce.com/about-tree-physiology-gce.html>
- <https://www.toppr.com/guides/biology/anatomy-of-flowering-plants/secondary-growth/>

Strand 4: Natural Resource Management

Unit 4 Types of forests and forestry

Content Standard 12.4.4 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: 12.4.4.3 Discuss how common tree species could be grown and commercialised on a large scale.

Topic: Commercialising Common Tree Species

Learning objective

- Identify the measures in which common tree species can be grown on a large scale
- Describe the ways of Commercialising common tree species
- Describe the ways to farm of common tree species locally for commercial purposes

Essential Questions

1. What tree species are grown for commercial purposes?
2. How are these common tree species grown on a large for commercial purposes?
3. What are some ways to promote tree farming locally?

Knowledge, skills, attitude and values

Essential knowledge, skills, attitude and values	
Knowledge	<ul style="list-style-type: none"> • Common types of tree species for commercial purpose • Measure used to grow common tree species • Ways of Commercialising the tree species on a large scale
Skills	<ul style="list-style-type: none"> • Identifying and describing
Attitude	<ul style="list-style-type: none"> • Develop a habit of caring for and planting trees
Values	<ul style="list-style-type: none"> • Understand the commercial value of common tree species.

Content background

Planting trees

Trees have been duly recognized for their amazing superpower of extricating and sequestering carbon from the atmosphere. However, in our haste to tap into tree planting as a Nature-based Solution to climate change, it is essential to understand that forests and natural ecosystems are much more than just trees and cannot easily be replicated. Whilst planting trees in degraded areas is highly encouraged, that first priority should always be to safeguard and protect forests which sustain biodiversity, provide essential ecosystem services, and support local livelihoods and human well-being.

Existing forest is essential to enabling adjacent degraded forest to regenerate effectively. To this end, scientists have come up with these 10 Golden Rules for Large-scale Tree-planting. Based on the insights and experience from scientists and practitioners around the world, these Rules should be our guide as we take up a tree planting agenda with forest restoration at its heart.

1. Protecting existing forest first
2. Priorities the participation of local people
3. Maximize biodiversity recovery
4. Select the right area for reforestation
5. Use natural forest regrowth wherever possible
6. Select the right tree species
7. Make the trees are resilient to adapt to a changing climate
8. Plan ahead how to source seeds/trees and to work with people
9. Learn by doing; combine scientific and local knowledge
10. Think about a source of income for all stake holders.

Planting of trees on a large scale for commercial purpose is called afforestation. Traditional plantations consist of a large plot of land planted with a single species, such as eucalyptus or pine. This is now starting to change, for several reasons. With the rise in human population paired with decline in fertile land, large plots of land for conventional plantations are becoming scarcer and more expensive. In addition, conventional large plantations, although attractive in their size and efficiency, are particularly susceptible to pests and fires, creating outsized risks of catastrophic loss. In some countries, these large-scale plantations also face political risks as local communities may view them as exploitative land grabs.

These realities are giving rise to a new type of plantation within the commercial forestry sector: distributed plantations, where trees are grown on different small plots of farmland. The farmers manage the trees during the growth period, but the supply of timber is aggregated by the company, which manages everything from seedling production to harvest to processing. The company has exclusive harvest rights, and farmers are compensated upon harvest.

Growing trees the right way

Foresters known as Resource Land Managers plant the tree quite close together, which encourages them to grow tall rather than producing a lot of excess branches. That's important because branches make knots in the wood, weakening it.

We nurture the forest, monitoring its growth and addressing any needs the trees may have for decades. Halfway through their lifecycle, we may "thin" the forest, removing unhealthy trees and trees that are too crooked to make good lumber. This gives the best trees more room to grow.

Main Harvested Species

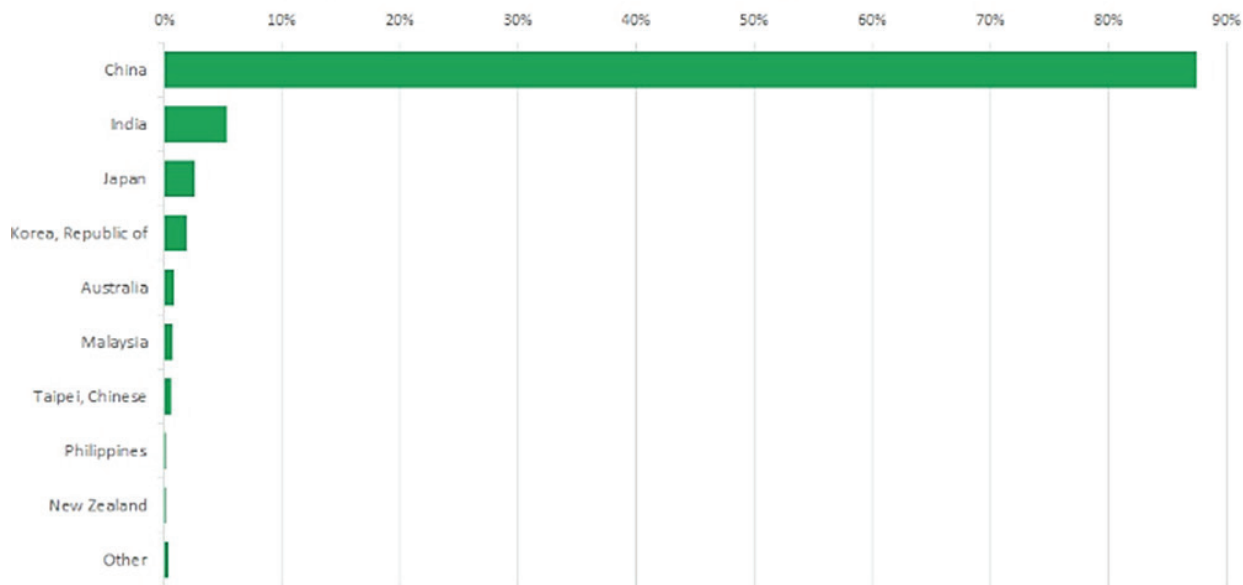
There are many species harvested from PNG's forests. The 10 most important species for export from PNG include Taun (*Pometia pinnata*), Merbau, locally known as Kwila (*Intsia spp.*), Malas (*Homalium foetidum*), Calophyllum (*Calophyllum spp.*), Terminalia (*Terminalia spp.*), Kamarere (*Eucalyptus*

deglupta) from plantations, Dillenea (Dillenea spp., mainly *D. papuana*), Red Canarium (Canarium spp.), Pencil Cedar (Palaquium spp), and PNG Mersawa, also known as Palosapis (*Anisoptera thurifera*).

Export

The country's forest industry is predominantly based on the export of logs from natural forests. From the graph below, China is by far the most important destination for PNG's timber, notably roundwood. The other destination markets remain important for the exports of processed wood products, such as sawn wood.

Top-10 export markets of Papua New Guinea in 2018



Source: ITC (2020) Main markets, in terms of export value, for the product '44 Wood and articles of wood, wood charcoal' exported by Papua New Guinea in 2018

Assessment task

Research other tree species and non- wood species that can be farmed in Papua New Guinea their methods of cultivation.

Source

- <https://www.britannica.com/science/wood-plant-tissue#ref216127>
- https://www.nature.org/content/dam/tnc/nature/en/documents/Business_of_Planting_Trees_Report.pdf
- <https://www.kew.org/read-and-watch/trees-new-guinea>
- <https://www.timbertradeportal.com/en/papua-new-guinea/91/timber-sector>

Strand 4: Natural Resource Management

Unit 4 Types of forests and forestry

Content Standard 12.4.4. 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 12.4.4.4 Examine and explain how forest products are harvested, processed, preserved and marketed in different contexts and environment.

Topic: Forest Products

Learning Objectives:

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

- Explain what forests products are and how they are harvested, processed, preserved and marketed.

Essential Questions:

1. How are forest products harvested and processed?
2. How are forest products preserved and marketed?
3. What procedures are involved in the preservation of forest products?

Essential Knowledge	Forest Products
Essential Skills	Harvesting, processing , preserving, marketing
Essential Attitudes	Taking care of the environment
Essential Values	Being responsibility

Content Background

Forest Products

A forest product is any material derived from forestry for direct consumption or commercial use, such as lumber or paper. Wood is by far the dominant product of forests. It is used for many purposes, such as wood fuel (in the form of firewood) or the finished structural materials used for the construction of buildings or as raw materials in the form of wood pulp that is used to make paper.

All other non-wood products derived from forest resources, comprising a broad variety of other forest products are described as non-timber forest products. They are foods, substances, materials and commodities obtained from the forest apart from timber. Harvest ranges from wild collection to farming. They include Fruits, nuts, vegetables, seeds, game animals, turpentine, latex (rubber raw product), spices, resin, gum, medicines and herbs, fish, insects, etc.

Harvesting Forest Products

Forest harvesting is defined as the combination of all operations related to the felling of trees and the extraction of their stems, or other usable parts from the forest for processing into industrial products. Nowadays, harvesting no longer refers only to the process of extracting the selected trees from the forest to the roadside but also takes into account the importance of forest as a source of non-wood products and an environmental service as well as for the conservation of biological diversity and cultural values.

Types of logging systems

Logging has been a vital industry for centuries in the harvesting of forest products especially timber products. The innovation has eventually led to three types of logging systems.

Clearcutting

The clearcutting system removes all the trees in a designated area. Many large-scale logging companies use the clearcutting method to harvest timber. The main reason behind logging companies opting for clearcutting is simply because it is fast and cheap. Many environmental advocates are strongly against clearcutting for many reasons. The most obvious reason is that, they destroy wildlife's habitat

Shelterwood

As opposed to taking every and any tree in a particular area, shelterwood only takes trees that are of similar age and size. The key with shelterwood is that it leaves mature trees to support growth from seed trees. In other words, the shelterwood system naturally has a regeneration strategy in place. Another feature of the shelterwood system is that it incorporates a silvicultural system, that is, it controls the forest's species and growth.

Selective Cutting

Selective cutting system is the least destructive logging method. The main difference about selective cutting is that it only removes trees of specific type or size and quality. The primary benefit of selective cutting is that it does not affect the growth of the surrounding trees. The downfall, however, is that it gets more expensive over time because the regeneration is much slower.

Processing of Wood

Here are some of the many different types of products that can be made from trees harvested.

- softwood lumber, such as dimension lumber, beams, wood paneling, siding, door and window frames and furniture parts
- plywood from softwood veneer
- hardwood lumber and plywood used in cabinetry, millwork, furniture

and flooring

- engineered wood products, such as laminated veneer lumber, glulam beams and columns, finger-jointed lumber, I-beams, cross-laminated timber and other products
- composite wood products, such as particleboard, hardboard and fiberboard, made largely from residuals generated by sawmills and plywood mills
- posts, poles and timbers, such as utility poles, house logs, fence posts, pilings, treated timbers, cross-arms and railroad ties
- pulp and paper products from wood fiber, including packaging, printing paper, newsprint, tissue, toweling, absorbents, adhesives and fluff pulp
- Millwork, including products such as cabinets, furniture and fencing
- biomass energy from mills burning wood waste to generate heat and electricity for manufacturing, or power plants replacing coal with timber harvest waste
- heating uses such as wood pellets and bricks made from sawdust and mill residue
- other wood products, including shipping pallets, pencils and musical instruments

Preserving Wood

Protecting timber from insect pests begins at harvest and continues with good hygiene practices in the mill. There are several options for treating timber with preservatives to protect it from insect pests.

Freshly-felled 'green' timber can be damaged by beetles. At harvest, damage can be minimized by quickly removing logs from the forest and promptly sawing and drying the timber. If this isn't possible, logs should be debarked and sprayed with an approved insecticide. At the mill in PNG, green timber may be treated by dip diffusion, which should be undertaken promptly after sawing. Otherwise, timber should be dried promptly (Figure 1).



Figure 1: How to avoid insect pest damage to timber *BFCA is sometimes used in PNG to treat freshly-sawn green timber by dip diffusion.

Dry timber can be damaged by beetles and termites. PNGS 1293:2012 lists timber species susceptible to lyctine beetle attack. AS 5604 lists timber species susceptible to termite attack. The Report summaries insect pest susceptibility for common species in PNG. If sapwood is susceptible, it can be removed or treated with an approved preservative (Figure 2). There are several treatment options and selecting the most suitable treatment depends on what the timber will be used for (Table 1)

Timber treatment options available in PNG are summarised in Table 1.

Table 1. Hazard classes – Papua New Guinea. Classification of hazards in PNGS:2012

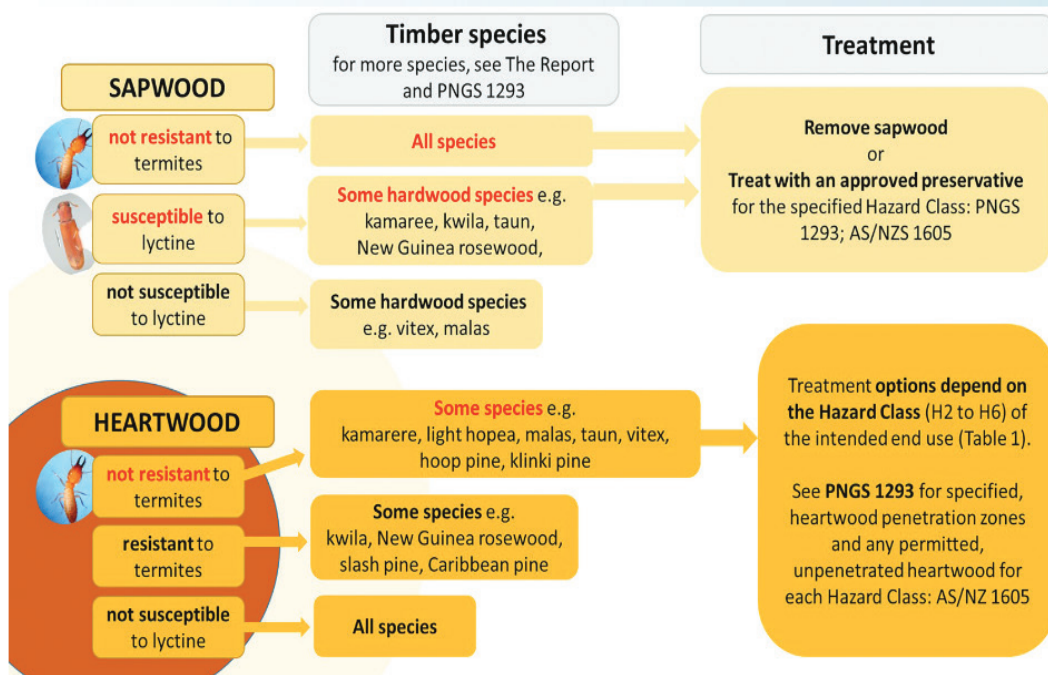
Hazard Class	Exposure	Specific service condition	Hazard type and level	Examples	Treatment options
H1	Inside, above ground	Completely protected from the weather and well ventilated, and protected from termites	Lyctid susceptible	Framing, flooring, furniture, interior joinery	CCA, boron, ACQ*, synthetic pyrethroids, fluorine
H2	Inside, above ground	Protected from wetting. Nil leaching	Borers and termites	Framing, flooring, and similar, used in dry situations	CCA, ACQ, LOSP: synthetic pyrethroids
H3	Outside, above ground	Subject to periodic moderate wetting and leaching	Moderate decay borers and termites	Weatherboard, fascia, pergolas (above ground), window joinery, framing, cladding, decking, laminated beams exterior and interior high risk	CCA, ACQ, copper azole, creosote, LOSP†: TBTN / TBTO, copper naphthenate, PCP, PCP+TBTO, synthetic pyrethroids
H4	Outside, in ground	Subject to severe wetting and leaching	Severe decay, borers and termites	Fence posts, greenhouses, pergolas (in ground) and landscaping timbers	CCA, ACQ, copper azole, creosote
H5	Outside, in ground contact with or in fresh water	Subject to extreme wetting and leaching and / or where the critical use requires a higher degree of protection	Very severe decay, borers and termites	Retaining walls, piling, house stumps, building poles, cooling tower structure and fill, bridge decking, wharf decking	CCA, ACQ, creosote
H6	Marine waters	Subject to prolonged immersion in sea water	Marine wood borers and decay	Boat hulls, marine piles, jetty cross-bracing, landing steps, pontoons and similar	CCA, creosote, CCA+creosote

* ACQ is copper quaternary

† LOSP preservatives should be formulated to include both fungicides and insecticides, and may also contain a water repellent

PROTECTING TIMBER FROM INSECT PESTS–PNG

Figure 2. Managing timber to avoid insect pest damage



Marketing Forest Products

The world is changing rapidly and with it, the business environment. Marketing in the forest sector has evolved, and has changed drastically responding to new challenges in the business environment. Marketing philosophies have also changed from production oriented to marketing oriented and a new era is beginning: responsible forest industry — responsible marketing.

Marketing can be seen as a tool for satisfying the needs of society. It provides the link between the production taking place in a company and the demand by individual consumers. To function properly, this link must provide information in both directions. Marketing integrates the various functions of a company to target specific markets in order to best meet the needs of customers—and helps to create relationships with those customers. Thus, marketing can be simply defined as identifying the needs of a customer, providing a product/service that meets those needs, and obtaining a profit in the process.

A customer- or market-oriented company focuses first on the customer and develops a product

or service to meet the customer's need. When the business is customer- or market-oriented, the relationships with customers becomes strong, and markets and marketing strategies direct business planning on all levels, from investments, to raw material procurement, to manufacturing and production. For example, if you produce a commodity product, such as such as dimension lumber, the manufacturing equipment you use is likely very different from the equipment needed to produce a custom-made product, such as custom cabinets. Understanding that profits are created through customer needs and buying behavior will allow you to focus on meeting those needs

What is strategic marketing?

Pursuing a sustainable competitive advantage is the essential goal of strategic marketing. One role of marketing, regardless of company size, is to constantly produce information about the business environment of the company (especially customer needs, market trends, and demand). Based on this information, you can formulate appropriate marketing strategies, marketing structures, and marketing functions (Figure 1).

From these, you can create your marketing action plan



Figure 1. The structural hierarchy of strategic marketing.

Marketing Strategies

The most basic components of a marketing strategy are the products you will provide, the customers and market areas you will serve, and the core competencies (the unique skills or attributes that differentiate a firm) you possess.

The essence of strategic marketing is making good choices about the components of a marketing strategy and recognizing the effect of those choices on the design of marketing structures and functions. When you design your marketing strategy, you do so by making decisions regarding each of four strategy components:

1. products,
2. customers,
3. market area, and
4. core competencies.

The first three components can be considered along a continuum from general to specific. For example, the product component can generally be divided into three areas of emphasis, from a general, generic commodity product to a special product to a specific, custom-made product (Figure 2)

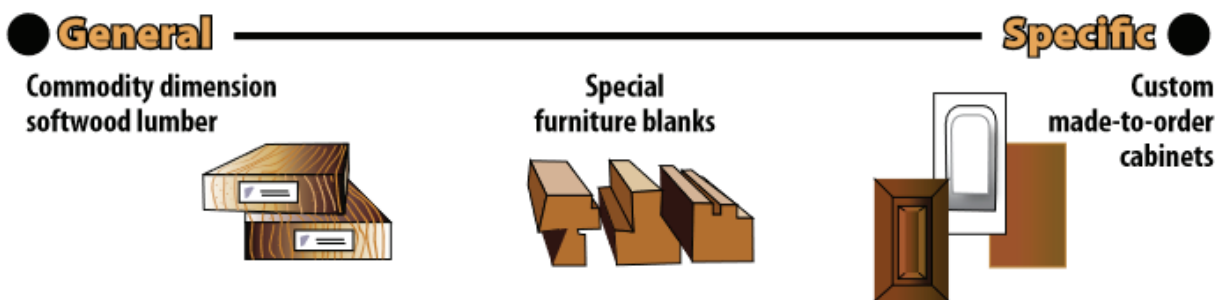


Figure 2. The continuum of marketing (product) strategy choices.

Product

As you might guess, the product component of your marketing strategy must be specific for your company. For example, if you make pallets you might choose to produce any one of the following:

- Commodity — Grocery Manufacturers of America standard size pallet
- Special — specific size and performance level required by the berry industry
- Custom-made — high performance, custom-designed pallet required by an electronics manufacturer

Customer

The customer component of your marketing strategy consists of the customer groups you will target for your product. From general to specific,

these customer groups are as follows:

- As many customer groups as possible
- Few, well-specified customer groups
- Known (individual) end-users
- The customer groups you choose to target will generally be based on the type of product you make.

Market area

Another key strategy decision is the market area upon which you will concentrate your business. Market areas may be:

- Local
- Regional
- National
- Global

Again, these represent a continuum ranging from someone in the immediate area of your company to a truly global market. The basic concept here is a market area that is narrow versus wide.

Core competencies

Core competencies are those skills you possess that provide you with competitive advantage.

Essentially these are things that you can do better than the competition, thereby differentiating you and your product. The following are examples of core competencies:

- Product/service quality
- Truly unique product or raw material
- Customer relationships
- Superior/unique marketing communication
- Fast delivery
- Being a local producer

Assessment task

Research how a forest product is harvested, processed, preserved and marketed

Source

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

<https://oregonforests.org/content/products>

http://www.pip.com.pg/images/stories/documents/wood_processors_tool_kit/B.3.1_Pest_Protection_Factsheet.pdf

<http://www.pip.com.pg/resources/wood-processors/welcome.html>

https://owic.oregonstate.edu/sites/default/files/pubs/strategic_marketing.pdf

Strand 4: Natural Resource Management

Unit 4 Types of forests and forestry

Content Standard 12.4.5 Students will be able to investigate and analyze the different types of forestry practices and management systems used in different environments and places to harvest, process, preserve, market, regulate, and consume forests products.

Benchmark 12.4.5.1 Explain the principles of marketing and discuss how these can be used for marketing forest products.

Topic: Principles of Marketing

Learning Objectives:

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

- Define the principles of marketing
- Discuss how these can be used to market forest products

Essential Questions:

1. What are marketing principles?
2. How will they be useful in marketing forest products?

Knowledge	Marketing principles
Skills	Explain, Negotiation,
Values	Collaboration
Attitudes	Cooperation,

Content Background

The 7 Marketing Principles

These seven are: **product, price, promotion, place, packaging, positioning and people**. As products, markets, customers and needs change rapidly, you must continually revisit these seven Ps to make sure you're on track and achieving the maximum results possible for you in today's market place.



The 5 areas you need to make decisions about are: PRODUCT, PRICE, PROMOTION, PLACE AND PEOPLE. Although the 5 Ps are somewhat controllable, they are always subject to your internal and external marketing environments.



Marketing is absolutely essential for your brand or product. But if you feel unsure of where to start, you aren't alone. There's a massive amount of work and thought that goes into a marketing strategy.

However, it's helpful to have some guidelines to serve as a foundation — principles that could help you figure out the best course of action to market your company, brand or product.

Today we're talking about the seven marketing principles that can help you make business decisions as you market your brand. These include the 4 Ps (product, price, place, promotion) and a few additional ones that have been recently added to the marketing mix.

We'll break down each one, providing a detailed definition as well as actionable advice and examples to help you know how to apply the principle to your brand.

What Are Marketing Principles?

The 7 key marketing principles are:

- Product
- Price
- Place
- Promotion
- People
- Process (or Positioning)
- Physical Evidence (or Packaging)

The classic principles of marketing, known as the 4 Ps, were initially defined several decades ago by a marketing professor at Harvard University. These principles — which consist of Product, Price, Place and Promotion — can be traced all the way back to the 1940s, and make up the set of resources that a company should use to market itself to its target audience.

While most people recognize the 4 Ps model, some use a version of these marketing principles that's geared more toward consumers: Consumer, Cost, Convenience and Communication.

20 years later, researchers revisited these marketing principles and lengthened the list, creating 7 Ps in total. People, Process (or Positioning) and Physical Evidence (or Packaging) were added to the classic principles of marketing.

Since the first 4 Ps are more applicable to tangible products, these additional principles are helpful for service-based businesses. In some cases, people add even more principles — such as productivity and quality, or partners.

The 7 Ps should serve as a guide to help figure out the best marketing strategy for your business. These principles will help you make decisions about what to sell, who to sell it to and how to retain customers. Ultimately, they can leave a positive impact on your bottom line.

1. Product

The first of these seven marketing principles is product. A product can be defined as simply an item that addresses a consumer's wants or needs. Some products are goods, or tangible objects.

Others—such as an experience—are intangible. If someone asked you what your company's product is, you would probably be able to quickly reel off the details. (If not, you should be able to!) An important key here is that your product must meet the wants and needs of your customers.

How to Apply It

Conduct market research to make sure your product stands out. Market research is the process of obtaining information about your target market so you can understand whether a certain product will succeed. This will help you get an idea of whether there is a need for your product in the marketplace - if your product solves a problem your customer has.

You can conduct market research via methods like:

- Customer surveys or questionnaires
- Interviews
- Satisfaction analysis
- User persona research
- Competitive analysis

These are all great ways to better understand your target audience. From there, you'll be able to make any necessary changes to your product so it will better meet their needs.

2. Price

The second marketing principle is price. The price is simply the amount a consumer pays for a product. Coming up with your pricing, however, isn't always that easy. It takes careful market research to understand what your competitors are charging for comparable products, what your customers expect to pay for your product and what you should actually charge.

How to Apply It

Coming up with your pricing can be a tricky task. Start by calculating the costs needed to create your product and bring it into the market. Make sure to add up not only the goods you need to make your product, but any materials used for promotion and packaging as well as the production time.

Next, put your profit margin on top of that number. Figure out what percentage of profit margin you want to earn. Then divide your total variable costs (the number you came up with in the first step) by one minus your desired profit margin. Finally, you'll add in the fixed costs associated with running your business.

This pricing method is known as cost-plus pricing. It works because it's sustainable long term. Over time, you can work off of this base price to allow for trends or how your product is priced compared to your competitors' products. But this initial number will give you a place to start.

3. Place

Place is the location where your product is available for consumers to purchase. Place is all about providing access for the consumer. It doesn't have to be a physical, brick-and-mortar store; it could also be a website or other online location.

One out of every four people shops online. The key is to make your products as accessible as possible so the buying journey will be convenient for consumers.

How to Apply It

Think about the distribution channels where your product is offered. In what places or what ways do you sell your product? And, importantly, are these the places where your target audience spends their time? Think bigger than your store and consider where else you could market your product — such as a trade show, festival or another local store.

Similarly, if you're selling online, you don't have to stop with your website. Depending on the nature of your product, you might also consider selling on:

- Amazon
- Etsy
- Shopify
- Bonanza
- eBay
- Handshake
- Facebook
- Instagram

Jewelry shop Love Stylize sells its products on its own website-but you can also make a purchase from Instagram. This helps the brand reach more people with another point of sale.

4. Promotion

Promotion is the marketing communications put out by your brand. Your promotional efforts should be geared toward your target audience. Your goal is to make them aware of who you are and what you have to offer. Then you can start to move them through the sales funnel.

There are several types of promotional marketing strategies, including:

- Social media marketing. Platforms might include Facebook, Instagram, Twitter, YouTube, Pinterest, LinkedIn or TikTok depending on your brand audience.
- Public relations. Public relations is a way to manage how the public views your brand.
- Email marketing. Send marketing emails and/or email newsletters to help leads move through the sales funnel.
- Content marketing. This is typically long-form content such as blog posts, videos, ebooks, podcasts or webinars.
- Advertising. Advertise your company through radio, television, mobile ads or other types of ads.
- Search marketing. SEO, or search engine optimization, can help your website rank more highly in search engine results.
- Direct marketing. With direct marketing, you go straight to your ideal customer to communicate with them.
- Sales promotion. A sales campaign is a special offer designed to stir up interest around your product.

A healthy digital marketing strategy draws on many types of promotion.

Create stunning social media graphics

- Present social media graphic dimensions
- Create and resize content quickly and easily
- Engage your audience through visuals

How to Apply It

When you promote your brand, include both explicit promotions and content that simply seeks to provide value. In addition to finding the right promotional balance, you'll need to figure out what you are communicating (your message) and how often to communicate it.

Spotify is an example of a brand with an excellent overall marketing strategy. This well-known music app uses data to design creative campaigns that speak directly to users.

The company does a good job of getting on top of social media trends. And what's more personalized than your Spotify Wrapped at the end of the year? These shareable campaigns cement brand loyalty and provide exposure to a new audience.

5. People (or Positioning)

The people you're selling to—and the people in your company who are doing the selling — are an important aspect of marketing. Whether the “people” you're referring to are customers interacting with your brand or the employees who make the magic happen, people are a component of your marketing that you can't overlook.

Some researchers prefer to use the word Positioning instead. This refers to positioning the product correctly to get it in front of the right audience.

How to Apply It

Implement this marketing principle by improving your customer service. For a retail store, focus on training all employees (even the ones who may feel as if customer service isn't their job) on any new products and the latest deals.

They should be encouraged to address customers by name, and they should always be willing to go the extra mile for a customer. Having a “script” for employees to fall back on in common situations can help.

Customer service for ecommerce looks a little different. Respond as quickly as possible to any message or complaints, using digital tools to help your team keep messages organized.

Consider providing a self-service option with a chatbot (like Sephora's chat option shown below) or portal. At the end of the day, however, the same principles apply: Be personal, friendly and as helpful as humanly possible.

6. Process

Process is what happens behind the scenes as you create your product or service. From the employees who are doing the hands-on work, to the employees who sit in offices answering emails, it's all part of your business' process.

This principle can also refer to the entire customer experience journey—the service a customer receives from your company, from start to finish. Your goal is to make this process as smooth and enjoyable as possible.

How to Apply It

Optimize your internal processes to help your team work more efficiently. Streamlining your workflow will increase productivity as well as improving the quality of the work.

Analyze your current workflow and go from there to improve. Consider introducing automation, or creating resources to train new employees so they can easily jump on board the processes you've already instilled.

Improve the process of a customer's journey by doing the same thing—analyzing what the customer journey looks like for your average customer and then introducing changes that will help.

A CRM (customer relationship management platform) is a good way to standardize customer communication. Your goal is to have a reliable customer experience, with each and every customer receiving the same great service.

7. Physical Evidence (or Packaging)

Physical evidence consists of anything your customer sees or experiences when interacting with your business. Is your store clean and bright? Is your website well-designed and optimized for browsing? Do you have good customer reviews? These can all serve as signals to a potential customer that you're a reputable business and you'll be easy to work with.

If you're a service-based business, physical evidence becomes especially important. Physical indicators of your product might include things like your website or business cards.

It's essential for these pieces of evidence to be right on brand and to align with the rest of your marketing. Since customers may not be able to view a tangible item before converting, it's important to provide as much evidence as you can to convince them to take the plunge.

Some researchers add Packaging as the final principle of marketing. In this case, they're referring to the way that your products (or services) are presented to customers. 72% of US consumers say that a product's packaging design has an impact on their decision to buy. It's clear that packaging is extremely important.

How to Apply It

Physical evidence can be almost anything. It might be five-star customer reviews. Or an immediate response to a customer service message. Or a deliverable that's turned in well ahead of time. This marketing principle will vary from industry to industry and business to business. Essentially, however, anytime you do your work well, this counts as physical evidence for your

company.

To put the alternate seventh principle, Packaging, into practice, consider the following tips. First, make sure the packaging of a single product makes sense within your entire brand strategy. All packaging should be on-brand and reflect not only the product itself, but also your overall brand.

Keep things clear and simple, using just a few main colors or selling points. And of course, the packaging should be functional, too — after all, its primary job is to get the product safely to its end destination.

Assessment Task:

Discuss how marketing principles can be applied in marketing forest products.

Strand 4: Natural Resource Management

Unit 5: Forest harvesting (creation) practices and management systems

Content Standard 12.4.5 Students will be able to investigate and analyze the different types of forestry practices and management systems used in different environments and places to harvest, process, preserve, market, regulate, and consume forests products.

Benchmark 12.4.5.2 Investigate and evaluate the importance of marketing functions and marketing channels for forest products.

Topic: Forest products

Learning Objectives:

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

- Appraise the importance of marketing functions and marketing channels

Essential Questions:

1. What is a marketing channel?
2. Are there different kinds of marketing channels?
3. How does marketing functions differ from marketing channels?

Knowledge	Marketing functions and channels
Skills	Investigate, Evaluate
Values	Appreciate
Attitudes	Acknowledge different marketing function

Content Background

Functions of marketing.

The following are the functions of marketing:

- Promotion.
- Selling.
- Product management.
- Pricing.
- Marketing information management.
- Financing.
- Distribution.

10 Most Important Functions of Marketing Channel

Some of the important functions of a good marketing channel are as follows: Marketing channels serve many functions, including creating utility and

facilitating exchange efficiencies.

Although some of these functions may be performed by a single channel member, most functions are accomplished through both independent and joint efforts of channel members. When managed effectively, the relationships among channel members can also form supply chains that benefits all members of the channel, including the ultimate consumer.

1) Information Provider:

Middlemen have a role in providing information about the market to the manufacturer. Developments like changes in customer demography, psychography, media habits and the entry of a new competitor or a new brand and changes in customer preferences are some of the information that all manufacturers want. Since these middlemen are present in the market place and close to the customer they can provide this information at no additional cost.

2) Price Stability:

Maintaining price stability in the market is another function a middleman performs. Many a time the middlemen absorb an increase in the price of the products and continue to charge the customer the same old price. This is because of the intra-middlemen competition. The middleman also maintains price stability by keeping his overheads low.

3) Promotion:

Promoting the product/s in his territory is another function that middlemen perform. Many of them design their own sales incentive programmes, aimed at building customers traffic at the other outlets.

4) Financing:

Middlemen finance manufacturers' operation by providing the necessary working capital in the form of advance payments for goods and services. The payment is in advance even though the manufacturer may extend credit, because it has to be made even before the products are bought, consumed and paid for by the ultimate consumer.

5) Title:

Most middlemen take the title to the goods, services and trade in their own name. This helps in diffusing the risks between the manufacturer and middlemen. This also enables middlemen to be in physical possession of the goods, which in turn enables them to meet customer demand at very moment it arises.

6) Help in Production Function:

The producer can concentrate on the production function leaving the marketing problem to middlemen who specialize in the profession. Their services can best utilized for selling the product. The finance, required for organising marketing can profitably be used in production where the rate of return would be greater.

7) Matching Demand and Supply:

The chief function of intermediaries is to assemble the goods from many producers in such a manner that a customer can affect purchases with ease. The goal of marketing is the matching of segments of supply and demand. The matching process is undertaken by performing the following functions:

- i) Contractual: Finding out buyers and sellers.
- ii) Merchandising: Producing goods that will satisfy market requirements.
- iii) Pricing: Process of attaching value to the product in monetary terms.
- iv) Propaganda: Sales promotion activities.
- v) Physical Distribution: Distribution activities.
- vi) Termination: Settlement of contract, i.e., paying the value and receiving the goods.

8) Pricing:

In pricing a product, the producer should invite the suggestions from the middlemen who are very close to the ultimate users and know what they can pay for the product. Pricing may be different for different markets or products depending upon the channel of distribution.

9) Standardizing Transactions:

Standardizing transactions is another function of marketing channels. Taking the example of the milk delivery system, the distribution is standardized throughout the marketing channel so that consumers do not need to negotiate with the sellers on any aspect, whether it is price, quantity, method of payment or location of the product.

By standardizing transactions, marketing channels automate most of the stages in the flow of products from the manufacturer to the customers.

10) Matching Buyers and Sellers:

The most crucial activity of the marketing channel members is to match the needs of buyers and sellers. Normally, most sellers do not know where they can reach potential buyers and similarly, buyers do not know where they can reach potential sellers.

From this perspective, the role of the marketing channel to match the buyers' and sellers' needs becomes very vital. For example, a painter of modern art may not know where he can reach his potential customers, but an art dealer would surely know.

Marketing Channels

A marketing channel is a system that ensures the distribution of the product from the producer to the consumers by passing it through multiple levels.

This is also said a channel of distribution.

This is an important tool for the management and is essential for developing a product and strategic marketing strategy.

In the past, people generally used to go for direct distribution like mailers or indirect marketing channels like television. But today, some of the most popular types of marketing channels include targeted digital advertising, email, websites, events.

Either way, all these advertising channels are different in terms of audience and reach. Your marketing channels focused on the global market will be different from your local marketing channels, and so forth. To understand the effective marketing channels in 2021 and beyond, let's take a look at the four major types of marketing channels that are getting popular these days;

Types of Marketing Channels in 2021

- **Websites:** Modern advertising and marketing companies are heavily dependent on websites to drive conversion through content.
- **Digital Advertising:** Another effective marketing channel of 2021 is digital ads. While advertising is a little bit expensive and it does need the company to understand its target audience well, it brings excellent results.
- **Email:** Email marketing has been one of the highest conversion-rate marketing channels for years. The main reasons behind its effectiveness are because email allows for personalization and has excellent reach. No doubt, the marketing landscape changes frequently, and email is no exception. And this is what makes email marketing steady.
- **Events:** Events are another great way to reach your audience. Event can be held digitally and also in-person. In digital event, everything happens online while offline events provide face-to-face contact and one-on-one community, but they are quite expensive and tough to manage.
- **Social Media Marketing:** In this modern era, social media has become a mandatory marketing medium to stay on top of the market. Besides, with organic reach declining on platforms like Facebook, it has become very challenging to become successful. But with a smart strategy and a disciplined approach can help you to succeed on social media. Just go for fewer networks to master and focus on producing on getting better results instead of maintaining a presence on every platform.
- **PPC:** Organic traffic has been a great way to build an audience. Besides, paid ads also work well for bringing direct conversions. Because consumers who click on ads are often ready to make a purchase.
- **YouTube/video marketing:** After Google, YouTube has become the second largest search engine. Since it makes it easier for people to watch a video and learn anything, people prefer YouTube instead of going through an extensive piece of content on the same topic. You can grow with YouTube by creating interesting and informative video content.
- **Podcast Marketing:** The podcast marketing is quite effective. This marketing channel does not only help you to increase your marketing demand but also helps in developing a unique relationship with your audience. Podcast episodes seem quite conversational and share a more human side of your business. Podcasts also create more opportunities for interaction, as customers are not restricted to listening while staring at their phone screen.

- Influencer Marketing: When a business partners with a relevant and popular creator in their industry to promote their brand or any specific pieces of content is known as influencer marketing. Leveraging this channel to meet your marketing goals is great for generating brand awareness and increasing social proof.

What is mostly used examples of Marketing Channels?

Here is a comprehensive list of potential platforms and means of customer communication

Affiliate marketing;

- Apps
- Blogs
- Websites
- Email
- SMS Marketing
- PR Events
- Social media networks
- Social Media Ads
- Events
- Press Releases
- TV Commercials
- Chatbots
- Online video

Well, there are many more to add. Some of these could even be broken down into multiple categories.

Assessment Task:

Discuss the importance of marketing functions and marketing channels in relation to forest products

Strand 4: Natural Resource Management

Unit 6: Forestry and Technology

Content Standard 12.4.6 Students will be able to examine how technology is used in the harvesting, processing, preservation, marketing, regulation, consumption, and management of forestry.

Benchmark 12.4.6.1 Research and design a system for establishing a plantation for a certain common tree species.

Topic: Plantation Establishment

Learning Objectives:

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

- Design and establish a plantation
- Identify a common tree species for the established plantation

Essential Questions:

1. What is a plantation?
2. How is a plantation established?
3. Can any tree species be grown on a plantation?

Knowledge	Plantation establishment
Skills	Research, Design
Values	Sustainability, Responsibility, Aesthetics
Attitudes	Appreciative, Creativity

Content Background

PLANTATION PLANNING AND DESIGN

SETTING GOALS

Think about how your reforestation project relates to short- and long-term landowner goals. Such goals might include producing income from timber, improving habitat for specific wildlife species, restoring a natural plant community, reducing soil erosion, improving water quality or enhancing the aesthetics of the land. Remember that many goals are compatible with each other, allowing a single forest planting to serve multiple purposes.

SITE EVALUATION

Planning reforestation activities begins with evaluating the planting site. Knowledge of potentially limiting site factors such as climate, soils, existing vegetation, topography, insects, diseases, animals and productivity potential will aid in selecting suitable species, preparing the site and prescribing post-planting management practices.

PLANTING DESIGN

The planting design will provide specific details for the creation and management of a planting, including acreage, species, number of trees, layout of roads and fire breaks, nursery stock type, site preparation and planting method, spacing, arrangement and any post-planting maintenance. Before planting, develop a written reforestation plan and map to help clarify all these details and facilitate any modifications prior to planting.

A plantation map can graphically display precise planting locations, species arrangement and access roads. The planting design is directly tied to the landowner's goals and the resources and capabilities of the planting site. Learn more by viewing the video [Green Side Up: Planting Plan](#).

GOALS AND CONSIDERATIONS

Below are examples of goals and their associated design considerations.

TIMBER MANAGEMENT

- Match species with area market demands and opportunities.
- Provide equipment access for thinning, pruning and harvesting.
- Include harvest roads and fire breaks.
- Add species that will create future natural regeneration opportunities.
- Leave space around power lines, underground cables and gas lines.
- Avoid steep slopes and wet areas.
- Provide closer spacing of hardwoods to improve sawtimber quality.

WILDLIFE MANAGEMENT

- Enhance biological diversity and complement habitat in the surrounding landscape.
- Offer habitats that are in locally short supply.
- Choose species that provide preferred food for desired wildlife.
- Establish or expand travel corridors to connect habitats.
- Create irregular boundaries for more habitat options.
- Enhance "interior" forest habitat by planting artificial openings, such as isolated fields.
- Plant around existing "wolf" trees (large trees that have wide-spreading crowns and inhibit or prevent the growth of smaller trees around them).
- Leave frost pockets and odd corners unplanted to improve habitat variety.
- Leave wildlife openings.

EROSION CONTROL

- Leave grass buffer zones near streams to prevent siltation.
- Plant trees along contours to help control runoff.
- Leave drainage pathways covered in grass.
- Concentrate trees in "problem areas."
- Plant tree species in riparian zones that have a long life expectancy.
- Plant highly erodible upland fields to decrease runoff.

AESTHETICS

- Use a wide variety of species, including wildlife shrubs.
- Use non-row plantings, curved rows and irregular edges for more natural effect.
- Plant species with desirable fall color.
- Leave openings or islands of differing size/age trees.
- Retain landmarks and distinct features.
- Create or retain scenic views.
- Locate trails or roads to take advantage of scenic quality.

SPECIES SELECTION

Tree species selected for reforestation must be compatible with the landowner's management goals and biologically suited to the planting site. After determining the potential advantages and limitations of the planting site, select a species or combination of species that emphasize the advantages and overcome the limiting factors. Things to consider are:

- site requirements, especially soil factors;
- climatic suitability;
- potential growth rate on site;
- sunlight requirements;
- potential competition problems;
- potential for insect and disease problems;
- wood and fiber properties and potential markets;
- compatibility with other species;
- timber, wildlife, erosion control and aesthetic values; and
- individual tree species' characteristics [PDF].

SPACING

Initial spacing will affect both the productivity and the management of a plantation. The choice of spacing will depend on the species selected, the product desired, the need for and intensity of intermediate stand treatments, the expected initial survival and the cost. Consider the relative advantages and disadvantages of wide and close spacing.

WIDE SPACING ADVANTAGES

- Planting costs are less.
- Trees attain larger diameters and become merchantable sooner.
- Trees may produce greater quantities of seed/mast at an earlier age.
- Increased understory growth will provide wildlife food and habitat.

WIDE SPACING DISADVANTAGES

- Increased weed competition and maintenance.
- Reduced stem quality due to greater taper and longer branch retention.
- Increased fire hazard.
- Reduced erosion control.

CLOSE SPACING ADVANTAGES

- Faster crown closure resulting in less weed competition and maintenance.
- Improved stem quality (straighter boles and small, self-pruning branches).
- Large wood volumes accumulate in early years.
- Greater number of trees to select from during thinning operations.

CLOSE SPACING DISADVANTAGES

- Increased site preparation, planting and seedling costs.
- Early timber stand improvement may be needed to reduce crown competition.
- Access during initial thinning operations may be difficult.

Height growth can be reduced at extremely high or low densities. Fortunately, the most commonly used tree planting densities fall within a range that does not reduce dominant tree height (Table 1).

Table 1. Number of trees per acre by spacing in feet.

Feet	4	5	6	7	8	9	10	12	15
4	2,722	2,178	1,815	1,556	1,361	1,210	1,089	907	726
5		1,742	1,452	1,244	1,089	968	871	726	581
6			1,210	1,037	908	807	726	605	484
7				889	778	691	622	518	415
8					681	605	545	454	363
9						538	484	403	323
10							436	363	290

Generally, for quality hardwood tree production, choose a closer spacing to encourage straight boles and small lower branches that self-prune easily. Hardwood plantings for wildlife purposes can use wider spacing to encourage crown development and earlier seed production. Note: Plantation spacing requirements may be specified by some cost-sharing and tax law programs.

PLANTING ARRANGEMENT

Planting arrangement refers to the pattern or distribution of tree and shrub species across a planting site. The arrangement of species may be varied to match topographic features, changing soils or site conditions. For example, a mixed hardwood plantation may concentrate black walnut seedlings on the deeper top soils of the lower slope and place red and white oak seedlings near the ridge tops and convex slopes. The arrangement should also consider the growth characteristics and compatibility of species planted next to each other. For example, due to the fast juvenile growth of green ash, an alternating pattern with white oak may result in suppression of the oak. One solution is to group the species within the planting to minimize problems associated with very different juvenile growth rates.

Recently, conifer and hardwood mixtures have been recommended for afforestation in Wisconsin. The benefits of these conifer-hardwood mixtures include:

- conifers assist in early crown closure and capturing the site;
- cost of plantation establishment is less than for a pure hardwood plantation;
- conifers improve the quality of hardwoods by shading out lower branches and forcing hardwoods to grow straight; and conifers provide wind protection and offer an easy alternative for a first thinning.

One disadvantage to this mixture is that once established the options for chemical release of the plantation are more limited than pure conifer plantings. Initial site preparation treatments are critical for successful conifer-hardwood plantations. In addition, alternate row plantings may necessitate the removal of all conifers during the first thinning, unless other thinning methods are designed into the plantation.

INTERPLANTING

Interplanting is the practice of planting new seedlings “between” or “among” existing forest growth. Sometimes forests fail to regenerate as expected after a harvest and interplanting provides a way to supplement natural regeneration. The planting arrangement in this situation will depend on an evaluation of the number, size and spatial distribution of desirable advanced reproduction. Do not forget to factor in the contribution of stump or root sprouts to fill all or part of the reproduction deficiency. Interplanting is almost always accomplished by hand planting. Interplanted trees will be in competition with other vegetation so their success can be measured against the growth of dominant competing vegetation. Generally, larger sized seedlings (e.g. 2-0 or 3-0 hardwoods and 3-0 or transplant conifers) are needed to compete with the advanced reproduction and sprouts. These types of plantings generally require some type of release early in the establishment phase.

PLANTING STOCK AGE CLASSES: WHAT THE NUMBERS MEAN

Bare root stock is often sold using an age class designation, such as 1-0, 2-0, 3-0 or 2-1. The first numeral refers to the number of years spent in a seedbed. For example, a 2-0 designation means the tree spent two years in a seedbed. The second numeral refers to the number of years spent in a transplant bed. For example, a 2-1 designation means the tree spent two years in a seedbed and one year in a transplant bed (transplanting improves root development).

DIRECT SEEDING VS. SEEDLINGS

One of the initial planning decisions is whether to plant seeds or seedlings. Each method has advantages and disadvantages in terms of ecology, operation and expense.

ADVANTAGES

- Less expense for conifer plantings or small areas.
- Quick establishment of tree cover to “capture” the site.
- Applicable on difficult terrain or shallow soils.
- Good root development with no transplant shock.
- More uniform stocking than a naturally regenerated stands.
- Improved hardwood stem quality in high-density plantings.
- Direct seeding often is not successful, many times because of improper planning. Multiple factors influence seed germination, making careful planning critical in highly variable field environments.

DISADVANTAGES

- Necessity for intensive site preparation and follow-up weed control.
- Difficulty controlling stand density.
- Greater costs for hardwoods depending on the quantity of seed used.
- Small planting areas may be subject to heavy seed predation.
- Hardwood seed is difficult to obtain in most years and does not store well.
- Proper seed collection, handling and storage are critical to establishing direct seeded plantations. Seed collected during an abundant seed year is usually higher quality, especially if mature seeds are collected just before or simultaneously with seed fall. Always consider seed source by collecting from quality trees that are within 100 miles of the planting site or from sources that have proven performance through genetic testing. Properly store, stratify and treat seed to maximize germination rates.

SEED SOURCE SELECTION

Seed source is an often overlooked but critical component in a successful reforestation program. Selecting appropriate seed sources will improve the overall productivity of the plantation since the trees will be adapted to the environment of the planting site. Appropriate seed source selection will also reduce catastrophic plantation losses due to poorly adapted genetic material. Poorly adapted seed sources can survive and grow for many years, until an environmental event, such as an early frost or extremely cold winter, results in catastrophic losses.

Local seed sources (e.g. Wisconsin) are the most appropriate unless proven otherwise through genetic testing. For example, genetic testing has revealed that southern Ontario white spruce sources are well adapted to Wisconsin’s environmental conditions and also offer improved growth rates over local sources. Tree improvement efforts continue to examine seed source performance across Wisconsin in order to identify appropriate sources and seed zones (Figure 1). Advanced tree improvement practices include the establishment of seed production areas to facilitate the collection of seed from quality native stands, the establishment of progeny tests where individual families are tested and selected for high performance and seed orchards for the production of high quality seed with superior genetic potential.

STOCK TYPE SELECTION

How the planting site will influence seedling establishment and early growth is important in selecting the best nursery stock type for a given situation. Consider the relative advantages and disadvantages of containerized vs. bare root stock in order to select seedlings that will meet the landowner's goals and overcome any limiting factors of the planting site.

Containerized stock is usually less than 1-year-old and is grown, shipped and planted in a soil "plug" of peat, perlite (or vermiculite) and sand. Its use in the Great Lakes states has been restricted primarily to conifer seedlings, but recent advances in pot sizes have allowed some production of containerized hardwoods. Seedlings from containerized stock can be grown in six to 15 weeks. They have high survival rates, superior initial height growth, more uniform size and good plantability, especially on rocky sites where it may be difficult to open a large hole for bare root seedlings. In addition, these seedlings are less likely to experience transplant shock since the tree is planted in the rooting medium and the process makes more efficient use of seed. Finally, containerized stock extends planting seasons and seedlings can perform well on adverse sites. Containerized seedlings also are more resistant to heat and drying stress, so transportation and storage are less problematic. Containerized stock, however, is more expensive than bare root stock, more bulky to transport and handle, less able to compete with weeds, susceptible to deer browse, prone to frost heaving when planted on bare mineral soil and often smaller in size.

Bare root stock is seeded and grown in nursery beds for one to three years and may be moved to a transplant bed to improve root development. Conifer seedlings should have a 4-6 mm caliper and a 2:1 shoot/root ratio. Hardwood seedlings should have good lateral root development with a minimum of five primary lateral roots (>1 mm in diameter) for optimal seedling survival and growth. Advantages of bare root stock include lower costs, ease of transportation and storage, better weed competitor, less susceptibility to deer browse and faster root regeneration. Bare root stock, however, takes longer to grow, can dry out quickly due to exposed roots, is prone to root damage and deformity during planting operations and may require special planting considerations due to the larger seedling size.

Assessment Task: Design and construct a model plantation.

Performance Indicator: Create a (3D) model of a plantation

Strand 4: Natural Resource Management

Unit 6: Forestry and Technology

Content Standard 12.4.6 Students will be able to examine how technology is used in the harvesting, processing, preservation, marketing, regulation, consumption, and management of forestry.

Benchmark 12.4.6.2 Research and explain clonal forestry and evaluate its benefits.

Topic: Clonal forestry

Learning Objectives:

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

- Define clonal forestry.
- Evaluate the benefits of clonal forestry.

Essential Questions:

1. What is clonal?
2. What is a clonal tree?
3. What is a clonal plantation?

Knowledge	Clonal forestry
Skills	Research, Identify, Explain, Evaluate
Values	Sustainability, Interdependence
Attitudes	Appreciative, Care, Concern

Content Background

Cloning is a propagation technology that can be very effective in making practical use, via clonal forestry; of proven superior individuals occurring in nature or developed by cloning.

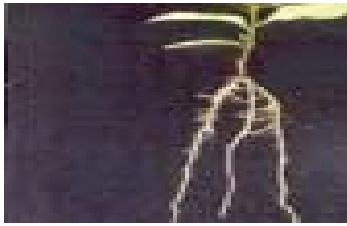
Vegetative propagation has become an important tool for increasing the areas under forest plantations. Clonal forestry reaches its highest potential when it is used to establish vegetative forests of hybrid endowed with better quality of wood and higher volumetric growth. Clonal forestry offers the greatest potential to deliver the benefits of the best individuals from a controlled cross.

Genetically improved planting material of broad leaved trees has transformed the productivity and profitability of forest plantations. Average yields from such plantations are 20-25 times higher than naturally occurring forests. Propagation of forest trees from genotypes with highest breeding values is an efficient way of increasing productivity of forest plantations.

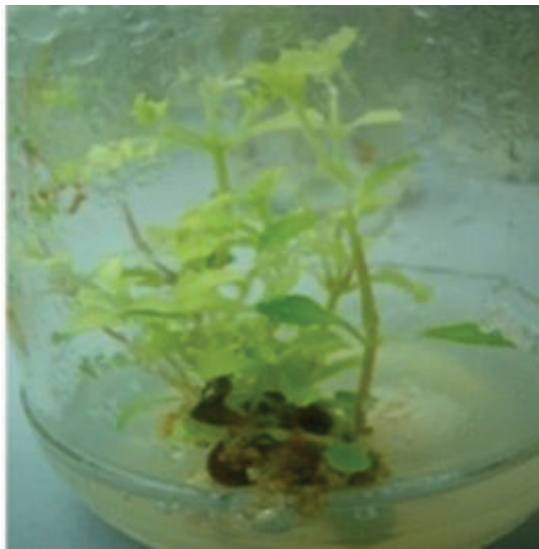


Sequence of the micro-cutting technique under controlled conditions Micro propagation (A); rooted micro-cuttings (B) Mini clonal hedge (C) Large scale micro cutting rooting (D)

Industrial plantation	(million ha)	Non-Industrial plant
18.4		0
18.4		0
0.5		0.3
5.4		2.8
41.8		15.1
17.5		3.9
4.1		8.3
10.7		0
2.7		0.01
3.6		2.2
8.7		0
22.2		0
103.3		20.4



Sequence of the mini-cutting technique in forestry plantations Rooted macro cutting (A); collecting sprouts from macro cutting (B) rooted mini cutting (C) mini clonal hedge (D) large scale rooting mini cuttings ©



Propagation of *Stevia rebaudiana* under controlled conditions in-vitro (A) seed germination on MS medium (B) shoot multiplication (C) Root development

Assessment Task: Research and evaluate the benefits of clonal forestry

Performance Indicator: Oral presentation on the benefits of clonal forestry

STRAND 6: AGRIBUSINESS

Strand	Unit	Benchmarks	Topic	Lesson Titles
Agribusiness	Starting Up and Managing an Agribusiness	12.5.1.1. Discuss the importance of inventory control systems and explain how they are implemented in business.	Inventory Control	Stock control and inventory Importance of inventory control
		12.6.1.2. Explain and calculate the operating cycle (accounts receivable turnover and inventory turnover).	Accounts receivable and Inventory turnover.	Accounts receivable turnover. Inventory turnover
		12.6.1.3. Explain and prepare a bank reconciliation.	Bank reconciliation	Analysing bank reconciliations. Preparing bank reconciliations
		12.6.1.4. Explain and apply the double-entry system of accounting to record business transactions and prepare a trial balance.	Double entry accounting system	Double entry system of accounting in an agribusiness.
		12.5.1.5. Explain accounts receivable and accounts payable and develop a plan for managing these accounts.	Accounts receivable and payable.	Accounts receivable and accounts payable in agribusiness.
		12.2.2.6. Compare actual income and expenses to budgeted amounts for a specific period.	Financial Reports	Financial reporting for an agribusiness

Strand 6: Agribusiness Unit 1: Starting Up and Managing Agribusiness

Content Standard 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 12.6.1.1. Discuss the importance of inventory control systems and explain how they are implemented in business

Topic: Inventory Control

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

- Evaluate the importance of inventory control of a business enterprise.
- Compare different types of inventory control systems of a business enterprise.

Essential Question:

1. What is an inventory control system of a business?

Knowledge	Inventory control systems
Skills	Evaluate the importance of inventory control.
Attitudes & Values	Appreciate the value of inventory control

Content Background

STOCK CONTROL AND INVENTORY

Stock control, otherwise known as inventory control, is used to show how much stock you have at any one time, and how you keep track of it.

It applies to every item you use to produce a product or service, from raw materials to finished goods. It covers stock at every stage of the production process, from purchase and delivery to using and re-ordering the stock.

Efficient stock control allows you to have the right amount of stock in the right place at the right time. It ensures that capital is not tied up unnecessarily, and protects production if problems arise with the supply chain.

Stock control systems - keeping track manually

Stocktaking involves making an inventory, or list, of stock, and noting its location and value. It's often an annual exercise - a kind of audit to work out the value of the stock as part of the accounting process.

Codes, including barcodes, can make the whole process much easier but it can still be quite time-consuming. Checking stock more frequently - a rolling inventory - avoids a massive annual exercise, but demands constant

attention throughout the year. Radio Frequency Identification (RFID) tagging using handheld readers can offer a simple and efficient way to maintain a continuous check on inventory. See the page in this guide on using RFID for inventory control, stock security and quality management.

Any stock control system must enable you to:

- track stock levels
- make orders
- issue stock

The simplest manual system is the stock book, which suits small businesses with few stock items. It enables you to keep a log of stock received and stock issued.

It can be used alongside a simple re-order system. For example, the two-bin system works by having two containers of stock items. When one is empty, it's time to start using the second bin and order more stock to fill up the empty one.

Stock cards are used for more complex systems. Each type of stock has an associated card, with information such as:

- description
- value
- location
- re-order levels, quantities and lead times (if this method is used)
- supplier details
- information about past stock history

More sophisticated manual systems incorporate coding to classify items. Codes might indicate the value of the stock, its location and which batch it is from, which is useful for quality control. Computerised stock control systems run on similar principles to manual ones, but are more flexible and information is easier to retrieve. You can quickly get a stock valuation or find out how well a particular item of stock is moving.

A computerised system is a good option for businesses dealing with many different types of stock. Other useful features include:

Stock and pricing data integrating with accounting and invoicing systems. All the systems draw on the same set of data, so you only have to input the data once. Sales Order Processing and Purchase Order Processing can be integrated in the system so that stock balances and statistics are automatically updated as orders are processed.

- Automatic stock monitoring, triggering orders when the re-order level is reached.
- Automatic batch control if you produce goods in batches.
- Identifying the cheapest and fastest suppliers.

Bar coding systems which speed up processing and recording. The software will print and read bar codes from your computer.

Radio Frequency Identification (RFID) which enables individual products or components to be tracked throughout the supply chain. See the page in this guide on using RFID for inventory control, stock security and quality management.

The system will only be as good as the data put into it. Run a thorough inventory before it goes “live” to ensure accurate figures. It’s a good idea to run the previous system alongside the new one for a while, giving you a back-up and enabling you to check the new system and sort out any problems.

Strand 6: Agribusiness Unit 1: Starting Up and Managing Agribusiness

Content Standard 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 12.6.1.2. Explain and calculate the operating cycle (accounts receivable turnover and inventory turnover).

Topic: Accounts receivable and Inventory turnover.

Learning Objective:

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

- Analyze an accounts receivable turnover of a business enterprise compare different types of inventory control systems of a business enterprise
- Examine the inventory turnover of a business enterprise.

Essential Question

1. What is accounts receivable turnover? What is inventory turnover?

Knowledge	Accounts receivable turnovers and inventory turnovers.
Skills	Compare different types of inventory control systems. Examine the inventory turnover of a business.
Attitudes & Values	Appreciate the role of operating cycles.

Content Background

Accounts Receivable Turnover Definition

Accounts receivable turnover analysis can be used to determine if a company is having difficulties collecting sales made on credit. The higher the turnover, the faster the business is collecting its receivables. In addition, express it in the following ways:

A useful tool in managing and improving accounts receivable Turnover ratio indicates how many times the accounts receivable have been collected during an accounting period receivable turnover is the Flash Report.

Accounts Receivable Turnover Analysis Meaning

Accounts receivable turnover measures how efficiently a company uses its asset. It is also an important indicator of a company's financial and operational performance. Many companies even have an accounts receivable allowance to prevent cash flow issues.

A high accounts receivable turnover indicates an efficient business operation or tight credit policies or a cash basis for the regular operation.

Whereas, a low or declining accounts receivable turnover indicates a collection problem from its customer. When you hold onto receivables for a long period of time, a company faces an opportunity cost. Therefore, reevaluate the company's credit policies to ensure timely receivable collections from its customers.

Accounts Receivable Turnover Formula

A profitable accounts receivable turnover ratio formula creates both survival and success in business. Phrased simply, an accounts receivable turnover increase means a company is more effectively processing credit. In comparison, an accounts receivable turnover decrease means a company is seeing more delinquent clients. It is quantified by the accounts receivable turnover rate formula.

Accounts Receivable Turnover = Annual credit sales / Average accounts receivable

Average Accounts Receivable is the average of the opening and closing balances for Accounts Receivable.

In real life, it is sometimes hard to get the number of how much of the sales were made on credit. So, as a shortcut, investors can use total sales. When this is done, it is important to remain consistent if the ratio is compared to that of other companies more.

A useful tool in managing and improving accounts receivable Turnover ratio indicates how many times the accounts receivable have been collected during an accounting period receivable turnover is the Flash Report.

Inventory Turnover Ratio Analysis Definition

Inventory turnover ratio, defined as how many times the entire inventory of a company has been sold during an accounting period, is a major factor to success in any business that holds inventory. It shows how well a company manages its inventory levels and how frequently a company replenishes its inventory. In general, a higher inventory turnover is better because inventories are the least liquid form of asset. A Flash Report is a useful tool in measuring

and managing inventory turns.

Inventory Turnover Ratio Analysis Explanation

Inventory turnover ratio explanations occur very simply through an illustration of high and low turnover ratios. Despite this, many businesses do not survive due to issues with inventory. A low inventory turnover ratio shows that a company may be overstocking or deficiencies in the product line or marketing effort. It is a sign of ineffective inventory management because inventory usually has a zero rate of return and high storage cost. Higher inventory turnover ratios are considered a positive indicator of effective inventory management. However, a higher inventory turnover ratio does not always mean better performance. It sometimes may indicate inadequate inventory level, which may result in decrease in sales.

Inventory Turnover Ratio Formula

The following inventory turnover ratio formulas are listed below:

Inventory turnover = Sales / Inventory Or Inventory Turnover = Cost of goods sold / Average inventory

Source: <https://strategiccfo.com/accounts-inventory-turnover-analysis/>

Strand 6: Agribusiness

Unit 1: Starting Up and Managing Agribusiness

Content Standard 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 12.6.1.3. Explain and prepare a bank reconciliation.

Topic: Bank reconciliation

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

- Prepare and analyze the bank reconciliation statement of a business enterprise.
- Estimate and assess reconciliation statement for a business enterprise.

Essential Question

1. What is a bank reconciliation statement?

Knowledge	Bank reconciliation
Skills	Prepare and analyze the bank reconciliation statement. Estimate and assess reconciliation statement for a business
Attitudes & Values	Value the role of bank reconciliations.

Content Background

What Is a Bank Reconciliation Statement?

A bank reconciliation statement is a summary of banking and business activity that reconciles an entity's bank account with its financial records. The statement outlines the deposits, withdrawals and other activities affecting a bank account for a specific period. A bank reconciliation statement is a useful financial internal control tool used to thwart fraud.

Understanding the Bank Reconciliation Statement

Bank reconciliation statements ensure payments have been processed and cash collections have been deposited into the bank. The reconciliation statement helps identify differences between the bank balance and book balance, in order to process necessary adjustments or corrections. An accountant typically processes reconciliation statements once a month.

Important Points:

- A bank reconciliation statement summarizes banking and business activity, reconciling an entity's bank account with its financial records.
- Bank reconciliation statements confirm that payments have been processed and cash collections have been deposited into a bank account.
- All fees charged on an account by a bank must be accounted for on a

reconciliation statement.

- After all adjustments, the balance on a bank reconciliation statement should equal the ending balance of the bank account.

Required Information to Create Bank Reconciliation Statement

Completing a bank reconciliation statement requires using both the current and the previous month's statements, including the closing balance of the account. The accountant typically prepares the bank reconciliation statement using all transactions through the previous day, as transactions may still be occurring on the actual statement date.

Bank Reconciling Statement: Adjusting Balance per Bank

The accountant adjusts the ending balance of the bank statement to reflect outstanding checks or withdrawals. These are transactions in which payment is en route but the cash has not yet been accepted by the recipient. An example is a check mailed on Oct. 30. When preparing the Oct. 31 bank reconciliation statement, the check mailed the previous day is unlikely to have been cashed, so the accountant deducts the amount from the bank balance. There may also be collected payments that have not yet been processed by the bank, which requires a positive adjustment.

Bank Reconciling Statement: Adjusting Balance per Books

The balance of the cash account in an entity's financial records may require adjusting as well. For instance, a bank may charge a fee for having the account open. The bank typically withdraws and processes the fees automatically from the bank account. Therefore, when preparing a bank reconciliation statement, any fees taken from the account must be accounted for by preparing a journal entry.

Another item that requires an adjustment is interest earned. Interest is automatically deposited into a bank account after a certain period of time. Thus, the accountant may need to prepare an entry that increases the cash currently shown in the financial records. After all, adjustments are made to the books, the balance should equal the ending balance of the bank account. If the figures are equal, a successful bank reconciliation statement has been prepared.

Strand 6: Agribusiness Agribusiness

Unit 1: Starting Up and Managing

Content Standard 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 12.6.1.4. Explain and apply the double-entry system of accounting to record business transactions and prepare a trial balance.

Topic: Accounting Systems

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

- Examine and discuss and double entry system of a business enterprise

Essential Question:

1. What is a double entry account system?

Knowledge	Accounting systems
Skills	Examine and discuss double entry system of a business
Attitudes & Values	Appreciate the double entry accounting system.

Content Background

Double-entry bookkeeping

Double-entry bookkeeping, in accounting, is a system of bookkeeping where every entry to an account requires a corresponding and opposite entry to a different account. The double-entry has two equal and corresponding sides known as debit and credit. The left-hand side is debit and right-hand side is credit. In a normally debited accoun... Wikipedia Double entry, a fundamental concept underlying present-day bookkeeping and accounting, states that every financial transaction has equal and opposite effects in at least two different accounts. It is used to satisfy the accounting equation: $\text{Assets} = \text{Liabilities} + \text{Equity}$. With a double entry system, credits are offset by debits in a general ledger or T-account. The Basics of Double

Entry

In the double-entry system, transactions are recorded in terms of debits and credits. Since a debit in one account offsets a credit in another, the sum of all debits must equal the sum of all credits. The double-entry system of bookkeeping or accounting makes it easier to prepare accurate financial statements and detect errors. Types of Accounts

Bookkeeping and accounting are ways of measuring, recording, and communicating a firm's financial information. A business transaction is an economic event that is recorded for accounting/bookkeeping purposes. In general terms, it is a business interaction between economic entities, such as customers and businesses or vendors and businesses.

Under the systematic process of accounting, these interactions are generally classified into accounts. There are seven different types of accounts that all business transactions can be classified: Assets, Liabilities, Equities, Revenue, Expenses, Gains, and Losses

Bookkeeping and accounting track changes in each account as a company continues operations.

Debits and Credits

Debits and credits are essential to the double entry system. In accounting, a debit refers to an entry on the left side of an account ledger, and credit refers to an entry on the right side of an account ledger. To be in balance, the total of debits and credits for a transaction must be equal. Debits do not always equate to increases and credits do not always equate to decreases.

A debit may increase one account while decreasing another. For example, a debit increases asset accounts but decreases liability and equity accounts, which supports the general accounting equation of $\text{Assets} = \text{Liabilities} + \text{Equity}$. On the income statement, debits increase the balances in expense and loss accounts, while credits decrease their balances. Debits decrease revenue and gains account balances, while credits increase their balances.

KEY

TAKEAWAYS

Double-entry refers to an accounting concept whereby $\text{assets} = \text{liabilities} + \text{owners' equity}$. In the double-entry system, transactions are recorded in terms of debits and credits.

Double-entry bookkeeping was developed in the mercantile period of Europe to help rationalize commercial transactions and make trade more efficient.

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;

- aims and objectives of the course;
- teaching and learning activities;
- assessments to check student understanding of the topic.

Effective teaching demonstrates deep subject knowledge, including key concepts, current and relevant research, methodologies, tools and techniques, and meaningful applications.

Planning for under-achievers NORMA

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

Standards-Based Lesson Planning

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 Standards-Based Lesson Plan (Integrating STEAM)

Topic: Capture fishery products

Lesson Topic: Quality production factors

Grade: 12

Length of Lesson: 40 minutes

National Content Standard: 12.4.1

Grade-Level Benchmark: 12.4.1.1

Essential Knowledge, Skills, Values, and Attitudes

Knowledge: Factors determining quality capture fishery products

Skills: Identifying factors that present quality capture fishery products

Values: Appreciate factors that determine quality capture fishery products

Attitudes: Value factors that determine quality capture fishery products

STEAM Knowledge and Skills

Knowledge: As above

Skills: As above

Performance Indicator: Correctly state factors determining quality capture fishery products

STEAM Performance Indicator: As above

Materials: Chart papers, Markers, Working groups

Lesson Objective: By the end of the lesson, students should be able to;

- Correctly state factors determining quality capture fishery products

Sample Lesson Procedure

Lesson Procedure

Teacher Activities	Student Activities
Introduction Introduction	
(5 minutes)	
<ul style="list-style-type: none"> Review the what Quality Fishery Products are 	<ul style="list-style-type: none"> Listen and use prior knowledge to answer teachers question
Body	
Modelling	
<ul style="list-style-type: none"> Ask students to get into their working groups (5 members) to create a quality fishery product using materials/ resources brought from home Invite students for a verbal feed back 	<ul style="list-style-type: none"> Discuss the factor and the processes involve in making up a Quality Fishery Product Provide a verbal feed back
Guided Practice	
<ul style="list-style-type: none"> Ask students to name factors that constitute a Quality Fishery Product Provide an example using tinned fish as a sample from extractive stage to finished product 	<ul style="list-style-type: none"> Reflect on and name some factors that constitute a Quality Fishery Product Observe attentively on the example provided by the teacher
Independent Practice	
<ul style="list-style-type: none"> Ask students to determine the factors that constitute a Quality Fishery Product 	<ul style="list-style-type: none"> Discuss factor that constitute a Quality Fishery Product
Conclusion	
<ul style="list-style-type: none"> Allow students to present their solutions on the board for discussion Make necessary corrections and summarise Conclude and highlight factors discussed 	<ul style="list-style-type: none"> Present solutions on the board and explain answers Make necessary corrections

Performance Assessment and Standards

National Content Standard: 12.4.1 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, categories them according to their characteristics, purposes and benefits, and investigate the different contexts, environments, and places where they are harvested.

Lesson Topic	Topic	Benchmark	Performance Assessment	
Capture fishery products	Quality production factors	12.4.1.1. Identify and analyse the factors that contribute to the production of quality capture fishery products	Student correctly state factors determining quality capture fishery products.	
	PROFICIENCY RUBRIC			
	Advanced	Proficient	Partially Proficient	Novice
	Identify all the factors that determine quality capture fishery products. and justified at least one process	Identify all the factors that determining quality capture fishery products.	Identify more than half of the factors that determining quality capture fishery products.	Identify less than half of the factors that determining quality capture fishery products.

STEAM Activity

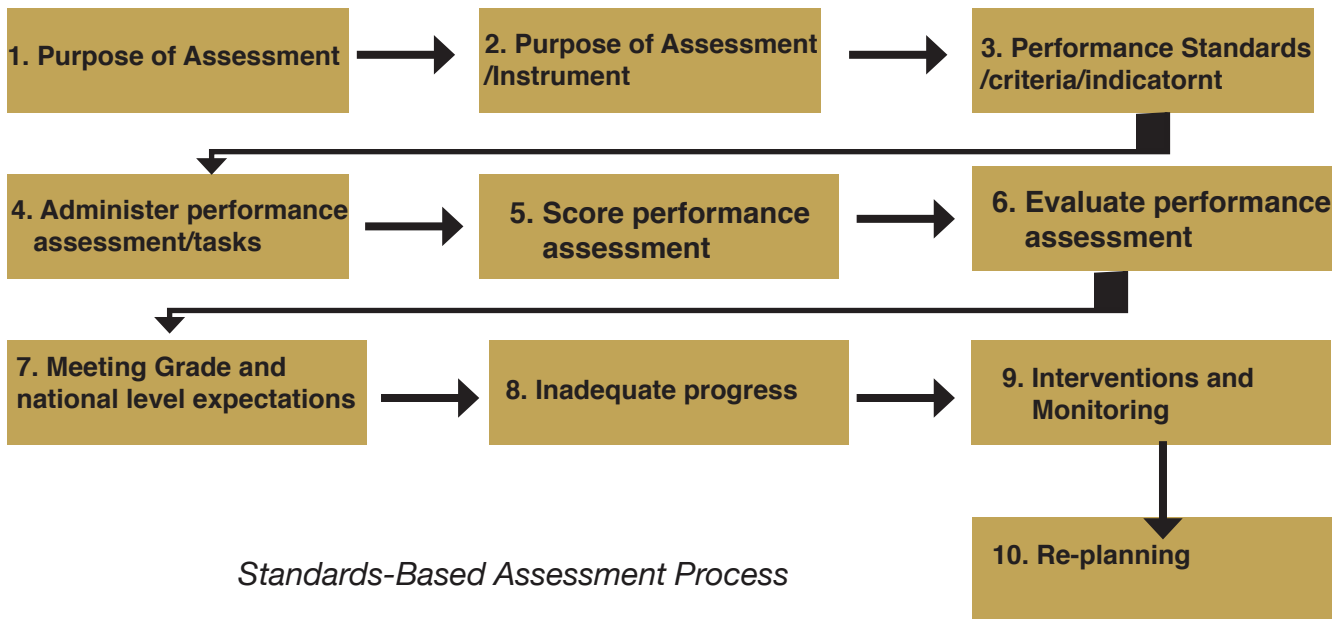
Students create a product of a quality capture fishery product.

Assessment, Monitoring and Reporting

What is Standards-Based Assessment (SBA)?

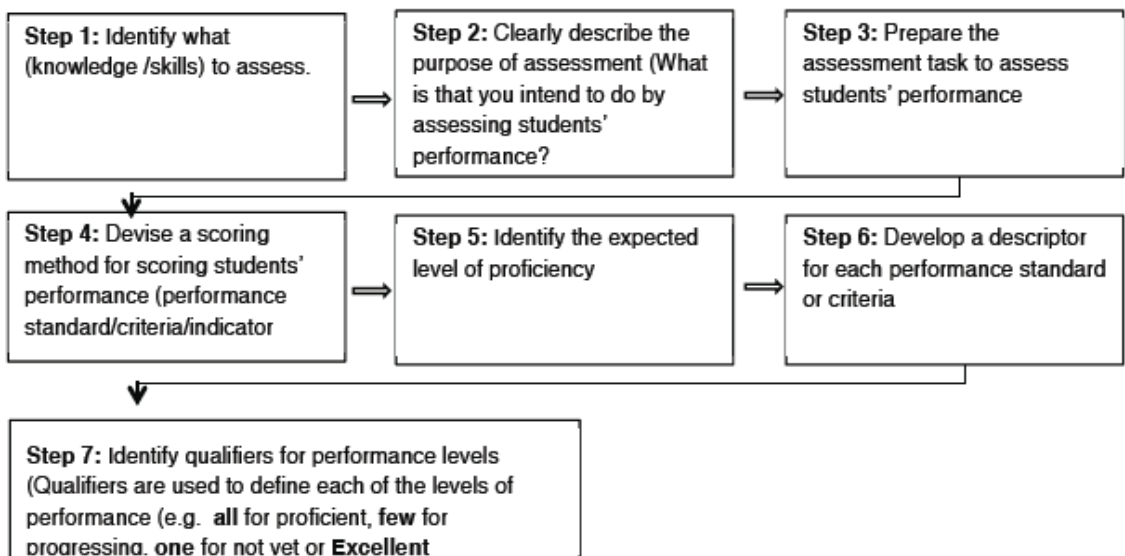
Assessment and reporting is an integral part of the delivery of any curriculum used in the schools. In Standard Based Curriculum (SBC) assessment encourages the use of benchmarks and commended types of assessment that promote standards for a range of purposes.

Standards-Based Assessment Cycle



Standards-Based Assessment Process

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.



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;

- emphasise on tasks that should encourage deeper learning,
- be an integral component of a course, unit or topic and not something to add on afterward,
- 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 their capacity for self-assessment,
- for improving performance that involves feedback and reflection,
- on-going rather than episodic,
- given the required attention to outcomes and processes, and
- 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 Learning*’ 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 she/he 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.
- Uses either summative or formative assessment methods in real life context.

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.

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 table below 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.

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 analyze 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.

Project Rubric

Category	Advanced	Satisfactory	Partial Credit	Unacceptable
	9 -10 points	7- 8 points	1 - 6 points	0 points
Quality/ Workmanship	Maximum effort was put forth to complete the project in a professional manner. Project demonstrates a high degree of quality and attention to detail. Workmanship is excellent.	Some effort was made to complete the project to a level that was sufficient for grading, but does not meet a professional level of quality or appearance. Workmanship is of acceptable quality.	Minimal effort was made to complete the project and the quality and workmanship is sub-par, but still meets the minimal standard.	Little or no effort was made to produce a quality project. Project obviously does not meet minimal standards.
Creativity/ Design	Project reflects many fundamental elements of design and creativity. Project demonstrates an advanced understanding of creative thinking and attention to aesthetics and presentation.	Project reflects some of the elements of design and creativity, but lacks attention to aesthetics and presentation.	Project was completed, but does not reflect the acceptable levels of design and creativity. Effort was minimal and project is mediocre at best.	Project was not completed on time or reflects little or no effort to complete assignment at an acceptable level.
Functionality	Project meets or exceeds the design requirements of purpose and functionality. All elements of the design have been met and the project does what it was designed to do.	Project meets some of the design requirements of purpose and functionality. Not all elements of the design have been met, but the project does what it was designed to do.	Project is somewhat functional, but reflects minimal effort. It is intermittent and doesn't always do what it was designed to do.	Project does not work and demonstrates a lack of effort or understanding of the basic elements of functionality and purpose.
Design Process	Project reflects a clear understanding and application of design process including evidence of research, brainstorming, design and problem solving, prototyping and testing.	Project reflects some understanding and application of accepted design loop principles and sequence including evidence of research, brainstorming, design and problem solving, prototyping and testing.	Project reflects minimal understanding and application of design process.	Project does not show evidence that design process was used. Project does not meet accepted levels of design criteria.

Criteria/ Constraints	Project was completed with all constraints and criteria met or exceeded. Reflects attention to detail and quality.	Project was completed with some of the constraints and criteria met. Reflects some attention to detail, but quality is minimal.	Project was completed with a few of the constraints and criteria met. Reflects minimal effort and lacks detail or quality.	Project was not completed and does not reflect the adherence to the constraints or criteria.
Time Management	Project completed and turned in on time. Student worked diligently when project time was available. Student was on task most of the time.	Project was completed, but had notable errors. Student utilized project time somewhat efficiently, but spent time socializing. Student was on task 70% - 80% of the time.	Project was not turned in on time and/or complete. The student was on task less than 60% of the time.	Project was not turned in on time and was not completed. Student wasted project time and at times was disruptive to others.
Resource Management	Always takes responsibility for use and care of all building components and resources. Always returns building components and materials to proper storage compartments.	Consistently takes responsibility for use and care of building components and resources. Somewhat consistent in returning building components to proper storage compartments.	Sometimes takes responsibility for use and care of building components and resources. Inconsistent in returning building components to proper storage compartments.	Does not take responsibility for the proper use and care of building components and resources. Is careless and does not practice proper storage and safety practices.
Teamwork	Notable teamwork shown with a determination to participate/contribute to team success. Completed required individual tasks that contributed to the success of the team.	Teamwork was noted, but was sometimes off task or working on non-related tasks. Contributed to the success of the team, but could have been more engaged to complete tasks sooner.	Notable time off-task with minimal effort given for team success, or did the project alone without relying on others to do their share of the project.	Was not a team player. Either took over project completely, or did not engage in team direction or plans.
Writing/ Reflection	Writing/reflection is very well organized and explained. Student includes all details in design process. Document has almost no grammatical errors.	Writing/reflection is somewhat organized and explained. Student includes most details in design process. Document has very few grammatical errors.	Writing/reflection is not organized and explained. Student includes only a few details in design process. Document has many grammatical errors.	Writing/reflection is incomplete or not turned in. Student includes no details in design process. Document has many grammatical errors.
Presentation	Presentation was well organized and presented in a logical sequence. Presentation reflects a full knowledge of the topic with clear answers and explanations to questions asked.	Presentation was fairly organized and most information presented in a logical sequence. Answers to questions were vague or lacked clarity or accuracy.	Presentation was unorganized and lacked a logical sequence. Presentation reflected little attention to detail. Answers to questions were inaccurate and confusing.	Presentation was not acceptable and reflects a lack of organization or knowledge of the topic. Presentation shows little effort to meet expectations.

GLOSSARY

WORDS	DEFINITION
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	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
Enteprenuer	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 ammounts, 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	Vuatmins 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 herdsmen 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: Bloom's Taxonomy

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, criticize, 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: 21st Century Skills

WAYS OF THINKING	<p>Creativity and innovation Think creatively Work creatively with others Implement innovations Critical thinking, problem solving and decision making Reason effectively and evaluate evidence Solve problems Articulate findings Learning to learn and meta-cognition Self-motivation Positive appreciation of learning Adaptability and flexibility</p>
WAYS OF WORKING	<p>Communication Competency in written and oral language Open minded and preparedness to listen Sensitivity to cultural differences Collaboration and teamwork Interact effectively with others Work effectively in diverse teams Prioritise, plan and manage projects</p>
TOOLS FOR WORKING	<p>Information literacy Access and evaluate information Use and manage information Apply technology effectively ICT literacy Open to new ideas, information, tools and ways of thinking Use ICT accurately, creatively, ethically and legally Be aware of cultural and social differences Apply technology appropriately and effectively</p>
LIVING IN THE WORLD	<p>Citizenship – global and local Awareness and understanding of rights and responsibilities as a global citizen Preparedness to participate in community activities Respect the values and privacy of others Personal and social responsibility Communicate constructively in different social situations Understand different viewpoints and perspectives Life and career Adapt to change Manage goals and time Be a self-directed learner Interact effectively with others</p>

Appendix 3: Standards-Based Lesson Plan Template

Standards-Based Lesson Plan

Topic: Lesson Topic: Grade:

Length of Lesson:

National Content Standard

Grade Level Benchmark

Essential Knowledge, Skills, Values, and Attitudes

Knowledge:

Skills:

Values:

Attitudes:

Materials:

- Lesson Objective:

Essential Questions:

Lesson Procedure

Performance Assessment and Standards

National Content Standard :				
Lesson Topic	Topic	Benchmark	Performance Assessment	
	Advanced	Proficient	Partially Proficient	Novice

Appendix 4: Standards-Based Lesson Plan Template-Integrating STEAM Standards-Based Lesson Plan (Integrating STEAM)

Topic:
Lesson Topic:
Grade:
Length of Lesson:

National Content Standard

Grade Level Benchmark
Essential Knowledge, Skills, Values, and Attitudes

Knowledge:
Skills:
Values:
Attitudes:

STEAM Knowledge and Skill
Knowledge:

Skill:
Performance Indicator:
STEAM Performance Indicator:

Materials:

Lesson Objective:
Essential Questions:

Teacher Activities	Student Activities
Introduction	
Body	
Modelling	
Guided Practice	
Independent Practice	
Conclusion	

Performance Assessment and Standards

National Content Standard :				
Lesson Topic	Topic	Benchmark	Performance Assessment	
	Advanced	Proficient	Satisfactory	Poor

STEAM Activity _____

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