COURSE GUIDE

AGR 201
GENERAL AGRICULTURE

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Introduction

Agriculture is the production of food, feed, fibre, fuel and other goods through the systematic raising of plants and animals. It encompasses farming, tending of orchards and vineyards and ranching. Ordinarily, agriculture means the cultivation and tillage of the soil of a field, in order to prepare a suitable seedbed, eliminate weed growth and improve the physical condition of the soil. Farming covers a wide spectrum of practices, ranging from subsistence agriculture (traditional production of food for family consumption and animal feeding), intensive agriculture, industrial agriculture to animal traction and farm mechanization. All these activities have a common objective of maximization of financial income from grain, produce or livestock.

However, modern agriculture covers all activities essential to food, feed, fibre production, including techniques for raising and "processing" livestock, and increasingly widening areas of human efforts and practices to ensure survival and sustainable development. Modern agricultural activities include pastoralism (nomadic farming), horticulture, fisheries, aquaculture, apiculture, forestry, wildlife conservation, food science technology, production of industrial chemicals and drugs, application of chemical fertilizers, wood ash and limestone, pest control, soil management, hydroponics, crop improvement, irrigation and sanitary engineering, packaging, processing and marketing of agricultural products. The use of radio and television for disseminating vital weather reports, etc. as well as computerization of farm operations are also agricultural activities.

Agriculture is not only basic to human existence but also an important factor in determining the complexity of the global socio-economic change from the original, simple and primitive hunter-gather cultures. While the latter ancient practices ensure a subsistent food and fibre

supply, intensive and industrial farming guarantees large-scale supplies of raw and processed foods, feeds, fibre, fuel and other goods for community consumption and incomes, and foreign exchange earnings for national development as well as global advancement. The role of agriculture in human development can therefore, not be over- emphasised.

The Course

This Course Guide gives a brief description of the topical areas of this course material. There is the need not only to understand the meaning and scope of agriculture as a basic activity to human existence, but also to appreciate the distinct classes of activities which combine to ensure international (global) food security. Agriculture is also a major

contributor to diverse environmental alterations which threaten human existence on the planet earth, in respect of the multitude of cultural operations used to achieve optimum crop, animal and forest yields. The ownership of land is critical to land use for agriculture and other purposes, and this varies widely with the existing laws and customs in different parts of the world.

In Nigeria, agriculture is the largest contributor to national development, and its development is greatly influenced by political history. Several intervention schemes have been implemented to ensure increased food production. Agriculture is ancient in origin, but has witnessed several random and systematic transformations resulting in complex, more sustaining and efficient modern systems of food, feed and fibre production. This accounts for the wide variations in the systems of farming, depending on the intensity of cropping and duration of bush fallow. Thus, tropical agriculture consists of largely the traditional multiple cropping systems which are strongly influenced by population growth, commercialization and modernization. Tropical cropping systems range from nomadic herding, and bush fallowing to crop rotation, monocropping, Taungya farming, alley cropping, mixed farming, which guarantee soil sustainability and environmental preservation. Cultural operations adopted in crop production not only ensure a favourable environment for optimum crop yield and quality, but also include breeding of improved varieties, adaptation to diverse environments and provide alternative to herbicides.

Seed propagation of crops is more ancient than asexual propagation, which in recent times led to the evolution of micro-propagation to produce new disease and pest-resistant crop varieties. In spite of these, the onset of the cropping season, cropping pattern and systems and the number of crops cultivable by farmers depend on the climatic factors, especially rainfall and temperature. In Nigeria, the distribution of crops
across ecological zones depends largely on the seasonality of rainfall, and the duration and regimes of the wet season. This accounts for the cultivation of the long-season root and perennial tree crops in the wetter south and the short-season grain crops in the drier north. Soil type, fertility and land use systems also exert considerable influence on agricultural production.

Animal husbandry involves the breeding and raising of animals not only for meat, milk, eggs and wool on a continual basis but also for companionship, farm work and secondary benefits such as pharmaceuticals, drugs, organic manuring and farm income. Farm animals vary widely in their feedings habits (ruminants, non-ruminants, monogastrics), the type of food they eat (herbivores, carnivores, omnivores) as well as the purpose of management (beef, dairy, work, egg-

laying). In Nigeria, farm animals vary widely in their spatial distribution across ecozones depending on the husbandry system, cultural, social, religious, ecological factors and the type of animal breed. However, the main livestock types are cattle, sheep, goats, pigs, donkeys, horses and poultry. The systems of management of these animals depend mainly on the intended scale of output (subsistence versus export), farmer's convenience, financial base and available resources such as land and pasture. The systems are largely traditional, nomadic and free range and to a smaller extent, semi-intensive, intensive and ranching. Certain practices are critical to adequate supply of good- quality animal products and by-products, not only to guarantee huge profits but also to sustain livestock production. These include selection of good animals, feeding, housing, disease control, etc.

Fish production is major source of animal protein for human consumption. Non-food fish products can be used as dietary supplements in livestock production while parts of fishes have several direct and indirect benefits to humans, particularly industrial uses. In Nigeria, fish production is highly valued as a renewable source of cheap, high-quality animal protein from large supplies of fish and other aquatic living organisms such as sea weeds and coral reefs. Fish production systems range from capture fisheries, industrial fisheries, small-scale fisheries and artisanal fisheries to culture fisheries (aquaculture). Fish vary widely in type depending on the habitat characteristics and body skeleton, and include tropical and coldwater fish, freshwater and marine fish, cartilaginous and bony fish.

Forest management is an important area of agriculture, which provides man with several economic, social, religious and environmental values. The forest contains not only a great quantity of timber reserves and manufacturing wood products (alcohol, plywood), but also abundant non-woody plant and animal resources such as mushrooms, honey, biomedicals and spices. Sustainable forest management involves silvicultural systems which assure full and inexhaustible benefits and services from natural forests, forest reserves and forest plantations. Silviculture is based on principles of forest ecology and ecosystem management which are targeted at the creation and maintenance of pure, even-aged stands of single tree species.

Wildlife management is a particularly important sub-sector of agriculture, because it generates huge foreign exchange through exports, game-viewing and tourism. It is also highly valued for its socio-cultural, religious and trado-medical benefits. In Nigeria, wildlife conservation is targeted at increasing animal protein supplies through bushmeat production, education, research, rural employment and ecological diversity. Ecotourism is the tourism industry's fastest growing sub-

sector, and offers new opportunities for effective national development, improved socio-economic life for citizens and a safe environment.

From the foregoing, it is apparent that agriculture is central to Nigeria's economic growth and development. There is therefore, a need to improve and sustain productivity through a critical analysis of the inherent production problems and careful planning and implementation.

Course Aims

The aim of the course is to elucidate the fundamental aspects, principles and practice of agriculture with particular reference to Nigeria.

Course Objectives

Arising from the aims as mentioned above, the course is set to achieve the following objectives:

- increase the student's knowledge of the multi-faceted nature of agriculture, with a view to encourage capacity building for self-reliance
- highlight the contribution of agriculture to national development and human survival
- explain the negative effects of agricultural activities on the environment
- discuss the influence of land ownership on agriculture and non-agricultural activities;
- discuss the trend, evolution, current status and opportunities for profitable investment in agriculture in Nigeria;
- explain the need to adapt traditional farming techniques in order to improve productivity
- explain the primary contribution of diverse crop groups to national production and spatial distribution in various ecological zones
- identify the basis for the dominance of multiple cropping and the external factor which affect the systems in tropical Africa
- learn about the fundamental aspects of cropping systems, their practical benefits and limitations in food production
- understand the aim, sequence, benefits and practical application of cultural practices in crop production
- understand the methods, advantages, limitations and practical application of crop propagation techniques
- learn about the roles of climatic and soil factors in crop production
- learn the various direct and indirect benefits of farm animals of various types, their distribution, aspects of good husbandry and management systems

- enumerate the food, non-food, socio-economic, cultural, religious and industrial benefits of various fish types; the aims and techniques of fisheries management in Nigeria; and aquaculture fisheries
- learn about importance of forest trees, especially wood and non-wood products, and sustainable forest management, especially silvicultural systems;
- understand the scope of wildlife management, its significance to the national economy and concepts of wildlife management and conservation;
- appreciate the principles, economic importance and impact of ecotourism in the environment; and to
- understand the pertinent measures for improving agricultural productivity in Nigeria.

Working through the Course

The understanding of this course is critically dependent on a patient and meticulous review of the course material. Much time has been devoted to the preparation of the material, and this accounts for its simplicity, extensive technical content and readability. The allocation of extra time to attend to the Tutor-Marked Assignment cannot be over-emphasized, in view of the immense benefits to knowledge acquisition.

The Course Material

The course materials comprise of

- Course Guide
- Study Guide
- List of Recommended Textbooks, and
- Internet Literature, which provides the most current information on most of the Course Units.

Study Units

The following are the Study Units contained in this course

Module 1

Unit 1 Scope of Agriculture
Unit 2 Importance of Agriculture
Unit 3 Agriculture and the Natural Environment
Unit 4 Land Tenure and Use Systems
Unit 5 Agricultural Development in Nigeria

Module 2

Module 3

Module 4

Module 5

Module 6

Module 7

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Assessment

The Course consists of two components, namely

a) Tutor-Marked Assignments (TMAs) and
b) End of Course Examination.

Tutor-Marked Assignment

The TMA is the continuous assessment component of your course. It accounts for 30% of the total score. You will be given 4 TMAs to answer. Three of these must be answered before you are allowed to sit for the End of Course Examination. The TMAs will be given to you by your facilitator and returned after you have done the assignment.

Final Examination and Grading

This examination concludes the assessment for the course. It constitutes 70% of the whole course. You will be informed of the time for the examination since it may or may not coincide with the University Semester examination.

Summary

This course is intended to provide you with the fundamental knowledge of agriculture and its components. By the end of this course, you should be able to answer the following questions:

- What is "agriculture"?
- State the difference between primary and secondary agriculture?
- Why is the agricultural sector an important source of employment in Nigeria?
- List four raw materials and the corresponding industries using the raw materials in Nigeria.
- Enumerate five ways through which agriculture causes environmental degradation?
- Briefly describe two land use systems in Nigeria.
- Which post-colonial agricultural development intervention is most impacting on agricultural growth in Nigeria?
- What is the consequence of poor performance of agriculture relative to population growth?
- State the highlights of the development of present-day agriculture.
- State the differences between the following groups of crops:
    - Class Gymnospermae and Class Angiospermae;
    - biennials and annuals; and
    - dicots and monocots.
- Enumerate five characteristics of tropical agriculture.
- State four factors which influence the type of cropping system practised by a farmer.
- Briefly explain four benefits of cultural practices to optimum crop

yields and produce quality.

- What factor differentiates the types of irrigation system?
- Name four methods of air-tight storage of farm products and four limitations of the methods.
- State four desirable features of budding and grafting.
- In what five ways is soil organic matter maintained on croplands?
- Why is guinea-corn regarded as the most versatile cereal crop in Nigeria?
- Identify, and enumerate four secondary benefits of farm animals.
- State any four advantages of the ruminant pre-gastric fermentation.
- State four reasons for the preponderance of pigs in southern Nigeria than in northern Nigeria.
- List and define the different management systems of managing farm animals.
- Why are grass-legume mixtures more desirable than sole grass or legume pastures?
- Write short notes on “fish waste products”.
- Outline any five criteria for selecting the fish species for aquaculture fish production.
- Identify five categories of freshwater fish and name two examples of each category.
- In what two broad ways do forests serve Man?
- What is “sustainable forest management”?
- State four factors to consider in implementing silvicultural systems.
- What are “non-timber forest products” and “special wood products”?
- Write short notes on “sericulture”.
- In what two ways do wildlife species help in scientific development?
- Why is political will critical to sustained agricultural development and economic growth?
- Mention the areas of focus of ecotourism.

We wish you the best of luck in this course. It is expected that you will be able to appreciate the importance of agriculture as the ancient activity which ensures human survival and sustainable national development.

MAIN CONTENT

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MODULE 1

UNIT 1 SCOPE OF AGRICULTURE

CONTENTS

1.0 INTRODUCTION

Simply defined, “agriculture” means cultivation and tillage of the soil of a field, in order to prepare a suitable seedbed, eliminate weed growth and improve the physical condition of the soil. However, modern “agriculture” covers all activities essential to food, feed, fibre production, including techniques for raising and “processing” livestock, and increasingly widening areas of human efforts and practices to ensure survival and sustainable development.

2.0 OBJECTIVES

This study unit is expected to:

- increase the student’s understanding of the multi-faceted nature of agricultural practice
- encourage capacity building in the various entrepreneurship opportunities for self-reliance.

3.0 MAIN CONTENT

3.1 Definition of "Agriculture"

Agriculture is the production of food, feed, fibre, fuel and other goods by the systematic raising of plants and animals. It encompasses farming, tending of orchards and vineyards and ranching.

3.2 Agricultural Activities

Farming covers a wide spectrum of practices, ranging from subsistence agriculture (traditional production of food for family consumption and animal feeding), intensive agriculture, industrial agriculture to animal traction and farm mechanization. All these activities have a common objective of maximization of financial income from grain, produce or livestock.

In modern times, agricultural activities include pastoralism (nomadic farming), horticulture, fisheries, aquaculture, apiculture, forestry, wildlife conservation, food science technology, production of industrial chemicals and drugs, application of chemical fertilizers, wood ash and limestone, pest control, soil management, hydroponics, crop improvement, irrigation and sanitary engineering, packaging, processing and marketing of agricultural products. In advanced countries of the World, airplanes, helicopters, trucks and tractors and combines are involved in seeding, spraying operations for insect and disease control, harvesting, aerial top dressing and transportation of perishable products. The use of radio and television for disseminating vital weather reports, etc. as well as computerization of farm operations are also agricultural activities.

3.3 Classification of Agricultural Practices

Agriculture can be distinctly classified into "primary" and "secondary" branches.

3.3.1 Primary Agriculture

This involves farming in all its branches. These include certain specific farming operations such as cultivation and tillage of soil, production, cultivation, growing and harvesting of any agricultural or horticultural commodity and the raising of livestock, bees, poultry and fur-bearing animals. Other primary activities include dairying (including putting the milk in containers, cooling it, and storage on the farm), the production, cultivation, growing and harvesting of trees or timber products by a farmer or on a farm, the production and processing of crude gum

(oleoresin), gum spirits of turpentine and gum resin from a living tree and by the producing farmer. The employment of man in any of these direct farming activities is called agriculture, irrespective of whether he is employed by a farmer or the activity takes place in enclosed houses (greenhouse or mushroom cellars) or on an open field in a village, city, industrial premises or non-farm premises.

3.3.2 Secondary Agriculture

This includes operations other than those which fall within the primary activities of agriculture. These are either farming or non-farming practices performed either by a farmer or on a farm leading to, or in addition to, such farming or non-farming operations. Typical examples are the separation of cream from milk, bottling of milk and cream, or making butter and cheese by a farmer or on a farm, when not performed on milk produced by other farmers or produced on other farms.

4.0 CONCLUSION

In this unit, you have learned about the meaning of agricultural activity, classes of farming and non-farming activities and the diverse nature of farming. This knowledge will facilitate the understanding of the subsequent study units in this course.

5.0 SUMMARY

Agriculture involves direct (primary) and non-direct (secondary) farming practices which deal with the production of food, fibre, animal feeds and processing of agricultural products for man's use.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define the term "agriculture" in its broad sense.
2. List four modern farming activities.
3. State the difference between primary and secondary agriculture.

7.0 REFERENCES/FURTHER READINGS

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UNIT 2 IMPORTANCE OF AGRICULTURE

CONTENTS

1.0 INTRODUCTION

Agriculture is not only basic to human existence but also an important factor in determining the complexity of the global socio-economic change from the original, simple and primitive hunter-gather cultures. While the latter ancient practices ensure a subsistent food and fibre supply, intensive and industrial farming guarantees large-scale supplies of raw and processed foods, feeds, fibre, fuel and other goods for community consumption and incomes, and foreign exchange earnings for national development as well as global advancement. The role of agriculture in human development can therefore, not be over-emphasised.

2.0 OBJECTIVES

This unit is expected to:

- discuss the various ways through which farming sustains human existence
- identify the contribution of the agricultural sector to Gross World Production (GWP) in general, and Nigeria's economic development in particular.

3.0 MAIN CONTENT

3.1 Roles of Agriculture

i. Provision of the basic food requirements of human populations.
ii. It is the predominant occupation of the working population, especially in agrarian nations.

iii. An important way of life, culture and custom of the people. Customs and festivals are observed in consonance with agricultural seasons, activities and products in most rural communities. Hunting on both agricultural and wild areas is a way of life, and hobby, in rural settings.
iv. The major source of income, especially for the rural populace.
v. Provision of raw materials for manufacturing industries, such as feed mills, textile factories, vegetable oil mills, packaging, biopharmaceuticals, industrial chemicals and leather.
vi. Agricultural experts are of great importance in foreign exchange earnings and government revenue.

3.2 Global Contribution of Agriculture

About 42% of the World's labourers are employed in agriculture, thus making it by far the most common occupation. In spite of this, agricultural production sector accounts for less than 5% of the Gross World Production, GWP (i.e. 5% of the aggregate of all national Gross Domestic Products, GDP).

3.3 Sectoral Contribution of Agriculture in Nigeria

i. Nigeria still remains an agrarian economy, in spite of the growing importance of oil. Subsistence agriculture is most important in the provision of staple foods (especially rice, maize, beans, taro/cocoyam, yams, cassava, sorghum, millet) for the teeming Nigerian populace. However, limited excess quantities of the harvested produce are sold in local markets for little incomes. The groups of agricultural crops grown in Nigeria are shown below (Table 1):

Table 1. Groups of crops grown in Nigeria.

Group	Crops
Cereals	Guinea-corn, millet, maize, rice
Roots & Tubers	Cassava, yam, cocoyam, potatoes (sweet, Irish)
Grain legumes & pigeon pea,	Cowpeas, locust bean, soyabean, groundnut,
Other legumes	Bambara nuts
Oil seeds & nuts	Melon, benniseed, kolanuts, coffee
Tree crops	Cocoa, oil palm, rubber
Vegetables & fruits	
Vegetables:	Onion, African spinach, Indian spinach, pumpkin, sweet Pepper, hot pepper, waterleaf, carrot, lettuce

Fruits:	Pineapple, pawpaw, mango, banana, plantain, citrus, guava.

ii. Generally, agriculture employs about 70% of the active labour force of the population, and this serves to augment the earnings from local produce sales. The raising of livestock (principally goats, sheep, cattle and poultry) and artisanal fisheries are also significant for income generation.

iii. New yam festivals and most traditional wedding and customary ceremonies are usually observed during farm seasons.

iv. Several industries use local agricultural products in their production operations. These include textile factories (cotton), oil mills and soap factories (groundnut, soyabean, and palm oil), packaging (jute, sisal), biopharmaceuticals (legal, illegal drugs), industrial chemicals (starch, sugar, and alcohols), plywood factory (timber), paper mills (timber), beverage industries (cocoa, coffee, and tea), canning factory (tomato, sweet peppers, beef), leather factory (hides) and tyre factory (rubber).

v. The agricultural sector remains the largest contributor to the Nigerian economy. The World Bank estimated an annual growth rate of 2.9% for agricultural GDP in Nigeria from 1990-1998. In 1998, the agricultural sector GDP contribution to the economy was 32%. Figures for the sectoral contribution and growth rate of agriculture GDP to the Nigerian economy for 1999-2006 are shown in Table 2:

Year	**Sectoral contribution (%)**	**Growth rate (%)**
1999	43.45	43.45
2000	42.65	42.65
2001	42.30	42.30
2002	42.14	42.14
2003	41.01	41.01
2004	40.98	40.98
2005	41.21	41.21
2006	41.95 (estimate)	7.17

4.0 CONCLUSION

Agriculture is fundamental to human existence, not only at the individual and community levels but also at the global level, where international agricultural and associated trade fosters food security.

5.0 SUMMARY

In this unit, you have learned that

- agriculture gives food, employment, income and clothing,
- exported crops and crop products give foreign exchange for national development,
- agriculture makes significant sectoral contribution globally, and locally with respect to the Nigerian economy.

6.0 TUTOR-MARKED ASSIGNMENT

1. State two roles of agriculture.
2. Why is the agricultural sector an important source of employment in Nigeria?
3. List four raw materials and the corresponding industries using the raw materials in Nigeria.

7.0 REFERENCES/FURTHER READINGS

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UNIT 3 AGRICULTURE AND THE NATURAL ENVIRONMENT

CONTENTS

1.0 INTRODUCTION

In all agricultural production systems, the multitude of cultural operations which enhance optimum crop yields also impact on the farm environment in particular, and the macro-ecosystems in general. For instance, in subsistence agriculture farmers adopt uncontrolled burning to get rid of excess, aggressive vegetation before sowing their crops. Even in intensive agriculture, the advanced technologies of farming and livestock production such as land preparation, conventional tillage, pesticide and fertilizer application for producing good-quality crops also have adverse effects on the natural environment. In the poultry industry, extensive odours from huge piles of faecal droppings cause serious pollution of the environment.

2.0 OBJECTIVES

This unit is aimed at highlighting the various negative effects of agricultural activities on the natural environment of man.

3.0 MAIN CONTENT

3.1 Natural Environments are Fragile but Ecologically Stable

However, agricultural activities cause serious environmental problems because they alter the natural ecosystem, and in the process, produce harmful by-products. The ultimate consequence of the alteration is the degradation of ecosystems through the following adverse effects:

i. Loss of biodiversity. This arises from the reduction of forests and other habitats after farming as well as the reduction in genetic diversity and increased vulnerability of high yielding varieties to

pests which thus necessitate heavy pesticide use. Global forest cover has been reduced by 20% since the industrial revolution. Tropical forest areas are being deforested at a rate of nearly 50 000 sq. miles per year. The conversion of virgin temperate forest to plantation is similarly continuing unabated, especially in Russia.

ii. Increasing contamination of waterways and wetlands by excess nitrogen and phosphorus release to rivers and lakes.
iii. Fertilizer application leads to soil salinisation.
iv. Detrimental effects of inappropriate and heavy use of pesticides (herbicides, fungicides, insecticides, other biocides) such as contamination of food and environment, and health hazards to farmers.
v. Pesticides also kill the natural enemies of pests, which subsequently multiply rapidly and create considerably more environmental nuisance than when pesticides are not used.
vi. Pest resistance to agro-chemical pesticides is currently very appreciable, necessitating the development of more effective, but hazardous chemicals and their mixtures.
vii. Large-scale slash-and-burn techniques of subsistence farming result in nutrient-poor soil, especially in tropical forest environments. It is particularly ecologically destructive (of the forest integrity) where fields are not allowed sufficient time to regeneration before subsequent application, under high population pressure and under loss of a large number of vulnerable and endangered plant fallow species.
viii. Extraction of biomass in harvests of wood or charcoal diminishes further growth of any vegetation type due to poor residual soil productivity.
ix. Consolidation of diverse biomass into a few species.
x. Advances in agriculture technology require a large energy input, often from fossil fuel to maintain high levels of output.
xi. Increasing diversion of crop production strategies from food supplies to bio-fuel supplies.
xii. Heavy use of fresh water, depleting water supply for human consumption.
xiii. High dependence on technologies which further degrade the soil. For instance, in the United States a **dead spot,** due to fertilizer runoff into the Mississippi River has been discovered in the Gulf of Mexico.
xiv. Large-scale soil erosion is a major land degradation feature in tropical agriculture.
xv. Intensive agriculture depletes soil fertility over time, and potentially leads to desertification. Unfortunately, further growth

of any vegetation type is practically impossible for future generations.

xvi. Aggressive weed colonizers and associated pests, pathogens and dangerous animals (snakes, mosquitoes, etc.) are important environmental nuisance.

xvii. Extensive growth and surface cover of floating aquatic weeds is a menace to navigation. Also, eutrophication of water bodies by decomposing weed residues reduces the drinking and irrigation benefits.

xviii. Global climate changes, especially global warming due to excess CO_2 and NO_2 emissions into the atmosphere.

xix. In particular, the United Nations consider the livestock sector (especially cows, chickens, pigs) as one of the most significant contributors to most serious environmental problems, both at local and global levels. The sector is one of the largest sources of greenhouse gases, especially CO2, which accounts for 18% of the world's gas emissions. Also, it produces 65% of human-related NO2 (296 times more warming potential than CO2) and 37% of all human-induced CH4 (23 times more warming potential than CO2). The sector also generates 64% of the NH3, which contributes significantly to acid rain and acidification of ecosystems.

4.0 CONCLUSION

In this unit, you have learned that agriculture is a major contributor to diverse environmental alterations which threaten human existence on the planet earth.

5.0 SUMMARY

Agricultural activities cause serious environmental problems in water, on land and in the atmosphere. These problems strongly affect the ability of man to optimally explore the benefits of agriculture in producing food, feeds, fibre and other products.

6.0 TUTOR-MARKED ASSIGNMENT

1. In what main way does agriculture cause serious environmental problems?
2. What is the ultimate consequence of the adverse effect of agriculture on the environment?
3. Enumerate five ways through which agriculture causes environmental degradation.

7.0 REFERENCES/FURTHER READINGS

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UNIT 4 LAND TENURE AND USE SYSTEMS

CONTENTS

1.0 INTRODUCTION

The way the land is held or owned differs in different parts of the world, depending on the existing laws and customs. Similarly, the ownership of land is critical to the purpose of use of the land. Traditionally in West Africa, land ownership is either communal or individual. Also, although most land is used for agricultural purposes land ownership affects the development of agriculture.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- understand the different forms of land ownership
- appreciate the way land is used for various purposes, including agriculture.

3.0 MAIN CONTENT

3.1 Land Tenure System

3.1.1 Definition

Land tenure is defined as the system of land ownership by individuals, family, community or government agency either for temporary use or as permanent property.

3.1.2 Classes of Land Tenure System

i. **Communal Land Tenure:** The land belongs to the entire community, as represented by a family, a village, or a clan. This is a typical traditional practice in Nigeria. Every member of the community is entitled to a piece of the land for agriculture. Also, allottees have the freedom to grow choice crops, to use the land for any purpose and freedom to make desired improvements on the land without restriction. However, the individual allotted can neither sell any part of the land nor under normal circumstances, transfer the land to a stranger. The land tenure system involves a small population of users and subsistence farming, which hampers mechanization and economic exploitation in spite of abundance of land. There is a limitation to the acquisition of more available land by an intending farmer. Communal land cannot be used as security for accessing credit facilities in commercial banks.

ii. **Inheritance Land Tenure:** This involves the acquisition of land by inheritance from parent(s) or generation to generation. In Nigeria, most agricultural lands are acquired through inheritance.

iii. **Leasehold System:** This system involves the payment of a certain amount of money for the use of the land over a specified period of time.

iv. **Rent Land Tenure:** This system involves the payment of a certain amount of money as rent for the use of a land by a farmer over a short period of time.

v. **Individual Land Tenure:** This involves the ownership of a piece of land by an individual through either freehold or rent tenancy.

Freehold Ownership

Advantages are

- complete freedom of owner over the land,
- permanent ownership of land,
- freeholder can use the land for any purpose, and
- freeholder ownership of land offers great security to freeholder, with high prospects of huge investment and returns on investment on land.

Disadvantages are

- Individuals who have none or inadequate land can neither rent or buy from freeholder,
- Possibility of land fragmentation by freeholder, thus making intensive or large-scale agriculture difficult and reducing the associated economic efficiency.

Rent Tenancy: This land tenure system involves the renting of portions or all of the land by the individual land owner to farmers as tenants. The tenants pay rent for using the land as well as remit a proportion of the yield from the land to the land owner.

vi Land tenure by purchase or freehold: This involves an outright purchase of the land for agriculture.

vii Land tenure by free gift or pledge: This involves the acquisition of land as a gift.

viii. Tenancy at the will of government: In Nigeria, the Federal Government reformed the land tenure system by the Land Use Decree of March 1978. The decree removed land from all traditional custodians and placed it in the hands of State Governors and local Government Authorities. Each individual is entitled to ½ ha of land for house building purpose in urban areas, 500 ha for intensive agriculture and 5000 ha for grazing land. A Certificate of Occupancy (C of O) obtained from government would certify the owner's authority. The limitations of this system are that there is no provision to freehold title to land, procedures for freehold title to land are difficult and there is no provision for consolidation which militates against the issue of C of O.

3.2 Land Use

Nigeria's total land area is 92.4 m ha. About 91 m ha of this is adjudged suitable for cultivation. Also, approximately half of this cultivable land is effectively under permanent and arable crops while the rest is covered by forest wood land, permanent pasture and built-up areas.

3.2.1 Land Use Systems

i. Agriculture: In Nigeria, as shown in 3.2, most land is used for farming. The various farming activities include growing food crops, plantation crops or feed crops; pastoralism, bush or planted fallow, and forest reserves.

ii. Non-agricultural land: The use of land for housing, roads, railways, sea-ports, airports, reservoirs, shops, industries and

warehouses. Others are military installations, offices, hospitals, parks and wildlife resorts. Non-agricultural land use involves a small proportion of total land area in Nigeria, in spite of the increasing population and industrial growth.

3.3 Factors Causing Changes in the Usage of Agricultural Lands

i. The establishment of forest reserves.
ii. Road and railway construction, especially connecting farm production centres.
iii. Construction of houses, hospitals, office complexes and non-agricultural structures essential for human welfare, which commands some prices on land sale by the farmer.
iv. Population growth and the need to increase food crop production for consumption and export earnings for national development.

4.0 CONCLUSION

In this unit, you have learned:

- the different systems of land tenure, their benefits and limitations in agricultural land use;
- the different land use systems in Nigeria, and
- the factors which influence the use of agricultural lands.

5.0 SUMMARY

In West Africa, especially Nigeria, land is traditionally held in trust by the entire community, but this limits the acquisition of land for agricultural purposes. Other systems of land tenure have their inherent benefits and limitations. Also, the usage of agricultural lands greatly depends on other non-agricultural sectors such as forestry, construction and population growth and pressure.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define the term “Land tenure”.
2. Mention five classes of land tenure system in practice in West Africa.
3. State the difference between leasehold tenure and rent land tenure systems.

7.0 REFERENCES/FURTHER READINGS

Adegbola, A.A., Are, L.A., Ashaye, T.I. and Komolafe, M.F. (1972). *Agricultural Science for West African Schools and Colleges*. Oxford University Press: Nigeria.

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UNIT 5 AGRICULTURAL DEVELOPMENT IN NIGERIA

CONTENTS

1.0 INTRODUCTION

Nigeria is primarily an agrarian nation. However, the agricultural history of Nigeria evolved with its political history in three phases, namely pre-colonial, colonial and post-colonial periods. In spite of the persistent influence of political changes, agriculture has witnessed dramatic transformations from the colonial era. In t his era, agriculture was tied to intensive production of choice crops for export to the colonialist's nation for processing into highly diversified advanced products, such as beverages. Specifically, the post-colonial period is characterized by the establishment of increasingly sophisticated and notable schemes and institutions of agricultural development.

2.0 OBJECTIVES

By the end of this unit, you should be able to understand:

- the trend of agricultural development during Nigeria's political history
- the evolution of agricultural development schemes and institutions which have facilitated food production
- the current status of agriculture, and the opportunities for profitable investment in the agricultural sector.

3.0 MAIN CONTENT

3.1 Phases of Agricultural Development

i. Pre-colonial era: Agriculture was the mainstay of the traditional economy during this period.
ii. Colonial era: During this era (1861-1960), the British colonialists paid an *ad hoc* attention to agricultural development, in favour of considerable emphasis on research and extension services.
iii. Post-colonial era: The first national development plan (1962-1968) was drafted. The plan emphasized the introduction of more modern farming techniques, establishment of farm settlements, co-operative plantations, supply of improved farm implements such as hydraulic hand presses for oil palm processing and considerably expanded agricultural extension service.

Thus, two major specialized development schemes were implemented during this period, namely Farm Settlement Schemes and National Accelerated Food Production Programme (NAFPP, which was launched in 1972). Also, within the same period, the following agricultural development interventions for improving food production were experimented upon:

a. Operation Feed the Nation (OFN, 1976);
b. River Basin & Rural Development Authorities (RBRDA), established in 1976;
c. Green Revolution Programme (1980), and
d. The World Bank-funded Agricultural Development Programmes/Projects (ADPs, early 1970s), which constitute the most practical demonstration of integrated approach to agricultural development in Nigeria.

In addition, several research institutes and extension research liaison services were also established. These are the Agricultural Extension Research Liaison Service (AERLS), in Ahmadu Bello University (ABU), Zaria (1963), International Institute of Tropical Agriculture (IITA), Ibadan, and International Livestock Centre for Africa (ILCA) located within IITA.

3.2 Growth of Agriculture

3.2.1 Contribution of Agriculture to GDP

i. In 1960, agriculture contributed about 60% the GDP, a figure which is considered typical for developing agrarian nations.

ii. From 1975-1979, there was a sharp decline in the contribution of agriculture to 25% of the GDP. This sharp decline was attributed to the phenomenal growth of the mining and manufacturing sectors and the disincentive created by the macro-economic environment during the period.

3.2.2 Growth Rate of Agriculture

From 1972-1980, agricultural production stagnated at less than 1% annual growth rate, compared to the annual population growth rate of 2.5-3.0%. During this period, export crop production declined sharply while food crop production increased slightly. The ultimate result of these situations was the need to augment domestic food supply by large food imports. This accounts for the considerable increase in food import bill from as low as ₦112.88 m per annum from 1970 to 1974, to as high as ₦ 1964.80 m in 1991.

4.0 CONCLUSION

In this unit, you have learned that:

i. agricultural development in Nigeria evolved in phases during the country's political history,
ii. increased food production during the post-colonial era arose from the implementation of several development schemes, and
iii. agriculture makes the largest contribution to the national GDP.

5.0 SUMMARY

Agriculture is the largest contributor to national GDP in Nigeria, and its development is greatly influenced by the nation's political history, culminating in increased food production through several intervention schemes, particularly the Agricultural Development Projects.

6.0 TUTOR-MARKED ASSIGNMENT

1. Indicate the three phases of agricultural development in Nigeria.
2. Enumerate the high points of post-colonial development of agriculture in Nigeria.
3. Which post-colonial agricultural development intervention is most impacting on agricultural growth in Nigeria, and why?

7.0 REFERENCES/FURTHER READINGS

'Opportunities in Nigeria's Agricultural Sector'. In http://www.nigeriabusinessinfo.com/agric.htm

MODULE 2

UNIT 1 HISTORY OF AGRICULTURE

CONTENTS

1.0 INTRODUCTION

Agriculture originated in the pre-historic times. Before agriculture, people lived on hunter-gatherer cultures, i.e. by hunting wild animals and gathering edible plants. The herds were plentiful and edible plants grew luxuriantly in the environment. However, with the migration of the herds in the wild man was forced to follow them about and in the process, found out a new variety of edible plants to supplement their diet. Several decades of random and systematic transformations of these primitive practices have resulted in complex, more sustaining and efficient modern sedentary (settled) systems of food, feed and fibre production for the ever-increasing population of man world-wide.

2.0 OBJECTIVES

By the end of this study unit, you should be able to:

- understand the origin(s) of agriculture
- trace the evolution of modern-day sedentary agricultural practices
- appreciate the need to adapt traditional farming techniques in order to improve agricultural productivity.

3.0 MAIN CONTENT

3.1 Origin of Agriculture

3.1.1 Ancient Origins

3.1.1.1 Traditional Agriculture

Agriculture was developed independently by geographically distinct populations. Archeological evidence showed that animal domestication (mainly dogs used as hunting aids) started thousands of years before 7000 B.C., which marked the beginning of agriculture. Further evidence indicates that the keeping of sheep and wild ox and wheat cultivation were practised in 9800 B.C. in Kurdistan. However, intensive food gathering involving permanent settlements and extensive use of existing plants appeared to have started in the Near East around 9000-7000 B.C. Thus, although farmers sporadically used wild cereals earlier, systematic agriculture was first practised in Southwest Asia in the Fertile Crescent (present-day Southern Iraq and Syria). There are several archeological theories of the beginning of seed sowing. However, one theory suggests a correlation between seed spill during a migration and sudden abundance of the plant and the evolution of the knowledge of seed storage and subsequent re-seeding for future food supplies. There is confirmation that agriculture-oriented farmers started the selection and cultivation of food plants with desired characteristics around 9500 B.C. The eight “founder” crops of agriculture were emmer, einkorn wheat, hulled barley, peas, lentils, bitter vetch, chick peas and flax.

3.1.1.2 Small-Scale Agriculture

This practice reached Egypt in 7000 B.C., from where it then spread to the Indian subcontinent with wheat and barley cultivation and followed

thereafter, by mid-scale farming on the banks of the Nile River in 6000 B.C. At this latter time, rice became the primary crop in the Far East as mung, soy, azuki and taro in China and Indonesia. In addition, highly organized net fishing of rivers, lakes and ocean shores in these areas provided considerable volumes of essential protein complements of carbohydrates.

3.1.1.3 Large-Scale Agriculture

Intensive cultivation of land, monocropping, organised irrigation and use of a specialized labour force was developed by the Sumerians in the Persian Gulf around 5000 B.C. In this civilization, the townships provided central services of seed storage that the villages could not handle. Similarly, the large-scale use of animals for food/fibre and as beasts of burden evolved with the domestication of wild aurochs and mouflon into cattle and sheep, respectively. Thus, the shepherd became an essential complementary provider of food and fibre for sedentary and semi-nomadic societies. Other crops such as maize, manioc (cassava) and arrowroot were first domesticated in the Americas around 5000 B.C. while the potato, tomato, pepper, squash, beans, Canna, tobacco, etc developed in the New World. Also, extensive terracing of steep hillsides was developed in the Andean South America. In later years, the Greeks and Romans made few fundamentally new advances based on techniques pioneered by the Sumerians. The Greeks and Macedonians became dominant agrarian societies for years, in spite of the limitation of poor soils for agriculture. The cultivation of crops for trade was emphasized by the Romans.

3.2 Agriculture in the Middle Ages

Further agricultural advances were made with the development and dissemination of agricultural technologies including irrigation system based on hydraulic and hydrostatic principles, use of machines (e.g. norias), water raising machines, dams and reservoirs by the Muslim farmers of North Africa and Near East. They wrote Farming manuals, which were suitable to specific locations and instrumental to the wider adoption of crops as sugar-cane, rice, citrus fruit, apricots, cotton, artichokes, aubergines and saffron. The Muslim farmers also introduced crops such as lemons, oranges, cotton, almonds, figs and bananas to Spain.

3.3 Present-Day Agriculture

The vast improvement in agricultural efficiency in modern times arose from the invention of a three-fold system of crop rotation during the Middle Ages and the importation of Chinese-made mouldboard plough.

After 1492, further development occurred in agriculture through global trade (exchange) of previously local crops (tomato, maize, potato, cacao, tobacco, coffee) between the New and Old Worlds. Several varieties of wheat and spice were also exchanged between the two worlds. With respect to animal trade, the most significant exportation was that of the horse (including donkeys and ponies) from the Old World to the New World, essentially as beasts of burden. By the early 1980s, the improvement in agricultural techniques (primitive genetic engineering in the 1950s), implements, seed stocks and cultivars led to considerable improvement in yield per unit land over the level recorded in the Middle Ages. In particular, agricultural mechanisation (especially tractorisation) improved rapidly between the late 19th and 20th centuries (e.g. mechanical tomato harvesters in early 1960s in the USA) allowed farming activities to be carried out more speedily and on an incredibly large scale. This culminated in tremendously high farming efficiencies in nations such as USA, Argentina, Germany and Israel, and associated super-optimal high-quality produce per unit land.

4.0 CONCLUSION

In this unit, you have learned that:

i. agriculture evolved in the pre-historic times and developed in phases (traditional, small-scale, large-scale), and
ii. modern-day agriculture has its origin in the Middle Ages.

5.0 SUMMARY

Agriculture evolved with the Pre-historic man but has followed complex phases of development to the present-day sedentary form, involving mechanization and improved agricultural practices for sustainable food and fibre production for man.

6.0 TUTOR-MARKED ASSIGNMENT

1. What were the two components of intensive food gathering by the Early man?
2. Classify the phases of the historical development of agriculture.
3. State the highlights of the development of present-day agriculture.

7.0 REFERENCES/FURTHER READINGS

History of Agriculture. *Encyclopaedia Britannica*. http://www. Britannica.com/eb/article-910607/history-of-agriculture

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UNIT 2 CLASSES OF CROPS

CONTENTS

1.0 INTRODUCTION

The grouping of crops probably evolved with their domestication from wild ancestors, and concurrent selection for various uses to satisfy man's needs for food and non-food purposes. This may account for their initial classification on the basis of their economic importance in terms of the consumable parts of the plant. Thereafter, the development of scientific agriculture gave rise to other methods, especially the classification based on nomenclature or binomial system. The use of botanical characteristics is of fundamental scientific significance in crop identification. However, grouping on the basis of economic (agronomic) role in human survival, ranging from food production, fibre supply especially for clothing, and industrial conversion of crops as raw materials to useful products and by-products, is by far the most popular basis for classifying crops, and also the most emphasized in the literature.

2.0 OBJECTIVES

By the end of this unit, you should be able to understand:

- the various ways of grouping crop plants
- why cultivated plants are regarded as primary contributors to national GDP in Nigeria.

3.0 MAIN CONTENT

3.1 Classification Based on Nomenclature i.e. Binomial System

This scheme was formulated by Linnaeus, as a universally acceptable system of naming plants, animals and minerals. This scheme groups plants into divisions, sub-divisions, classes, orders, families, genera, species, subspecies and varieties. Plants are either seed-producing (division Spermatophyta) or non-seed producing (viruses, bacteria, algae, fungi, lichens, mosses and liverworts, ferns and horsetails). Spermatophytes are the most highly evolved and structurally complex plants and are separated into two classes, namely

3.1.1 Class Gymnospermae

These are plants that produce naked seeds, usually in cones which constitute the female organs. They often exhibit structural adaptations to reduce water loss. It comprises the others: Ginkgoales, Coniferales (the most important to horticulture), Cupressaceae and Taxaceae.

3.1.2 Class Angiospermae

These plants produce seeds that are protected by fruits and have flower structures as the means of sexual reproduction. Many of the families are important to horticulture, both as crop plants and weeds. The sub-classes are:

i. Sub-class Monocotyledonae- contains some horticultural families such as Liliaceae (tulips, onions), Amaryllidaceae (daffodil family), Iridaceae (Iris family), Graminae (all grass species).

ii. Sub-class Dicotyledonae- has many more families significant to horticulture, including the Compositae (e.g. chrysanthemum); Cruciferae (e.g. cabbage, Brussels sprouts); Rosaceae (e.g. apples, pear, rose); Leguminosae (Fabaceae, e.g. pea and bean family, pod-priducing and contain starchy seeds), Solanaceae (e.g. potatoes, tomatoes), Cocurbitaceae (e.g. cucumbers, marrows), Labiatae (mostly culinary herbs), Cactaceae and Crassulariaceae (widely used as ornamentals); and Aceracea (e.g. common sycamore, ornamental *Acers*); and Salicaceae (e.g. willows).

Generally, plants are identified by means of the composed *generic* and *specific* names viz. chrysanthemum as Chrysanthemum (*genus*) morifolium (*species*).

3.2 Classification Based on Botanical Characteristics

Crop plants are grouped into monocotyledonous species (species having only one seed-leaf or cotyledon) and dicotyledonous species (species having two cotyledons in their seeds). Typical examples of monocots are cereals (maize, barley). Dicot crops include legumes/pulse crops (cowpea, soybean, alfalfa).

3.3 Classification Based on Duration of Crop Growth

This scheme groups crops into:

i. annuals- crops which complete their life cycle in one year e.g. maize, cowpea, tomato, soybean, amaranthus okra and yam.
ii. biennials- crops which complete their life cycle in two years e.g. cassava, brassicas,
iii. perennials- crops which live for more than two years or year-in-year-out e.g. cacao, rubber, plantain/banana, oil palm, ginger and sugar-cane.

3.4 Classification Based on Economic/Agronomic Importance

This scheme groups crops variously by the use of the parts consumed directly, their food and non-food nutrients, or indirectly by man for the provision of food, fibre and other essential purposes. The groups include:

i. **Starch Plants -** These are crops grown primarily for their high calorific value in human diets as starch, carbohydrates and sugar. However, a larger part of the crop is processed into pure starch used in industries for sizing threads and cloth finishing, in pharmaceutical preparations, as powder in cosmetics and medicines, drying material, for glues (pastes), filter (as dextrin, sugar, dextrose, maltose and fructose syrup). Examples include cereals (maize, rice), pseudocereals (rye, oats), roots (cassava, Irish potato) and tubers (yams, sweet potato) and others (breadfruit, banana).

ii. **Sugar Plants -** These crops are essentially grown for the production of sugar. The sugar is used in sweetening drinks, baked foods, enhancing flavour in many food preparations, canning industry, and production of sweets. Examples are sugar-cane, sugar beet, and others such as sugar palm, sugar-rich *Sorghum* and agaves.

iii. **Oil Plants-** These are crops grown essentially for their oil supply. The production of oil plants ranks third in world production in terms of value, after starch plants and fruits, and higher than that for beverages and stimulants, and sugar. Over 90% of the plant oils are used as edible oil in human diets and the remainder for technical purposes. As edible oil, they supply vitamin A (e.g. carotenoids), vitamin E (tocopherol) and ergosterol (pro-vitamin D2), phospholipids and sterols, and are used for drying fat. Technically, they have varied uses including making soaps and detergents, as suppositories, and for lighting and burning. Plant oils include cooking oils (e.g. oil palm, soya oil), vegetable butter (e.g. cacao butter, sheabutter), salads and margarine (e.g. sesame), and technical oils (e.g. *Brassica juncea*, coconut, linseed).

iv. **Protein-Providing Plants-** These are crops desired for their protein value in human diets. Plant proteins mostly contain insufficient quantities of essential amino acids and therefore, inferior to animal proteins. However, they contribute a significant proportion of the world protein supply, especially cereals which contribute the largest proportion of the plant protein supply, followed by oilseeds especially soybean. The "true" protein plants, the pulses crops (cowpea, soybean, pigeon pea, lentils, lupins), contribute only a small portion.

v. **Vegetables-** This group of plants is found in a variety of crop species, including cereals, seasonings, roots and tubers, legumes, fruits, and oil seeds. Vegetables are of great significance in the tropics and subtropics as food (supplying minerals, vitamins, proteins) and as commercial products of market gardening. Leaf vegetables are important sources of protein in the tropics. Examples of vegetables are leaf vegetables such as jute mallow, cabbage, spinach, lettuce, fluted pumpkin), fruit vegetables (tomato, cucumber, melon, gourd, eggplant, calabash, peppers, okra) and root vegetables (carrots, turnips, radish, beetroot, clove, sweet potato). Other crops are sweet corn, asparagus, cauliflower, cocoyam, sweet potato, Irish potato, and seed legumes such as beans.

vi. **Fruits-** These are crops grown and then, eaten for their refreshing and aromatic taste which give pleasure to human, and even, animal consumers. They have a very important role in human nutrition and health. They contain substances which regulate and stimulate food digestion, organic acids which act as mild laxatives or diuretics, and pectins and phenolic compounds, which regulate pH in the intestine, thereby normalizing the

intestinal flora. The compounds also act bacteriostatically, virostatically and detoxify heavy metals. Examples are many fresh fruits (cashew, mango, grapes, avocado) and dry fruits (dates, figs, muskmelon, watermelon).

vii. **Nuts-** These are fruits with dry shells (hazel nuts), parts of fruits (coconuts, walnuts), or seeds (Brazil nuts), which, due to their pleasant flavour, are eaten raw, roasted or cooked. Thus, they are widely used in confectionery as aromatic agents and in other foods. They have a high nutritional value in respect of their energy and protein contents. Other examples are peanuts, chickpeas, sunflower seeds, cashew nuts, chestnuts, almond, macadamia and pecan nut.

viii. **Beverages, Masticatories and Stimulants-** These are plants which contain chemical compounds that increase the physical and mental effectiveness, quench thirst and hunger, break down psychic inhibitions, or produce fantastic dreams. Some stimulants are only for consumed their aroma (caffeine-free, coffee substitutes and nicotine-free tobacco). The active constituents (caffeine, theobromine, morphine, codeine, cocaine, arecoline, glucoside) of some stimulants are used in other areas of activity. Examples include coffee, tea, cacao, kola nuts, betel-pepper, tobacco, quinine and opium.

ix. **Spices-** These include all culinary herbs, seasonings and condiments of vegetable origin. They are used for improving the taste of foods in food industry, beverages industry and technical raw materials. They serve as medicinal plants (e.g. Cinchona spp.), stimulate the flow of saliva and the secretion of enzymes (protein and fat digestion) in the stomach-intestinal systems. Other examples are mustard, black pepper, onion, clove, pepper, vanilla, ginger, hop, sweet basil, garden thyme and nutmeg.

x. **Medicinal Plants-** To the agriculturalist, the most important medicinal plants are those containing active constituents which cannot be synthesized by the pharmaco-chemical industries (or only at very high cost), and which cannot be substituted by other compounds e.g. alkaloids (e.g. Cinchona, Datura, Papaver), Digitalis glycosides, flavonoids and mucilages. They include many spices and stimulants. However, they are of very little economic importance to the cultivator but of great importance to the pharmaco-chemical industries.

xi. **Essential Oils-** These are volatile substances. They, therefore, have distinct odours and thinness for paints (turpentine oil,

camphor oil). They are used in perfume industry and for cosmetic articles such as soap, ointments and powder; for technical purposes as solvents and floatation agents, for masking smells in plastics, artificial leather, rubber, floor wax and household sprays. Also, they are valuable in pharmaceutical preparations because of their specific effects (anise oil, fennel oil, camomile oil), their antiseptic properties and to improve taste (toothpaste). Examples are citrus oils (peel oils from lemon, lime, mandarin, grapefruit, bergamot), leaf oils (petitgrain oils), flower oils (orange flower oils, neroli oil from bitter orange), and grass oils (citronella oil, lemon grass oil, vetiver oil, palmarosa oil).

xii. **Fibre Plants-** These are plants grown for use in weaving a great variety of household and commercial materials. They are highly valued in textiles and curtains (flax, sunn hemp, cotton), packaging and paper materials (particle boards and composites), floor coverings (jute, kenaf, agave fibre, door mats from coir), making tear-proof paper (halfa grass), brooms, basket-work and building materials (piassava, sorghum, agave fibres, raffia and other palm fibres).

xiii. **Elastomers-** These are natural and synthetic polymers with rubber-elastic properties. The natural elastomers are polyisoproprenes which are either caoutchouc (with highly elastic properties or gutta-percha, with slight elasticity but having strongly thermoplastic properties (softening at high temperatures; and hardening at room temperature). Polyisoprene is concentrated in the vacuoles of cells, especially in the latex tubes. Elastomers are very useful in making tools (e.g. knife handles), natural rubber (vehicle tyres, packings, break pads, insulators, driving belts, golf balls), as a caulking material for boats and containers, and for making toys, chewing gum and wax. Like milk, elastomers are used for coffee, manioc diseases etc., and are of medicinal importance. Examples of plants are rubber (cautchouc), guoyule and gutta sundek.

xiv. **Resins and Gums-** Resins are complicated mixtures of diterpenes with volatile terpenes (e.g. pinene), coniferyl esters, gums and aromatic compounds. The resins are not always separable from gums but most burn well. In the plants, they are exuded in a liquid state into secretory ducts in the bark and the wood, but most often, the resin flow is stimulated by wounding the bark of the wood. Most resins are obtained from wild trees or shrubs. The cultivated plant sources are *Shorea robusta*, arar tree, copaiba balsam, rattan plam, grass-tree gum and sal tree. The resins and gums are used as solvents (turpentine oil), as aromatics

in perfumes, fumigation products , cosmetics (skin creams) and chewing gum, and technically for making colophony, putty, picture and photograph lacquers, in cheap paints, incense and salves and as flavouring in lemonade, bakery, soaps and sweets.

xv. **Tannin Materials-** These are complex phenolic compounds with a large number of oxygen functions. They can exist as hydrolysable tannins (oak gall, chestnut) or condensed tannins, made up of flavonoids, flavones and catechins (e.g. mimosa bark). They are found in the parenchymatic tissues of many plants, in usable concentrations especially in the bark, wood of the trunk, roots, fruits and galls. They are used for tanning leather through precipitation of protein which thereafter prevents swelling in water and resists rotting, medicinal benefits in pharmaceutical preparations (e.g. tara rubber), technically for reducing the viscousity of drilling slurry from deep-drilling projects and as a colourant (e.g. black colourant in *Caesalpinia spinosa* tara powder). Other examples are black wattle and brown mallet.

xvi. **Dyes and Colourings-** These include plant pigments found in the plant cells, either in the plastids or in vacuoles. They belong to a variety of chemical groups such as anthocyanins (red pigments), betacyanins (betamin), some carotenoids (bixin from annatto, capsanthin from paprika, zeaxan from tomatoes, carthamin from safflower), yellows from the carotenoids xanthophylls, zeaxan and azafrin; curcumin from *Curcuma longa* and chlorophyll. The uses of dyes and colourings are beautifying the body, clothing (e.g. indigo) and home decorations, as colourant additions in food (rice dishes, manioc, fatty foods, fat-free foodstuffs, gums, starch preservatives), drinks, confectionery and cosmetic industries, as aromatics for sweets, baking, lemonade and chewing gum, for producing ink (e.g. *C. sappan* in India) and for dyeing leather, hair and fingernails. Other examples are *Bixa orellana*, *Acacia catechu, Indigofera arrecta, Lawsonia inermis* and *Escobedia scabrifolia*.

xvii. **Pesticides-** These are plants that contain natural protective compounds (pyrethrins from pyrethrum, rotenone from derris and cube, nicotine from tobacco, anabasine from Anabasis aphylla; alkaloids such as wilfordine from Thundergod vine and ryanodine from ryania) against insect pests, ectoparasites, etc. Other plants have molluscicidal and nematicidal properties.

xviii. **Waxes-** These are fatty substances, characteristically containing esters of long-chain fatty acids with long-chain primary alcohols,

bivalent alcohols, hydroxyl fatty acids, paraffins and resins, as unwanted impurities. Most of the waxes of economic importance are exudates from the epidermis of leaves, stems and fruits. The most important sources are carnauba, candellia, jojoba and Japan wax. Wax is also extracted as a by-product from the processing of sugar-cane, rice and sorghum (sugar sorghum, grain sorghum) from the production of raffia fibres and from the bark of Douglas fir. Waxes are used for coating fruits (citrus, apples), in cosmetics (especially in lipsticks), textile, leather and paper industries, in making candles, matches, painting materials, carbon paper, chewing gum, polishing materials for floors, furniture, cars and shoes, and in pharmaceutical preparations.

xix. **Forage and Pasture Plants-** These are plants produced for feeding various domestic animals, including silkworms, bees and lac insects. The plants include tropical legumes and grasses, fodder melons (*Citrullus lanatus*), fodder gourds (*Cucurbita pepo*), fodder beets (*Beta vulgaris*), Japanese fodder radish (*Raphanus sativus*), fodder kale (*Brassica* spp.) and fodder sorghum and *Pennisetum americanum*. Tropical pasture fodder crops include Southern gamba (*Andropogon tectorum*), molasses (*Melinis minutiflora*), pigeon pea (*Cajanus cajan*), calopo (*Calopogonium mucunoides*) and centro (*Centrosema pubescens*). Other plants are maize, grain sorghum, cassava, cowpea, hyacinth bean, breadfruit and dates. Bees are fed on pawpaw leaves, and silkworms and lac insects on pigeon pea.

xx. **Ancillary Plants-** These are plants cultivated in agriculture and forestry not for direct benefits to man but for their capacity to encourage the growth and development of other plants. These benefits arise from soil improvement, ground covering, prevention of soil erosion, as wind-breaks, shade provision, support for climbing plants and “living fences”. Examples of the plants are *Grevillea robusta*, black pepper, belch pepper, vanilla, *Centrosema pubescens*, Gliricidia, vetiver, acacia and cashew.

4.0 CONCLUSION

In this unit, you have learned that:

i. crops can be classified differently on basis such as nomenclature, botanical features, duration of growth and economic use; and
ii. several crop parts are highly valued for domestic and foreign exchange, leading to significant contributions to national development.

5.0 SUMMARY

Crops vary widely not only in their nomenclature, botanical features, duration of growth but also in their economic importance. The latter grouping is by far the most commonly appreciated due to the emphasis on direct and indirect uses of parts of the crops and the contributions of different crops to the national GDP.

6.0 TUTOR-MARKED ASSIGNMENT

1. Mention the four bases of grouping crops.
2. Why is binomial nomenclature the most universally acceptable basis for classifying crops?
3. State the difference between the following groups of crops:

a. Class Gymnospermae and Class Angiospermae; (b) biennials and annuals; and dicots and monocots.

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UNIT 3 CHARACTERISTICS OF TROPICAL CROPPING SYSTEMS

CONTENTS

1.0 INTRODUCTION

Tropical Africa lies south of the Sahara Desert. It extends over the entire equatorial belt of Africa and latitudinally to about 20^0N and 26^0S, thus exhibiting great diversity in relief, climate, vegetation and crops grown. The diversity in the number of crops grown and variations in cropping and farming systems has been attributed to the multiple racial background and linguistic grouping, differences in cultural, economic, colonial and political backgrounds and experiences, the level of technological development and resource availability. These aspects have great implications for the characteristic features of tropical agriculture.

2.0 OBJECTIVES

By the end of this study, you should be able to understand:

- the basis for the predominance of the traditional multiple systems of cropping and farming in tropical Africa
- the external factors which influence the traditional cropping systems.

3.0 MAIN CONTENT

The characteristics of tropical agriculture are strongly influenced by the prevailing customs and the needs of the farmer.

3.1 The General Characteristics of Tropical Cropping Systems

i. there is a diversity of farming systems ranging from "true" shifting cultivation where the settlement is moved to permanent cultivation;
ii. "true" shifting cultivation is rare and restricted to certain areas;
iii. permanent cultivation occurs in compound farms, kitchen or homestead gardens, some soils of high fertility, confined sites, and overcrowded areas of high population densities;
iv. the compound farm system is the most widespread permanent cropping or farming system and often forms the nucleus of other field systems;
v. semi-permanent long and short bush or planted fallow systems vary in cultivation period relative to length of fallow;
vi. the most important staples and cash crops are usually grown in the first year following clearance of forest, natural bush, planted fallow or grassland;
vii. intercropping is widespread with the highest complexity in the compound gardens, especially in the rainforest where annual staples, vegetables and perennial fruit trees are intercropped;
viii. mixed intercropping and relay intercropping are more common than sequential cropping monocultures;
ix. classical crop rotations involving sequences of crops grown in monoculture are rare in traditional farming systems;
x. farm sizes are usually small ranging from less than 1 ha up to 5 ha;
xi. cash or export crops are more likely to be grown as sole crops or in association with fewer crops than non-cash staples;
xii. farming involves simple tools and much human labour;
xiii. the most widespread land clearing systems involve the use of fire; and
xiv. most cropping systems rely on rainfall except some locations in semiarid and arid areas where irrigation is practised. The uncertainties in rainfall distribution and intensity determine the variations in cropping patterns and mixtures.

3.2 Factors Causing Variations in Tropical Cropping Systems

Variations and changes in cropping systems are caused by

i. the introduction of Asian crops such as taro, water yam, bananas and rice and American crops such as maize, cassava and sweet potatoes;
ii. population growth, which follow the introduction of Asian and American crops;
iii. the development of markets for perennial crops;
iv. expansion of cassava production due to its adaptation to shorter periods of fallow leading to lower soil fertility and demands for cheaper staple foods in urban centres;
v. development of commercial production of food crops and market gardening-especially close to urban centres;
vi. development of railways, road systems, and markets and the growth of settlements and farms along roads and railways and close to markets; and
vii. increased fruit and vegetable production for sale and in support of local canning industries.

4.0 CONCLUSION

In this unit, you have learned that:

i. agriculture is characterized mainly by traditional multiple systems arising from diverse cultural, economic, colonial and historical backgrounds, among other factors, and
ii. external factors such as population growth, commercialization and modernization caused variations in traditional cropping systems.

5.0 SUMMARY

Tropical agriculture comprises predominantly of traditional multiple cropping systems which vary with prevailing customs and needs of farmers, and changes with population pressure, commercialization and modernization, etc.

6.0 TUTOR-MARKED ASSIGNMENT

1. What two factors influence the characteristics of tropical agriculture?
2. Enumerate any five characteristics of agriculture in the tropics.
3. What factors account for variations in tropical cropping systems?

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UNIT 4 SYSTEMS OF CROP PRODUCTION

CONTENTS

1.0 INTRODUCTION

Cropping systems probably originated as a second and advance phase in the transformation of intensive food gathering by the Early Man, with the practice of food selection and cultivation around settlements. The compound farms system is the most widespread permanent cropping system. It often forms the centre of diversity to other field systems. A common feature of traditional farming systems is the production of several crop species and varieties of each species by each farmer. However, a great variety of farming systems ranging from the “true” shifting cultivation to permanent cultivation, have developed thereafter and these were significantly intertwined with man’s history and the need for abundant food supply, in different parts of the world. Basically, the two common objectives of these diverse systems are soil sustenance for adequate food supply and sufficient agricultural productivity.

2.0 OBJECTIVES

By the end of this unit, you should be able to learn:

- the fundamental aspects of cropping systems
- their practical benefits and limitations in food production.

3.0 MAIN CONTENT

3.1 Evolution of Farming Systems in Tropical Africa

The factors influencing the diversity in the number of cultivated crops and variations in cropping systems include cultural diversity, economic differences, colonial background, political history, experience, level of technological development, and availability of resources.

The early cropping systems are based on these factors and include nomadic herding, shifting cultivation, rudimentary sedentary cultivation, non-rice-based intensive agriculture, special horticulture and plantation agriculture. More advanced classification schemes of tropical agriculture have identified the influence of vegetation type, migration, rotation, clearance, cropping and tool systems on cropping systems. However, the most important bases for differences in cropping systems are intensity of cropping and duration of the fallow period for soil fertility restoration. Based on the various classification schemes, two categories of farming systems are identifiable:

A. Traditional and Transitional Systems- These Comprise of

i. Nomadic Herding (Shifting Cultivation Phase I, Land Use Factor (L) > 10^2 years)'
ii. Bush Fallowing/Land Rotation (Shifting Cultivation Phase II, L= 5-10 years),
iii. Rudimentary Sedentary Agriculture (Shifting Cultivation Phase III, L= 2-4 years),
iv. Compound Farming & Intensive Subsistence Agriculture (Shifting Cultivation Phase
v. IV, L < 2 years),
vi. Terrace Farming & Floodland Agriculture, and
vii. Mediterranean Agriculture (traditional).

B. Modern Farming Systems and their Local Adaptations

i. Livestock Ranching,
ii. Intensive Livestock Production (poultry, pigs, dairying),
iii. Large-scale Farms & Plantations

- Large-scale Food & Arable Crop Farms, based on natural rainfall
- Irrigation Projects involving Crop Production
- Large-scale Tree Crop Plantations

iv. Specialised Horticulture

- Market gardening
- Truck Gardening and Fruit Plantations
- Commercial Fruit & Vegetable Production for Processing

v. Mediterranean Agriculture (modern).

3.2 Types of Cropping Systems

3.2.1 Nomadic Herding

This system is common in t he arid regions where low rainfall prevents the cultivation of crops on a large scale. Therefore, animal husbandmen herd their livestock from place to place in search of green pasture (especially grass) and water. This practice is referred to as "transhumance pastoral nomadism".

3.2.2 Bush Fallowing

This is a type of subsistence agriculture in which land is cultivated for a period of time and then left uncultivated for several years so that its fertility will be restored. It involves fixed settlements, but periodic shifting rotation of fields within the cultivated land. In the early times, fallow fields may be left untilled or tilled but not planted for the fallow period. Sometimes, the fallow fields were used for pasturage for animals, which had the incidental benefit of fertilizing the soil. Short rotational bush and grass fallow systems are the dominant systems of traditional agriculture of both the forest and savanna environments. Reasons for this are lack of a suitable alternative for soil fertility sustenance and crop production and higher frequency of cultivation. Fallow types may be natural (colonized by invading weeds), or planted with quick, improved fertility-regenerating leguminous (weed) species e.g. Peuraria phaseoloides, Mucuna utilis (herbs) and Crotalaria spp. (shrub). Planted green fallows are common in some parts of Eastern Nigeria in response to high population pressure on available land. An added advantage of this is the superior competitive ability of the green fallow species over the native weeds in the fallow, although the practice requires huge time and money investments in seed sowing, which may reduce the cost/benefit ratio.

3.2.3 Shifting Cultivation

In this system, a piece of land is cultivated for a few years and when the soil is showing exhaustion in form of poor crop yields, the farmer abandons the land and moves to another, more productive site for

cultivation. Unlike bush fallowing, shifting cultivation in addition to periodic rotation of fields, involves an occasional movement of settlements with cultivated fields. It is the most common system of subsistence farming, and specifically incorporates slash-and burn practice (the cutting and burning of forests or woodlands to create fields for agriculture or pasture for livestock). The advantages include keeping the soil sufficiently fertile when there is abundant available land for farming and preventing the spread of insect pests, other pests and plant pathogens. The disadvantages are greater, and include inadequate cultivable land for food production, requirement of large land area, inadequate time for soil fertility restoration and waste of farmers' energy resources in frequent slashing of agricultural fields.

3.2.4 Mixed/Multiple Cropping Systems

These involve the simultaneous cultivation of two or more crops on the same piece of land in at least a part of the growing season. No organization or sequence of crop planting is required in this system as in multiple cropping. The systems constitute a major component of traditional farming and typically mimic species diversity in uncultivated and virgin lands. Significant advantages include security of food and income and the maintenance of soil productivity, through prevention of soil erosion and weed interference and soil nitrogen fixation by legume components. The most widespread varieties of mixed cropping are mixed intercropping and relay cropping and relay intercropping. Relay cropping involved two crops following each other in sequence such that the time between the growth periods of the two crops is reduced to the barest minimum; one crop is brought in as the first crop is maturing e.g. wheat/soybean. In relay intercropping, the component crops grow together for longer e.g. cassava/maize; cassava is planted 4 weeks before sowing maize. Other mixed cropping systems include double cropping, triple cropping and alternate strip cropping in market gardens and with specific vegetable crops.

3.2.5 Continuous Cropping

This is a modern cropping system in which the same piece of land is cultivated year-in-year-out. The system is a response to frequent human population pressure and unavailability of arable land. Chemical fertilization and organic manuring are very critical practices for soil fertility sustenance. Components of this system include monocropping, plantation agriculture (monoculture) and rotational cropping.

3.2.6 Crop Rotation

Crop rotation practice dates back to the end of the Middle Ages, traceable to the ancient Romans, African and Asian cultures and thereafter, with the practice of three-year rotation by farmers in Europe. This is the practice of growing a well-planned series of dissimilar and specific types of crops in the same space in sequential seasons to avoid the build-up of pathogens and pests that often occur in continuous cropping of a plant species. The succeeding crops are of a different genus, species, subspecies, or variety than the previous crop in the rotation. No two crops subject to similar diseases follow each other within the disease's incubation period while the rotation makes it more difficult for emerging insect pests to find their preferred food, either above (in the growing crops) or below the soil. A well-planned rotation helps create a garden that is constantly new (green) and fascinating. Rotation sequences may be for a two- or three-year or longer. It is mainly targeted at the use of organic farming, where pest control may be achieved without expensive synthetic pesticides and sustainable soil fertility without bush fallowing. The general purposes of crop rotation are

i. improvement or maintenance of soil fertility through the use of green manure in sequence with cereals and other crops;
ii. reduction of soil erosion
iii. reduction of the build-up of pests and pathogens, thereby reducing reliance on chemical pest and disease control;
iv. spread of the workload on farms
v. reduction of the risk of weather damage
vi. reduction of the reliance on agricultural chemicals, including inorganic fertilizers;
vii. increased of net farm profits
viii. beneficial residue herbicide carry-over, thereby improving weed control especially parasitic weed species;
ix. improvement of soil tilt and aggregate stability through alternation of deep-rooted and shallow-rooted crops;
x. soil water management
xi. reduction of allelopathic or phytotoxic effects, and shifts in weed populations, whereby certain weed species are suppressed by competition from the crop or by selective use of herbicides.

Generally, these combine to give immediate economic benefit through improved crop yields, while allowing the farmers to keep their fields under continuous production. This obviates the need for bush fallowing as well as expensive chemical fertilizers.

3.2.7 Monocropping

This is a modern cropping system in which different but specific crops are grown on the same piece of land in a logical or scientific sequence. The component crops are selected on the basis of complementary or supplementary relationship; deep soil feeders (e.g. yams) should follow shallow soil feeders (e.g. maize. The system is chemical intensive, and problematic because farmers practice a lot of deforestation and shorter fallowing.

3.2.8 Taungya Farming

This is an agro-forestry practice whereby crop husbandry is combined with forest management, especially in forested areas protected as reserves. Timber contractors are allocated plots within which they are allowed to fell valuable timber trees, and simultaneously use the land for the cultivation of annual and biennial crops. Forest tree seedlings are nurtured along with the food crops. The main target of the system is to enhance an optimum establishment of a forest.

3.2.9 Alley (Hedgerow) Cropping

This involves managing parallel single or multiple rows of perennial woody plants with annual agronomic and horticultural crops, and forage crops planted in the wide interspaces (alleys) of the woody species. Advantages of alley cropping are high soil fertility from both nitrogen fixation trees (NFTs) and green manure from decomposing periodic mulch prunings, and weed suppression by hedgerow canopy cover and mulch. This also reduces the demand on chemical fertilizers. When yams are cultivated, the stalks of hedgerow species serve as stakes for the growing yam vines. Examples of woody hedgerow species are *Leucaena leucocephala*, *Gliricidia sepium*, *Gmelina arborea*, *Calliandra calothyrus* and *Sesbania grandiflora*. On sloping land, trees act as a physical barrier to surface water runoff and erosion. The hedgerow species also enhance soil physical conditions which improve nutrient utilization, reduce wind erosion and modify the microclimate for improved crop growth. Alley cropping also provides excellent opportunities for improving wildlife habitat.

3.2.10 Mixed Farming

This system involves the complementary raising of crops (arable agriculture) and livestock (pastoral farming). In a typical mixed farm, a farmer may cultivate pasture or maize to feed some of the animals while the animals provide traction and transportation services as well as manure. The manure (additional droppings, wastes) facilitates soil

improvement which ultimately improves crop yields. When properly maintained, mixed farming encourages the intensification of land use for cropping through short fallows. In this system, the farmer is usefully engaged throughout the year thus spreading labour and re-utilising resources to earn more income from the crop and livestock enterprises. Mixed farming is a lower-risk strategy than monoculture, especially when climate, pests and disease and market prices are unfavourable for one crop or type of livestock. Mixed farming also preserves natural resources and the environment, thus improving biodiversity and environmental benefits of agriculture. Generally, the efficiency of the system depends on the socio-economic preferences of the farmers and biophysical conditions such as rainfall, radiation, soil type and disease pressure. Mixed farming systems are classified on the basis of land size, type of crops and animals, geographical distribution, market orientation, etc. The three major categories in four different modes of farming are on-farm versus between-farming mixing, mixing within crops and/or animal systems and diversified versus integrated systems. The modes of farming refer to different degrees of availability of land, labour and inputs, and these range from plenty of land to a shortage of land. Mixed farming was first introduced into parts of Northern Nigeria in the 1930s. In these areas, the rotational grass fallow system of food and export-crop production is combined with aspects of animal husbandry.

4.0 CONCLUSION

Cropping systems originated from the pre-historic era of subsistence agriculture but have systematically transformed into highly advanced, specialized and diverse systems which essentially guarantee soil sustainability for adequate food production, agricultural productivity and environmental preservation.

5.0 SUMMARY

Farming systems vary widely the intensity of cropping and duration of bush fallowing for soil fertility restoration, from traditional /transitional agriculture to modern sedentary systems, which assure commercial food production.

6.0 TUTOR-MARKED ASSIGNMENT

1. State any four factors which influence the type of cropping system practised by a farmer.
2. State the major difference between Bush Fallowing and Shifting Cultivation.
3. Define the following cropping systems:

(a) mixed cropping, (b) mixed farming, (c) Taungya farming, and (d) alley cropping.

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UNIT 5 CULTURAL PRACTICES IN CROP PRODUCTION

CONTENTS

1.0 INTRODUCTION

Crop production is a complex process involving series of sequential and non-sequential operations leading to the harvest of mature consumable produce. These operations are practices and techniques carried out during the crop production process which are directly aimed at creating a favourable environment for crop growth and development, and the realization of crop's potential yield and produce quality. Specifically, the "cultural" practices are beneficial to optimum crop yield and quality through improved competitiveness with weeds, control of weeds, other crop pests and pathogens and modify the soil environment (such as physical conditions, water status, fertility level, biochemical activity).

Breeding of improved crop varieties (especially genetic engineering) is a modern cultural operation which has contributed significantly to considerable increases in crop yields and produce quality through pathogen and pest resistance, adaptation to adverse environments, and even pesticide-resistant crop varieties. In some cropping situations, cultural practices serve as alternative to herbicides when none is available or when the grower decides against herbicide use.

2.0 OBJECTIVES

By the end of this unit, you should be able to:

- learn about the overall aim of carrying out cultural operations in crop farms
- become familiar with the sequence of operations used in producing crops generally, and specific crops in particular
- understand the specific benefits of certain operations in crop production
- understand the practical application of the various operations for profitable and environment-friendly crop production.

3.0 MAIN CONTENT

3.1 Pre-Planting Practices

3.1.1 Seed Pre-Treatment

Dormant seeds are often difficult to germinate because they have hard seed-coats or other seed coverings. These dormancy problems are removed physically by scarification (especially using sand-paper), shelling or cracking and soaking in water overnight. Seeds of some crops require hot water treatment or scarification with concentrated sulphuric acid to break their dormancy. Cold temperatures (stratification/vernalisation) and use of chemicals such as gibberellic acid (plant growth hormone) and potassium nitrate also helps to break seed dormancy of some seeds types.

3.1.2 Seed Protection Treatments

Seed health and protection are the first steps in the reliable production of economically-viable crops. Seed treatment, whether by chemical, physical or biological means, is a vital input in today's agricultural and horticultural production systems. Seed treatment fungicides are useful tools to manage seed- and soil- borne pathogens. Lower-quality seeds or poor seed viability results in poor crop establishment and associated higher weed pressure and reduced final yield and farm income. Seed-

borne diseases are controlled using disinfectants and systemic fungicide treatments. Disinfectants are applied to seed surface to control pathogens. Often, organo-mercury chemicals are effective. Fungicide treatments help to control pathogens within the seed structure. The applied chemical is absorbed by the developing seedling where they inhibit internal fungal development e.g. Carboxin. The use of soil sterilants for controlling soil-borne diseases is restricted largely to control environment soils because they are generally non-selective. Soil protectant fungicides are more useful, and can be applied at sowing time to protect emerging seedlings from attack by soil pathogens such as damping-off e.g. thiram, captan. However, there is a need to identify the pathogens on the specific field in order to choose the best fungicide or combination of fungicides. Also, choosing the correct fungicide is critical to limit the losses due to seed-borne pathogens. Other seed treatments for the control of seed- or soil-borne disease in grain cereal and legume crops are Apron plus, Apron XL (mefenoxam), Maxim (fludioxonil), Allegiance (metalaxyl), Agrosol FL (captan, TBZ), Agrosol T (thiram TBZ), Raxil-Thiram (tebuconazole, thiram), Vitavax-200 (carboxin, thiram). For vegetatively-propagated crops (e.g. cassava, yams), stem cuttings, meristem cuttings, yam setts or seed yams should be obtained from healthy mature plants. Fungicide powders, e.g. Benlate and wood ash, are very effective for dusting setts and seed yams while fungicide dips are used for treating cuttings.

3.1.3 Land Preparation

3.1.3.1 Land Clearing

Soil preparation for sowing involves land clearing and tillage. Wet soil may need to be drained while dry soil may require irrigation. Land clearing may be done manually (using machete, hoe), mechanically (using bulldozers!, stumper) or chemically (using non-selective herbicides in zero or no-tillage system). Bush burning (uncontrolled, controlled) helps to get rid of fallow or excess debris. Except in mechanical land clearing, farmers retain the heavier, bigger and more economically-useful trees such as palms, fruits, exportable timber, nitrogen-fixing trees, NFTs, some of which also help to preserve the soil environment.

3.1.3.2 Tillage

This involves the turning of the topsoil either manually (traditionally, minimum tillage) mechanically (conventional tillage), essentially targeted at creating a favourable environment for crop establishment. Primary tillage loosens the soil and mixes in fertilizer and/or plant material, resulting in soil with a rough texture. Secondary tillage

produces finer soil and sometimes shapes the rows. It is done by using various combinations of equipment such as mouldboard plough, disc plough, harrow, dibble, hoe, shovel, rotary tillers, subsoiler, ridge- or bed –forming tillers, and rollers. No-till farming involves the growing of crops without tillage through the use of herbicides, genetically-modified (GMO) crops that tolerate packed soil and equipment that can plant seeds or fumigate the soil without really digging it up. Tillage uses hoofed animals, animal–drawn wooden plough, steel plough and tractorised ploughing.

3.1.4 Planting/Transplanting

Seeds of many crops can be planted by direct sowing in well-prepared field plots. Direct seed-sowing is achieved by broadcasting (especially for small seeds), drilling and planting in holes. In manual planting, seeds are sown using planting stick or cutlass. Mechanical planters are available and some of them perform combined operations such as seed sowing, fertilizer and pesticide application simultaneously. Vegetative propagules are usually manually planted in holes dug in soil with a cutlass and at reasonable depth, or mechanically. For some crops, seeds require pre-nursery (e.g. oil palm) or nursery (e.g. tomato) where seeds and seedlings are hardened for subsequent field establishment. Growth chambers, nursery bags and seedbeds are also required for germinating some crops. Transplanting involves carefully moving seedlings (potted, unpotted ‘nursery transplants’) at appropriate times from the nursery to the field, during the rainy season or under copious irrigation. Field planting of crop propagules requires adequate spacing to obtain optimum yields.

3.2 Post-Planting Practices

3.2.1 Thinning

This is the removal of excess seedling stands from a hill or row of crop. Thinning helps to reduce interplant competition thereby creating adequate growth environment for optimum productivity.

3.2.2 Supplying

This involves the filling of empty stands of crop arising from sowing, germination or emergence failure, or localized herbivory in a field. In some crops, viable seedlings removed during thinning may be used for supplying missing stands.

3.2.3 Watering

In transplanted crops, copious watering is required immediately after transplanting for initial seedling establishment on the field. Irrigation, through controlled application of water over a crop field, is required for dry planting and production of crops. Proper irrigation leads to increased yields from more plants, and higher yields from healthier plants. Over-irrigation is damaging, because poor drainage causes waterlogging which results in poor crop establishment, growth and salting of farmlands. The type of irrigation to be adopted depends on water sources, methods of water removal and transportation of water. Techniques include manual system using buckets (bucket irrigation), sub-irrigation (seepage irrigation), lateral move (side roll, wheel line) irrigation, centre-point irrigation, sprinkler (overhead) irrigation, drip/trickle irrigation, localized irrigation, surface irrigation and in-ground irrigation.

3.2.4 Weed Management

This encompasses all aspects of weed control, including prevention of spread and land use practices and modification in the crop's habitat that interfere with the ability of the weeds to adapt to the crop's environment. The three methods of weed management are:

i. Preventive Approach- This involves forestalling the incidence of weed infestation through plant quarantine, animal quarantine, fallow management, farm sanitation, rogging isolated stands, preventing weed seeding, re-seeding and propagule regrowth and weed contamination of crop propagules. Other measures are choice of variety and field, planting rather than sowing, crop sequence, accurate sowing and planting, using certified weed-free plants, seeds, growth media and soil amendments.

ii. Eradication Approach- This involves the complete removal of a weed species from infested land. It is achievable in non-agronomic situation but undesirable in agro-ecosystems. The reasons for this are that it is too costly, it disturbs natural ecosystem functioning and the activity of bioagents may lead to crop failure.

iii. Control Approach- This involves the suppression of weed populations to a tolerable level that renders the cropping situation economically safe for agricultural production. It is the most important and environment-friendly approach to weed management in agro-ecosystems. The different methods are cultural, mechanical, chemical and biological control. Cultural weed control involves any practice adopted by the farmer in his

crop production effort not directly aimed at weed control. The practices help to minimize the number of weeds in the crop, suppress competition by surviving weeds and reduce weed seed production, thereby making the crop more competitive with weeds e.g. shifting cultivation, land preparation (stale seedbed), clean crop propagules, crop rotation, mixed cropping and mulching or soil cover with plant residues or plastic mulch. It is very efficient in controlling weeds in subsistence (peasant) agriculture. Mechanical weed control involves any procedure governing direct physical removal or suppression of weeds on agricultural lands. These include hand weeding, hand hoeing, slashing, mowing, cultivation/tillage, flooding, burning (flaming) and smothering with non-living (*in situ*) mulch. Chemical weed control involves the use of chemicals (herbicides) at toxic concentrations to kill or suppression (interrupt normal growth and development) of weed growth. Herbicides may be inorganic (early types) or organic (most herbicides) compounds, which may be primarily selective (benzoic acids, carbamates) or non-selective (bipyridylium salts, glyphosate). They can also be applied pre-plant, pre-emergence, post-emergence or post-maturity to the crop. Herbicides are of diverse formulations, including solutions, emulsifiable concentrates, wettable powders, flowables, granules, liquids, pellets suspensions, dust, paste, micro-encapsulation and micro-granules. A major limitation of chemical weed control is the insufficient specificity of chemicals under the mixed farming systems of the humid tropics. The National Advisory on Weed Control (NACWC) has published "Weed Control Recommendations for Nigeria", Series 3, under the sponsorship of the Department of Agriculture, Federal Ministry of Agriculture, Nigeria. Biological weed control is the use of natural enemies (bioagents) of weeds in weed control. The organisms may be predators (fish, insects, snails), parasites (nematodes, plants) and pathogens (fungi, bacteria, viruses). Other methods are live mulching, preferential grazing, cover cropping of food and non-food species, allelopathy, crop manipulation and myco-herbicides (plant pathogens). However, biocontrol enhances shifts in weed species composition and possible allelopathic interaction.

iv. Integrated Weed Management- This is a weed management method that economically combines two or more weed management systems at low inputs to obtain a level of weed suppression superior to that ordinarily achieved with one weed management system. It ensures that weed interference is kept below threshold economic levels, thus preventing economic loss to the farmer. It is aimed at efficient and economic use of

resources with minimum hazard to the environment and ultimately, sustained crop production.

3.2.5 Fertiliser Application

Fertilisers are chemical (inorganic) or organic materials containing plant nutrients, which are added to the soil to supplement its natural fertility or replenish lost fertility. There are many types of fertilizers, namely nitrogen fertilizers (primarily supply nitrogen; ammonium sulphate (AMS), calcium ammonium nitrate (CAN), urea), phosphorus fertilizers (primarily supply phosphorus; single superphosphate (SSP), triple superphosphate (TSP), basic slag, natural rock phosphate), potassium fertilizers (primarily supply potassium, potassium chloride (KCl), potassium sulphate, K_2SO_4, potassium-magnesium phosphate, K_2SO_4-$MgSO_4$), and mixed fertilizers (e.g. NPK 15-15-15, NPK 20-10-10, NPK 23-13-13, mono-ammonium phosphate (MAP), di-ammonium phosphate (DAP), potassium nitrate (KNO_3). Fertilisers may be applied by broadcasting, row placement by banding and ringing, or topdressing by either method. Micronutrients are also applied as foliar sprays to target crops. Organic fertilization involves manuring (especially the ageing form) and composting (use of compost consisting of crop residues, straw, manure, kitchen wastes, etc.). Also, liming involves the use of lime, steel slag or other materials to the soil to increase its pH level and subsequently, improve conditions for the growth of both crops and micro-organisms. Natural sources of lime are coral, marl, wood ash and steel slag. Artificial sources are lime, CaCO3 and CaO (unslaked lime). In a closed irrigation system, artificial fertilizers and pesticides are applied through “fertigation”.

3.2.6 Green Manuring

This consists of ploughing in green (non-woody) species or parts of living mulch, cover species of second crop (grown after the main crop), fallow weed vegetation, or leaf-litter or prunings of shade or hedgerow plants. A major objective of this practice is making nutrient available to the main crop. Green manure crops include Crotalaria spp., cowpea, Mucuna utilis and Leucaena leucocephala. The blue-green algae (used as biofertilser in India) and green alga (Azolla Africana for rice in China and Vietnam) are potential green manure sources.

3.2.7 Mulching

This involves the covering of the ground in a crop field with organic (dead, living) or inorganic materials, especially to protect the soil from degradation and ensure sustainable agriculture. Organic mulch materials include crop residues, straw, leaf-litter, prunings, weedfree compost and

black soil. Inorganic mulch materials such as paper, biodegradable and plastic films are particularly desirable for physical weed control in high-premium vegetables and greenhouse crops.

3.2.8 Cover Cropping

This is the practice of planting food and non-food crops which are capable of spreading growth on the soil surface and "smothering" weed growth. Food cover species include sweet potato, pumpkin, melon, pulse crops, rye, oats, and sorghum-sudan grass. Non-food cover species are mostly herbaceous weed legumes and fodder grasses.

3.2.9 Pest and Disease Control

Pests and pathogens are among the most serious factors limiting economically-efficient crop production and utilization of natural resources in both tropical and temperate agriculture. Pests, which cause damage to crops, consist of both arthropods (winged and wingless insects, mites, millipedes) and non-arthropods (slugs, snails, nematodes/ eelworms, birds, mammals). Micro-organisms such as viruses, bacteria, fungi and mycoplasma cause crop diseases, such as anthracnose, leaf spots, mosaic virus disease, bacteria wilt, blast and stem and root rot. Approaches to pest and disease control are many and varied, but they are broadly based on the principles of prevention, control/curative and eradication in special situations. The methods include physical, cultural, biological, chemical and legislative measures. These include the use of resistant crop varieties (less effective than in disease control), cultural methods (crop rotation, burning, soil cultivations, soil drainage, crop sowing time, removal of alternative weed hosts and crop residues, plant quarantine), chemical methods (pesticides) and prophylactic measures for pest control. In disease control, resistant cultivars of crops have been successfully bred for multiple resistances to diseases, crop rotation (most common), weed control, soil drainage, type of soil cultivation, low nitrogen fertilization, choice of sowing date and destruction of inoculum sources. Legislative measures include seed certification schemes and preventing the movement of diseased plants within a country. As in pest control, a large number of pesticides is available for the control of soil-borne diseases (sterilants, protectant fungicides, systemic fungicides) and air-borne diseases (foliar protectant fungicides e.g. maneb; foliar eradicants; foliar systemic fungicides, benomyl). Generally, insecticides and fungicides are most commonly applied to crops during the post-planting period.

3.2.10 Staking

This is the process of providing support for plant stems or vines. It is commonly practised in tomato and yam production. In yam, staking enhances crop leaf exposure to full sunlight for optimum growth and yield. In tomato, staking prevents lodging and fruit rot by infection by soil pathogens.

3.2.11 Harvesting

For different crops, there is need for one complete harvest or several pickings e.g. cowpea. Timely harvesting is necessary to prevent infestation by pests and infection by pathogens. Traditionally, most crops are harvested manually by hand or aided by the use of simple implements such as the sickle, hoe and cutlass. Mechanical harvesting in some crops (especially cereals), is facilitated by using combined harvester.

3.2.12 Storage

Harvested (usually surplus) crop produce is stored in good condition until needed. A good storage should be effective against rain, excessive direct heat, theft, insects (especially weevils) and other pests (rodents, birds), and pathogens (moulds). Crop products can be stored in many different kinds of storage containers, varying from earthen gourds, baskets, cribs to big metal and cement silos. The method of storage is determined by the financial status, available materials and external (climatic) conditions. Storage methods can also be separated into airtight and non-airtight storage. Airtight storage can be achieved using pots and gourds that are vanished or treated with linseed oil, pitch, bitumen or any thick, sticky substance. Other airtight methods include plastic bags, the Pusa bin, oil drums, metal silos, underground pits and brick or concrete silos, which are specially treated with waterproof mortar or waterproof paints. Airtight storage has the advantages of cheap insect eradication and prevention of the entry of moist outside air. The disadvantages include the need for complete air drying before storage, impossibility of complete airtight storage, inability to use part of the stored material during storage, and difficulty of regular check of the product.

3.2.13 Farm Mechanization

This involves two types of implements, namely farm tools and farm implements. Farm tools are mostly simple hand tools and used for manual work, e.g. cutlass (machete), hoes, mattock, pick-axe (digger), axe, rake, spade, shovel, digging fork, hand fork, trowel, garden shears, secateurs, watering can, wheelbarrow, go-to-hell, scraper, budding knife and sickle. Farm implements are heavy, usually animal- or tractor-drawn

and used for difficult farm work. They include ploughs, harrows, ridgers, cultivators, planters and combine harvesters. Both farm tools and implements are maintained by washing and drying immediately after use, greasing of dried parts with engine oil or palm oil, lubricating with oil and grease, and storing in cool, dry place, preferably a shed or store. In addition, farm machines such as tractor are maintained daily by checking the level of engine oil and water, to prevent damage to the engine through friction.

4.0 CONCLUSION

By the end of this unit, you should be able to understand that:

i. crop production involves a series of cultural operations to ensure sustainable and optimum food quantity and quality,
ii. specific crops require specific cultural operations for optimum production, and
iii. cultural operations need to be judiciously carried out as recommended to achieve the desired objective in the crop production process.

5.0 SUMMARY

Crop production is a complex process which requires the implementation of certain cultural operations for optimum and good-quality produce.

6.0 TUTOR-MARKED ASSIGNMENT

1. Make a distinct classification of the cultural practices used by farmers in producing their crops.
2. Briefly explain four benefits of “cultural” practices to optimum crop yields and produce quality.
3. Differentiate manual and mechanical land clearing.

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MODULE 3

UNIT 1 PROPAGATION OF CROPS

CONTENTS

1.0 INTRODUCTION

Plant species are naturally endowed with the ability to regenerate themselves through self- or cross-pollination of their flowers to produce seeds. When physiologically mature, seed germinate under optimum

environments and generate new individual plants to perpetuate the parent plant. Similarly, plant species whose seeds are not adequately viable to produce new plants and/or sterile (e.g. plantains) and depend primarily on the induction of vegetative sections (leaf, stem, root, flower stalks) containing viable buds are particularly more vigorous in asexual propagation of these plant species. Seed propagation of crops is more ancient than asexual propagation, and evolved with the origin of agricultural crop production in pre-historic times. Historically, human use of seeds marks the transition from nomadic food gathering to sedentary civilizations based on agriculture, in different parts of the world. In recent times, technological advances have led to the development of micro-propagation, which involves the culturing of individual cells or groups of cells (tissues) under highly aseptic conditions to produce whole new disease- and insect-free plants.

2.0 OBJECTIVES

By the end of this unit, you should be able to explain:

- the distinction between sexual and asexual plant propagation
- the various methods of propagating different crop types, including non-food crops
- the advantages and limitations of the propagation techniques
- the practical application of the techniques for self-sustenance.

3.0 MAIN CONTENT

3.1 Types of Propagation Methods

3.1.1 Sexual Propagation

This is a method of plant propagation involving the fusion of distinctly different sex cells (male, female) to produce a plant. The fusion of sex cells allows the exchange of genetic materials leading to heterogeneity and formation of hybrids, which vary widely in their appearance, physiological status, etc. and conforms on the emerging plants diverse adaptation to varying environmental growth conditions.

3.1.2 Asexual (Vegetative) Propagation

This method involves the induction of a vegetative section or part of a living plant to form roots and subsequently, developing it into a whole new plant. Plant multiplication does not involve the seed cycle (exchange of genetic materials) and therefore, it is the best way to maintain some species as clones; individuals identical to the parent.

3.2 Types of Propagating Materials (Propagules)

3.2.1 Seed

'Seed' is the generative part of the plant used for propagation. A seed is a small immature plant (embryo) protected by a seed coat or testa, which is formed from the outer layers of the ovule after fertilization. The seed is the basic unit of propagating many tropical crops, including yam and fruits (mango, pawpaw, passion fruit). Even in crop species whose primary mode of propagation is by vegetative means (e.g. mango, avocado pear), seed sowing constitutes an important method of regenerating new plants, and obviating the limitations (e.g. poor adaptation) of vegetative propagation. Seeds are sown in three different ways, namely by broadcasting, drilling/row-seeding, and pocket drilling/ sowing in holes. Advantages of sexual propagation are ease of transportation of propagating materials, less cost, skill and work to raise seedlings, ease of vegetative propagation in mature plants, hybrid vigour and associated benefits of development of new varieties and wider adaptation to varying environments. The disadvantages include slow seedling growth, non-prototype offsprings, problem of ensuring uniform produce quality since most seeds originate from cross-pollination (by wind, insects), weaker seedlings and longer period to plant maturity than vegetatively-propagated crop species.

3.2.2 Budding/Bud Grafting

A process consisting of the engrafting of the bud (scion) of a plant into the stem (stock) of another plant of the same genus. Generally, it is very suitable for propagating deciduous fruit (Citrus spp.) and shade trees. Budding of improved materials on regenerated chupons is one of the new methods of rehabilitating cacao in Nigeria. In the most common T-budding pattern, the desired scion from a young, actively-growing shoot of a chosen crop variety is immediately slid into a T-shaped slit on the rootstock. The joined bud and rootstock are held by a winding of rubber-band/special tape/wrap which holds it until sealed, which prevents drying or contamination of grafted materials. Chip budding is used for budding species whose barks do not "slip" (when cut, the bark easily lifts in one uniform layer from the underlying wood) easily without tearing. Bud grafting is faster, easier and less messy than other forms of grafting discussed below. Bud grafting allows the production of plants identical to a parent plant. Also, it may give increased productivity of crops through the hardness, superior rooting capacity, drought tolerance and insect or disease resistance of the rootstock. However, the method is labour-intensive, requires great skill of nursery operations (and therefore, expensive) and can only be efficient when performed at very specific times when weather conditions and crop physiological growth

status are optimum. Also, the vascular cambium of the both the bud scion and rootstock must be aligned to stimulate tissue growth on the basal ends before rooting.

3.2.3 Grafting

This is similar to budding in theory, but different in the sense that grafting involves the joining of the upper part (scion wood, 0.63-1.27 cm diameter and only with leaf buds) of one plant to the understock (rootstock) of another plant of the same species (clones, varieties). Grafting is an old art and science of plant propagation in pears, citrus, mangoes, grapes and other fruit tress, traceable back 4000 years to ancient China and Mesopotamia. Some plants graft naturally, where two branches are in close contact over several years (e.g. ivy). Grafting allows gardeners to produce plants identical to a parent plant, allows growers to control size and shape of a tree or shrub (e.g. apples) and gives more vigorous and earlier-fruiting plants. Also, two varieties can be grown on the same tree to facilitate pollination (e.g. in apples). However, like budding grafting is labour-intensive, expensive, inefficient in poor weather and plant growth conditions, and where cambiums of both scion wood and rootstock are not precisely aligned. Other disadvantages are graft incompatibility, sucker production in grafted plants and death of rootstock due to rooting of the scion arising from planting the graft union below the ground. There is a need to protect the grafted area from dislodging the scion out of alignment, especially by bracing. Also, there is a great risk of the topgrowth being very brittle thus, failing to harden off before cold weather.

Reasons for budding and grafting

i. Opportunity to change varieties or cultivars for crop improvement;
ii. Optimising cross-pollination, especially in fruit trees that are not self-pollinating;
iii. Advantage of particular (desired) rootstocks, especially in respect of superior growth habits, disease and insect resistance, and drought tolerance;
iv. Benefit from interstocks, valuable in a situation of graft incompatibility;
v. To perpetuate clones by grafting onto seedling rootstocks when clones of plant species (e.g. conifers) cannot be economically reproduced from vegetative cuttings due to low rooting percentage of cuttings
vi. To produce certain plant forms e.g. weeping or cascading forms as in weeping hemlock (*Tsuga canadensi* Carr var. *pendula*);

vii. To repair damaged plants, arising from maintenance equipment, disease, rodents or winter storms, through in arching, approach grafting, or bridge grafting;
viii. To increase growth rate of seedlings, especially in seedling progeny of many trees requiring 8-12 years to fruit with natural development; and
ix. To facilitate virus indexing, through confirmation of presence or absence of the virus by grafting scions from the plant onto another plant that is highly susceptible and would quickly show symptoms of infection.

3.2.4 Layering

This involves bending a branch/part of the stem of a growing plant and anchoring (with a rock or peg) and burying a portion of it, with a view to establishing a new root system at the point of contact between the bent part and the earth (i.e. on the shoots that are still attached to the parent plant). A light soil increases rooting success as will wounding or girdling of the buried portion. Treatment with a rooting hormone (e.g. Rootone, Hormondin^{R}, Hormonex^{R}) is most desirable, particularly one containing a fungicide. Plants with flexible branches are particularly suited to this method. As soon as the new plant is established, the connection with the parent plant is severed and the new plant becomes independent. Layering is a good propagation choice when only a few plants are needed. A heavy soil will reduce rooting success while covering the tip of the parent plant (bent shoot) kills it. Other types of layering are serpentine/compound layering, continuous/trench layering and mound/stool layering.

3.2.5 Cuttings

A cutting is a vegetative plant part which is severed from the parent plant in order to regenerate the parent plant (by regaining loss tissues), thereby forming a new plant. Both woody and herbaceous plants are asexually propagated by cuttings of stems, leaves and roots. Cuttings regenerate new plants through change of mature cells into meristematic cells that are found at rapid growth sites like buds. As in layering, the use of rooting hormone as a dip, preferably one containing a fungicide, helps to hasten rooting, increase number of roots, or gives uniform rooting, except on soft fleshy stems. Rooting medium may be coarse sand, vermiculite, soil, water or a mixture of peat and perlite. A major advantage of cuttings is the practical regeneration of whole plants from actively-growing plant parts/organs. Cutting technique also, typically as with other asexual methods of plant propagation, produces several whole new plants, and which are genetically identical clones of the parent plant. Important disadvantages are that cuttings should be made

as soon as possible after collection of plant material; not all species of plants can be propagated from cuttings (e.g. *Acacia* spp.); cuttings must be shielded from direct sunlight, especially if they are under glass or plastic; stock plants (plants used for asexual propagation) should be healthy and well-branched as should the tools and conditions for preparing cuttings to ensure healthy new clones; choice of correct rooting medium to achieve optimum rooting within the shortest possible time. There are many types of cuttings. Based on the vegetative part of the plant providing the cutting material. There are:

3.2.5.1 Stem Cuttings

This technique is the most commonly used method of propagating many woody ornamental plants and houseplants; sweet potato, sugar-cane and cassava are food crops propagated from stem cuttings. Stem cuttings of many favourite shrubs are quite easy to root whereas those of a tree species are more difficult to root. A glasshouse is not necessary for successful propagation by stem cuttings but it is critical to maintain high humidity around the cutting. Facilities for rooting cuttings include flower pots, trays, small hoop frame and/or an intermittent mist system. Materials for making stem cuttings should be vigorous, new growth with no flower buds and free of diseases and insects. Cuttings should be 5.08-10.16 cm long, cut from older stems and have 2-3 leaves (2-3 nodes) attached. Dipping the base of the stem, including the node area, into a rooting powder stimulates rooting. The stem should however, be dry when dipped. Four main types of stem cuttings are identifiable based on the growth stage of the stock plant, which is very critical in the rooting of cuttings, namely:

i. **herbaceous cuttings-** cuttings taken from non-woody plants, such as perennials and houseplants e.g. Chrysanthemums, rose. Cuttings are 5.08-15.24 cm stem pieces, with a terminal bud.

ii. **softwood cuttings-** cuttings taken from soft, succulent, new growth from non-woody stock plants, before the new growth starts to harden (mature). The cuttings are used to propagate flowering shrubs. They must be taken after rain or water is required to keep them cool in the morning. The larger diagonal cut gives more area to develop roots. Cuttings should be kept in water before rooting.

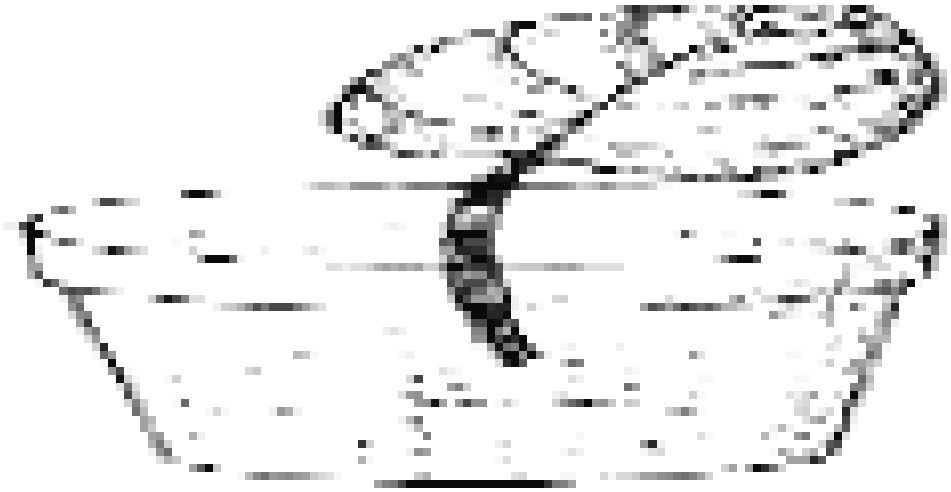
iii. **semi-hardwood cuttings-** cuttings prepared from partially mature (firm) wood of the current season's growth, just after a flush of growth. The method is used for propagating many broadleaf evergreen shrubs, some conifers, holly, rose and cacao (using the tips of shoots).

iv. **hardwood cuttings-** cuttings taken from tissue that has become woody (firm) and the plant is mature and dormant with no signs of active growth. Several cuttings can be made from the same branch of some shrubs. Basal cuts should be just below a node, while the upper cut should be slightly above a bud. Cuttings should be kept moist until rooting. The system is most often used for deciduous shrubs and many evergreen species e.g. grape, fig and rose. The three types of hardwood cuttings are straight, mallet and heel cuttings.

3.2.5.2 Leaf Cuttings

Leaf cuttings are used almost exclusively for propagating a few indoor plants. Leaf cuttings do not include an axillary bud, and thus, can only be used for propagating plants that are capable of forming adventitious buds. The method involves the use of a healthy leaf blade or leaf without petiole in propagating new plants, following the same procedures as for stem cuttings, particularly treating leaf cuttings with growth hormones to stimulate rooting and quick bud development. There are several types of leaf cuttings, and for all of them, the old leaf is not as part of the new plant and is thus, usually discarded. In most cases, the old leaf provides the energy food source for nurturing the newly-generated plant e.g. *Bryophyllum pinnatum*.

i. **Whole leaf with petiole-** This involves a whole leaf with about 3.81 cm of the petiole. The lower end of the petiole is dipped into a rooting medium after which one or more new plants form at the base of the petiole. The old petiole may be reused after the new plants have formed their own roots. African violets and peperomia are propagated in this way.



ii. **Whole leaf without petiole-** This method is used for propagated plants with sessile (petiole-less) thick, fleshy leaves. The leaf is inserted vertically into the medium after which one or more new

plants will form from the auxiliary bud. The leaf may be removed after the plant forms its own roots.

iii. **Split-vein-** The veins on the lower surface of a leaf from the stock plant (e.g. *Begonia* and snake plant) are slit before the leaf cutting is laid on the medium. The rooting medium is used to hold down the margins of a curling leaf. A variation of this method involves inserting leaf wedges cut with at least one main vein into the medium with the main vein partially covered. In both cases, new plants form from the base of the split vein and leaf wedge.

iv. **Leaf-bud cuttings-** These are used for many trailing vines and when space or cutting material is limited. Each node on a stem can be treated as a cutting. A leaf-bud cutting consists of a leaf-blade, petiole, and a short piece of stem with an attached axillary bud. The cuttings are placed in the rooting medium with the bud covered 1.27-2.54 cm and the leaf exposed. Rubber plant, Camellia, Rhododendron and blackberry are propagated using this method.

v. **Flower stalks-** This follows the same technique as leaf cuttings. It involves plant propagation from a flower stalk, usually with large leaf ears devoid of flower buds. This enhances chimera production in African violet.

3.2.6 Root Cuttings

This involves the propagation of plants from a section of a root. In some species, the root cuttings produce new shoots which subsequently form their own root system whereas in others, root cuttings develop root system before producing new shoots. Plants propagated from root cuttings include blackberry and rose. In most cases, root cuttings of woody plants are usually taken during the dormant (inactive growing period) season when roots have large carbohydrate levels. Root cuttings can also be taken from actively-growing plants i.e. throughout the growing season. In plants with large roots that are normally propagated outdoors in a hotbed, the root cuttings should be 5.08-15.24 cm in length, with a straight cut at the proximal end and slanted cut at the distal end of the root cutting. In plants with small roots, the root cuttings are 2.54-5.08 cm in length and are laid horizontally about 1.27 cm below the soil or sand in a flat. The flat is then placed under shade, which is removed after new shoots appear.

3.2.7 Divisions

Divisions are segments produced by cutting or breaking a crown or clump of suckers. Suckers are aerial stems formed from adventitious buds. Each segment consists of a bud and some roots, which when replanted grows into a new plant vertical to the parent plant. In cocoyam and taro, plants are propagated from young shoots. Pears and raspberries are propagated by suckers.

3.2.8 Bulbs and Corms

Bulbs are specialized underground stems whose leaves are used as food-storage organs. The fleshy stem part is usually very short (compressed) and attached to a basal plate while the fleshy leaves (bud scales) protect the terminal bud, which eventually grow into a new plant under appropriate (favourable) environment. Bulbs can be propagated by removing small bulblets (young bulblets) or offsets (mature bulblets/large buds as in lilies) that form at the base of the parent bulb. The small bulbs mature into plants that produce flower in 2-3 years. In other crops such as grape hyacinth (*Muscari* spp.), scooping (complete removal of the basal plate) and scoring (making three knife cuts cross the base of the bulb enough to destroy the main shoot) removes apical dominance and encourage bulblet formation, more than from offset propagation. Also, in daffodil (*Narcissus* spp.) bulblets form from bulb clipping and twin scaling, where respectively, bulblets develop from the basal plate between scale leaves and at the edge of the basal plate. A corm is the swollen base of a stem enclosed by dry scale-like leaves. It is a solid stem structure with nodes and internodes. Natural increase of new corms and cormels (miniature corms) in the field enhance corm propagation. The same procedure of propagating bulbs applies to corms, corm bits and cormels. Both methods are used in gladiolus, lilies, onion, plantain and bananas. In bananas, corm bits are better sources of planting material because corm bits uniquely assure clean planting material free of nematodes and weevils, easily prevent transfer of banana weevils and nematodes from infested banana to new plantations, provide enough planting materials from the few available scarce suckers, are easier to treat with Furadan (nematicide/insecticide mixture) than suckers, and are easier to transport for planting than suckers.

3.2.9 Runners/stolons

These are the lateral stems or vines of crops such as grass species and sweet potato, which run and grow horizontally on the soil surface to produce nodal adventitious roots and subsequently plantlets. The organs are cut into smaller sections, each with one or more buds, and partially buried in the ground to produce new plants. Examples of plants propagated through these organs are strawberries and yarrow.

3.2.10 Tubers

The “tuber” is specialized kind of swollen, modified and compressed stem structure that functions as an underground food storage organ developed from either the base of the stem (stem tuber) or the root (root tuber) of a plant. The tubers of root crops such as yam and Irish potato are sliced into setts from which axillary buds (“eyes”) sprout into new plants or by planting whole tubers. In Nigeria, setts are treated with pesticide dip containing 100 g Mancoceb + 70 ml Basudin in 10 litre of water to ensure healthy seed yams at harvest. Sweet potato is propagated from the tuberous roots (swollen secondary roots modified for food storage) which are capable of producing shoots at the proximal end and new roots at the distal end. The tuberous root propagation in dahlia is achieved by crown division.

3.2.11 Suckers

A sucker is a branch of the parent plant that will occasionally appear in a leaf axil of the plant. Propagation can be achieved by cutting the suckers from the parent plant and rooting in a rooting medium, e.g. African violet. Some trees and roots have shallow roots which produce separate plants called suckers. Cutting through the roots around the suckers helps to separate the suckers, more easily with smaller suckers about 60 cm. The advantages of suckers compared to corm bits are ease of preparing suckers for planting and ease of identifying sucker qualities (bad, good) through observations of the parent plant. Suckers are best planted at the onset of the rainy season to allow them access to sufficient and prolonged water supply. In banana, young plants or offsprings (side shoots/suckers) are produced by a mature plant, namely water sucker (a weak side shoot with wide leaves, a surface runner), sword sucker (a side shoot with narrow pale sword-shaped leaves), maiden sucker (a large sucker with wide leaves, t hat has not yet flowered) and peepers (a young shoot with scale leaves). Sword suckers are the only suckers suitable for propagating banana.

3.2.12 Rhizomes

Rhizomes are horizontal stems running at or just below the ground surface, specially modified to food storage organs. Unlike roots, rhizomes have nodes and internodes, with the nodes containing growing points (“eyes”).When cut into smaller sections or segments containing one or more viable buds and scale leaves, the buds sprout into new plants. Ginger, iris, couch grass and strawberry are propagated from rhizomes.

3.2.13 Micropropagation or Tissue Culture

This modern technique of plant propagation is based on the principle that each plant cell has the potential to grow into a new plant exactly like the parent plant. In this method, individual or small group of plant cells (tiny pieces of bud, leaf and stem) are manipulated in a way to enable them produce a new plant. Mass propagation of sweet potato tubers is achieved by *in vitro* culture of nodal segments in MS medium containing 9% sucrose under continuous darkness using Jar Fermentor Technique. Begonia and roses are also propagated by tissue culture using the meristem-tip. The advantages of this method are speed and efficiency of plant propagation and production of disease-free (aseptic) plants. Disadvantages include spontaneous natural mutations and very exacting conditions for growing tissue culture materials, such as absolute sterile conditions, strict control of temperature, light, humidity and atmosphere with costly electronic sensors and computer equipment.

4.0 CONCLUSION

In this unit, you have learned that

i. plants can be propagated by both sexual and asexual/vegetative methods, and
ii. crop and non-crop plants are propagated differently.

5.0 SUMMARY

This unit has discussed the distinction between sexual and asexual plant propagation, the various methods of propagating different crop types, including non-food crops, the advantages and limitations of the propagation techniques and the practical application of the techniques for self-sustenance in agriculture.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is a “seed”?
2. Enumerate three advantages and two disadvantages of sexual propagation of plants using the seeds.
3. Define the following terms:

(a) Softwood cuttings, (b) grafting, (c) budding, and (d) divisions.

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UNIT 2 CLIMATIC FACTORS AFFECTING CROP PRODUCTION

CONTENTS

1.0 INTRODUCTION

Climate, especially rainfall, is one of the three most important aspects of the physical environment which notably influence Nigerian agriculture. Climatic factors such as rainfall and temperature exhibit seasonal variations, and these are not only critical in determining the cropping patterns and systems, but also critical in determining the length of the growing season. These, in addition to the influence of climate on the occurrence of rain and crop physiological growth, ultimately determine the magnitude of the yields of cultivated crops in the different ecological zones of Nigeria.

2.0 OBJECTIVES

By the end of this unit, you should be able to discuss:

- the components of climate that are of importance to agricultural crop production, and
- the roles these factors play in crop production.

3.0 MAIN CONTENT

3.1 Rainfall

Rainfall is the most important climatic variable, and it has far-reaching influence on agricultural crop production. Its roles in agricultural production include

i. main source of moisture supply to the soil for the activation of plant growth,
ii. replenishment of water in rivers to allow irrigation operation,
iii. build-up of underground water reserves which are later tapped by wells in dry area through seepage and percolation, and
iv. influence on soil/water/plant relationships; soil moisture status has significant direct relevance for plant growth because water balance= total rainfall- (run-off + evapotranspiration).

The amount, incidence, variation and reliability of rainfall determine differences in cropping pattern in various ecological zones in Nigeria. In Nigeria, the rainfall pattern follows a south-north gradation in amount. The latitudinal sequence is disturbed only around Jos Plateau, Mambila Plateau and the foothills of the Cameroon mountains. Two broad cropping patterns are thus, defined based on the variation in total rainfall or other rainfall parameters, namely

i. the perennial tree and root-crop zone in the wetter south, and
ii. the seasonal grain and pulse crop zone in the drier north.

3.1.1 Effects of Excessive Rainfall

Excessive rainfall (when total rainfall is greater than 2540 mm per year in the south) adversely affects crop production through high run-off, soil erosion (most serious effect worldwide), leaching, nutrient losses, waterlogging, vigorous vegetative growth or weed infestation, and general disruption of agricultural activities.

3.1.2 Effects of Inadequate Rainfall

Inadequate rainfall (when total rainfall is less than 101.6 mm per year in the north) makes crop growth impossible for most of the year except, with irrigation.

The seasonality, duration and regimes of the wet season and the number of months of inadequate rainfall per month are more important to agricultural activities than total rainfall. Therefore, crop growth is only sustainable for varying periods in different ecological zones during the

year, essentially in response to the alternating wet and dry seasons of varying duration. Also, the number of months with 1016 mm rainfall is 3-5 months south of Rivers Niger and Benue and more than 9 months in the northern part of Borno State (i.e. dry areas; Sahel savanna zone).

The onset of the rains, regime and duration of wet seepage across ecological zones also influence the timing of planting operation, number and types of crops that can be grown, and seed germination and seedling growth. This accounts for the following conditions:

i. suitability of perennial tree crops (e.g. cocoa, oil palm) and food crops with long growing periods (e.g. white yam, cassava) to most parts of the forest zone with rainfall for 250 or more days;
ii. the possibility of cultivating two consecutive or alternate crops in a year e.g. maize/cowpea;
iii. the cultivation of vegetable crops e.g. melon, pumpkin; and
iv. the predominance of short-season crops (especially cereals such as guinea-corn, millet) in the northern savanna zones with 80-200 rain-days.

Variation in the duration of the wet season determines the variety of crops grown in different zones. Thus, perennial crops such as cocoa, kolanut and oil palm, thrive well in most parts of the forest zone where the rain falls for 250 days, depending on the soil fertile-ity status. In areas with more than 250 days of rain, rubber and oil palm are particularly important and the areas well suited to food crops with long growing periods (e.g. white yam) and others with high rainfall requirement such as rice and cocoyam. Also, two consecutive crops are possible per year, e.g. maize + cowpea. In addition, the duration of rainfall is very significant in the cultivation of some vegetables in the forest zone e.g. melon and pumpkin. Northward (i.e. savanna zone), the wet season shortens (100-200 days) and therefore, cereals and exports crops with short maturity periods occupy a dominant position e.g. guinea-corn and millet.

The onset of rains varies with ecological zones, viz. March in the interior part of southern Nigeria, April in a large part of the Middle Belt and May/June in the Sudan zone. The latter crop is particularly cultivated in drought-prone areas which mark the northern limit of arable agriculture.

Generally, there are distinct regional and seasonal features of rainfall on the basis of soil/water/crop relationships. Every part of Nigeria experiences water deficit varying from a few weeks in the south to several months in the north. This, in addition to the relatively short duration of the rain (80% falls within the first 30 minutes) and high

annual evapotranspiration losses (1000 mm), further deplete the water balance and necessitate irrigation on farmlands in Nigeria. In the south, irrigation is met by sinking wells and harvesting run-off water from smaller streams. Contrarily, in the north there is considerable water shortage and therefore, the water supply is inadequate for large irrigation projects except only in the Middle Belt area. Further north, farmers have adapted to the distinct periods of water cycle by

a) planting fields with high moisture status due to the largest moisture deficit at the onset of rains, and fields with a high deficit later;
b) exploiting the soil moisture status between the end of rains and end of growing season, because the end of rains coincides with the flowering of cotton, bud maturation of groundnut and heading of guinea-corn. Thus, the success of cereal crops in the north depends on the extent to which the water demands match seasonal pattern of water availability. Severe drought, especially in the north, causes a decline in the amount of cultivated land, decline in crop yield, and decline in available food and export crops.

3.2 Temperature

Temperature is one of the major factors limiting the distribution of plants and animals on a global scale. It is of secondary importance in influencing evapotranspiration, photosynthesis and soil warming. The effects of temperature on farming system include

i. rapid soil organic matter (SOM) decomposition due to high microbial activities and increased rates of biochemical reactions,
ii. high temperatures render built-in fallows ineffective,
iii. high temperatures enhance the incidence of pathogens and pests,
iv. high night temperature favours high respiratory rates and exhaustion of plant assimilates, resulting in low net assimilate accumulation and poor crop yield, and
v. effects on plant life processes such as seed germination, pollination, flowering, fruiting, ion uptake, leaf growth and cell enlargement.

In Nigeria, air temperature is not limiting to crop growth. Thus, variations in regional and seasonal distribution are of local importance to agriculture. The higher mean annual temperature in the north than in the south encourages higher evapotranspiration, thereby lowering the water balance level. Higher evaporation rates from water surfaces in rivers and lakes in the Sudan and Sahelian zones caused by high temperatures also deplete water resources and render them inadequate

for irrigation system. However, higher night temperatures in the forest zone reduce potential photosynthesis below that of the savanna. This influences crop productivity in the different zones. Soil temperatures are more important to plant growth than air temperatures. In potatoes, optimum soil temperature for tuber growth is 17^0C whereas no growth occurs at soil temperatures greater than 29^0C. Pertinent features of temperature in Nigeria are that day temperature is higher inland except in highland areas; diurnal temperature range increases with distance from the sea, especially in the north; and mean daily temperature for January (peak of dry season) decreases northwards. However, farmers have adapted to these problems by early crop harvesting, mixed cropping, mulching, minimizing run-off/erosion, organic matter supply in decaying residue, high nutrient supply, suppression of weed growth, and protection and shading of soil.

3.3 Solar radiation

Surface reflectivity over different agricultural crop surfaces, net radiation (photosynthetically-active radiation, PAR) and energy budget and relationship of solar radiation to dry matter production and economic yields, all have implications for agricultural crop production . Solar radiation is essentially important during photosynthesis, which utilizes visible light to produce dry matter from water and CO_2. Thus, dry matter production depends on incoming solar radiation and the type of plant that is exploiting it under normal conditions. Solar radiation is very important in determining the final yield of some crops in areas of adequate water supply e.g. sugar-cane and lowland rice.

3.4 Relative humidity

This is the ratio between the amount of water vapour actually held in the air and the maximum possible amount that can be held at a particular temperature. It is a measure of the dampness of the atmosphere. Differences in relative humidity are more critical to the unpleasant climate of West Africa than high temperature. The coastal areas are under the South-west Monsoon winds for most of the year; hence, they have higher relative humidity of about 100% especially during the dry season. High relative humidity increases disease incidence on cropped farms and reduces the crop’s ability to intercept solar radiation. Contrarily, low relative humidity leads to high evapotranspiration and transpiration which eventually cause wilting of crop stands. In Nigeria, farmers use different stand geometry and leaf arrangement to maximize light interception in order to adapt the crops to relative humidity.

3.5 Daylength/Photoperiod

This indicates the length or duration of sunlight hours per day. It is variable due to the apparent movement of the sun either on the northern or the southern hemisphere. These trends also affect wind movement and rainfall occurrence. Daylength affects flowering and tuber formation, vegetative development, seed germination (e.g. some rice and soybean varieties that are sensitive to photoperiod), and timing of agricultural operations such as planting, harvesting and type of crops to plant. On the basis of photoperiod, there are three groups of plants, namely long-day plants (those that flower under daylength of less than 14 h., e.g. Irish potato, wheat, barley, oat); short-day plants (those that are induced to flower under daylength of less than 10 h., e.g. sweet potato, maize, soybean); and day-neutral plants (those that are not induced by daylength e.g. cowpea). However, most tropical crops are highly sensitive to daylength, and therefore are identified in two groups:

i. those with critical daylength of less than or equal to 121/4 h. e.g. *Corchorus olitorius*; and
ii. those with critical daylength greater than or equal to 121/4 h. e.g. *Phaseolus lunatus*.

3.6 Winds and Ocean Currents

These climatic variables strongly influence rainfall occurrence and duration of the rainy season. The predominant air masses in West Africa are the equatorial maritime air mass (moisture-laden south west monsoon winds, SWM) and the tropical continental air mass (dry and dusty north-east trade/harmattan winds, NET). The meeting point of these two air masses is called the Inter-Tropical Front (ITF), whose relative dominance brings in rain (northward movement) and harmattan (southern movement). Rain falls only in areas lying south of the ITF. The northward movement of the ITF occurs in February when the NET starts to retreat and being replaced by the advancing SWM. In July, most areas south of latitude 20^0N fall under the influence of rain-bearing wind from the south. In August, the ITF reaches its inland limit and remains stable for a few weeks before moving coast-ward. In January, the ITF is near the coast once more while the NET again becomes the dominant winds. Other winds of importance to agricultural production include sea breezes, land breezes and ocean currents. The ocean currents are three, namely the Cold Benguella current, Guinea counter-current and the Cool Canary current. The currents influence climatic conditions through the winds blowing over an area; winds blowing over a warm current are usually moisture-laden while those blowing over a cold current usually have a cooling effect on the coast, arising from the formation of fog instead of rain.

4.0 CONCLUSION

In this unit, you have learned about the influence of climatic factors, especially rainfall and temperature on crop productivity, and sustainable supply of food, in Nigeria.

5.0 SUMMARY

Climatic factors play a significant role in determining the onset of the cropping season, cropping pattern and systems and the number of crops cultivatable by farmers in various ecozones of Nigeria.

6.0 TUTOR-MARKED ASSIGNMENT

1) Outline four ways in which rainfall affects agricultural crop production.
2) Differentiate (a) the cropping systems of Nigeria based on rainfall; and (b) excessive and inadequate rainfall.
3) What is the significance of inadequate rainfall?

7.0 REFERENCES/FURTHER READING

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UNIT 3 EDAPHIC FACTORS AFFECTING CROP PRODUCTION

CONTENTS

1.0 INTRODUCTION

Soil is the uppermost layer of the earth which supports the growth of higher plants, mainly by providing a medium for plant roots and supplying elements that are essential to the entire plant. The soil is the regulator of water supplies in rivers, lakes and underground aquifers; it recycles raw materials as humus, and a habitat for soil organisms, including beneficial organisms, predators, preys, producers, consumers and parasites. In Nigeria, the variations in the patterns of distribution of soil results in marked regional differences in agricultural specializations. Soil type, fertility and the present and potential systems of soil management have considerable influence on agricultural production. Regional variations in soil types often influence the prospect of growing

particular crops in different parts of the country. Also, fertility level influences soil types and traditional soil management techniques used in their maintenance.

2.0 OBJECTIVES

By the end of this unit, you should be able to explain:

- the influence of soil is physical, chemical and biological properties on crop production, and
- the spatial distribution of soil types in Nigeria.

3.0 MAIN CONTENT

Crop productivity is strongly dependent on physical, chemical and biological conditions of the soil.

3.1 Physical Soil Factors Affecting Crop Production

These include the soil's texture, structure, porosity and bulk density.

3.1.1 Soil Texture

This is defined as the relative proportions of the sand, silt, clay and gravel/stone particles (composition) in the soil. The proportion of solid soil particles provides a useful guide to a soil's potential for agricultural crop production, since it exerts a major influence on soil characteristics. The soil texture influences the water-holding capacity (through the clay type and content and capillary conductivity), temperature, drainage and nutrient retention capacity of the soil. Also, soil texture influences the efficacy of soil-applied pre-emergence herbicides and other pesticides. Soils are classified into light (sandy, workable), medium (loamy, most workable) or heavy types (clay, unworkable) on the basis of soil texture, due to its close relationship to the workability (the ease of working the soil with machinery) of the soil.

3.1.2 Soil Structure

This is defined as the arrangement of the particles (sand, silt, clay) in the soil. It influences the soil tilth, root growth and development, gaseous exchange/aeration, drainage, water infiltration into the soil, and efficiency of water and nutrient uptake by plants (through capillary conductivity). "Structural stability" is the ability of the soil to resist deformation when wet. It is influenced by the clay content, presence of lime, iron oxides and humus. However, soil structure is not a stable soil property, and therefore changes with time and weather. Poorly stable

soil aggregates slake (collapse) easily while good aggregate structure maintains the shape when wetted for a short time and gradually piece off thereafter. A good structural stability is essential to prevent soil degradation and limited crop growth. Soil structure can be improved by addition of decomposable OM (e.g. farmyard manure, FYM), crop roots and crop residues. Heavy machinery causes damage to soil structure in wet soil, especially heavy clay soils.

3.1.3 Soil Porosity

This is defined as the percentage volume filled with air when the soil is fully drained of saturated water. The pore sizes include micropores (smallest pores containing only water which rarely dries out and is unavailable for crop uptake); mesopores (middle-sized pores containing water available to plants and which allow free aeration of the soil); and macropores (pores greater than 0.1 mm in diameter, can drain easily to allow in air after full wetting of the soil). Soil porosity influences the infiltration of water into the soil, water-holding capacity, drainage and aeration of the soil aggregates; these properties have significant influence on the SOM status. Ecologically, soil aeration plays a significant role in organic residue decomposition; oxidation-reduction of elements, especially nutrients; plant growth; nutrient and water uptake; soil compaction; soil structure; and soil cultivation. Aeration capacity is very high in sandy soils, optimal in loamy soils and very low in clay soils. However, organic matter additions (which increase the number of meso- and macro-pores) can improve the aeration capacity of clay soils.

3.1.4 Soil Bulk Density

This is mass of soil per unit volume of the soil. It is determined by the volume of pore spaces in the soil; the more the pore spaces, the lower the bulk density, and vice versa for high bulk density or soil compaction. Soil bulk density affects the workability of the soil, especially with respect to mechanical cultivation, and especially in dry weather. No-tillage or minimum tillage is also strongly affected by soil compaction.

3.1.5 Soil Water

Water is held in the soil in three forms, namely:

i. capillary water (water held by surface tension forces as a continuous film around the particles and in the capillary pore spaces of the soil);
ii. gravitational water (water held to the soil particles against gravitational forces and suction force of the roots, and which drains under the influence of gravity); and

iii. hygroscopic water (water adsorbed from an atmosphere of water vapour as a result of attractive forces in the surface of the soil particles and aggregates).

Soil water is very critical to root absorption of essential nutrients from the soil, soil temperature, microbial and microbial soil activities, organic matter decomposition, etc. The farm soil needs to be at field capacity always to ensure optimal growth and development.

3.2 Chemical Factors of Soil Affecting Crop Production

The soil chemical characteristics are of primary importance in crop nutrition. They include

3.2.1 Soil Organic Matter (SOM)

This is the proportion of the fresh organic material and humus (partly decomposed and synthesised organic material). These materials exert a profound influence on crop nutrients (through slow nutrient-release mechanism), soil structure and cultivation. Organic matter serves as the soil granulator, being largely responsible for particle aggregation through its efficiency on cohesion and plasticity. It is a rich source of important plant nutrients, particularly nitrogen which is entirely derived from organic matter. Organic matter influences the colour, temperature (by minimizing evaporation from soil surface), water-holding capacity, water retention, infiltration, pH and exchangeable capacity of the soil. It is the main source of energy for heterotrophic soil microorganisms, which stimulates their reproduction and growth, thus facilitating their capacity to make the nutrients in SOM available to the plants. Organic materials in the soil are decomposed by primary decomposers (insects, earthworms, fungi) and secondary decomposers (bacteria, fungi). This, in addition to cultivation and bush burning reduce SOM content. Contrarily, SOM can be maintained by bush fallowing, agro-forestry, no-tillage, crop rotation, mixed farming, ground cover management, alley cropping and incorporation of organic materials into the soil. Important sources of organic matter are FMW, composts, straw, green manure, animal products, cadavers, garbage, industrial wastes (especially food processing wastes), urban liquid wastes, city refuse, peat (Sphagnum moss, sedge), sawdust, leaf mould, sewage sludge, slurry, sewage effluent, leys and mulch.

3.2.2 Soil pH

This indicates the degree of acidity or alkalinity of the soil. It is significant in determining the soil chemical reactions. Soil acidity (low soil pH) is caused by carbonic acid in rainfall water, organic acids (e.g.

humic acids) from microbial breakdown of organic matter (OM), ammonia from nitrification, and loss of calcium in drainage and crop removal. Liming helps to correct soil acidity; liming materials include $CaCO_3$, CaO, $Ca(OH)_2$ and Magnesian limestone. Although crop families can occur at pH 5 and below, it is necessary to analyse the soil pH regularly to determine the lime requirement.

3.2.3 Available plant nutrients

Soil minerals are derived from rock weathering; the primary minerals are derived directly while the secondary minerals are derived from the primary minerals by weathering and synthesis. Plant nutrients are of three main forms, namely macro-, meso-and micro-nutrients. The macro-nutrients (nitrogen, phosphorus, potassium) are primarily important in crop growth, because they are required in large quantities. The meso-nutrients are calcium, magnesium and sulphur. The micro-nutrients are required in minute quantities but are also important for the normal growth of some crops and certain physiological processes, namely enzyme systems, protein and carbohydrate metabolism, nitrogen fixation, chlorophyll formation, pod maturation and production, growth hormones and starch forms. They include copper, molybdenum, chlorine, boron, manganese, zinc and iron. A knowledge of the available nutrients not only guides in determining the suitability of the site (soil) for a particular crop but also in formulating soil fertilizer requirements.

3.3 Biological Factors of Soil Affecting Crop Production

These are complex, and include the soil fauna and flora.

3.3.1 Soil Fauna

This includes both the beneficial and damaging animal organisms. Beneficial organisms are those which break down and incorporate crop residues, and further aid in water movement and aeration e.g. earthworm. The damaging organisms consist of the larval stages of click beetle/wireworms, crane fly, chafer grubs and eelworms/nematodes.

3.3.2 Soil Flora

Pathogens such as bacteria, fungi and viruses are important as sources of soil infections in crop lands.

3.4 Spatial Distribution of Soil Types in Nigeria

About six or more soil types are found distributed across different ecological zones in Nigeria. The soils are:

3.4.1 Alluvials

There are three types of alluvials which are important, namely alluvial of marine deposit found in mangrove areas which are suitable only for coconut growing; the alluvial near the coast which has a high sulphide content and when drained, has the tendency to become acidic, and alluvial on lacustrines and riverine deposit, which constitutes the most useful alluvial soil under controlled drainage conditions.

3.4.2 Ferrasols

These are also called acid sands (pH= 5.0-5.5) and are also reddish-yellow in colour. They cover the southern parts of the forest zone of western Nigeria and extensive areas of mid-Western and eastern states. They are of low fertility or agricultural value but potentially suitable for mechanical agriculture.

3.4.3 Ferruginous Tropical Soil

This is a soil formed from crystalline acid rock, except those developed on sandy, undifferentiated and sometimes hydromorphic soils. It is of high natural fertility but traditional management practices have caused problems for crop utilization. In the forest zone, it is suitable for planting cocoa while in the savanna zone it is suitable for export and food crops e.g. beniseed, cotton, guinea-corn, maize, yam, millet and groundnut. The soil is relatively more suitable for agriculture than any other soil type.

3.4.4 Lithosols

These soils are of local significance and usually associated with ferruginous tropical soils. Agricultural activity is very low but they need to be protected from soil erosion to avoid damaging adjacent and more fertile soil.

3.4.5 Vertisols

These soils have characteristics of considerable agricultural importance. These features include dark colour with large amount of clays of the expanding lattice type (kaolinite); occurrence of deep cracks during the dry season; very limited horizon/less deep development; richness in calcium, especially $CaSO_3$ and $CaSO_4$. Those developed from calcerous rocks have the greatest potential for agriculture. However, they have little use because of difficulty of tillage but dry season guinea-corn is extensively grown in some.

3.4.6 Regosols

These overlay semi-arid brown and reddish-brown soil. Organic matter content is nearly constant to a considerable depth. Many of these soils show an increase in clay content with soil depth.

Generally, organic matter and nutrient contents of soils decline during production or cropping and increase under fallow for varying periods. Therefore, several methods are used by the farmers to maintain soil fertility, including crop rotations, shorter fallows and use of crop residues.

4.0 CONCLUSION

In this unit, you have learned about the effects of soil properties on agricultural crop production and productivity, and aspects of the distribution of soil types and their agricultural value in Nigeria.

5.0 SUMMARY

Agricultural crop production is greatly influenced by soil properties, especially soil type, fertility status and potential management systems.

6.0 TUTOR-MARKED ASSIGNMENT

1) Define the following terms:
   (a) soil texture, (b) soil organic matter,
   (c) hygroscopic water, (d) mesopores, and
   (e) soil structural stability.

2) Enumerate the different types of soil texture.

3) Write short notes on the influence of soil structure on crop productivity.

4) List four ways of improving soil structure.

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UNIT 4 DISTRIBUTION OF CROPS IN NIGERIA

CONTENTS

1.0 INTRODUCTION

The distribution of crop species in the various ecozones of Nigeria relates most significantly to the seasonality of rainfall, and the duration and regimes of the wet season. In areas where cropping is mainly by rain-fed agriculture, these have great implications on the crop type, cropping pattern, cropping sequence and the scale of crop production. Thus, the long-season root and perennial tree crops, which are highly demanding on soil moisture, dominate in the wetter south, contrasting the short-season grain crops of the drier north. The situation is also significantly true in areas of irrigated agriculture, since floodplains and rivers supplying water to irrigation systems need to be replenished by rain water. Soil types and vegetation characteristics are also important factors in crop distribution across ecozones in Nigeria.

2.0 OBJECTIVES

By the end of this unit, you should be able to explain:

- the patterns of distribution of various crop groups in Nigeria, and
- the factors governing the extensive cultivation of crops in specific parts/regions.

3.0 MAIN CONTENT

3.1 Distribution of Root Crops

The main root crops of Nigeria are yams, cassava, cocoyam, and to a lesser extent, sweet potato which is a minor crop. Root crops occupy a significant position in agricultural production in the country. However, the amount of land allocated to the cultivation of the three leading root crops is less significant. Thus, when compared with other crops such as cereals root crops, especially yams and cassava have high relative value per unit of land used in their cultivation. The eastern states constitute the most important root crop-producing area of the country, and have more extensive areas allocated to the crops than any other part of the country. Three main areas of these states account for over 75% of land cultivated to root crops, namely an extensive coastal plain covering the southern parts of Cross River State and the eastern parts of Rivers State except where fishing is dominant in the forest zone; less extensive area covering parts of Ogoja, Ikom, Obubra and Abakaliki areas in the grassland savanna; and a relatively limited area covering the western parts of Onitsha, Orlu and owerri divisions in the forest zone. The well-known root crop-producing areas of the Oyo, Ondo, Benue and Plateau States fall considerably behind the eastern states, accounting for 25-49% of land cultivated to the crops in both the forest and savanna-producing areas. The amount of time and energy available for root crop cultivation are limited by export crops. Root crops are produced in the far north but production is really marginal in areas north of Rivers Niger and Benue.

3.2 Distribution of Cereals and Pulses

In Nigeria, cereals and pulses (guinea-corn, millet, maize, cowpeas, rice) account for a large proportion of the land used for agricultural cultivation of the major crops.

3.2.1 Guinea-Corn

This crop is the most extensively cultivated, and most of the production occurs in northern Nigeria where it is suited to most soil types. The four

major species of sorghum produced in Nigeria are the Guinea, Kaura, Farafara and Chad. Guinea-corn is also the most versatile of the cereals, being produced in all ecological zones except the Sahel savanna. It is most important in the southern and northern Guinea savanna and subhumid Sudan savanna. Further north, sorghum does better on the heavier soils in depressions and floodplains as the rains decrease. It is a very minor crop in the derived savanna and forest zones. The most important growers of guinea-corn in Nigeria are Kaduna, Borno, Sokoto and Kano States. In Zaria, most land is cultivated to guinea-corn interplanted with millet, and less to sole guinea-corn.

3.2.2 Millet

Most parts of northern Nigeria where millet production is practised on 30% or more land coincide approximately with the areas where the crop ranks first in agricultural use. These areas are Borno, Bauchi and Sokoto States. There is some overlap of guinea-corn and millet-producing areas in parts of Sokoto, Kano and Katsina. A higher proportion of the most important producing areas are located in the Sahel savanna zone, where moisture conditions are marginal for crop production. However, it is grown as far south as Lat. 10^0N in parts of Borgu Province of Kwara State and Lat. 8^0N in parts of Benue State.

3.2.3 Maize

This is the most important cereal crop in the agriculture of the southern parts of Nigeria. Also, the south-western parts are outstanding in maize production contrary to the south-eastern parts, where production is less important. The Niger Delta area is relatively unimportant for maize production. Although it occurs in all ecological zones except the Sahel savanna zone, the crop is of only marginal importance in many parts of the northern region. There are three core areas where 30% or more of cultivated land is allocated to maize production in Nigeria. The most extensive of these areas is the Yoruba savanna, covering large parts of Oyo State and Egbado division and a limited area south-west of Ilorin. Less intense maize cultivation extends into Osun and Ibadan Divisions to the east. The other two areas are found within the forest zone in the heart of the cocoa zone in Ife-Ijesa Divisions and the parts located near the Obubra-Ikom coca-producing areas. Other areas of maize production are Edo State, Nasarawa, Lafia and Wukari Divisions of Benue and Plateau States. Generally, there is a systematic decline in maize production towards the north, where sporadic production of the crop occurs.

3.2.4 Rice

Rice has been cultivated in parts of northern Nigeria since the 16th century. The cultivation of rice is undertaken in four main types of environments in Nigeria, namely rain-fed uplands, especially in southern Nigeria; tidal freshwater mangrove swamps, naturally-flooded areas such as the fadamas of northern Nigeria, and irrigated lands. These ecologies are found in many parts of the country; thus, rice is produced in virtually all ecological zones.

3.2.5 Cowpeas

These are widely cultivated and eaten in Nigeria. Its production in northern Nigeria is very closely associated with sorghum and millet. The most important producing areas of cowpeas are located in the Sudan savanna zone (Borno, Bauchi, Kano and Sokoto States), with 508-1016 mm of rain per year, due to its requirements of light rainfall, good loamy soils and drought-resistant nature. The only important cowpea-producing areas located in the Guinea savanna zone are northern parts of Niger State, northern Oyo State and southern Ilorin Division of Kwara State. Its cultivation under the less ideal conditions in the latter two areas is attributed to special consumption preferences for the crop in Oyo Yoruba. Thus, about 50% of the cowpea crop produced in the wetter Ilorin areas is sold to the more southern western states

3.3 Distribution of Tree Crops

The main ecologically significant tree crops grown in Nigeria are cocoa, oil palm, rubber (important export crops) and kola (mainly produced for internal trade). The areas of coffee and cashew production are diffuse. Cocoa, oil palm, rubber and kola are all grown in the forest zone, but with the production of specific crop species in different sections. Thus, cocoa and kola are produced in the western part of the forest zone, rubber in the central parts, and oil palm in denser stands in the eastern states in spite of its more widespread cultivation across the zone than the other tree crops.

3.3.1 Cocoa

It is produced in two main moisture belts, namely in western Nigeria where annual rainfall is 1143-1524 mm, and in the south-east, where annual rainfall is 1905-3048 mm. Ogun, Oyo and Ondo States account for over 95% of Nigerian cocoa production. Cocoa production in the eastern states is increasing tremendously, but the amount of land allocated to the crop is very small. There is also limited production of cocoa in the Bendel and Kwara States.

3.3.2 Kolanuts

Cola acuminata (Gbanja) is the kola of commerce, large quantities of which are transported to the northern states, where it is widely consumed. The western states are the leading producers of C. nitida kolanuts in Nigeria, accounting for over 80% of the country's production. The main areas of kolanut production in western Nigeria are located in parts of Abeokuta, Ijebu and Ibadan provinces. The dominant areas of production are in the forest zone, while the less important areas are widely scattered in the cocoa zone.

3.3.3 Rubber

Edo State is the main rubber-producing area of Nigeria, with more than 80% of the production coming from the peasant holders. However, the greater part of the output in other parts of the country is obtained from private or government plantations. 3.3.4 Oil palm- The oil palm is considered to be an indigenous crop of West Africa, where the sources and banks of water courses, moist valleys, especially in the forest/savanna transition zone, banks of lakes and swamps, and low-lying islands in humid tropical environments serve as the natural habitats of the plant. Oil palm groves are found mainly in areas of secondary forest throughout southern Nigeria and in parts of the derived savanna. There are three main types of oil palm groves in man-made habitats in the country, namely secondary rain forest with oil palms; palm bush; and dense palm grove or farmland with palms. Also, there are planted village groves and peasant plantations. The oil palms in the secondary rain forest are found mainly in western Nigeria and Edo State. Oil palm bush is also found in parts of Asaba and Warri Divisions of Edo State and Kabba and Igala Divisions of Kwara State.

3.4 Distribution of Oil Seeds

The most important oil seeds produced in Nigeria both for export and internal use are groundnuts, beniseed and soybeans. They are cultivated mainly in northern Nigeria and outside the forest environment.

3.4.1 Groundnuts

Groundnuts are produced predominantly in northern Nigeria, where its spread and cultivation date back to the 1800's. Most of the important groundnut-producing areas are located in the drier parts of the Sudan savanna zone, especially in areas with less than 1016 mm annual rainfall. These areas are characterized by modest moisture requirements of the crop and extensive light sandy soils. The Kano region, which started the cultivation of the crop, is still the largest producer. However,

the important groundnut-producing areas extend into the Borno and Sokoto States, other states, namely Bauchi, Adamawa, Taraba, Katsina and Gombe. The production of the crop is much less intensive in Sokoto and Niger States. Only very limited groundnut output is noted in areas south of Lat. 110N, mainly in Bauchi, Gombe and Adamawa States.

3.4.2 Beniseed

A high proportion of the beniseed output of Nigeria is produced in four main areas, namely the Tiv Division; Doma District, both in Benue State; Igbira Division of Kwara State; and the Kwali area of Niger State. Most of the producing areas are located in the Guinea savanna zone, where annual rainfall is 1016-1397 mm.

3.4.3 Soybeans

Although an exotic crop, soybean production trends are very similar to those of beniseed. The main producing areas are also found in Tiv Division, which extends into adjacent Niger and Kabba Provinces. Soybean production also extends northwards into southern Zaria and even southern Katsina Provinces.

3.5 Industrial Crops

The main industrial crops of Nigeria are cotton, tobacco, sugar-cane and kenaf.

3.5.1 Cotton

Cotton has been grown in Nigeria for many centuries before the advent of the Europeans. It was traditionally associated with the spinning and weaving industries, the main centres of which were located at Kano in the north and Iseyin in the south-west. The three main regions of cotton production in Nigeria are the northern (most extensive production), eastern (moderate production) and southern (minor production) zones. The northern zone covers the whole of Zaria Province and the southern parts of Kano and Katsina Provinces. The eastern zone covers considerable areas of south-eastern Bauchi, adjoining districts of Adamawa and south-western Borno State. A small extension is also found in the Lowland and Pankshin Divisions of Plateau State. The main concentration of production is around Gombe and Kumo, both of which have cotton ginneries. The main areas of cotton production in the southern zone are the Borgu Division in north-west Kwara State and the Ankpa area in the Idoma Division of Kogi State. Other areas are parts of Bida Division and the area between Nasarawa and Keffi in Nasarawa State.

3.5.2 Tobacco

The cultivation of this crop in Nigeria has been known for ages. Air-cured tobacco is produced both in western (Ogbomoso) and northern (Zaria, *fadamas* of Shinkafe, Gusau, Birnin Kebbi, Kano, Hadeija, Sokoto) Nigeria. In western Nigeria, the crop is grown in several scattered smallholdings ranging from 0.4 to 2.0 ha in size. Flue-cured tobacco is mainly produced in north-western Oyo State, extending from Saki in the north to Iseyin and Igbo-Ora in the south, where the annual rainfall of 1016-1270 mm is adequate for production. Other desirable factors are the availability of light soils for growing the crop and abundant dry wood for firing during the curing process.

3.5.3 Sugar-Cane

Small quantities are traditionally produced by Nigerian farmers on the floodplains of rivers. Limited quantities of crude brown sugar were produced at Kano, Katsina and Zaria before the refining of sugar started in the early 1960s. This led to the commercial production at Bacita near Jebba, on the southern bank of the Niger floodplain in 1957. This also marks the origin of the Nigerian Sugar Company and other sugar-cane estates in various parts of the floodplains of both the Niger and Benue rivers.

3.5.4 Kenaf

This crop has been grown for centuries by farmers in several parts of Nigeria. Kenaf was found to be a good substitute for jute under Nigerian conditions and this led to the commercial production of unretted kenaf fibre at Jema'a (northern Nigeria) in the early 1960s. Other areas of kenaf production include the floodplains of the Niger and Benue rivers, and parts of Oyo State.

4.0 CONCLUSION

In this unit, you have learned about

i. the important crops grown in different parts of Nigeria,
ii. the spatial distribution of the production of crop types and groups and the factors influencing this, and
iii. the areas of intensive cultivation of specific crops.

5.0 SUMMARY

Crop types and groups of crops differ widely in spatial distribution across ecozones of Nigeria, especially due to seasonal rainfall patterns and soil type.

6.0 TUTOR-MARKED ASSIGNMENT

1) Identify fully, the most important areas of root crop production in eastern Nigeria.
2) Why is guinea-corn regarded as the most versatile cereal crop in Nigeria?
3) Why is the Sahel savanna reported to be the highest millet-producing zone?

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UNIT 5 ECONOMIC IMPORTANCE OF ANIMAL HUSBANDRY

CONTENTS

1.0 INTRODUCTION

Livestock production is the second most important agricultural practice for the production of food and non-food materials to man. Farm animals are kept for many reasons, particularly for food benefits.

2.0 OBJECTIVES

By the end of this unit, you should be able to discuss the general and specific benefits of keeping farm animals.

3.0 MAIN CONTENT

3.1 Food Benefits of Farm Animals: Farm Animals are Kept for the Production of

1) **Meat:** This is the muscle tissue or flesh and the associated fat, connective tissue of slaughtered animals. Meat presents a source of high quality protein in human diet, which is essential for body building and repairs.

2) **Milk:** This is a white, cream-coloured secretion from the mammary glands of female farm animals, which is produced after parturition (birth of the young animal). It is also a very valuable source of high-quality protein. Food by-products of milk such as ghee, butter and cheese are highly desired sources of protein in human diets.

3) **Eggs:** These are produced by poultry, and they serve as a very good source of protein in man's diet.

3.2 Farm Work

Farm animals serve as a good source of power, especially in rural communities where there are no motorable roads. Oxens (cows, bulls, bullocks) can be trained to draw ploughs, harrows, cultivators and carts.

3.3 Transportation

Donkeys, horses, buffalo, bullocks and mules are used to transport farm inputs, farm workers and loads of farm produce to both farm settlements and markets.

3.4 Non-Food Benefits of Farm Animals

Livestock species have other uses derived from other products obtainable from them. These include

i. provision of skin and hides for industrial manufacture of leather;
ii. extractions from internal organs of farm animals such parts as liver, pancreas, intestine, gall bladder, etc. used in making drugs in pharmaceutical industries;
iii. provision of animal fats used in making soap, lubricating oil and drugs;
iv. provision of hooves and horns used in industrial production of gelatin, glues, buttons, combs and other kitchen household equipment;
v. provision of manure (e.g. farmyard droppings, excrements) used as alternative fertilizer materials to inorganic fertilizers in crop farms; and
vi. as a source of household income when livestock and livestock products are sold. In peri-urban areas and rural settings, livestock farmers keep animals primarily to meet their daily expenditures. Livestock keeping also offers huge employment opportunities. This also has important social benefits.

4.0 CONCLUSION

In this unit, you have learned that farm animals are primarily kept for food benefits and secondarily for non-food benefits and services.

5.0 SUMMARY

Man derives considerable food and non-food benefits and services, especially as sources of supplementary farm work and transportation.

6.0 TUTOR-MARKED ASSIGNMENT

1) Write short notes on the non-food benefits of farm animals.
2) In what three ways are farm animals used for providing farm power, and transportation?
3) List two farm animals that are important for transportation, and farm power.

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MODULE 4

UNIT 1 CLASSES OF FARM ANIMALS

CONTENTS

1.0 INTRODUCTION

Farm animals vary widely not only in their types, but also in their feeding habits (which relate mainly to the structure of their gastro-intestinal system), type of food they eat as well as the purpose of keeping the animals.

2.0 OBJECTIVES

By the end of this unit, you should be able to explain:

- the principles guiding the grouping of farm animals, and

- the types of farm animals found in each grouping.

3.0 MAIN CONTENT

3.1 Basis of stomach structure (feeding habit)

Farm animals can be classified into three groups, namely

3.1.1 Ruminants

A ruminant is any of the various hoofed, even-toed, usually horned mammals of the suborder Ruminantia, characteristically having a stomach divided into four compartments and chewing a cud (rumination) consisting of regurgigated, partially digested food. The stomach is compartmentalized into a rumen, reticulum, omasum and abomasum, thereby conforming the capacity to handle leaves, grasses, shrubs and other herbage rich in cellulose and hemi cellulose. Fibre is broken down into the three short-chain (volatile) fatty acids (VFAs), namely acetic, propionic, and butyric acids by bacteria and protozoans (including ciliates such as Paramecium) by fermentation. The stomach can also handle other foodstuffs. They eat quickly, storing masses of grass (grazers) and foliage (browsers) in the rumen. Most of them have small or no upper incisors. Examples are cattle, sheep, goats, deer and giraffes. Some have three-chambered stomachs e.g. okapis, pronghorn, camels and chevrotains. Other examples of ruminants are llamas, bison, buffalo, wildebeest, and antelope. The major advantages of the ruminant pregastric fermentation are

c) microbial products are of value to the host (e.g. VFAs, B vitamins) and are presented to efficient absorptive sites in both the rumen and the lower bowel;
d) ammonia and substances that are metabolized to ammonia (e.g urea) are used by the microbes for synthesis of high-quality microbial protein, which is subsequently subjected to gastric and small bowel digestion;
e) selective retention of particles at the reticulo-omasum orifice, and the added opportunity for mechanical breakdown of fibres during rumination, enhance digestion of coarse foods;
f) the large quantities of gas that are produced may be readily released from the system by eructation (belching);
g) the large input of saliva provides a highly buffered medium with a consistency that permits effective mixing by ruminal contractions; and
h) toxic substances in the diet may be detoxified during fermentation by exposure to small intestinal absorption.

3.1.2 Non-Ruminants

These are those that have simple stomachs. They feed also on grasses and other materials but do not chew the cud. Some of them exhibit a behavioural specialization called "coprophragy" i.e. the re-ingestion of a special kind of faeces (soft faeces; the softer, larger lighter type which are not dropped by the animal but eaten directly from the anus) within the caecum, which allows the food to pass through the entire digestive tract a second time thus facilitating a more complete digestion and utilization. The adaptation helps the animals to circumvent the disadvantage of locating the cellulose fermentation in the posterior part of the intestinal tract. Coprophragy is common in rodents e.g. rabbits, hares. Prevention of coprophragy results in rapid development of deficiencies of vitamin K, biotin and other vitamins; it also reduced growth rate (15% in rats) and abnormal growth and decrease food digestibility, protein utilization and nitrogen retention in affected animals. Cellulose digestion in a large number of non-ruminant mammals e.g. horses, also depends on fermentation by symbiotic microorganisms in the distal part of the GIT, the caecum which is a large diverticulum from the intestine. Many birds have two large caeca suitable for cellulose fermentation. In some non-ruminant herbivores e.g. langur monkey and quokka, multiple-compartment stomachs give a similar digestion as that of the ruminants, except for the absence of the regurgitation and re-chewing of food which distinguishes them from ruminants.

3.1.3 Monogastric Farm Animals

In this group, the stomach is relatively simple in structure, and similar to that of man without compartments. Generally, non-ruminants such as pigs, poultry (chickens, ducks, turkeys, guinea-fowl and geese) and especially fish, require feed that contains more expensive and high-quality ingredients than ruminants. Pigs and poultry require protein-enriched feed to supply the required amino acid balance. Also, laying hens are often fed yellow maize to influence yolk colour. Pigs, like man, are omnivorous and eat both plant and animal tissues. Non-cereal feed resources for pigs include sugar-cane juice, sugar-cane molasses, juice from sugar palm tree, oil, whole fruit and by-products of the African oil palm, cassava roots and by-products, and organic waste from urban households, restaurants and canteens. Other products and by-products from tree, root and tuber crops are included in tropical pig diets on an *ad hoc* basis.

3.2 Basis of type of food eaten

Farm animals are classified into three groups, namely

3.2.1 Herbivores

Ruminant and non-ruminant farm animals that feed on plant materials. They need to maintain continuous fermentation and absorption in those parts of the GIT where cellulose-containing materials can be broken down. Functional differences between species can be related to the rates at which digesta pass through the different parts of GIT.

3.2.2 Carnivores

These are farm animals that obtain their food by eating other animals, and whose digestion relies largely on enzymes rather than microorganisms. Microbial digestion of cellulose occurs in the colon of the dog, but to such a small extent that the colon can be removed without affecting the perfect survival of the animal.

3.2.3 Omnivores

These are farm animals that feed on both plants and animals, but whose digestion is mainly enzymatic as in carnivores. Pig, an omnivore, is herbivorous under domestication because in addition to enzymatic digestion, a good deal of microbial breakdown of plant material occurs in the large intestine, and also, to a large extent in the stomach of the animal.

3.3 Basis of Purpose of Keeping Farm Animal

There are four groups of farm animals, namely

3.3.1 Beef Animals

These are farm animals that are kept primarily for the production of meat e.g. beef cattle, goats, sheep, broilers, turkeys, geese.

3.3.2 Dairy Animals

These are farm animals kept primarily for milk production e.g. cow.

3.3.3 Work Animals

These are farm animals kept primarily for use as source of farm power e.g. bull, mules, bullocks, buffaloes.

3.3.4 Egg-Laying Animals

These are farm animals primarily kept for egg production e.g. poultry such as hens.

4.0 CONCLUSION

In this unit, you should have learned that farm animals can be grouped on the bases of their feeding habits, food eaten and purpose of keeping them.

5.0 SUMMARY

Farm animals vary widely in their feeding habits, type of food they eat and the purposes for which they are managed.

6.0 TUTOR-MARKED ASSIGNMENT

1) What is a "ruminant" animal?
2) State any four advantages of the ruminant pre-gastric fermentation.
3) Write short notes on "coprophragy".
4) Enumerate the limitations of the multi-compartment stomachs of some ruminant herbivores.

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UNIT 2 DISTRIBUTION OF FARM ANIMALS IN NIGERIA

CONTENTS

1.0 INTRODUCTION

Traditionally, most of the types of livestock reared in Nigeria are kept by rural households mainly for family consumption, ceremonial demands, and occasionally for sales to provide quick money for the children's education. However, the change in social and religious orientations and urbanization has tended to increase the commercial value of livestock such as sheep, poultry, goats and cattle, especially in southern Nigeria. This has resulted in considerable movement of the latter two from the northern parts of the country to the rapidly urbanized southern parts. The strong influence of climate accounts for the natural adaptation of specific breeds of goats, sheep and cattle to locations or ecozones of occurrence.

2.0 OBJECTIVES

By the end of this unit, you should be able to discuss:

- the different systems of keeping farm animals, and
- the patterns of spatial distribution and factors influencing these patterns in Nigeria.

3.0 MAIN CONTENT

The main livestock types in Nigeria are cattle, sheep, goats, pigs, donkeys, horses and poultry. There are two rearing systems of livestock,

namely domestic system involving the rearing of animals in small numbers by thousands of households, and large herds of cattle reared by nomadic and semi-nomadic peoples.

3.1 Types of Livestock

3.2 Domestic Livestock Keeping

The average number of all livestock kept per household in northern Nigeria is higher than the national average, judging from the large numbers of all animal types dispatched from northern Nigeria to southern Nigeria. The reasons for this distribution pattern are

i. the need to provide means of sustenance to secluded women,
ii. the widespread use of droppings as manure,
iii. the scavenging habits of some domestic animals, which make the rearing of livestock significant in the rural economies of northern Nigeria, and the use of beasts of burden in may parts of northern Nigeria.

Domestic livestock is widely distributed among households, being kept by a large proportion of rural households. Poultry, goats and sheep are the most widely distributed in that order of households rearing them. Contrarily, the proportion of the rural households keeping cattle is surprisingly low, but still larger for northern Nigeria than the national average. This is primarily because cattle are not easy to handle by small households, and to a large extent also, the exclusion of nomadic groups which specialize in rearing them from surveys.

3.2.1 Goat Distribution

Goats are widely distributed in the country. The reasons for this are the convenience of women and children in caring for them, their ability to survive in nutritional environments that are incapable of supporting other livestock types, their ability to survive on supplementary feeds or fodder (collected grain, tree foliage) and the ease of sheltering them in verandas of houses and *garis*. There is a considerable variety of breeds with different physical characteristics, namely the Sokoto Red/Maradi (most prevalent in Sokoto State), Kano Brown (dominant in Kano-Katsina region), the desert goat (more widespread in parts of Borno State), and the dwarf goats of the forest zone. However, goats are more preponderant in northern Nigeria (68.7% by 1960-70 data), especially in Kano, Katsina, Bornu and Bauchi areas, than in the southern Nigeria. Also, domestic goat keeping is characterized by fluctuating significance nation-wide; there is a high demand for goats in western Nigeria, where there is limited capacity to satisfy the demand.

3.2.2 Sheep Distribution

The distribution is similar in many aspects to that of goats. Most of the sheep are reared in northern Nigeria, with the highest numbers in Borno, Bauchi, Adamawa, Taraba and Kano States. There is a strong relationship between sheep distribution and the prevalence of Islam; rams are slaughtered during some of the Muslim festivals. This also accounts for the larger proportion of sheep kept in western Nigeria, than in Edo and some eastern states. Furthermore, environmental conditions influence the type, size and number of sheep found in different parts of the country. This accounts for the preponderance of the dwarf, short-legged breeds in the south, the medium-sized Yankassa breed in the savanna areas, the Fulani herds and rural households, and the Ouda in the rigorous climatic conditions of the Sahelian zone(mainly along the Nigeria-Niger border).

3.2.3 Other Livestock

The distribution of poultry and beasts of burden (donkeys, camels, horses) shows regional variations. Camels are commonest in the tsetse-free areas of the Sudan and Sahelian zones. Poultry is more widespread in northern Nigeria than in southern Nigeria, where the local breeds in northern Nigeria are specially adapted to the temperature conditions (greater heat tolerance), there is higher women involvement in indoor rearing, while the social structure and spacious nature of the compound are more favourable for the rearing of various kinds of poultry, including turkeys, ducks and guinea-fowls. The number of swines (pigs) kept by Nigerian households is relatively small, compared to that of goats and sheep. Their distribution is also particularly restricted to northern Nigeria, due to the predominantly Muslim population which abhor the eating of pork for religious reasons. Also, many parts of the Sudan zone of northern Nigeria are too dry for pigs, which require a humid environment. However, ecological conditions in the forest and Guinea savanna areas of Nigeria are more favourable to the rearing of pigs on a household basis. This is partly because most of the local breeds reared originated from the wild species *Sus vitatus* which developed under warm, humid, tropical rainforest conditions, and partly because of the less widespread practice of Islam in the latter areas. Also, the shade, shallow standing water suitable for wallowing, and large quantities of waste food products available over extensive areas of southern Nigeria and the Middle Belt render the environment suitable for pigs. These account for the over 50% of the country's swine population which are found in the southern states. They are most widespread in Anambra and Imo States in spite of the small share (10%) of the national total distribution.

3.3 Herding of Cattle

Cattle are different from other types of livestock on account of their occurrence in herds of varying sizes outside households, their almost complete dependence on open pastures and the transhumance movements they are involved in especially during the dry season. About 94% of the country's cattle population is found in northern Nigeria, with most of the cattle being concentrated in the Sudan and Sahelian ecological zones. Only 2-3% of the cattle is found in the south; a large proportion of the cattle are in transit to consumers in the large urban centres. The main cattle-producing areas of Nigeria are found in Sokoto, Katsina, Kano and Bornu Provinces in northern Nigeria. The five main concentration areas are the Sokoto-Rima valley, the Kano-Katsina complex, northern, central and eastern Borno State, the Mambila plateau and the Jos plateau.

3.3.1 Seasonal Distribution of Cattle

Factors which influence the distribution of cattle are

i. Incidence of tsetse fly: The distribution of cattle in Nigeria is significantly influenced by the presence or absence of tsetse flies (*Glossina* spp.) and the associated trypanosomiasis disease in cattle. This accounts for the main distribution of cattle in tsetse-free areas of the Sudan zone during the wet season.

ii. Availability and adequacy of pastures: This is an important factor, especially in relation to the carrying capacity of tropical African pastures. The Sudan zone is overstocked while the Guinea savanna zone is undergrazed. The reason for this is that the pastures in the Sudan zone provide sufficient nutrients for cattle for only 3-5 months of the year, and fall below maintenance level in the dry season. Cattle are therefore moved generally southwards to the Guinea savanna areas in search of better grazing and water. In the Sudan zone, the grasses are annual, and characterized by low productivity, slow recovery and utilizable by cattle for only a short period. In contrast, in the Guinea savanna zone the abundant grass becomes available too quickly, and it is difficult to control and maintain them in a palatable and easily assimilable state for cattle.

iii. The habitation and social characteristics of the herdsmen, and the variations in cattle breeds reared: The majority of cattle in northern Nigeria are still under the management of the nomadic Fulani, whose social life is closely related to the seasonal movements of cattle. The wet season, which marks the greatest concentration of their herds in the tsetse-free high plains of Hausaland and the plateau, coincides with a period of intense

social activity such as family and festive celebrations, and meetings of clan members. Predetermined routes during seasonal movements cause changes in the pattern of distribution of cattle, even during the dry season. The main stabilizing factor in the concentration of cattle in northern Nigeria, especially in the savanna zone, is the considerable number of semi-nomadic and settled cattle owners. The cattle herds owned permanently by settled cattle owners and mixed farmers enhance the cattle population of the Sudan zone during the dry season.

Generally, cattle distribution in Nigeria is related to the different breeds reared and their possible adaptation to conditions outside their areas of origin. The White Fulani is the most adaptable and widely distributed breed in the country. In the Guinea savanna, the breed is used to upgrade local breeds such as the N'dama and Keteku of western Nigeria, and the Adamawa Gudali of northern Nigeria. Most of the other breeds are restricted in their adaptability to the areas where they are found, and this limits the movement of herds and the numbers that can be reared. These breeds are the zebu cattle such as the Shuwa (Borno, Adamawa, Taraba); the Azaouak (northern Katsina, Kano State); the Kuri (near Lake Chad); and the Sokoto Gudali (Sokoto area). The distribution of cattle in the Guinea and derived savanna areas of southern Nigeria is due largely to the resistance to trypanosomiasis of the Keteku, the N'dama and the Muturu breeds.

4.0 CONCLUSION

In this unit, you have learned that farm animals are reared both domestically and in large herds. In the latter, animal populations are influenced not only by the system of domestication, but also by breed type, ecological, socio-cultural and religious factors.

5.0 SUMMARY

Farm animals vary widely in their spatial distribution across ecozones in Nigeria. It depends, among others, on the husbandry system, cultural, social, religious, ecological factors and breed types.

6.0 TUTOR-MARKED ASSIGNMENT

i. List the major types of livestock reared in Nigeria.
ii. Mention and differentiate the two systems of rearing livestock in Nigeria.
iii. Justify the assertion "the average number of livestock kept per household in northern Nigeria is higher than the national average".

iv. Why is cattle considerably less widely found in Southern Nigeria than the other types of livestock?
v. Give any two reasons why goats are widely distributed in the country.

7.0 REFERENCES/FURTHER READING

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UNIT 3 LIVESTOCK MANAGEMENT SYSTEMS

CONTENTS

1.0 INTRODUCTION

The system of management of farm animals depends mainly on the intended scale of output, farmer's convenience, financial base and available physical resources, such as land and pasture. Thus, traditional farmers largely keep their animals on free range, which is cheap and requires little or no care thus allowing more time to be allocated to crop production. However, more advanced and capital-intensive systems of livestock management evolved in response not only to increasing human demand for animal proteins, but also to meet the rising cost of living and urbanization.

2.0 OBJECTIVES

By the end of this unit, you should be able to understand the scientific strategies for managing farm animals in Nigeria.

3.0 MAIN CONTENT

3.1 In Nigeria, there are Four Systems of Managing Farm Animals, namely

i. Nomadic Herding: This is perhaps the first and oldest system of managing farm animals. It involves the movement of animals by man from place to place in search of water and pasture. Animals are thus exposed to various natural hazards, and are therefore poorly productive. The droppings from the animals cannot be properly used as organic fertilizer source for the farmer's crops, due to constant movement of the animals. Also, the animals have the tendency of overgrazing natural pastures and destroying

farmlands in their tracks. However, the system is simple and cheap to practice.

ii. Free Range System: In this system, the animal farmer is settled in one area or village, while his livestock (especially cattle, sheep and goat) is allowed to wonder about either on their own or sometimes, under the supervision of a herdsman. Occasionally, the animals are fed on farm or kitchen wastes. In general, there is little or no care, and additional feed is rarely provided. The cost of production is low in terms of labour and cash investment, and therefore, stock production and quality are very low. The animals are exposed to hazards like in nomadic herding, resulting in very high losses and poor reproductive rates. Although the system is poor, unthrifty and traditional, it is still widely practised in many rural areas.

iii. Semi-intensive System: This system can be regarded as the intermediate between the free range and intensive systems of livestock management. In this system, the farm animals are kept indoors part of the time where they are fed regularly, and sometimes allowed to graze outdoors and fend for themselves in specially allocated pastures called paddocks.

iv. Intensive System: This system is the extreme opposite of nomadic herding of farm animals. In intensive system of livestock production, farm animals are kept under the most scientific management techniques, such as indoor housing all the time with optimum temperature, balanced and precise feeding, for the maximum efficiency and output of the farm animals. Although the system is very expensive and labour-intensive, it can be very profitable if properly managed. A typical example of intensive livestock management is the battery cage system of poultry production.

3.2 Ranching

This is the practice of raising grazing livestock such as cattle and sheep for meat or wool. It is also a method used to raise less common livestock such as elk, American Bison or even ostrich and emu. A ranch is an area of landscape, including various structures, given primarily to the practice of ranching. Ranches generally consist of large hectarages, but may be of nearly any size. If the ranch includes arable or irrigated land, the ranch may also engage a limited amount of farming, raising crops for feeding the animals, such as hay and feed grains. Dude ranches are ranches that cater exclusively for tourists e.g. horseback rides, cattle

drives or guided hunting. Ranchers/stockgrowers are the people who own or operate a ranch.

4.0 CONCLUSION

At the end of this unit, you have learned that the systems of animal husbandry range from the traditional system of regular movements of herded animals across ecozones and around homesteads in Nigeria, moderately organised method combining indoor and outdoor care, to highly scientific methods involving complete indoor management and highly specialised technique for rearing animals for specific benefits, i.e. ranching.

5.0 SUMMARY

The systems of managing farm animals vary with the intended scale of output and farmers' resource outlay.

6.0 TUTOR-MARKED ASSIGNMENT

1) List and define the different systems of managing farm animals.
2) Write short notes on "ranching".

7.0 REFERENCES/FURTHER READING

Agboola, S.A. (1979). *An Agricultural Atlas of Nigeria*. Oxford University Press: U.K. 248.

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UNIT 4 PRINCIPLES OF LIVESTOCK MANAGEMENT

CONTENTS

1.0 INTRODUCTION

The ultimate objectives of livestock production are adequate supply of good-quality animal products and by-products, which not only assures of huge profits on investment but also sustains livestock production systems. This makes it highly imperative to adopt highly efficient principles and practice of livestock production, especially in the selection of the breeder stock.

2.0 OBJECTIVES

By the end of this unit, you should have learned about the basic aspects of good animal husbandry, which assure sustained and profitable supply of high-quality animal products and services.

3.0 MAIN CONTENT

3.1 Selection of Good Animals

The best start for good livestock management lies in the selection of good animals for the farm. The selection of farm animals depends on a number of factors, including

i. Heredity- The parents of the farm animals, especially the sire (male), has to be well known and must be of proven stock with superb economic and performance record;

ii. Health- The animal must be healthy, and this may be certified by looking at the eyes, which should be clean and clear i.e. free from mucus, lacrymation and being blood-shot. The nose should be fairly moist but not running, not swollen, and free from ticks and other animal pests. The mouth, tongue, teeth and gums should be moist, blood-filled, free from swelling wounds or cuts or any infections. The teeth should be strong. The anus should be free from swelling or cuts; the dung and urine should be of the right texture (neither too hard nor too soft) and not stained with blood. The legs should be well formed and free from infection such as swellings, cuts and bruises. The skin coat should be shining, of the right colour and covering, and free from cuts, bruises and parasites.
iii. Age- The younger the animals, the better and cheaper and the more the opportunity for maximum production.
iv. Fertility and fecundity- Where an animal is to be used for breeding, it is important to select one from a well-known herd or very fertile and fecund animals.
v. Conformation or body-build- It is advisable to select an animal on the basis of good conformation by examining the essential parts of the animal in relation to the purpose of keeping the farm animal such as

Dairy production: Cows should be of slender body and low body weight, but the udders (milk factory) have to be big and healthy with pronounced and open teats;
Meat production: Beef animals should be very fleshy around the rump, forelimbs and chest, with short legs and a square rump and long, broad back;
Farm power: Work animals should have long legs, thick necks and broad shoulders for carrying the implements. They should be docile, of good temperament and very strong;
Egg production: Egg-laying beds should be of a good breed reputed to be a high egg-laying potential.

3.2 Feeding

Different kinds of farm animals have different organs for food digestion, and these dictate the kind of food they eat. On the basis of the food they eat, farm animals can be classified as herbivores (feed on plant materials); carnivores (feed on animal flesh); and omnivores (feed on both plant and animal materials). The quantity and quality of food fed to animals is very important in animal management. Food should be regular, fed fresh and contain the relevant nutrients (water, carbohydrate, fats and oil, protein, vitamins, minerals) for the

development of the animal. Feeding of young animals is a delicate management affair and the following key points must be adhered to:

a) they should be fed small quantities of food per time, three or four times daily,
b) the food should preferably be in liquid form and high in protein,
c) in the case of mammals, they should be fed milk from their mother for at least two weeks,
d) they should always be fed at room temperature, and
e) when they are fed solid food, it has to be balanced, fortified with vitamins and minerals, and given in small quantities for a start.

3.3 Housing

Housing of farm animals is a very important aspect of good livestock management. Farm animals are housed to protect them from wild beasts, theft, strong wind, rain, intense direct sunshine, pathogens and pests. The following factors need to be considered in animal housing:

i. Type of Animal: Birds require smaller houses and more temporal structures while bigger animals such as cattle require stronger and more ventilated structures.
ii. Type of Production: Where the product is expensive and cleanliness is important (e.g. meat, butter, cheese, eggs), the building must be such that can be easily and regularly cleaned.
iii. Type of Management: Housing is not important for the Free Range System. Similarly, elaborate housing is not necessary in the Semi-Intensive System. However, in Intensive System where animals are kept completely indoors the housing situation is a critical to successful management business and profit.

Generally, the essential conditions for good housing include

i. the protection of animals from rain, heat, wind, pests and pathogens;
ii. the provision of a dry bed (e.g. dry clean grass);
iii. avoidance of draught;
iv. keeping off flies as much as possible;
v. avoidance of overcrowding;
vi. removing dung and manure from the house regularly;
vii. avoiding sharp edges and holes in buildings to prevent accident to animals;
viii. consistent provision of strong fence to facilitate exercise by animals, and where possible, few trees for shade;
ix. provision of feeding and water troughs within the building as well as on the paddocks; and

x. provision of a separate building/area where sick animals can be isolated as preventive disease control measure.

Grooming of Farm Animals

Farm animals are groomed by brushing, washing and cleaning of all their body parts. The reasons for grooming are many and include

i. keeping the animal free of ectoparasites, which are brushed off when grooming is done properly;
ii. encouraging the taming of the animals to facilitate easy handling by husbandmen;
iii. quick detection of wounds, cuts and injuries, sickness and animals on heat;
iv. keeping animals warm, particularly after exposure to cold or rainy weather;
v. to facilitate operations such as dehorning, tattooing and castration, on the animals; and
vi. to stimulate milking.

3.4 Disease Control in Farm Animals

Livestock diseases are of paramount importance to farmers because of their economic effects. Livestock diseases constitute a major factor for poor animal performance. They cause loss of production through death and frequently, a loss of body condition. Animals are born free of diseases or parasites but they usually acquire these maladies through contact with diseased animals, improper sanitation and improper management, feeding and care. Many diseases are transmissible between classes of animals and from classes of animals to Man (zoonotic diseases) e.g. Bird flu, rabies, mad cow disease. The signs of ill-health include change in general posture of the animal, loss of appetite, raised hair coat and lusterless hair, sunken eyes, lacrimation or glued eyes, dungs with poor consistency, scouring, dark/bloody urine, bad breathing, and other detailed signs detectable by the Veterinarian such as variation in body temperature, pulse rate and behavioural pattern. There are several common diseases associated with livestock, classified according to the etiological agents responsible for them, such as viral, bacterial, protozoan, helminthic, ectoparasitic and rickettsial diseases. Also, the diseases require different measures of controlling them such as good sanitation, quarantine, dipping, culling and vaccination.

3.5 Pasture Establishment

Pastures are established in order to provide a favourable environment for seed germination, seedling emergence and growth of planted vegetative

material in relation to initiation of new roots and shoots; to destroy or control the growth of unwanted, competitive plants and to remove unproductive plants to facilitate re-seeding of the pasture species. The successful establishment of a pasture is directly influenced by soil type and fertility, type of pasture species, rainfall, availability/cost of planting material, type and quality of animal to be fed and management skill. Examples of tropical grass and legume pasture crops include *Axonopus compressus*, *Digitaria decumbens*, *Melinis minutifolia*, *Panicum maximum* and *Pennisetum purpureum* (grass), and *Calopogonium mucunoides*, *Centrosema pubescens*, *Gliricidia sepium*, *Leucaena leucocephala*, *Pueraria phaseoloides* and *Stylosanthes guyanensis* (legume). Grass-legume mixtures (2:1) are more desirable than either grass or legume pasture because legumes have higher nutrient quality than grasses; legumes have a different growth cycle, they add variety to diet quality, and they fix nitrogen which facilitate the growth of associated plant species in the pasture.

3.6 Pasture Management

The main aims of good pasture management are to obtain maximum herbage yield with the highest possible nutritive value throughout the year at the lowest possible cost; to keep pasture productive and prevent any overall decline in quality; to ensure efficient utilization of forages and convert the feed to saleable products such as meat and milk, and to maintain a good grass-legume balance in the pasture. Pastures are managed during establishment following planting and after establishment or in established pasture. Management during establishment involves early grazing, weed control and pest and disease control (through propagule treatment, good crop hygiene, crop rotation, disease-resistant varieties, plant quarantine). After establishment, pastures are managed by controlling the stocking rate (number of grazing animals per unit hectare of land per time), animal distribution in space and time (by fencing), animal quality (based on adaptation to forage, climate and performance) and renovation (through re-seeding and fertilizer application).

3.7 Grazing Management

This aims at obtaining and maintaining high production of consistently good-quality forage, maintain a favourable balance between different herbage species in the pasture, achieve efficient utilization of forage and high animal production. The choice of grazing systems depends on climate, topography, forage species and intensity of grazing. The different types of grazing systems are continuous grazing (extensive, animals remain in paddocks for prolonged periods of time); rotational grazing (intensive, improved pasture/ley pasture, division of paddock);

zero grazing/soiling (animals kept indoors or in paddock); strip grazing (modification of rotational grazing, restricted grazing of animals); and deferred grazing (preserved areas for future grazing, hay, seed-set, or hay). All systems require regular water supply, race, and fenced paddocks.

3.8 Forage Conservation

This is one important way of improving animal performance during periods of forage scarcity and dry months, whereby excess herbage/fodder and forage crops such as cereals and legumes are kept for future livestock feeding. Conservation processes include bush foggage (standing hay), hay (dehydrated green forage), silage (fermented green forage), silage haylage (ensilage hay in the absence of oxygen), husklage (salvage feed consisting primarily of husks and cobs with limited grain), and fodder bank (fenced area of densely planted forage legumes).

4.0 CONCLUSION

In this unit, you have learned that good livestock management involves the selection of good animals, good feeding and housing, efficient grooming of farm animals and adequate care.

5.0 SUMMARY

Efficient livestock management involves not only the selection of good breeding stock, but also delicate handling of farm animals in terms of food, housing and health conditions.

6.0 TUTOR-MARKED ASSIGNMENT

1) Identify three main aims of pasture establishment and two aims of pasture management.
2) List any five factors which enhance pasture establishment.
3) Name three grass and two legume species used in the establishment of pastures.
4) Why are grass-legume mixtures more desirable than sole grass or legume pastures?

7.0 REFERENCES/FURTHER READING

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UNIT 5 ECONOMIC IMPORTANCE OF FISH TO MAN

CONTENTS

1.0 INTRODUCTION

"Fish" is a term used to describe all living produce of water, including fin-fish and poikilothermic vertebrates that breathe by means of gills and move by means of fins. This category of water produce is regarded as "fish" because it dominates 90% of aquatic food resources. However, other aquatic living produce of water which are economically important to man are reptiles (crocodiles, sea turtles); mammals (whales, tortoises, dolphins, seals); other aquatic invertebrates (crustaceans: shrimps, crabs, lobsters); mollusks (oyster clams, periwinkles, cuttle fish); and aquatic plants such as sea weeds and coral reefs.

2.0 OBJECTIVES

By the end of this unit, you should be able to understand that:

i. fish includes fish species and non-fish species, such as reptiles, mammals, mollusks and aquatic plants, and
ii. fish are sources of food, non-food, socio-economic, cultural and religious benefits.

3.0 MAIN CONTENT

3.1 Food for Human Consumption

Fish, particularly fin-fish, is regarded as first-class protein (provides 16% of the world population's protein), containing abundant calorific value, vitamins, phosphorus and other essential elements for good growth and maintenance of a healthy body. Other food fish products are shelled molluscs (calm, mussel, oyster, winkle, and scallop) and crustaceans (shrimp, lobster, crayfish, crab), eggs (roe) of various

species of fish, marine invertebrates (sea urchins, shrimp), squid, octopus, sea cucumber and certain jellyfish species. Marine plants also serve as food (seaweeds) as well as a suspending, thickening, stabilizing and emulsifying agent in dairy products (Irish Moss). In 2002, about 76% of estimated world fisheries were used for direct human consumption. Fish products include canned products, fresh and frozen products, pickled, spiced and marinated products, salted and/or dried products and prepared/secondary products.]

3.2 Non-Food Fish Products such as Fish Meal and Fish Oil are used as Dietary Supplements in Livestock Production

In 2002, their manufacture accounts for 24% of world fisheries production.

i. Some parts of the fish body are used for purposes such as leather and polishing materials (skin of some cartilaginous fishes e.g. carp), scales of coating glass beats and artificial pearls. Non-food fish products, such as fish oil, are used in the manufacture of soap and other pharmaceutical products.

ii. Sea horse, star fish, sea urchin and sea cucumber are used for traditional medicine in China. Eating fish and seafood has been reported to reduce the risk of chronic illness in Canada.

iii. Pigments such as tyrian purple are made from marine snails, and sepia from the inky secretions of cuttle fish. Phycocolloids (extracted from seaweed) and certain fine biochemicals have valuable industrial uses.

iv. Fish glue, made by boiling the skin, bones and swim bladders of fish, is valued for use in several products including illuminated manuscripts and Mongolian war bow.

v. Isinglass, a substance obtained from the swim bladders of fish (especially sturgeon) is used for the clarification of wine and beer.

vi. Fish emulsion is a fertilizer emulsion produced from the fluid remains of fish processed for fish oil and fish meal industrially. Knotted wrack is used for making liquid fertilizer.

vii. Shark skin and ray skin which are covered with tiny teeth (dermal denticles) are used as sand paper.

viii. The above-mentioned skins are used for leather; shark skin leather is used in the manufacture of hilts of traditional Japanese swords. The skin of hagfish is used for making "eel leather" converted into "eelskin" products in Korea.

ix. Whole fish e.g. cleupids, enchovy, capeline and other discards (wastes) and shrimp heads are used for producing animal feeds (fish meal, silage).

x. Fish waste product (offal; consists of skins, heads, eviscera/internal organs, bone/cartilage) is used for organic farming, fish meal production (48-52% protein), liquefied fish (by addition of enzymes), composting (high in nitrogen), commercial baits (buffalo fish heads, carp heads, whole carp, sucker heads, shad), production of formulated bait (crab, crayfish, lobster) and formulated feed (aquaculture).

xi. Provision of income and employment- Fisheries and aquaculture provide full-time, part-time and occasional primary sector employment; aquaculture provides increasingly more opportunities than capture fisheries. Worldwide in 2002, this workforce represented 2.8% of the 1.33 billion people economically active in agriculture.

xii. Fish is desired for recreational fishing through angling(shortfin mako, lognfin mako, white shark, bluefin tuna), fishkeeping and sport fishing of both freshwater fish (bass, trout, salmon, catfish, yellow perch) and salt water fish (swordfish, tuna, merlin, halibut, salmon).

xiii. Fish is caught indirectly for human consumption in industrial fisheries.

xiv. Fish serves as ornamentals and for common exhibition e.g. freshwater fishkeeping, marine aquaria, brackish water aquaria, home aquaria, offers, etc. Pearl and mother-of-pearl are valued for their lustre. Spa treatments are very rich in minerals and enzymes.

xv. Some seafood restaurants keep live fish for cultural beliefs, as deities and religious symbols.

xvi. Fish trade; live fish, pearl trade, trade of dry cod, etc. In 2002, total world trade of fish and fishery products increased to USS 58.2 billion, up 5% relative to 2002 and a 45% increase since 1992.

xvii. Bacteriological agar from cultivated Geldium, a type of red algae, used for cutting bacteria and other microorganisms in most laboratories in British Columbia.

xviii. Hagfish are currently of special interest in genetic analysis of the relationships between chordates; the mucus secreted by the fish includes strong, thread-like fibres similar to spider silk which has potential uses as new biodegradable polymers, space-filling gels and as a means of stopping blood flow in accident victims and surgery patients.

4.0 CONCLUSION

In this unit, you have learned about

v. the scope of fish as aquatic living organisms, and
vi. the various food, non-food and other benefits derivable from keeping fish.

5.0 SUMMARY

Fish species of various types have considerable value as food and non-food products, as well as industrial, scientific and economic benefits.

6.0 TUTOR-MARKED ASSIGNMENT

1) What is fish?
2) Enumerate any five benefits of fish to man.
3) Write short notes on “fish waste products”.
4) List any ten food fish products.

7.0 REFERENCES/FURTHER READING

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MODULE 5

UNIT 1 FISHERIES AND FISH PRODUCTION IN NIGERIA

CONTENTS

1.0 INTRODUCTION

In Nigeria, like other developing countries of the world, there is an increasing need for abundant sources of high-protein food to meet the protein requirements of the ever-increasing population, and the associated supply and costs of animal protein sources, such as meat, milk and eggs. Fish production provides a renewable source of cheap, high-quality animal protein and it is therefore, highly emphasized as an agriculture sub-sector. Fisheries not only supplies fish of various types, but also other aquatic living organisms, including plants such as sea weeds and coral reefs.

2.0 OBJECTIVES

By the end of this unit, you should be able to discuss:

- the aims of fisheries management, and
- the techniques of fish production in Nigeria.

3.0 MAIN CONTENT

3.1 Objectives of Fisheries in Nigeria

xxxviii. To increase fish production by employing modern methods of fishing and technology;
xxxix. To improve the nutritive food value of human diets;
xl. To exploit as profitably as possible the fishery resources through rational exploitation for sustainable production and conservation;
xli. To improve the utilization of aquatic resources by the introduction of modern methods of processing and marketing facilities;
xlii. To raise the standard of living and socio-economic status of indigenous fishermen through cooperative societies, purchase of fishing inputs at subsidized rates (loan-in-kind fishermen programme);
xliii. To reduce the importation of fish and fish products to the barest minimum in order to conserve the scarce foreign exchange;
xliv. To increase fish production and facilitate exportation and fish and fish products for foreign exchange; and
xlv. To generate maximum employment for the populace.

3.2 Fish Production in Nigeria

Based on the source of production, the fishing industry is divided into two groups, namely

3.2.1 Capture Fisheries

This involves fishing in the open sea. Fish are regarded as natural endowments and captured freely without consideration for their reproduction, growth and development. Fishing is done by fishermen at no cost and without replacement. However, the system accounts for more than 90% of the total domestic fish production in Nigeria. There are two sub-divisions, namely Industrial fisheries and Small-scale fisheries. The latter is further divided into Subsistence fisheries and Artisanal fisheries. The bulk (about 80%) of fish production from capture fisheries is contributed by the artisanal sector and the remaining contribution comes from the industrial sector.

3.2.1.1 Industrial Fisheries

The features of this system are higher capital/labour ratio, in-board diesel engines, general ownership of boats by entrepreneurs with the boats manned by salaried crews, high level of organization and efficient shore-based infrastructural facilities (berths for vessels, stores for

products); and generally high productivity (catch per unit effort) and incomes.

3.2.1.2 Small-Scale Fisheries

This system employs small, traditional, largely unmotorised craft, and simple, hand-operated gears; it involves low capital investment, low production per unit effort, usually marine, brackish and inland water operations, unreliable statistics of landing catches, scattered fishing units, high labour requirement, poorly-developed storage and processing plants and therefore, high spoilage and wastage losses, and inadequate credit facilities from banks.

3.2.1.3 Artisanal Fisheries

The features of this system are remoteness of village fishing centres to commercial centres; poor access roads to fishing villages; inadequate preservation and processing capabilities; absence of appropriate village-level extension services; absence of well-established marketing system and associated infrastructure; and inaccessibility to formal credit market in addition to inadequate knowledge of the lending channels.

3.2.2 Culture Fisheries

This is the growing of fish in confined water bodies through the manipulations of water parameters and fish to achieve desired production level. It is also referred to as Fish farming or Aquaculture. It can be likened to intensive livestock farming or battery cage system in poultry production.

4.0 CONCLUSION

In this unit, you have learned that the fisheries sector is a very important sector of Nigeria's agricultural economy, and various techniques are adopted in fish production.

5.0 SUMMARY

Fish production in Nigeria is well-focused at meeting the food and non-food benefits of fish species, through a variety of scientific methods that cut across different groups of fish farmers.

6.0 TUTOR-MARKED ASSIGNMENT

1) Outline any five objectives of fisheries in Nigeria.
2) Classify fully, the fishing industry in Nigeria.

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UNIT 2 AQUACULTURE

CONTENTS

1.0 INTRODUCTION

Aquaculture is a distinct commercial activity which has provided an excellent response to the global demand for fish and sea food through the nutritious and affordable source of animal protein. The technique not only facilitates the domestication of fish, but also guarantees optimum fish health and high-quality fish products through good feeding and care of cultivated fish, as well as sustainable harvest of fish of various types.

2.0 OBJECTIVES

By the end of this unit, you should be able to identify:

- the principles of aquaculture fisheries, and
- the types of aquaculture as a fisheries method.

3.0 MAIN CONTENT

3.1 Objectives of Aquaculture

i. To increase fish production, and consequent protein intake;
ii. To stock waters which are heavily depleted of their natural resource through pollution, over-fishing and high predation of offsprings;
iii. For the production of fishing baits for commercial, industrial fisheries sector;

iv. production of fishing species population for ornamental purposes; and
v. For large-scale production of miscellaneous fish species for industrial purposes e.g. fish meal, fish flour, etc.

3.2 Aquaculture (Aquafarming) as a Fisheries Technique

Aquaculture is the cultivation (farming) of natural produce of water such as fish, shellfish, algae and other aquatic organisms in fresh or salt water. It is distinguished from fishing by the idea of active human effort in maintaining or increasing the number of organisms involved, as opposed to simply taking them from the wild. Economically, aquaculture is restricted to practices such as broodstock maturation, larval rearing, fingerling production, research animal production, specific pathogen-free (SPF) animal production and caviar and ornamental fish production. Aquaculture methods include Mariculture (aquaculture in the ocean), Algaculture (the production of kelp/seaweed and other algae), Fish Farming (the raising of catfish, tilapia and milkfish in fresh water and brackish ponds or salmon in marine ponds) and the growing of cultured pearls. In 2003, aquaculture contributed about 31% of the total world production of fisheries product. The growth rate of aquaculture is very rapid, higher than 10% per year for most species, compared to the flat contribution of wild fisheries to total production. Aquaculture minimizes environmental damage due to fishing through the use of a recirculating system (RAS), a series of culture tanks and filters where water is continuously recycled. Water is treated mechanically through the removal of particulate matter and biologically through the conversion of harmful accumulated chemicals into non-toxic ones to prevent the deterioration of water quality. Optimum water quality is maintained through UV sterilization, ozonation and oxygen injection, thereby increasing the efficiency of feed utilization and growth of fish. Aquaculture also minimizes escaped fish, water usage and introduction of harmful pollutants. A drawback of aquaculture is water exchange, which can however, be reduced through aquaponics such as incorporation of hydroponically-grown plants and denitrification.

3.3 Types of Aquaculture

3.3.1 Aquaculture

Aquaculture can be intensive, semi-intensive or extensive, depending on the inputs (liming, fertilizer application, stocking, management) applied. It may involve stocking of a single species of fish in a pond (monoculture) or culturing/stocking of different species of fish in ponds (polyculture). The criteria for selecting the fish species to stock are local

availability, ability to live and breed in confinement (captivity), ability to efficiently convert food to flesh, relative freedom and resistance to parasites and diseases, and recognition and acceptance as food fish and high market value. The types of fish in aquaculture are tilapia (*Tilapia zilli*, *Oreochromis niloticus*), cod, trout (e.g. Rainbow trout), Atlantic salmon, catfish (*Cyrysichthys nigrodigitans*), mud catfish (*Clarias gariepinus*, *Heterobranchus bidorsalis*), moonfish (*Citharius citharius*), African bony tongue (*Heterotis niloticus*), Niger/Nile perch (*Lates niloticus*), Snake head (*Chana obscura*), mormyrid (*Gymnarchus niloticus*), milkfish, common carp, mudfish, gourami, Asian carp, silver carp, bighead carp, black carp, grass carp, shellfish and catla.

3.3.1.1 Intensive (Closed-Circulation) Aquaculture

This involves the use of a network of circulation systems in culturing fish.

3.3.1.2 Extensive (Pond) Aquaculture

Available food supplies are by natural sources. Zooplankton feeding on pelagic algae or benthic animals such as crustaceans and mollusks are limited.

3.3.1.3 Specific Types within Intensive and Extensive Aquaculture Include

i. integrated recycling systems- involving the use of large plastic fish tanks in a glasshouse with a hydroponic bed placed near, above or between the tanks;
ii. irrigation ditch or pond systems- the use of irrigation ditches or farm ponds to raise fish;
iii. cage system- the use of synthetic fibre cages to raise fish in rivers, lakes, filled quarries, etc.;
iv. classic fry farming- the use of fry or fingerlings to raise trout and other sport fish.

4.0 CONCLUSION

In this unit, you have learned that aquaculture involves the cultivation of fish in either fresh or salt water, based not only on the need for maintenance, or increasing the population of fish species but also to minimize environmental damage, ensure optimum water quality, etc. using extensive, semi-intensive and intensive techniques.

5.0 SUMMARY

Aquaculture is a distinctly significant fishing method and contributes more to sustainable fish production and safe water environment for fish than any other fishing method, in spite of the requirement of water exchange.

6.0 TUTOR-MARKED ASSIGNMENT

1) What is "aquaculture" and the principle behind the technique?
2) Write short notes on aquaculture methods.

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UNIT 3 TYPES OF FISH

CONTENTS

1.0 INTRODUCTION

Fishes vary not only in their habitat characteristics such as water source and type, but also in body skeleton. Thus, fish can be either temperate or tropical types, freshwater or saltwater types, or bony and cartilaginous types. Each sub-group consists of a large and variable number of fish types and distinguishing characteristics.

2.0 OBJECTIVES

By the end of this unit, you should be able to explain:

- the various ways of grouping fish species, and
- the fish species found in different groups.

3.0 Main Content

Fish are classified using various schemes. These bases of classification include

3.1 Water Source: Fish are classified as

3.1.1 Tropical fish

These are the fish that live in either salt or freshwater but which need a warm (tropical) medium or temperature to live. The types can be Tropical Freshwater species or Tropical Marine species.

3.1.2 Coldwater fish

These fish can be salt or fresh water fish that need colder water temperatures. Like tropical fish, coldwater fish can also be Coldwater Fresh water species or Coldwater Marine species.

3.2 Type of Water Body: Fish are classified

3.2.1 Freshwater Fish

These are the fish that live in freshwater, usually found in inland rivers and streams of most continents. They can be as colourful as marine fish and yet need less care. Most freshwater fish in the ornamental hobby are tropical fish, which require a heater. Freshwater fish can be further grouped on the basis of temperament, lighting needs, habitat needs and swimming level, as shown below:

Fish type	Temperament	Lighting needs	Habitat	Swimming level	Size (cm)
Shovelnose (catfish)	peaceful	reduced	plants/rocks	bottom	2.8''
Bristlenose(algal eater)	peaceful	reduced	plants/rocks	bottom	2"
Giant (crab)	peaceful	bright	plants/rocks	all	4.75"
Butterfish	peaceful	reduced	plants/rocks	top	4.75"
Pacu	peaceful	bright	plants/rocks	middle	20"
Spotted Puffer	aggressive	bright	plants/rocks	all	6"

Culled from: Starting a Fish Tank

Fresh water fish can also be classified on the basis of shared characteristics of categories as

i. killifishers and livebearers- livebearers, killi fishes, mosquito fishes, gambusies, pup fishes;
ii. darters and sculpins- darters, sculpins, longperches;
iii. flatfishes, sunfishes and perchlike fishes- flounders, sunfish, perches, basses, crappies;
iv. elongate fishes with long snouts- paddle fish, sturgeons, pikes, pickerels, gars;
v. eel-like fishes and catfishes- lampreys, eels, bowfins, catfish, bullheads;
vi. minnows and shiners- daces, shiners, long minnows, shads;
vii. trouts and salmons- whitefishes, trouts, salmons, graylings;

3.2.2 Marinefish

These are the fish that live in salty seawater. Most commonly, marine fishes need tropical climate.

Saltwater types of fish are also categorized as above into

i. sharklike fishes- sharks, dogfishes, ratfishes;
ii. skates and raylike fishes- rays, mantas, stringrays, skates
iii. eellike fishes and long dorsal-finned fishes- hagfishes, morays, wolffishes, eelpouts, midshipmen;
iv. drumlike fishes, cods, trouts and catfishes- trouts, drums, sea catfishes, clds, cobias;
v. sticklebacks- sticklebacks;
vi. long, slender fishes- cutlass fishes, flying fishes, needlefishes, pipefishes, trumpetfishes;
vii. seahorses- seahorses;
viii. fishes with spiny rays or tapering bodies- rockfishes, scorpion fishes, lizard fishes, sculpins;
ix. basslike fishes, grunts and snappers- temperate basses, seaperches, grunts, snappers;
x. angelfishes and disc-like fishes- angelfishes, opaleyes, spadefishes, surgeonfishes, butterflyfishes;
xi. parrotfishes and wrasses- parrotfishes, wrasses;
xii. spindle-shaped fishes and large, robust fishes- jacks, whitefishes, tunas, bonefish, bonitos;
xiii. flatfishes- sanddabs, halibuts, flounders, soles; and
xiv. puffers, boxfishes and fishes with lures- goosefishes, boxfishes, filefishes, puffers, lunpfish.

3.3 Basis of Body Skeleton

Fish can be divided into three groups.

3.3.1 Jawless Fish

These include the lampreys (Class Cephalaspidomorphi) and hagfish (Class Myxini/Hyperotreti).

3.3.2 Lampreys

A lamprey (lamprey eel; Family Petromyzontidae) is a jawless fish with toothed, funnel-like sucking mouth. They are known for boring into the flesh of other fish to suck their blood; they constitute a minority and have vastly different morphology and physiology. They have no scales but measure up to 13-100 cm. Also, they have no paired fins but have large eyes, one nostril on the top of the head and seven gills on each side. They have cartilaginous skeleton and are regarded as the sister taxon of jawed vertebrates (gnathostomoes) hence, not classified within the Vertebrata itself. Lampreys live mostly in coastal and fresh waters, and are found in most temperate regions except Africa, because of their low tolerance to high water temperatures. Lampreys begin life as burrowing freshwater larvae (ammocoetes) but transform in a metamorphosis into adults after 5-7 years, which exhibit efficient predatory/parasitic life. The adult attaches its mouth to a fish, secreting an anticoagulant to the host and feeding on the blood and tissues of the host. This phase lasts about 18 months. There are 40 recorded species in nine genera and three sub-families, namely Geotriinae, Mordaciinae, and Petromyzontinae.

3.3.3 Hagfish

These are primitive marine vertebrates. They exhibit unusual feeding habits and slime-producing capabilities. They are long (1/2 m in average length), vermiform and can exude copious quantities of a sticky slime or mucus, which finds use as escape strategy. An adult hagfish can secrete enough slime to turn a large bucket into gel in a matter of minutes. Hagfish have elongated, ‘eel-like’ bodies and paddle-like tails. Their colours depend on the species and range from pink to blue-grey, with or without black or white mottling. Eyes may be vestigial or absent. They have no true fins or jaws, but there are six barbells around their mouth and a single nostril. Unlike Gnathostomata, they have a pair of horizontally moving structures with tooth-like projections for pulling off food. The hagfish enter both living and dead fish, feeding on the insides, and polychaete marine worms. They cannot enter through the skin but

they often enter through mouth, gills or anus. Like leeches, they have a sluggish metabolism and can go months between feedings.

3.3.4 Cartilaginous Fish

This consists of fishes that belong to the Class Chondrichthyes. The characteristics are presence of internal jaws (palatoquadrate), paired appendages (pectoral, pelvic fins) supported by an internal skeleton which provide more efficient locomotion, three semi-circular canals; teeth-modified dermal scales; more proficient predators than the jawless fish; internal skeleton composed of cartilage, which may be prismatically calcified, placoid scales, second gill arch (hyoid) involved in jaw suspension, swim bladder or lung absent, have oil filled liver to provide natural buoyancy, claspers (modified pelvic fins) present in males (internal fertilization), persistent notochord; ventral mouth; and replacement teeth rows. There are two subclasses, namely Subclass Elasmobranchii (comprising the rays, skates, and sharks) and Subclass Holocephali (consisting the Chimaeras/rayfishes). The categories of ray fishes are Subcategories Pristiformes (sawfishes), Rajiformes (common rays and skates), and Torpendiniformes (electric rays).

3.3.5 Bony Fish

This consists of fishes found in the Class Osteichthyes. Like all fishes, the fishes are cold-blooded vertebrates that breathe through gills and use fins for swimming. Bony fishes have several distinguishing features, namely a skeleton of bone, scale, paired fins, one pair of gill openings, jaws and paired nostrils. The class includes the largest number (23, 500) of living species of all scientific classes of vertebrates. It consists of 73 fish families ranging from the Sturgeons, Herring and Tarpon to the Deep Sea Anglers. They account for about 96% of all fish species, except the Chondrichthyes, the Myxini (hagfishes) and the Cephalaspidomorphi (lampreys). The subclasses are

i) **Subclass Dipnoi (lungfishes),** which have an upper jaw fused to the brain case, fused teeth, and the presence of an air-breathing organ that opens to the oesophagus. A lungfish's canal fin is continuous with its dorsal and anal fins. The pelvic and pectoral fins are long and tubular.

ii) **Subclass Crossopterygii (coelacanths),** which have cosmoid scales, two dorsal fins and fleshy paired fins that contain skeletal elements.

iii) **Subclass Actinopterygii** (all other living bony fishes), which are characterized by rayed fins.

4.0 CONCLUSION

In this unit, you have learned that fish differ widely in their type, depending on water source, type of water body and body skeleton.

5.0 SUMMARY

Fish types are differentiated by the location of water source used as habitat (warm tropical, cold temperate), type of water (freshwater, saltwater or marine) and body skeleton, whereby fish can be jawless, bony or cartilaginous.

6.0 TUTOR-MARKED ASSIGNMENT

1) List the bases for classifying fish.
2) Differentiate coldwater and tropical fish types.
3) Write short notes on bony fish.

7.0 REFERENCES/FURTHER READING

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UNIT 4 IMPORTANCE OF FOREST

CONTENTS

1.0 INTRODUCTION

Man's need for wood started in pre-historic times. The Early man relied on wood for survival, shelter, tools and hunting implements such as clubs, spears, bows and arrows. The wild forests served sufficiently as the original source of wood. Inadvertently, in his search for wood from the forests, man discovered other benefits of forest trees, especially wood products and by-products, and innumerable beneficial services such as biodiversity conservation and recreation. Thus, the roles of forests in providing significant economic, social, religious and environmental values to man cannot be over-emphasised.

2.0 OBJECTIVES

By the end of this unit, you should be able to discuss the economic importance of forests to man.

3.0 MAIN CONTENT

3.1 Importance of Forests

3.1.1 Forest Products

These include:

a) timber, sawn timber, used for various construction works including furniture-making;
b) fruits and other food items (tubers, leaves) to supplement man's dietary nutrient requirements;
c) fodder tree species such as for livestock feeding;
d) ethno-medicare, through herbs used for medicinal purposes;
e) wildlife that supplies animal protein;
f) chewing sticks and sponges;

g) raw materials for handicraft and small-scale enterprises e.g. fibres of *Pandanus* used for weaving mats and baskets, and rattans for making furniture items;
h) non-timber forest products (NTFPs) such as culinary materials, dietary supplements, mushrooms, ferns, sponge and charcoal;
i) fuel wood and pole from timber;
j) industrial raw materials such as latex, gum and resins; and
k) provision of materials that are of cultural and religious significance e.g. leaves of *Newbouldia laevis*, used during traditional chieftaincy coronation; dedication of some forests to the worship of deities and traditional gods (sacred/fetish groves).

3.2 Forest Services

Modern forestry is aimed at assisting forests to:

i. provide and conserve biodiversity for wildlife habitat;
ii. regulate natural water, including water flow and water erosion;
iii. stimulate recreation, through eco-tourism;
iv. enhance landscape and community protection;
v. provide employment;
vi. provide aesthetically appealing landscapes;
vii. provide a "sink" for atmospheric carbon-dioxide (through carbon sequestration), in order to purify air and water, and prevent global warming by greenhouse gases;
viii. detoxif and decompose wastes;
ix. generate and renew soil fertility;
x. stabilize the climate and moderate temperature extremes; and
xi. provide windbreak and shelterbelt;
xii. provide foreign exchange;
xiii. provide employment opportunities; and

4.0 CONCLUSION

In this unit, you have learned that forests are important for the provision of both timber and non-timber products, cultural and religious benefits and services, such as biodiversity, relaxation and employment.

5.0 SUMMARY

Forests are highly valued not only for timber and non-timber products, but also for cultural, religious benefits and services which ensure safe environment for man's development and survival.

6.0 TUTOR-MARKED ASSIGNMENT

1) In what two broad ways do forests serve Man?
2) Outline any four products and six services of forests.

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UNIT 5 SUSTAINABLE FOREST MANAGEMENT

CONTENTS

1.0 INTRODUCTION

The concept of sustainable forest management evolved with the advancement of civilization, and the associated rapid depletion of forest resources by man. Through several development strategies therefore, man has continued to enjoy full and inexhaustible benefits and services which both natural forests, forest reserves and forest plantations provide not only for his survival and development, but also for the preservation of his environment.

2.0 OBJECTIVES

By the end of this unit, you should be able to explain the principles and strategies for sustainable forest management.

3.0 MAIN CONTENT

3.1 Sustainable Forest Management

This is defined as the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regenerative capacity, vitality and their potential to fulfill, now and in the future, relevant ecological and social functions, at local, national and global levels, and that does not cause damage to other systems.

The seven thematic areas of sustainable forest management are

i. extent of forest resources
ii. biological diversity
iii. forest health and vitality
iv. productive functions and forest resources
v. protective functions and forest resources

vi. socio-economic functions; and
vii. legal, policy and institutional framework.

3.2 Strategies for Sustainable Forest Management

i. Ecosystem Approach

This is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. It is based on the application of appropriate scientific methodologies focused on the levels of biological organization, encompassing the essential structures, processes, functions and interactions among organisms and their environment. It recognizes man and his cultural diversity, as an integral component of the ecosystem.

ii. Independent Certification

Third-party certification schemes evolved in the 1990s as a credible tool for communicating the environmental and social performance of forest operations. The potential users include forest managers, investors, environmental advocates, business consumers of wood and paper, and individuals. It helps individual organizations to develop standards of good forest management, and also independent auditors to issue certificates to forest operations that comply with those standards. The certificate verifies that the forests are well-managed (based on a particular standard) and ensures that certain wood and paper products come from responsibly-managed forests. There are several different systems of third-party certification. Some common standards are Canadian Standards Association (CSA), Forest Stewardship Council (FSC), Sustainable Forestry Initiative (FSI) and Programme for the Endorsement of Forest Certification Schemes (PEFC).

4.0 CONCLUSION

In this unit, you have learned that sustainable forest management maintains biodiversity, health, socio-economic functions and safety of forests at local, national and global levels, through ecosystem approach and independent certification.

5.0 SUMMARY

Forests need to be sustainably managed through appropriate scientific methodologies and development of standards of good forest management, in order to realize the full benefits of forests to Man.

6.0 TUTOR-MARKED ASSIGNMENT

1) What is meant by "sustainable forest management"?
2) Identify and describe the strategies for ensuring the sustainable management of forests.

7.0 REFERENCES/FURTHER READING

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MODULE 6

UNIT 1 SILVICULTURAL SYSTEMS

CONTENTS

1.0 INTRODUCTION

Specifically, silvicultural systems derive from the strategies of sustainable forest management. The main focus of the systems is the creation and maintenance of pure, even-aged stands of single tree species in forest plantations, so as to meet the diverse needs and values of both the land-owners and the larger society. The systems involve regeneration strategies and yield regulation before subsequent sale, harvest and extraction of plantation species for man's use.

2.0 OBJECTIVES

By the end of this unit, you should be able to explain the basic aspects of the practice of silviculture.

3.0 MAIN CONTENT

Silviculture is based on the principles of forest ecology and ecosystem management; it is more of the imitation of natural processes of forest growth and development than a substitution for them. The goal of silviculture is the creation and maintenance of pure, even-aged stands of single species of trees.

3.1 Silvicultural Systems

These are integrated schemes covering both intermediate and reproduction treatments that help to maintain pure, even-aged stands of a single tree species. Significant biological and economic considerations in these systems include desired uses of land, kinds of products and services desired, prospective costs and returns of the enterprise presented by management of the stand, funds available for long-term investment in stand treatments, harvesting techniques, harvesting equipment, reduction of losses from damaging agencies and the natural requirements that must be met in reproducing the stand and fostering its growth. The systems are:

3.1.1 Regeneration

This is the act of renewing tree cover by establishing young trees naturally or artificially, after removing the previous stand/forest. The method, species and tree density are chosen to meet the goal of the land-owner. Forest regeneration practices include changes in tree planting density through human-assisted natural regeneration, enrichment planting, reduced grazing of forested savannas and changes in tree provenance or species genetics. Human-assisted natural regeneration is the establishment of a forest age from natural seeding or sprouting after harvesting through selection cutting, shelter (seed-tree) harvest, soil preparation or restricting the size of a clear-cut stand to secure natural regeneration from surrounding trees. Enrichment planting is increasing the planting density, plants/ha in an already growing forest stand. There are five different regeneration methods, namely

3.1.1.1 Single-Tree Selection

This involves the removal of typically large and valuable specimens from the overstorey and creating a gap in the canopy that stimulates the

death of an old-age tree. It is an even-aged harvest method most suitable for regenerating shade-tolerant trees and can be very difficult to implement in dense stands and may lead to residual stand damage.

3.1.1.2 Group Selection

This is an even-aged regeneration method most desirable for regenerating shade-intolerant tree species. Residual stand damage is minimized by directional felling of trees. Also, foresters can select across the range of daiameter classes in the stand, and this helps to maintain a mosaic of age and diameter classes.

3.1.1.3 Clear-Cut

This is an even-aged regeneration method that can employ either natural or artificial regeneration. Clear-cutting can be biologically appropriate with species that typically regenerate from stand-replacing fires e.g. lodgepole pine (*Pinus contorta*). Alternatively, clear-cutting can increase species richness on a stand with the introduction of non-native and invasive species. However, it can prolong slash decomposition, expose soil to erosion, impact visual appeal of a landscape and remove essential wildlife habitat.

3.1.1.4 Seed-Tree

This is an even-aged regeneration method that retains widely-spaced residual trees in order to provide uniform seed dispersal across a harvest area. It is most suitable for light-seeded species and those not prone to windrowing. In this method, 5-30 seed trees/ha are left on site to regenerate the forest. The remaining trees are left on site until regeneration is established after which they can be removed. Re-entry of cuttings to remove the remaining seed trees is not always economically viable or biologically desirable. Disadvantages are as in clear-cutting.

3.1.1.5 Shelterwood

This is a regeneration method involving the removal of trees in a series of three harvests, namely preparatory cut, establishement cut, and removal cut. The objective of the method is to establish new forest reproduction under the shelter of the retained trees. Unlike the seed tree method, residual trees alter the understorey environmental conditions such as sunlight, temperature and moisture that influence seedling growth.

3.2 Intermediate Stand Treatments

These are aimed at regulating the yield and determination of allowable cut. The treatments are

3.2.1 Release Treatments

These include weeding (implemented during the stand's seeding stage to remove or reduce competition from herbaceous species or woody shrubs); clearing (release of select saplings from competition by overtopping trees of a comparable age and enhances the establishment of a desired tree species and stem quality) and liberation cutting (releases tree seedling or saplings by removing older overtopping trees).

3.2.2 Thinning

This is aimed at controlling the amount and distribution of available growing space. Its advantages are altering stand density, influencing the growth, quality and health of residual trees, helping to capture tree mortality and cull the commercially less desirable, usually smaller and malformed trees. Thinnings are not aimed at establishing a new tree crop or creating permanent canopy openings. However, ecological thinning (i.e. thinning aimed at increasing the growth of selected trees in order to enhance the development of wildlife habitat e.g. hollows) is a new approach to landscape restoration for some types of eucalypt and woodlands in Australia. Common methods of thinning include low thinning (thinning from below /German thinning); crown thinning (thinning from above/French thinning); selection thinning (thinning of dominants/Borggreve method); mechanical thinning (row/geometric thinning); and free thinning.

3.2.3 Pruning

The removal of the lower branches of the young trees to clear knot-free wood which can subsequently grow over the branch stubs. Such lumber has a higher value than knotty wood. It is an extensive practice in *Radiata* pine plantations of New Zealand and Chile. It is being gradually replaced by the Finger joint technique of producing lumber and mouldings.

3.3 The Third Phase of Sustainable Forest Management Involves the Sale, Harvesting and Extraction of Crops

4.0 CONCLUSION

In this unit, you have learned that silvicultural systems achieve pure, even-aged stands of single species of trees through diverse techniques of forest management.

5.0 SUMMARY

Silvicultural systems imitate the natural processes of forest growth and development to create and maintain pure stands of trees.

6.0 TUTOR-MARKED ASSIGNMENT

1) Define the following terms (a) silvicultural systems, and (b) single-tree selection.
2) List four practices for regenerating forests.
3) Write short notes on intermediate stand treatments.
4) State any four factors of important consideration in implementing silvicultural systems.

7.0 REFERENCES/FURTHER READING

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UNIT 2 NON-TIMBER (NON-WOOD) FOREST PRODUCTS (NTFPs/NWFPs)

CONTENTS

1.0 INTRODUCTION

The forest is a plant community composed of trees and other vegetation which contains not only a great quantity of timber reserves, but also abundant non-woody plant and animal resources otherwise known as non-timber forest products (NTFPs) or non-wood forest products (NWFPs). For example in China, there are over 1,900 species of woody plants in the forested areas; 340 species of aromatic plants; more than 120 species of edible plants; 400 species of medicinal plants; over 100 species of economic plants; 80 species of nectariferous (nectar-producing) plants; and over 500 species of wildlife. The Food and Agriculture Organisation (FAO) estimates that 80% of the developing world relies on NWFPs for some purpose in their everyday life. These materials also play important role in the international marketplace with over US$ 1.1b in trade. NWFPs are usually collected on a local level by peasant farmers. However, some of the materials have been successfully domesticated for large-scale production e.g. honey.

2.0 OBJECTIVES

By the end of this unit, you should be able to identify the non-wood benefits of forest trees to man.

3.0 MAIN CONTENT

3.1 Non-Timber Forest Products

These are the huge variety of materials derived from forests excluding timber and fuel wood. Alternatively, the NTFPs are parts of plants, fungi and other biological materials harvested within, and on the edges, of

natural, manipulated or disturbed forests. NTFPs include foods (bark, roots, tubers, corms, leaves, flowers, nuts, fruits, fungi, mushrooms, honey, game, gum, sap); food additives (spices, herbs, flavourings, sweeteners), fodder, fibres (furniture, clothing, construction), fragrances for perfume, ornamental pods and seeds, resins, oils, and plant and animal products such as meat, skins, teeth and bones, and those with medicinal value. The raw materials for NTFPs are gathered from government-owned and communal lands, especially honey, game meat, liana vines and grasses, where land tenure systems may hinder access to the products. Many of the products are often seasonal in supply, and depend on natural growth and regeneration which make their productivity unpredictable e.g. mushroom. NTFPs are many and diverse in nature, and vary widely in range in different regions depending on inherent genetic characteristics, land use practices, edaphic conditions and environmental influences. Many of the products are available during the farming season, and thus, contribute to farming activities.

3.2 Economic and Potential Values of NTFPs

i. Household subsistence- Many NTFPs are used as food, fodder, fibres, grazing supplements, medicine and construction materials;
ii. Food and nutrition- NTFPs provide a large variety of diets and dietary supplements which are important sources of nutrients to man.
iii. Income and employment- The exploitation of many NTFPs can provide income to people with limited alternative employment opportunities and low income.
iv. Medicinal uses- Several NTFPs are valued for their use in trado-medical and pharmaceutical preparations.
v. Cultural and spiritual uses- Several NTFPs serve valuable cultural (coronation ceremony) and deity purposes.
vi. Cottage industries- Several industries process NTFPs for man's domestic and commercial use.

The following table shows the benefits derivable from some NTFPS.

Species	Uses
Acacia nilotica	Tannin and dye
Pleurotus tuber-regium (mushrooms)	Consumed for nutrient supply
Gnetum africanum	Consumed for nutrient supply
Hynocarpus spp	Oil used in treating leprosy
Irvingia gabonensis	Food and cottage industries
Azadirachta indica	Medicinal and jam
Parkia spp.	Soup condiment
Chorysophyllum albidum	Food, arts and craft

Garcinia mannii	Chewing stick
Indigofera spp.	Dye
Acacia Senegal	Gum Arabic
Viteblaria paradoxa	Shea butter and oil
Apia mellifera	Honey
Khaya senegalensis	Medicinal
Afzelia Africana	Cane production
Laccosperma secuncli	Mats
Pandanus candelabrum	Native salt
Rhizophora spp.	Ropes

3.3 Classification of NTFPs

There are four major classes of NTFPs, namely culinary NTFPs; wood-based NTFPs (obtained from whole or parts of non-timber sized trees), floral and decorative NTFPs, and medicinal and dietary NTFPs. However, the Food and Agriculture Organisation (FAO) of the United Nations classified NTFPs into three groups viz. vegetal NTFPs (the use of forest plants for food, forage, fibre, medicine and biochemicals), fauna NTFPs (the use of animals such as birds, reptiles, insects and fishes found in the forest as food, fur, pet, hides and skin), and service NTFPs (services rendered by the forest such as soil improvement, soil protection, parks, reserves, windbreaks and historical sites).

4.0 CONCLUSION

In this unit, you have learned that several non-timber parts of forest species, including fungi provide good sources of foods, food additives, etc. for man.

5.0 SUMMARY

NTFPs are diverse, including culinary, wood-based, decorative, medicinal and dietary materials, and have immense economic and potential values to Man.

6.0 TUTOR-MARKED ASSIGNMENT

1) What are “non-timber (non-wood) forest products”?
2) Name three sources of NTFPs.
3) List four factors that determine the range of NTFPs.
4) Enumerate any five potentials values of NTFPs.

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UNIT 3 WOOD PRODUCTS AND WOOD COMPONENTS

CONTENTS

1.0 INTRODUCTION

The early migration of man including the exploration of the world are closely associated with the utilization of wood. Similarly, the advancement in science and technology has brought about diverse and more sophisticated uses for wood, such as lumber, poles, posts, wood veneer, plywood, particleboard, fibreboard, match splint, toothpick, transparent filament, charcoal, etc. Thus, there is also a close association between the level of economic development of a nation and the dependence of the nation on wood both in its conventional and modified forms.

2.0 OBJECTIVES

By the end of this unit, you should be able to explain:

- wood as a complex forest material, and
- the valuable uses of wood.

3.0 MAIN CONTENT

3.1 Wood

Wood is a complex material of biological origin derived from the forest such as trees, shrubs, certain climbers and woody liana in the process of growth. They are composed of cellulose (reinforcing material), hemi-celluloses (matrix and binding materials) and lignin (cementing material). Extraneous materials are of diverse chemical composition, and include sugars, starches, gums, pectins, polyphenols, tannins, dyestuff, proteins, organic acids and ash minerals. These materials are responsible for the beautiful colour, durability, susceptibility to bio-

deteriorating agents, impermeability, greasy, feel, smell, difficulties in sawing, bonding and pulping characteristics of certain wood species.

3.2 Uses of Wood

The use of wood by humans dates back to antiquity, when the pre-historic man relied on wood for survival, shelter, tools and hunting implements (weapons, such as clubs, spears, bows and arrows), fuel, and construction of primitive furniture (small-sized trees stems and branches). The advancement of science and technology has facilitated the development of different wood product industries that engage in the production of sawnwood, wood-based panel products, pulp and paper, furniture and joinery, energy, chemically-treated wood, wood-derived chemicals and specialty products such as toothpicks and tool handles.

3.3 Manufacturing Wood Products

These include

i. Chemical products and extractives- These are products of wood obtained through chemical processing resulting in complete structural transformation of wood. The products include those from pulping such as cellulose (pulp), lignin, alcohol and yeast, di-methyl sulphide, lingo-sulphates and purified lingo-sulphate; tall oil, wood bark products such as esters and rubber latex, chemicals from foliage such as chlorophyll and leaf protein.

ii. Semi-finished wood products- These are primary products of wood which serve as input raw materials for other wood products e.g. sawn timber, plywood, particle boards and fibre boards.

iii. Final (finished) wood products- These are made up of construction materials, furniture products, packaging materials, technical articles and special products. The construction materials include products which range from doors, windows, formwork frames to prefabricated wood buildings. Furniture products are variable depending on their area of use, namely household furniture, school furniture, office furniture, and furniture used in standing position (shelves, cupboards, wardrobes, work benches), in sitting position (chairs, tables, desks), and in sleeping position (wooden beds). Other furniture items are peculiar to people and places depending on history, culture, conception, technology, interaction and standard of living. Packaging materials are cases/ boxes and drums. Technical articles are partially produced from wood and completed with other components which are non-wood materials e.g. pencils, match splints, ice-cream holder and rulers.

Special products are products of wood that are used in special areas such as sports (skis, crosses for hockey, tennis rackets), music (drums, violin, guitar) and transportation (veneer, plywood and densified wood for boats, platforms and body of vehicles).

4.0 CONCLUSION

In this unit, you have learned that wood has diverse structural extraneous components, which have valuable primary uses and industrial applications.

5.0 SUMMARY

The significance of wood to Man dates back to pre-historic times. However, current developments in science and technology have led to the production of more versatile industrial materials such as sawnwood, extractives and furniture items.

6.0 TUTOR-MARKED ASSIGNMENT

1) What is a wood?
2) List and enumerate the three major components of wood.
3) Write short notes on extraneous wood materials.

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Forest Products. http://www.forestproducts.co.uk

UNIT 4 BASIC PRINCIPLES OF FOREST MANAGEMENT

CONTENTS

1.0 INTRODUCTION

Forest resources of use to man and other living organisms are not inexhaustible. This therefore, implies the need to introduce several approaches for managing the forest ecosystems. Effective forest management will not only sustain the product and service benefits of forests, but it will also protect and restore the ecosystems through the best forestry practices as well as maximally exploit the forest land and environment for man's development. Forestry practices which serve these purposes include ecoforestry, agroforestry, forest gardening and certified forestry.

2.0 OBJECTIVES

By the end of this unit, you should be able to discuss the principles of forest management, their advantages and limitations.

3.0 MAIN CONTENT

3.1 Forestry

This is defined as the art, science and practice of studying and managing forested land, plantations and associated natural resources such as waters and wasteland, primarily for harvesting timber but also, for conservation and recreational purposes. It is related to silviculture, which involves the growing and tending of forests. Forestry involves the production (tree planting and maintenance), distribution and consumption of forest products and services. The activities involved in forestry are tree breeding, reforestation and deforestation (the conversion of natural forests or plantations to non-forest lands and non-vegetated lands).

3.2 Silviculture

This is defined as the theory and practice of controlling the establishment, composition and growth of stands of trees for any of the goods (including timber, pulp, energy, fruits and fodder) and benefits (water, wildlife habitat, microclimate amelioration, carbon sequestration) for which trees are desired. Alternatively, it can be defined as the art and science of controlling the establishment, growth, composition, health and quality of forests to meet diverse needs and values of land-owners and society.

3.3 Forest Management

This is defined as a range of interventions that affect forest ecosystems. They include policies for cutting trees for timber, planting and replanting of various species, cutting roads and pathways through forests and techniques for preventing or controlling outbreaks of fire. It also involves emphasis on watershed management, wilderness and recreation. The goal of forest management plans is to provide logs as raw material for timber, veneer, plywood, paper, wood fuel and other industries. Post-harvest site plans reforestation (tree planting by species) weed control, fertilization, thinning (spacing of young trees that are crowding one another), prevention and control of insect infestation, disease infections and forest and grassland fires, forest mensuration, wildlife conservation and watershed protection.

3.4 Ecoforestry

This is forestry that emphasizes holistic practices which strive to protect and restore ecosystems rather than maximize economic productivity. Practitioners of ecoforestry avoid practices like clearcutting, high

grading and pesticides. Ecoforestry is considered by some to be a traditional practice, whereby people tend to an area of forest, helping it to grow sustainably over many years. Practitioners of ecoforestry claim that their techniques promote self-regulating forest ecosytems with a diversity of species and natural habitats in harmony with landscape, weather, soil, water flows, and animals living there. It is rooted in family homesteads selectively cutting trees for home use.

3.5 Plantation Forestry

Plantation is a forest either by planting or sowing of trees primarily for timber production. Characteristically, plantations are usually monocultures (one tree species) or a mixture of only two or three species, compared to conventional forests which usually contain a far more diverse range of tree species. Plantations are always young forests in ecological terms, typically grown and harvested after 10 to 60 years, rarely up to 120 years. Plantations may include tree species that would not naturally occur in the area, especially hybrids and genetically-modified species; these are usually trees that are best suited to industrial applications for wood or pulp production. Plantations are usually of regular shape with fixed or clearly defined boundaries. Trees are usually planted at regular spacing, even-aged and more uniform in size and with a single-layered canopy structure. Plantations can either be industrial/home/farm plantations or environmental plantations.

i. Industrial plantations are those established for the production of a high volume (commercial) of wood in a short period of time, for making wood-based products.

ii. Home plantations are those typically established for the production of lumber and fire wood for home use, and sometimes for sale.

iii. Ornamental plantations are those established for watershed or soil protection, such as erosion control, landslide stabilization and windbreaks. Tree species for different plantation types include Gmelina arborea, Tectona grandis, Terminalia ivorensis (industrial); Acacia nilotica, Rhizophora spp., Azadirachta indica (farm/home).

3.6 Certified Forestry

Several organizations offer auditing services to certify or verify that a forest management operation is employing best practices in sustainable forestry. The **Forest Stewardship Council**, based in Bonn, Germany, issues global standards for sustainable forestry based on stakeholder input from industry, communities and environmental organizations. The FSC then **accredits** certification bodies to carry out audits. If a

forestland passes the audit, the certification body awards a "seal of approval" which can be used as leverage in the marketplace. The Sustainable Forestry Initiative (SFI) and Woodmark and Rainforest Alliance are similar organizations.

3.7 Sustainable forestry

This is a **forest management** practice which primarily aims at ensuring that the amount of goods and services yielded from a forest is at a level the forest is capable of producing without degradation of the soil, watershed features or seed source for the future. It differs from **Sustained Yield Forestry** and **Sustainable forest management** according to the sets of forest goods and services that are intended to be "sustained". The concept also assumes that human use will not detract from or degrade the use of forests by other organisms, that human use is ultimately subordinate to healthy ecosystems. The word 'forestry' implies use for human benefit, but to 'sustain' forests means to manage for healthy ecosystems, the by-products of which are "goods and services" like timber, recreation, wildlife and other resources that humans have come to expect from forests.

3.8 Woodland Management

This is practice of managing woodlands, either for the maximization of timber production or for the conservation of wildlife. A well-managed woodland can produce a steady supply of timber and also maintain a wide variety of environments for woodland species of birds, insects and flowers. Woodland management techniques are coppicing, pollarding and shredding.

3.9 Agroforestry

This is a land use system that involves the deliberate retention, introduction or mixing of trees or other plants into crop and animal production systems in order to increase profitability, sustainability, protection of the environment and social acceptance. It implies the combination of forest trees with crops or with domestic animals, or both. The aim of agroforestry is to increase crop yields through emphasis on the forest (silviculture) and managing grazing (pasture land). The system is intentional, intensive, integrated and interactive in implementation.
Agroforestry systems can be classified on the basis of

i. components associated with the woody perennials (agrosilvicultural, silvopastoral, agrosilvopastoral);
ii. spatial distribution of the components such as woody perennials, crops and livestock (compound farms, farmers' plots);

iii. temporal distribution of components (e.g. relay cropping of trees with crops);
iv. productivity and sustainability (taking into consideration the service role of agroforestry such as soil erosion, shelterbelts, etc.);
v. socio-economic criteria (scale of production, level of technology input and management) such as commercial, intermediate and subsistence agroforestry.

3.10 Forest Farming

In forest farming, high-value specialty crops are cultivated under the protection of a forest canopy that has been modified and manged to produce This is neither forestry nor farming in the traditional sense. It is an agroforestry practice characterized by intentional, integrated, intensive and interactive management of an existing forested ecosystem wherein forest health is of paramount concern. Forest farm management principles constitute an ecological approach to forest management through efforts to find a balance between conservation of native biodiversity and wildlife habitat within the forest and limited, judicious utilization of the forest's varied resources. It attempts to bring secondary growth forests that have been overused and dsrupted back into ecological balance through careful, intentional manipulation over time, emulating natural processes to restore original, natural diversity of species. In some instances, the intentional introduction of species for use as botanicals, medicinals or food products is added in combination with native species. The five categories of specialty crops are foods (mushrooms, nuts, vegetables, honey from bee plants, herbs, fruits, edible flowers, sap products), botanical products (e.g. Broom, liquorice), decoratives (e.g. mosses, ferns, *Eucalyptus*), handicrafts (basketry materials), and wood products (fuelwood, charcoal, specialty woods for carving, incense, garden mulches from clipped wooss and coppice). The methods of forest farming include

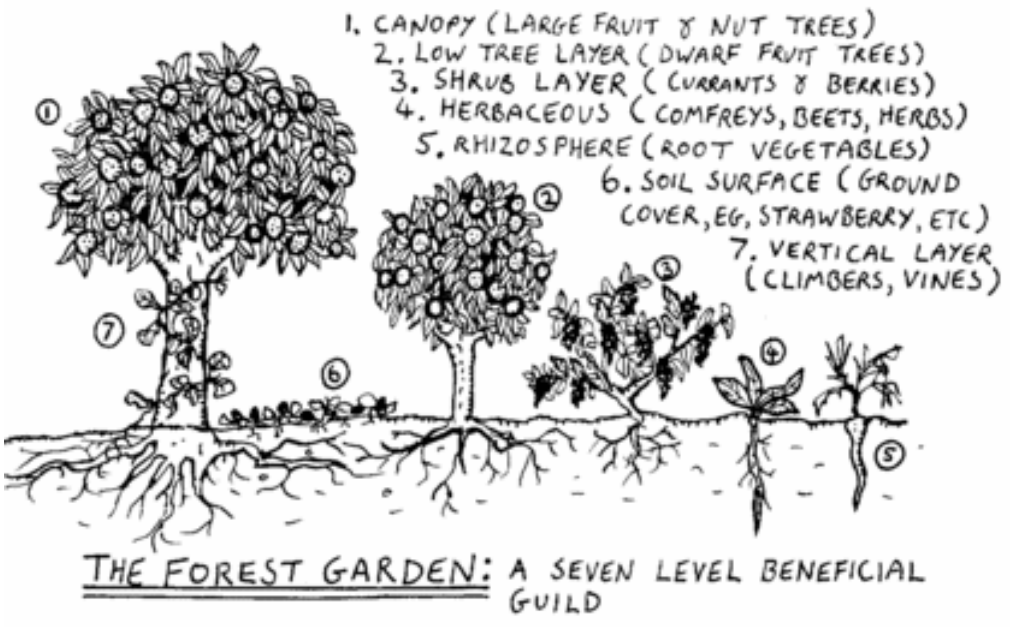
i. intensive, but cautious thinning of overstocked, suppressed tree stands; and
ii. multiple integrated entries to accomplish thinning of healthy trees and shrubs of all ages and species, rather than a monoculture of timber species.

Forest farm management is a type of forest stewardship ethic whose objective is to restore and maintain the health of the forest land's many and varied ecosystems. The benefits include economic benefits (e.g. sale of ginseng, logs, floral decoratives), modification of the ecosystem without ecosystem disruption, and provision of opportunities for short-term income from existing woodlands. The drawbacks include the

higher requirement of entrepreneurial attitude from farmers and landowners, need for research to locate potential buyers of specialty products, and high labour requirement.

3.11 Forest Gardening

Also known as 3-Dimensional Gardening, this is a food production and land management system based on replicating woodland ecosystems, substituting trees (such as fruit or nut trees), bushes, shrubs, herbs and vegetables which have yields directly useful to mankind. The crops which are produced often include fruits, nuts, edible leaves, spices, medicinal plant products, poles, fibres for tying, basketry materials, honey, fuelwood, fodder, mulches, game and sap products. It is based on the principle of companion planting, these can be intermixed to grow on multiple levels in the same area often 0.1-1 ha in size (as shown below), as do the plants in natural forest. It involves a series of agrosilvicultural systems such as improved shifting cultivation, alley cropping (hedgerow intercropping), multistory cropping, shade trees for plantation crops, mixture of plantation crops, taungya and shelterbelts. Forest/home gardens are an ancient gardening practice in tropical regions but more recent innovation in temperate regions. Woodland gardening is a variation of forest gardening. The benefits include creating a log-term biologically-sustainable system for growing food and other products for a household and little maintenance work after establishment. The main drawback is that planting out and establishment usually requires large numbers of plants and substantial work.



3.12 Sericulture

This is the rearing of silkworms for the production of raw silk. Although there are several commercial species of silkworms, *Bombyx mori* is the most widely used and intensively studied. According to Chinese records, the discovery of silk production from *B. mori* occurred about 2700 BC. Today, China and Japan are the two main producers, together manufacturing more than 50% of the world production each year. Silkworm larvae are fed cut-up mulberry leaves, and, after the fourth moult, they climb a twig placed near them and spin their silken cocoons. The silk is a continuous-filament fibre consisting of fibroin protein, secreted from two salivary glands in the head of each larva, and a gum called sericin, which cements the two filaments together. The sericin is removed by placing the cocoons in hot water, which frees silk filaments and readies them for reeling. The immersion in hot water also kills the silkworm larvae. Single filaments are combined to form yarn, which is drawn under tension through several guides and wound onto reels. Finally, the yarn is dried, and the now raw silk is packed according to quality.

3.13 Deforestation

This is defined as the conversion of natural forests or plantations to non-forest and non-vegetated lands. It involves the cutting down and removal of forest trees and other vegetative cover without replacement. Causes of deforestation include:

i. growing rate of population thus leading to higher demand for forest goods, services and forestlands;
ii. fiscal and development policies of the government;
iii. high cost of other sources of power (petroleum products, electricity) which discourages the use of alternative fuels to firewood;
iv. conversion of forestland into commercial agriculture and subsistence slash-and-burn farming system;
v. overgrazing and cattle ranching;
vi. indiscriminate logging and forest exploitation;
vii. fuelwood collection;
viii. mining and petroleum exploration; and
ix. infrastructure development and urbanisation.

The impact of deforestation include loss of biodiversity, disruption of hydrological cycle, soil erosion, disruption in the carbon cycle and ozone layer, desertification, potential losses in revenue and socio-economic benefits, and global warming.

4.0 CONCLUSION

In this unit, you have learned that forest management involves well-defined practices and strategies which aim at maximum exploitation of the plantations and forest environment for man's development.

5.0 SUMMARY

Several practices and strategies are employed in forest management, and these largely ensure forest conservation and sustainable provision of products and services to Man.

6.0 TUTOR-MARKED ASSIGNMENT

1) Define the following terms as applied to forest management:
(a) forestry, (b) silviculture, (c) ecoforestry,
(d) sustainable forestry, and (e) woodland management.

2) Write short notes on "sericulture".

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UNIT 5 IMPORTANCE OF WILDLIFE

CONTENTS

1.0 INTRODUCTION

Wildlife organisms vary in form, nature and behaviour or habit, and these ultimately relate to their economic value to man, with respect to food supply, supply of raw materials, social and religious services and monetary gains. The benefits of wildlife to the Nigerian nation are particularly numerous and significant to its socio-economic and environmental development.

2.0 OBJECTIVES

By the end of this unit, you should be able to discuss:

- the scope of wildlife;
- the various benefits of wildlife to man; and
- the significance of wildlife to the economy of Nigeria.

3.0 MAIN CONTENT

3.1 Wildlife

This refers to all non-domesticated plants, animals and other organisms. The Nigerian Conservation Foundation (NCF, 1965) defined wildlife as "all living things, plants, invertebrate and vertebrate animals outside the direct control of man, i.e. non-cultivated plants and non-domesticated animals". However, several wild plant and animal species have been domesticated for human benefit in all parts of the world with a major positive or negative impact on the environment. Wildlife can be found in

all ecosystems; it occurs with distinct forms in deserts, rainforests, plains and other areas, such as the most developed urban sites.

3.2 Importance of Wildlife

There are many benefits derived from wildlife conservation. They are categorized into food and raw material benefits, social services, monetary benefits and cultural/religious benefits.

3.2.1 Food and raw material benefits

i. Edible meat (Bush meat), obtained through hunting and game, is highly valued as animal protein by most people in both the rural and urban areas,
ii. Raw materials for traditional medicine, including the aphrodisiac properties of wild species e.g. primates and pangolins,
iii. Raw materials for clothing, local leather works, and making implements and weapons such as in warm sleeping robes (e.g. muskox), shoes and local drums, and
iv. Art work (souvenirs) and craft works.

3.2.2 Social services

i. Outdoor recreation, such as personal pleasure trek, hiking, feeding wild birds, hunting of big games, small mammals, upland bird, waterfowl hunting, sport fishing, canoeing, visits to park, whale watching, seabird viewing, polar bear observation, wildlife photography, wildlife activities at home or cottage,
ii. Outdoor laboratory for students studying ecology, animal behaviour and biologically-related courses. Wildlife is a common subject for educational TV shows all over the world, e.g. National Geographic Specials, BBC Natural History Programme, Animal Planet, NATURE and Nature Documentary,
iii. Tourism and Ecotourism- fast becoming a popular industry generating substantial income for poor nations with rich wildlife especially in Africa and India.
iv. Membership in wildlife and nature organizations, and
v. Environmental protection through quality maintenance for the proper functioning of the biosphere; health of wildlife is an indication of the health of the environment, and
vi. Inspiration of human activities such as legend, ceremony, art, music, dance, drama, story-telling and poetry.

3.2.3 Monetary benefits

i. Gate fees from tourist to national park/reserves,
ii. Hunting permit,
iii. Sales of animal (wild harvest generate income through job opportunities from seasonal influx of visitors to wildlife and particularly from wildlife activities),
iv. Export of live animals, and
v. Sport hunting e.g. hunting and non-commercial fishing.

3.2.4 Religious Benefits

i. Sacredness of certain animals in religious rituals due to their perceived spiritual significance in different cultures around the world e.g. muskox in Canada; eagles and hawks, and their feathers to Native Americans.

Generally, wildlife species play a key role in pollinisation, germination, seed dispersal, soil generation, nutrient recycling, predation, habitat maintenance, waste breakdown and pest control. It is important to science, agriculture and medicine, especially the preservation of genetic diversity, development of new drugs (sallicin from the bark of willow trees, taxol from bark of western yew, etc.) and treatments.

3.3 Economic Importance of Wildlife in Nigeria

Wildlife as a national heritage and natural endowment to Nigeria is very important in many respects. It has over the years, contributed significantly to the social, economic and environmental development of the country. The benefits include:

i. Source of animal protein- bushmeat is a principal source of animal protein for the rural majority in Nigeria;
ii. Game-viewing and Tourism- Two of the 36 wildlife reserves are currently open for game viewing and tourism. However, under the zoos and museums existing in some states provide opportunities for recreation, picnics, parties and education;
iii. Revenue from export- Nigeria derives a substantial sum of foreign exchange from wildlife exports annually.
iv. Employment opportunities and local participation- Local hunters are employed as game patrols and guards, who serve as anti-poaching groups, in addition to management appointments such as clerks, typists, drivers and game scouts. Other local groups are involved in conservation and development of reserves.
v. Education and research- These involve excursions to wildlife parks, zoos and botanical gardens, research on the behaviour of

wildlife animals and the use of common mammals such as rats and primates for ecological and immunological research in medical and science laboratories, ecological stability and perpetuation of the genetic pool.

vi. Wildlife by-products- Numerous by-products of wild animals such as skins, feathers, beaks, horns, skull, bones, eyes, spines, liver, eggs and tails are used for different purposes in Nigeria. The uses include traditional medicine, sorcery, witchcraft and folklore. Some of the bushmeat by-products and their folkloric medicinal/cultural uses are shown in the table below.

Class/Bushmeat by-product	Local names (Yoruba)	Uses
Monkey's head	Ori obo	Charms for casting away evil spirits
Giant rat (*Criceptonys gambianus*)	Okete	Protection against witches
Pangolin (*Mani tradactyla*)	Aaka	Part of the concoction for curing kleptomania
Shrew (*Crocidura* spp.)	Asin	Part of the concoction for curing convulsion, body pain and easy delivery
Hydrax's finger-tips (*Den drohydrax*)	Ori ika ofafa	Charm for safe travel
Python's head	Ori ere	Charm for good luck
Chameleon	Oga	Cure of dizziness
Duiker's horn (*Cephaloplus* spp.)	Iwo etu	Holding certain charms

4.0 CONCLUSION

Wildlife serves man not only for food and raw material benefits, but also for social, religious and monetary benefits.

5.0 SUMMARY

Wildlife is an important sub-sector of an agrarian nation like Nigeria. It is particularly significant as a major foreign exchange earner, due to the huge revenue accruable from wildlife exports, game-viewing and tourism. Also, wildlife by-products are highly valued for their use in trado-medical practice.

6.0 TUTOR-MARKED ASSIGNMENT

1) Enumerate the benefits of wildlife in Nigeria.
2) List the major categories of the benefits of wildlife conservation.
3) Write short notes on any one of these categories mentioned above.

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MODULE 7

UNIT 1 CONCEPTS OF WILDLIFE AND WILDLIFE MANAGEMENT

CONTENTS

1.0 INTRODUCTION

The idea of wildlife conservation is as old as man. In the process of making the land to sustain the production of annual crops of wildlife, the needs of wildlife are balanced with the perceived needs of man by considering ecological principles such as carrying capacity of the habitat. Thus, the conservation of natural resources in the wild has grown to include a wide range of concepts such as rational use,

sustained yield, multiple use and restoration. With respect to Nigeria, the main national wildlife objectives are increase in animal protein supplies through bushmeat production, promotion of game-viewing, tourism and foreign exchange earnings, preservation of national heritage, promotion of wildlife conservation for education and research, generation of employment opportunities in rural areas and promotion of ecological diversity.

2.0 OBJECTIVES

At the end of this unit, you should be able to explain;

- the basic principles of the wildlife, its management and conservation;
- the philosophy behind wildlife management;
- the methods of managing wildlife, including their application, advantages and limitations; and
- the merit/demerit of using fire as a wildlife management tool.

3.0 MAIN CONTENT

3.1 Philosophy of Wildlife Management

The process deals with protecting endangered and threatened species and subspecies and their habitats, as well as with non-threatened agricultural pests and game species. Most techniques of wildlife management aim at the preservation and control of habitat. Other methods such as reforestation, predator control techniques such as trapping, re-introduction of species or hunting, may also be used to help manage “desirable” or “undesirable” species. Management involves the maintenance of natural disturbances such as wildfire (e.g. controlled burns to achieve climax community) and grazing by wild animals.

3.2 Basic Concepts of Wildlife

3.2.1 Wild

This term refers to “animals not tamed, plants not cultivated in a garden, and man, uncivilized, unruly, uncontrolled, violent and mad”.

3.2.2 Wildlife

This term refers to all forms of wild animals and their environment. Alternatively, it refers to all non-domesticated plants, animals and other living organisms.

3.2.3 Wildlife Management

This is the active manipulation of wildlife animals and their habitats for the benefit of mankind. Alternatively, it is defined as the process of keeping certain wildlife populations at desirable levels determined by wildlife managers or the art of making land produce sustained annual crops of wildlife.

3.2.4 Wildlife Conservation

This practice involves strategies for the protection and rational utilization of both the wild animals and their habitats.

3.2.5 Wildlife (Wild) Gardening

This concept is aimed at creating an environment that is attractive to various forms of wildlife (aesthetics), such as birds, amphibians, reptiles, insects, mammals, etc. Organic gardeners also use wild gardening as a biocontrol method and for promoting biodiversity to the wider environment.

3.2.6 Wildlife (Wild) Garden

A wildlife garden is made up of a variety of habitats that have either been deliberately created by the gardener or allowed to self-establish by minimizing maintenance and intervention. The habitats include ponds to attract frogs, newts, toads, dragonflies; nesting boxes for birds and solitary bees, hedgehogs or certain insects; log piles to provide shelter for lizards and slow worms; and planting beneficial insect-attracting plants, including wild flower meadows, etc. The wild garden is dominated by a variety of native species under enhanced management, and preferably, some exotics. Also, the natural environment in a typical wild garden is optimal for local water supplies.

3.2.7 Game Reserve

A game reserve is defined as an area set aside for the preservation of wildlife. Specifically, forest reserves are created to ensure the perpetual exploitation of forest products, in response to the renewable but finite forest resources. Such areas are protected from destruction and unguided exploitation by the owner-state or the community. A typical example of game reserves in Nigeria is Borgu Game Reserve, which is aimed at creating a refuge for wild animals.

3.2.8 National Park

A national park is an area of land set aside for the protection and preservation of wild animals and their habitats. It gives protection to the animals, plants, soils, geologic formations, historical monuments, etc. in the designated area. According to the International Union for the Conservation of Nature and Natural resources (IUCN), a national park is "an area of relatively large size containing natural ecosystems of special interest, which are not materially altered by human exploitation or occupation, protected and managed by the highest competent authority of the country, and open to visitors under special conditions of inspiration, educative, cultural and recreational purposes".

3.2.9 Bushmeat

This is the flesh of wild animals. Bushmeat provides a large proportion of the animal protein consumed by both the rural populace and urban travellers.

3.2.10 Wildlife destruction

This involves all aspects of over-exploitation of the wildlife, which in most cases do not always lead to an extinction of the species under exploitation. The four general sources of wildlife destruction are:

i. overkill- This occurs when hunting is done at a rate greater than the reproductive capacity (reduced breeding age) of the population being exploited i.e. unsustainable hunting.
ii. habitat destruction and fragmentation- The loss of preferred area or territory and the decrease in the carrying capacity of the land for the wild species are caused by the processes associated with human habitation. These processes include changes in land use, especially for agriculture, grazing of bushland by farmed animals, changes to natural fire regimes, forest clearing for tuber production and wetland draining for city expansion.
iii. impact of introduced species- These species include out-of-control invasions and rats, cats, rabbits, dandelions and poison ivy which have become invasive threats to wild species in various parts of the world.
iv. chains of extinction (Domino effect)- This effect is of secondary importance in respect of wildlife destruction. However, it is by far the most destructive process that can occur in any ecological community due to the associated series of chain reactions imposed by the several complex intertwining links in the living ecosystem around the exploited species.

3.3 Types of wildlife Management

3.3.1 Manipulative Management

This method acts on a population by either changing numbers by direct means or influencing numbers by indirect means of altering food supply, habitat, density of predators or prevalence of disease. It is appropriate when a population is to be harvested, or when it decreases to an unacceptably low density, or increases to an unacceptably high level.

3.3.2 Custodial Management

This is a preventive or protective type of management. It aims at minimizing external influences on the population and its habitat. It is appropriate in a national park where one of the stated goals is to protect ecological processes. It is also appropriate for the conservation of a threatened species where the threat is of external origin, rather than being intrinsic to the system. The two conservation methods are:

i) In-situ (On-Site) Conservation

This is the process of protecting an endangered plant or animal species in its natural habitat, either by protecting or clearing up the habitat itself, or by defending the species from predators. It maintains recovering populations in the surrounding where they have developed their distinctive populations. It is a more common method of wildlife conservation. Its benefits include protection of wildlife habitats and maintaining sufficiently large reserves to enable the target species to exist in large numbers. In Nigeria, common in-situ wildlife management methods are National Parks and Games Reserve (Yankari, Kainji Lake, Obudu Cattle Ranch, Cross River, etc.), Strict Natural Reserves (in both the high rainforest and savanna zones), Forest Reserves (Olokemeji, Gambari, Omo, Ologbo, Obiaruku Forest Reserves) and Game Sanctuary (e.g. Okomu sanctuary, Wase Rock sanctuary, Damper sanctuary).

ii) Ex-situ (Off-site) conservation

This is the process of protecting an endangered species of plant or animal by removing part of the population from a threatened habitat and placing it in a new location, which may be a wild area or within the care of humans. It involves mostly the oldest and best known conservation methods and some more modern laboratory methods. The methods include colony relocation, human-care methods such as zoos, botanical gardens, seedbanks/germplasm and *in vitro* storage. A major disadvantage of this type is that it is rarely sufficient to save a species

from extinction. Thus, it is best as a last resort or supplement to *in-situ* conservation since it cannot recreate the habitat as a whole. Ex-situ methods in Nigeria are Zoological Gradens and Domestication of certain wildlife species such as African giant rat, grass cutter, bush fowl, guinea fowl, Pallas and Kob.

3.4 Fire as a Range Management Tool

Historically, man has used fire both as useful and destructive tool for hunting, war, roasting meat, warming food, etc. In wildlife management, when timely done, the use of fire has been advantageous with respect to

i. improving the visibility within forests and parks,
ii. improving the production of annual and permanent grasses,
iii. averting the danger of burning by poachers,
iv. creating easy movement within the range and parks,
v. encouraging tree growth, and
vi. eliminating undesirable and worn-out grasses thereby stimulating new flushes.

There are two types of burning in range management, namely

3.4.1 Early Burning

This is usually carried out between November and December, mainly to reduce the quantity of perennial grasses (e.g. *Pennisetum purpureum*) which inadvertently helps to increase the quantity of annual grasses such as *Hyperrhenia involucrata*.

3.4.2 Late Burning

This is done between March and April, mainly to reduce the number of trees, shrubs and forbs within a reserve or a park. It helps in the regrowth of more perennial grasses.

4.0 CONCLUSION

In this unit you have learned that

i. wildlife principles are complex and diverse, and
ii. effective application of wildlife conservation strategies not only guarantees the protection of endangered and threatened species, their subspecies and their habitats but also non-threatened agricultural pests and game species.

5.0 SUMMARY

Wildlife conservation is critical for the sustenance of the balance between the perceived needs of man with the needs of wildlife, using ecological principles which facilitate the preservation and control of wildlife habitats.

6.0 TUTOR-MARKED ASSIGNMENT

1) Differentiate between “wild” and “wildlife”.
2) Mention the two basic principles of wildlife conservation.
3) Write short notes on “wild gardens”.
4) Why are forest reserves created.

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UNIT 2 ECOTOURISM

CONTENTS

1.0 INTRODUCTION

Ecotourism is the tourism industry's fastest growing sub-sector, with an estimated world-wide annual growth of 10-15%. It is a promising means of advancing social, economic and environmental objectives in developing countries. It offers new opportunities for small-enterprise investment and employment and increases the national stake in protecting the biological resources of developing countries.

2.0 OBJECTIVES

In this unit, you should be able to identify:

- the principles and economic importance of ecotourism, and
- the impact of ecotourism on the environment.

3.0 MAIN CONTENT

3.1 Ecotourism

Also known as "ecological tourism", ecotourism is responsible for travel to natural areas that conserves the environment and improves the welfare of local people. It is a form which appeals to the ecologically and socially conscious; it is a recreational and educational travel based on natural attractions. It focuses on local culture, wilderness adventures, volunteering, personal growth and learning new ways to live on the planet, typically involving travel to destinations where flora, fauna and

cultural heritage are the primary attractions. Ecotourism activities include flora and fauna studies, surveys and visits, whale watching, turtle watching, hiking in National Parks, cycling in the outback, volcano watching, support to endangered species, recording local cultures, bird breeding support, trips to the frozen wastes, volunteering, ecolodging, and farm visits.

3.2 Benefits of Ecotourism

Ecotourism has great potential for sustainable development. It satisfies several criteria (defining points) such as

i. conservation of biological diversity and cultural diversity, through ecosystem protection;
ii. promotion of sustainable use of biodiversity;
iii. sharing of socio-economic benefits with local communities and indigenous people by having their informed consent and participation in the management of ecotourism enterprises, support for human rights and democratic movements, producing direct financial benefits for conservation through park entrance fees, tour company, hotel, airline and airport taxes, and voluntary contributions, providing empowerment for local people through income, and other tangible benefits such as potable water, roads, health clinics, etc.;
iv. increase of environmental and cultural knowledge through travel to natural destinations and education for both tourists and residents of nearby communities;
v. minimization of tourism's own environmental impact;
vi. affordability and lack of waste in the form of luxury; and
vii. local culture (ecotourism is culturally intrusive and exploitative), flora and fauna being the main attractions.

3.3 Direct Environmental Effects of Ecotourism

These effects include

i. environmental degradation with tourist infrastructure;
ii. population pressures from ecotourism also leaves behind garbage and pollution associated with the Western style;
iii. the activities disturb fauna and flora e.g. trampling of flora and fauna during picture-taking, wildlife viewing, nature hike;
iv. environmental hazards e.g. consumption of virgin territories by deforestation, disruption of ecological life systems, pollution types, etc. leading to environmental degradation;
v. no re-investment of profits into local economy or environmental protection;

vi. limited employment of local people, and entry at its lowest level and meager wages;
vii. resentment by local people e.g. due to unfair compensation benefits and displacement from traditional lands;
viii. development of destructive markets in wildlife souvenirs e.g. sale of coral trinkets contributing to illegal harvesting and poaching from tropical islands and animals products in Asia;
ix. threats to indigenous cultures e.g. illegal loss of homes, displacement to marginal lands with harsh climates, poor soils, lack of water and infested with livestock and disease; and
x. mismanagement of ecotourism sites- regulations for environmental protection are vaguely defined, costly to implement, hard to enforce and uncertain in effectiveness.

3.4 Ecolodge

This is the accommodation preferred by ecotourists and by those who are seeking an intimate contact with nature. It is used to identify a nature-dependent tourist facility that meets the principle of ecotourism. Ecolodges enhance the economic value of natural resources and cultural experiences. An ecolodge is a small-scale facility that blends with its surroundings, offering visitors an environmental experience of the natural world around them. Unlike the traditional tourist facility, the main attractions and activities in an ecolodge are related to the surrounding environment.

3.4.1 Characteristics of an Ecolodge

i. the ecolodge is constructed using natural and locally produced building materials;
ii. it ideally relies on solar or alternative energies;
iii. it recycles the waste and wastewater it generates;
iv. it serves locally grown and produced foods and usually donates part of its profit to local conservation efforts;
v. it is locally owned and operated and provides visitors with some form of environmental education, in order to enrich their understanding of planet Earth. This helps to preserve the world's natural habitat and cultural heritage and benefit local inhabitants.

3.4.2 Features of an Ecolodge

i. location and resource protection;
ii. natural and cultural attractions (outstanding natural beauty);
iii. facilities (distinct design features);
iv. capacity (typically harbours 25-100 guests);

v. activities (e.g. trail hiking, nature interpretation, bird watching, river trips, desert excursions, mountain biking, horse and camel riding); and
vi. general atmosphere (friendly, flexible and educational environment to give a sense of 'belonging' to visitors).

3.5 Ecotourism Development in Nigeria

The development of ecotourism in Nigeria can be traced back to 1889 when the colonial administration established the first forest reserve in the then Colony of Lagos. The number of reserves increased thereafter over the years to include wildlife sanctuaries, communal forests and national parks. Currently, there are 36 game reserves and six National Parks. The table below shows the game reserves and national parks by distribution. The Cross River National Park is made up of two sections, namely the Oban and Bosh/Okwong. The species found in both sectors include antelopes, chimpanzees, high forest monkeys, high forest elephants, manatees, bush pigs, baboon, leopards and gorillas, some of which are endangered species. The Cross River National Park is now the only significant park in the rainforest zone of Nigeria, and it is preserving major forest species and the future values associated with them.

Name	State	Status
Kainji Lake Park	Niger	National
Old Oyo Park	Oyo	National
Lake Chad Park	Borno	National
Yankari Park	Bauchi	National
Cross River Park	Cross River	National
Gashaka-guranti Park	Adamawa	National
Ebbazikampe Reserve	Kwara	Game
Okpara Reserve	Oyo	Game
Upper Ogun Reserve	Oyo	Game
Ofosu Reserve	Edo	Game
Okomu Reserve	Edo	Game

Ologbo	Edo	Game Reserve
Gilli gilli	Edo	Game Reserve
Iri Ada Obi	Edo	Game Reserve
Ologbo emu urho	Edo	Game Reserve
Orle River Game Reserve	Edo	Game Reserve
Anambra	Anambra	Game Reserve
Udi/Nsukka	Anambra	Game Reserve
Akpaka	Anambra	Game Reserve
Game reserve A	Cross River	Game Reserve
Game reserve B	Cross River	Game Reserve
Stubbs Creek	River	Game Reserve
Ibi	Plateau	Game Reserve
Wase Rock Bird Sanctuary	Plateau	Game Reserve
Ankwe River	Plateau	Game Reserve
Damper Sanctuary	Plateau	Game Reserve
Wase Sanctuary	Plateau	Game Reserve
Pandam	Plateau	Game Reserve
Nasarawa	Plateau	Game Reserve
Lame/Bura	Bauchi	Game Reserve
Kogin Kano	Kano	Game Reserve
Dagida	Niger	Game Reserve
Alawa	Niger	Game Reserve
Kamaku	Kaduna	Game Reserve
Kwaiambana	Sokoto	Game Reserve

Souce: Akegbejo-Samsons, Y. (1996).

4.0 CONCLUSION

In this unit, you have learned that

i. ecotourism is the fastest growing sub-sector of tourism,
ii. ecotourism is a potential source of improved socio-economic life in developing countries, and
iii. ecotourism ensures the protection of nature and biodiversity.

5.0 SUMMARY

The development of ecotourism is critical for effective national development, as it not only assures improved socio-economic life for the citizens but also assures a safe environment for human existence.

6.0 TUTOR-MARKED ASSIGNMENT

1) (a) What is "ecological tourism"?
(b) List any ten activities involved in ecological tourism.
2) Mention the areas of focus of ecotourism.
3) Enumerate any five benefits of ecotourism.

7.0 REFERENCES/FURTHER READING

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UNIT 3 MEASURES FOR IMPROVING NIGERIAN AGRICULTURE

CONTENTS

1.0 INTRODUCTION

Agriculture is central to Nigeria's economic growth and development on account of its overall strategic influence on the economy. However, productivity is constrained by several factors, among which are environmental problems, inconsistent policy formulation by Government, low capital for production, lack of infrastructural facilities in the rural areas, socio-economic aspects, especially inefficient supply and prohibitive costs of required inputs, poor or lack of organization (especially duplication of programmes), institutional problems, poor rural remuneration, low rural retention and lack of efficient storage facilities. In particular, inconsistent policies arising from political or administrative problems aggravate the risk and uncertainty inherent in agricultural planning.

2.0 OBJECTIVES

At the end of this unit, you should to explain:

- the pertinent ways through which agricultural productivity could be improved in order to ensure sustainable development of the sector, and thus the entire economy.

3.0 MAIN CONTENT

The measures of improving agriculture in Nigeria are:

3.1 Development for Efficient Information System

There is need for efficient and effective information system, which will facilitate planning, sound management and implementation of agricultural policies. Data collection on agriculture should be the sole function of a unit within the Federal and State Ministries of Agriculture. The Federal Office of Statistics should therefore, collaborate with the ministries to constitute a formidable reservoir of information for agricultural planning. Research institutes and Universities should serve as conventional sources of data collection.

3.2 Restoration of Subsidy

Agriculture is an accretionary process. Its effective management therefore, depends solely on the availability of supply inputs and distribution. However, productive agriculture thrives on incentive creation, most especially in the form of subsidy whose removal does more harm than good to agriculture. There is therefore, a need to restore the subsidies on some key inputs such as fertilizers.

3.3 Effective Research Extension and Farmer Linkages

The efficiency of government as an actor and/or regular is crucial to efficient management of agricultural resources. Indirect support of the agricultural sector through the activities of government agencies such as the National Agricultural Land Development Agency (NALDA) and Agricultural Development Programmes (ADPs), should feature prominently above direct government intervention. Other relevant stakeholders such as non-governmental organizations (World Food Organisation, Food and Agriculture Organisation, World Bank) should be accessed. Efforts must also be made to continue to link farmers with the activities of the research institutions, not only to pass down research findings to the farmers but also to ascertain the farmers' requirements.

3.4 Improvement of Rural Property Rights

The system of property institutions under which land is owned and used is a very critically important factor in agricultural productivity. However, at present Nigeria's Land Use Act of 1978 is hardly helping the Nigerian land user (apart from the State). Therefore, to maintain the role of the Act in the economy, an effective land-use reform which must be reasonable, familiar to the people, and have an integral and

supportive relationship to the system of local farming, should be instituted.

3.5 Repositioning Agriculture through Export Revitalisation

There is need for the federal Government to actualize her intention to encourage increased investment in agriculture for both large- and small-scale farmers, but with greater emphasis on the latter. There is a greater need for more incentives in all their ramifications, to facilitate increased food production to Nigerians and more rapid rehabilitation of economic trees to prevent importation of products for which the nation has always enjoyed resource abundance. Greater incentives should be provided to the private sector agriculturists to boldly invest and thus, improve the present situation. The institutions that support agricultural exports should be brought to the knowledge of real and potential agricultural exporters. The government should also work out arrangements that would favour the interest of Nigerian agricultural exporters at various for those institutions.

3.6 Consistent Government Agricultural Policies

For the past decades, government policies have been largely inconsistent and discontinuous. There is a strong need for efficient, practicable and consistent policies on agricultural production in order to ensure sustainable production and economic development through the agricultural sector.

3.7 Efficient Provision of Infrastructural Facilities

Agricultural production in most rural communities is constrained by poor infrastructure. There is a strong need to provide easy and accessible roads for inward flow of agricultural inputs as well as outward flow of farm produce. This, in addition to the provision of electricity will facilitate two-way communication, access to energy for powering farm structures, farmers' socio-economic development and rural education. It will also stem the tide of drift in rural-urban migration of productive youths.

3.8 Efficient Supply of Agricultural Inputs

Lack or erratic supply of agricultural inputs is a major factor causing low agricultural productivity in Nigeria. There is a strong need to ensure farmers have easy and prompt access to farm inputs, especially fertilizers, implements and seeds so as to facilitate timely land preparation, seeding and crop husbandry. Efficient supply of agrochemicals for seed and crop protection will not only enhance

disease-free seeds at planting but also, good health and large output crop and animal produce for human consumption. A similar case will apply to the issue of preventing the circulation of adulterated agrochemicals, especially pesticides.

3.9 Establishment of Modern Storage Facilities

The need for the introduction of modern storage facilities (refrigerators, cold rooms) will to a large extent, prevent the usual heavy losses in farm produce, especially the perishable types.

4.0 CONCLUSION

In this unit, you have learned that:

i. the solutions to the nation's agricultural problems are not only political, but also involve social, economic, human and environment considerations' and
ii. there is a critical need for tactical political will in the planning and implementation of agricultural policies in order to sustain agricultural production and national development.

5.0 SUMMARY

Agricultural development can be improved and sustained through a critical analysis of the inherent problems and careful planning and implementation.

6.0 TUTOR-MARKED ASSIGNMENT

1) Enumerate five problems of agricultural development in Nigeria.
2) Why is political will critical to sustained agricultural development and economic growth?
3) How does the improvement of rural property rights facilitate agricultural development?

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