NATIONAL OPEN UNIVERSITY OF NIGERIA

COURSE CODE AEA 510

COURSE TITLE: ENVIRONMENTAL ECONOMICS

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INTRODUCTION

Environmental economics is a two unit degree course at the Nation Open University of Nigeria. It is of recent origin in the field of agriculture and agricultural economics. Although the classical and neoclassical economist at their time reorganised the relevance of environment and environmental economics, they however failed to include it in their theories. There is a linkage between the environment and agriculture. Agricultural activities and production are carried out within a specified environment. The various activities of man in agricultural production processes exact different degrees of impact on the environment. Environmental economics is a sub-field of economics that is concerned with environmental issues. It focuses on how and why people make decisions that have environmental consequences and the role of economic institutions (organization, public or private, laws, etc) and policies influencing these decisions.

Environmental economics teaches us how to promote economic growth of nations with least environmental damage, restore harmony, to reconcile the interest of human beings and nature – an ecological reorientation of the economic policy is required. Environmental studies would help to create this awareness among the people. It is required for the collection of environmental taxes and charges. Environmental economics is used to address issues concerning individual (micro) and local or national (macro) decisions that have environmental implication. It is essential in environmental policy decision making and forward planning. It also important in data collection, analyss and interpretation of environmental issues..

WHAT YOU WILL LEARN IN THIS COURSE

This course is made up of five modules that are sub-divided into units.
This course guide tells you what the course is all about. What course materials you will be using and also suggests some general guidelines for the amount of time you are likely to spend on each unit of the course in order to complete it on schedule.
It also gives you guidance in respect of your tutor marked assignment (TMA) which will be made available in the assignment file. Please attend those tutorial sessions. The course will introduce you to the rudiments of agricultural economics.

COURSE AIMS

The course aims to provide an insight into environmental economics as a specialised area of agricultural economics with a view to prepare the student for a future career in this field of specialization.

COURSE OBJECTIVES

To achieve the aims set out, the course has a set of objectives which are set out as specific objectives under each unit. You should read these objectives before you study the unit. After going through this course you should be able to:

- Understand the basic concepts of environmental economics
- Know what ecosystem is all about
- Understand the meaning and importance of environmental economics
- Nature of environmental economics
- Scope of environmental economics
- Theory of production
- Agricultural decision and theory of production function
- Resource productivity and efficiency
- Resource and environmental sustainability
- Land resource and sustainable management
- Forest resources
- Conservation and management of natural resources
- Water resources
- Economics of irrigation and water use in agriculture
- Major problems of agricultural marketing
- Measurement of environmental degradation
- Cost – Benefit analysis of environmental conservation

WORKING THROUGH THE COURSE

This course involves that you devote a lot of time to read and study the contents. Each unit contains self assessment exercises for this course and at certain points in the course you would be required to submit assignments for assessment purposes.

At the end of this course, there is a final examination. I would therefore advice that you attend the tutorial sessions where you would have the opportunity of comparing knowledge with your colleagues.

COURSE MATERIALS

You will be provided with the following materials

- Course guide
- Study units
- References
- Assignments
- Presentation schedule

STUDY UNITS

Module 1: Basic Concepts of Environmental Economics

Unit 1 Basic Concepts
Unit 2 Ecosystems

Module 2: Scope and Concept of Environmental Economics

Unit 1 Meaning and Components of Environment
Unit 2 Meaning and importance of Environmental Economics
Unit 3 Nature of Environmental Economics
Unit 4 Scope of Environmental Economics

Module 3: Agricultural Production and the Environment for Sustainable Agricultural Production

Unit 1 Theory of production
Unit 2 Agricultural production decision and theory of production function
Unit 3 Resource productivity and efficiency
Unit 4 Resource and environmental sustainability

Module 4: Land, Water and Forest Resource Management for Sustainable Agricultural Production

Unit 1 Land Resources and sustainable Management
Unit 2 Forest Resources
Unit 3 Water Resources
Unit 4 Conservation and Management of Natural Resources

Module 5: Economics of Irrigation and Water Use in Agriculture, Measurement of Environmental Degradation and Cost- Benefit Analysis of Environmental Conservation

Unit 1 Economics of irrigation and water use in agriculture
Unit 2 Measurement of environmental degradation
Unit3 Cost-benefit analysis of environmental conservation

ASSESSMENT

There are two components of assessment for this course:
(a) The tutor marked assignment (TMA)
(b) The 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 four TMA's by your facilitator to answer before you can sit for the final examination.

FINAL EXAMINATION AND GRADING

This examination concludes the assessment for the course. The examination will account for 70% of total score. You will be informed of the time for the examination.

SUMMARY

This course intends to provide you with underlying knowledge of environmental economics and measures of environmental friendliness.

TEXT BOOKS AND REFERENCES

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Unit4 Scope of Environmental Economics

Module 3: Agricultural Production and the Environment for Sustainable Agricultural Production

Unit 1 Theory of production
Unit 2 Agricultural production decision and theory of production function
Unit 3 Resource productivity and efficiency
Unit 4 Resource and environmental sustainability

Module 4 Land, Water and Forest Resource Management for Sustainable Agricultural Production

Unit 1 Land Resources and sustainable Management
Unit 2 Forest Resources
Unit 3 Water Resources
Unit 4 Conservation and Management of Natural Resources

Module 5: Economics of Irrigation and Water Use in Agriculture, Measurement of Environmental Degradation and Cost- Benefit Analysis of Environmental Conservation

Unit 1 Economics of irrigation and water use in agriculture
Unit 2 Measurement of environmental degradation
Unit 3 Cost-benefit analysis of environmental conservation

Module 1: Basic Concepts of Environmental Economics

Unit 1 Basic Concepts
Unit 2 Ecosystems

Unit 1: Basic Concepts

1.0 Introduction
2.0 Objectives
3.0 Main content
    3.1 Natural resources
    3.2 Ecology

1.0 INTRODUCTION

Environmental economics is the application of economics principles in the study of the environmental resources. Environmental economics like economics is divided into two namely micro environmental economics and macro environmental economics. The micro environmental economics aspect is concerned with the study of individuals and small group in the use and management of environmental and natural resources while the macro environmental economics deals with the economic performance of the economies as a whole in relation to the environment. The environment is an important factor in the life of man as it provides the basic services required for production and household sector of the economy. It is the basic source of both renewable and non-renewable resources such as minerals, forest, energy, clean air and biodiversity. Other resources that provide life supporting services are,

2.0 OBJECTIVES

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

- Define natural resources and explain the types
- Explain the basic concepts of environment
- Explain economic sustainability and environmental goods

3.0 MAIN CONTENT

3.1 Natural resources

Natural resources are useful things provided by nature. Therefore, anything obtained from the physical environment to satisfy human needs relate to natural resources. Basic human needs are fulfilled by materials provided by nature itself. Broadly defined, natural resources include all the "original" elements that comprise the earth natural endowment life support systems such as air, water, soil, the earth's crust and radiation from the sun. Some representative examples of natural

resources are arable land, wilderness areas, mineral fuels and non-fuel minerals, watersheds and the ability of the environment to degrade waste absorb ultraviolet light from the sun. These stocks of the nature, useful to mankind are called natural resources. In the primitive age, man had used only those resources that supported his life. But the process of economic growth and increase in population has led to mismanagement of natural resources.

Natural resources are generally grouped into two major categories.

- Renewable resources and
- Non-renewable resources.

Renewable Resources: These are resources that are capable of regenerating themselves within a relatively short period, provided the environment in which they are nurtured is not unduly disturbed. They are usually present in unlimited quantity in nature. They are not likely to be exhausted by human activities. Examples include plants, fish, forests, soil, solar radiation, wind, tides, air, and water among others. These renewable resources can be further classified into two distinct groups: biological resources and flow resources.

Biological resources consist of the various species of plants and animals. They have no distinctive feature that is important for consideration here. While these resources are capable of self-regeneration, they can be irreparably damaged if they are exploited beyond a certain critical threshold. Hence, their use should be limited to a certain critical zone. Both the regenerative capacity of these resources and the critical zone are governed by natural biological processes. Examples of this type of resources are fisheries, forests, livestock and all forms of plants.
Flow resources include solar radiation, tides, and water streams. Continuous renewal of these resources is largely dictated by atmosphere and hydraulic circulation, along with the glow of solar radiation. Although these resources can be harnessed for specific use (such as energy from solar radiation or waterfalls), the rate at which the flows of these potential resources are regulated is largely governed by nature. This does not however, mean that humans are totally incapable of either augmenting or decreasing the amount of flow of these resources. A good

illustration of this would be the effect of greenhouse gas emissions (in particular carbon (iv) oxide emissions) have on global warming.

Non-renewable Resources: Non-renewable resources are those resources that either exist in fixed supply or are renewable only on a geological timescale, whose regenerative capacity can be assumed to be zero for all practical purposes. Non-renewable resources cannot be replaced when the initial stock is used up. Examples of these resources include metallic minerals like iron, aluminum, copper and uranium and non-metallic minerals like fossils, clay, sand and phosphates; coal, petroleum, natural gas, etc. The stock of these resources is limited. They are susceptible to

be degraded in quantity and quality by human activities. Therefore they must be carefully managed to avoid their shortage until acceptable substitutes are found.

Non-renewable resources can be classified into two broad categories. The first group includes those resources which are recyclable, such as metallic minerals. The second group consists of non-recyclable resources, such as fossil fuels.

Resources have three main characteristics, namely:

- Utility
- Limited availability (scarcity)
- Potential for depletion or consumption.

Utility: Utility is the measure of satisfaction derived from the consumption of a particular good or service. It also refers to the total satisfaction received by a consumer from consuming a good or service. Utility can be classified into form, place, time and possession utility.

Limited availability (Scarcity): Scarcity is the fundamental economic problem of having humans who have unlimited wants and needs. At the root of any economic study is the issue of resource scarcity. In fact, as a discipline, economics is defined as the branch of social science that deals with the allocation of scarce resources among competing ends. What exactly do economists mean by resource scarcity? What are the broader implications of scarcity?

For economists, scarcity is the universal economic problem every human society weather a tribal society or an economically and technologically advanced society is confronted with the basic problem of scarcity. That is, at any point in time, given societal resources endowments and technological know-how, the total sum of what people want to have (in terms of goods and services) is far greater than what they can have.

Considering that human wants for goods and services are immense and, worse yet, insatiable in a world of scarcity, what can be done to maximize the set of goods and services that people of a given society can have at a point in time? These questions suggest that significant economic problem involves rationing limited resources to satisfy human wants and, accordingly, has the following general implications:

Choice: The most obvious implication of scarcity is the need to choose. That is, in a world of scarcity, we cannot attain the satisfaction of all our material needs completely. Hence, we need to make choices and set priorities.

Opportunity Cost: Every choice we make has a cost associated with it; one cannot get more of something without giving up something else. In other words, an economic choice always entails sacrifice or opportunity cost-the highest-valued alternative that must be sacrificed to attain something or satisfy a want. In a world of scarcity, “there is nothing as a free lunch”.

Efficiency: In the presence of scarcity, no individual or society can afford to be wasteful or inefficient. The objective is therefore, to maximize the desired goods and services that can be obtained from a given set of resources. This state of affairs is attained when resources are fully utilized (full employment) and used for what they are best suited in terms of production (i.e. there is no misallocation of resources). Furthermore, efficiency implies that the best available technology is being used.

Social institutions: As noted earlier, the essence of scarcity lies in the fact that people's desire for goods and services exceeds society's ability to produce them at a point in time. In the presence of scarcity, therefore, the allocation and distribution of resources always cause conflicts. To resolve these conflicts in a systematic technique, some kind of institutional mechanism(s) needs to be well-known. For example, in many parts of the contemporary world, the market system is used as the primary means of rationing scarce resources.

Potential for depletion or consumption

This is the consumption of resources at a faster rate than the rate at which it can be replenished. Resource consumption is common in farming, fishing, mining, water usage and in fossil fuels consumption. Depletion of wildlife population is known as defaunation. High rate of resource consumption leads to its depletion. Examples of resource depletion are deforestation, soil degradation, overfishing among others.

3.2 Ecology

Ecology is the branch of science that systematically studies the relationship between living organisms and the physical and chemical environment in which they live. Ecology examines the life histories, distribution and behavior of individual species as well as the structure and function of natural systems at the level of populations, communities, ecosystems, landscape and biosphere. Ecological economists have analyzed the interdependence between the physical environment and economic activities in their models. According to them, some economic activities may be the cause of environmental degradation.

3.3 Industrial Ecology

Industrial ecology is the means by which humanity can deliberately and rationally maintain a desirable carrying capacity, given continued economic, cultural and technological evolution. It is a system in which one seeks to optimize or improve the total material cycle from virgin materials to finished material, components, product, obsolete product and ultimate disposal. Factors to be optimized include resources, energy and capital.

Industrial ecology redefines waste as a starting material for another industrial process. It also seeks to structure the economy's industrial base along the lines of natural economic systems whose cyclical flows of material and energy are both efficient and sustainable.

3.4 Environmental Pollution

A change in the physical, chemical or biological characteristics of the air, water or soil that can affect the health, survival or activities of human beings or other living organisms in a harmful manner is known as environmental pollution. Pollution in economics can be regarded as any loss of human well-being arising from physical environmental changes.

3.5 Ecosystem

Ecosystem is a term applied to a particular relationship between living organism and their environment. An ecosystem has two main components: (i) abiotic and (ii) biotic. All non-living components of the environment present in an ecosystem are known as abiotic components. These include the inorganic and organic components and climatic factors. On the other hand, the living organisms of an ecosystem are known as its biotic components which include plants, animals and micro organisms.

Ecosystem may be affected by anthrop genetic factors. They also face short and long run natural changes imposed from both within and outside the systems such as climatic changes. Let us explain the functions of ecosystems with examples.

Ecological goods and services rendered by Ecosystem	**Functions**
1. Gas regulations	Regulates atmospheric chemical composition
2. Water supply	Storage and retention of water
3. Raw materials and food production	Portion of gross primary production extractable as raw materials and food
4. Erosion control	Retention of soil within an ecosystem Sediment retention
5. Genetic resources	Sources of unique biological materials and products
6. Disturbance regulation	Damping and integrity of ecosystem response to environmental fluctuations
7. Nutrient cycling	Storage, internal cycling, processing and acquisition of nutrients.
8. Recreation	Providing recreation opportunities for tourism.
9. Climate regulation	Regulation of global temperature

The major components within the ecosystem are lithosphere (solid earth), the atmosphere, the hydrosphere (water) and the biosphere. There is also crysophere (of ice and snow).

3.6 Ecosystem Diversity

The ecosystem diversity can be classified into two major types: the aquatic and terrestrial ecosystem. The aquatic ecosystems are further classified into marine, estuarine and freshwater while the terrestrial are divided into sixteen biomes representing major formation in terms of vegetation types.

3.7 Social Carrying Capacity

Use of natural resource services is compared with defined bio-physical limits for the supply of such services. Biophysical carrying capacity expresses "the maximum population size that could be sustained under given technological capabilities". Social carrying capacity can be defined as the "maximum numbers of human beings which the environment can support". The population generally stabilizes around the carrying capacity. Social carrying capacity is determined by the influence of human consumption patterns, technological changes and its impact on the environment. It stresses on the fact that nature's bounds can be disobeyed by rapidly growing population and accelerated use of natural resources.

Sustainable carrying capacity on the other hand is the maximum number of persons that can be supported in time without end on an area with a given technology and set of competitive habits without causing environmental degradation.

3.8 Ecodevelopment and Economic Sustainability

Ecodevelopment has been defined as ecological sound development which is a process of positive management of the environment for human benefit. Ecodevelopment and sustainable development are interchangeable.

Economic sustainability is concerned with maintaining a non-declining level of economic welfare now ad into the future. This economic welfare is derived from the income generated by the capital stocks which include manufactured capital, human capital and natural capital.

3.9 Environmental Goods

Environmental goods are public goods. They include air quality, water quality and sun heat; e.t.c. Environmental goods are unique in nature. Excess use of these may lead to environmental degradation.

4.0 CONCLUSION

In this unit we have been introduced to the basic definitions and concepts of environmental economics and also environmental goods.

5.0 SUMMARY

In this unit we have learnt that:

- Natural resources are useful things provided by nature.
- Natural resources are grouped into two, namely: renewable and non-renewable resources.
- Ecology examines the relationship between living organisms and the physical and chemical environment in which they live.
- Industrial ecology is the means by which humanity can deliberately and rationally maintain a desirable carrying capacity, given continued economic, cultural and technological evolution.
- Environmental pollution is a change in the physical, chemical or biological characteristics of the air, water or soil that can affect the health, survival or activities of human beings or the other living organisms in a harmful manner.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the following terms:
(a) economic sustainability (b) ecology (c) ecosystem diversity (d) environmental goods
2. Define natural resources and briefly discuss their types.

7.0 REFERENCES/FURTHER READINGS

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UNIT 2: ECOSYSTEMS

1.0 INTRODUCTION

The ranked organization of biological systems often used as a starting point for an ecological study is the ecosystem. An ecosystem includes living organisms in a specified physical environment, the multitude of interactions between the organisms, and the non-biological factors in the physical environment that limit their growth and reproduction, such as air, water, minerals and temperature. Viewed this way, an ecosystem practically means the house of life. The definition of boundaries and the spatial scale of an ecosystem can vary. Simply put, an ecosystem shows the relationship that exit between living organisms, the environment and the factors that affects them. An ecosystem can be as small as a pond or as big as the entire earth. We can, therefore refer to the ecosystem of a pond or the ecosystem of the earth in its entirety. What is important in each case is the definition of boundaries across which inputs of energy and matter can be measured.

2.0 OBJECTIVES

At the end of this unit, it is expected that you should be able to:

- Explain the meaning and types of ecosystem
- Understand the goods and services rendered by ecosystem
- Know the impacts of man on ecosystem.

3.0 MAIN CONTENTS

3.1 Meaning and Types of Ecosystem

Ecosystem has been defined as the relationship existing between living organism and their environment. It is a unit that includes all the organisms (biological factors) in a given area interacting with the environmental (physical factors) so that a flow of energy can be achieved to a clearly defined tropic (nutrient requiring) structure, biotic diversity and material cycles (i.e. exchange of materials between living and non-living sectors). Thus, ecosystem is a term applied

to a particular relationship between living organism and their environment. In a nut shell, ecosystem is a term applied to a particular relationship between living organisms and their environment.

An ecosystem has two main components: abiotic and biotic. All the non-living components of environment present in an ecosystem are known as abiotic components. These include theinorganic and organic components and climatic factors. While all the living organisms within an ecosystem are known as its biotic components. They include plants, animals and micro-organisms. The major components of the ecosystem include the lithosphere (solid earth), atmosphere, hydrosphere (water), biosphere and cryosphere (of ice and snow).

3.1.0 Types of Ecosystem

Ecosystems are classified into two major types namely: the aquatic and the terrestrial.

3.1.1 Aquatic Ecosystem

Aquatic ecosystem is classified into freshwater, marine, coastal, mangrove and island.

Freshwater: These are highly productive with very rich biological diversity. They have a wide range of habitats. The lifestyle of the population is designed according to the nature of the ecosystem. Freshwater ecosystems include the standing waters of ponds and lakes as well as flowing waters of rivers and streams. They are characterized by the presence of little dissolved salts in them.

Marine: The marine ecosystems have high salt content. Marine ecosystems include large water bodies such as oceans and seas. The coral banks are high productive and are restricted to tropical shallow waters of the sea and harbor rich biological diversity. One of the unique features of the marine ecosystem is the sea grasses which play an important role in maintaining the biodiversity and productivity.

Coastal: The coastal zones represent a very specialized ecosystem which supports unique flora and fauna. The development strategies for this have direct impact on the lifestyle of the people. Some of the main activities in this region are shipping, fishing, oil and gas exploration and recreational activities.

Mangroves: Mangroves are specialized communities inhabiting intertidal zones of sheltered, low-lying, tropical and sub-tropical coast. The mangrove swamp forest forms a belt along the coast of Nigeria from Lagos State across Ondo, Edo, Delta, Bayelsa, Rivers, Cross River and Akwa Ibom States. The rainfall in this belt is very heavy with a mean annual rainfall of over 2500mm with an average monthly temperature of about $2,60^0$C throughout the year. This zone is characterized by the presence of the red mangrove plant (*Rhizophora racemosa*). Many of the

mangrove trees have prop and breathing roots. These enable them to grow well in the soft swampy areas.

Coconuts and reeds (canes) are common plants species found on sandy beaches along the seashores. Animal species found in the mangrove swamp forest vegetation include: tilapia, angel-fish, bloody clam (area), oysters, barnacles, mangrove crab, lagoon crab, hermit crab, mudskipper fish, mosquitoes and birds (heron).

Islands: Islands are characterized by significant land-sea interaction, large extent of littoral (coastal) areas and exclusive economic zone. These features relate to their volcanic origin or as coral islands, degrees of isolation and need for transportation and interaction. Tourism is the mainstay of their economy. Environmentally sound tourism, marine related employment, relevant human resource development and agricultural production are required for the development of islands.

3.1.2 Terrestrial Ecosystem

The important terrestrial ecosystems include: the deserts, mountains, hills, forests and the grassland.

Deserts: Deserts are characterized by low moisture levels and rainfall that is both infrequent and unpredictable from year to year. With little moisture to absorb and store heat, daily and seasonal temperatures can fluctuate from 0^0C at night to 30^0C by day. Vegetation in this biome is sparse and plants in this harsh climate need a variety of specializations to conserve water and protect tissues from production. Seasonal leaf production, water storage tissues and tick epidermal layers help reduce water loss. Spines and thorns discourage predators while also providing shade. Common desert plants include the *cactus* and *acacia*. Date palms occur around oases. Animals found here include pocket mice, kangaroo rats and camel.

Tundra: Tundra is the coldest of all the biomes. It is a tree-less biome. Tundra comes from the finish tunturi, meaning tree plan. It is noted for its frost-molded landscapes, extremely low temperatures, little precipitation, poor nutrients and short growing seasons. Dead organic matter functions as a nutrient pool. The two major nutrients are nitrogen and phosphorus. Nitrogen is created by biological fixation, and phosphorus is created by precipitation. Characteristic of tundra include: extremely cold climate, low biotic diversity, simple vegetation structure, limitation of drainage, short season of growth and reproduction, energy and nutrients in form of dead organic material, and large population oscillations (fluctuations).

Mountains: A large part of the forest area of the country and watershed region is included under this category. There are ten types which represent major formations and biomes. These are the

tropical wet evergreen, semi-evergreen, moist, and dry deciduous, subtropical wet evergreen and temperate.

Forests: The forest ecosystem is important for humankind. The tropical forests on the earth's surface comprise a precious ecosystem of varying habitats, species and individual groups of interacting with each other. The world has witnessed a major erosion of the forest ecosystem due to deforestation in tropical Asia, Africa and Latin America.

3.2 Ecological Goods and Services Rendered by the Ecosystems

Over the years, human beings have derived direct and free services from the biodiversity inherent in these ecosystems. The services rendered are exemplified by the maintenance of gaseous quality of the atmosphere which regulates the climate and biosphere process. Apart from carbon (iv) oxide absorption by plants, some species and ecosystems emit trace gases such as methane which acts as a greenhouse gas for regulating the atmospheric temperature. The terrestrial ecosystems have a direct influence on the precipitation and the water that infiltrates the soil. The ground water flexes are controlled by the plant flaxes. Earthworms, for example, influence the water storage capacity of the ground water profile and infiltration rates.

Evapotranspiration by vegetation is the single largest water flex from the biosphere to the temperature. Regulation of floods and droughts is also a free ecological service rendered by forests and surface ecosystems. Coral reefs (banks), sand dune vegetation and mangroves moderate the energy of water and reduce the erosive action along shore lines and hence help the protection of coastal zones. In fact, mangroves act as buffer against tidal waves, which otherwise kill millions of people during cyclones and storms. The generations and conservation of fertile soils which are the basis of soil-based productivity in agriculture and forestry are also ecological service contributed by the ecosystems. The entire process of weathering of rocks (breaking down of rocks), creation of new soils and stabilization is achieved through processes operating at the ecosystem level.

3.3 Impact of Human Intervention on the Functions of the Ecosystem

Human induced interventions have a direct effect on the ecological services rendered by the ecosystem. Some of the causative factors are: changes in land and water use, which in turn have a direct impact on habitat destruction and over exploitation of the resources and indirect impact on the composition of the atmosphere and the climate, both directly affecting the biodiversity. Change in biodiversity modifies the functions of the population, ecosystem and landscapes.
There are serious consequences when the changes occur in the land and water use, particularly major threats to forest ecosystems due to conservation of forest into: agricultural lands, urbanization, overexploitation, overgrazing, shifting cultivation and biological invasion.

The changes in atmospheric composition take place due to anthropogenic activities such as energy production and use, and deforestation coupled with disruptions in the bio-geo-chemical cycles. Various human induced activities relating to land and water use and atmospheric changes ultimately result in climate change. The human induced disturbances have reduced the global species and genetic diversity and have had adverse impact on ecosystem functioning. Loss of species and genetic diversity are irreversible with new evolutionary processes taking place very long. But the changes in atmosphere, land and water uses are reversible.

4.0 CONCLUSION

In this unit you have been introduced to the meaning and types of ecosystem. You have also been introduced to the ecological gods and services rendered by ecosystems as well as the impact of human on the functioning of the ecosystem.

5.0 SUMMARY

In this unit you have learnt that:

- An ecosystem includes living organisms in a specified physical environment, the multitude of interactions between the organisms and the non-biological factors in the physical environment that limit their growth and reproductions
- An ecosystem can be as small as a pond or as big as the entire earth
- An ecosystem has two components: abiotic and biotic

- Ecosystem are classified into two major types: aquatic and terrestrial
- Human beings derive direct and free service from the biodiversity inherent in ecosystems.
- Human activities have direct effect on the ecological service rendered by the ecosystem.

6.0 TUTOR MARKED-ASSIGNMENT

1. Define ecosystem. Discuss its relevance to environmental economics
2. What is ecosystem? What are the functions?
3. How does a human activity affect the functioning of an ecosystem?
4. List and discuss the types of aquatic ecosystem
5. List and discuss the terrestrial types of ecosystem.

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MODULE 2: SCOPE AND CONCEPT OF ENVIRONMENTAL ECONOMICS

UNIT 1: MEANING AND COMPONENTS OF ENVIRONMENT

1.0 INTRODUCTION

The classical and neoclassical economist at their time made specific comments about the significance of nature and environment but however, failed to include them in their explanation of theories. Today people have come to realize that environments is not just the study of flora and fauna but a synthesis (combination) of study of various branches of knowledge such as agriculture, science, philosophy, ethics, anthropology, among others.

Agriculture as a field involves the interaction between the agricultural activities and their environment. It involves the interaction between agricultural issues like the applications of fertilizers, water management, plant and animal diseases and food production. These activities affect the environment and the natural resources.

Farmers carry out agricultural activities without adequate insurance and sustainability measures to the environment. While agricultural economics applies the economic principles to agricultural industries, environmental economics looks at how and why people make decisions that have environmental consequences and the role of economic policies in influencing these decisions. Therefore, a study of environmental economics calls for a detailed understanding about various environmental factors, their influences on the economy, their functions upon the environment and their impacts on the life of the people of the present and the future.

2.0 OBJECTIVES

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

- define environment
- know the basic components of environment
- identify the present environmental challenge

3.0 MAIN CONTENT

3.1 Meaning of Environment

A broad definition of environment could be the surroundings: the conditions influencing development and growth. Everything that affects an organization during his life time is collectively known as environment. You may include any number of things that are around you as being part of your environment. Environment can therefore be referred to as all conditions, circumstances and influence surrounding and affecting the development of an organism or group of organisms. The environment for example can be defined to include all flora and fauna, aquatic ecosystems energy and material resources, and the atmosphere.

Environment also means the complex components of physical, chemical and biotic factors that act upon an organism or an ecological community and ultimately determines its form and survival. In a nutshell, environment is the sum total of all external conditions that affect the growth and development of all living organisms. Examples of these external conditions may be the air we breathe, the soil on which we live in and non-living things around us. The basic components of environment are:

- atmosphere or the air
- hydrosphere or the water and
- living components of the environment or the biosphere.

These components due to forces like population explosion, pressure on land, environment and over-utilization has given rise to modification or changes of the environment to cater for the increasing population and the demand for quality environment. This tends to threaten the environment in diverse ways which include:

i. **Depletion of non-renewable resources:** Non-renewable resources are those resources for which there is no replacement or rate of growth is so slow to be invisible in human life span. Non-renewable resources are also known as finite resources that do not renew itself at a sufficient rate for sustainable economic extraction in meaningful human time frames. Examples of non-renewable resources include soil, water, wind, tides, solar radiation, crude oil, coal and natural gas. Supplies of these resources are diminishing at an increasing or alarming rate, the utilization of the resources of energy results to air and water pollution, landscape modification and mining damage.

ii. **Climate change:** Industrial activities have led to enhanced rate of input of substances in the atmosphere which has caused a measurable rise in the concentration of atmospheric carbon (iv) oxide and other greenhouse gases. A high concentration of these gases in the atmosphere acts like a big blanket around the globe which obstructs loss of heat from the earth's surface. This effect is referred to as global warming. The earth trapped in the earth's atmosphere causes a discomfort in the climate resulting to the process known as climate change

iii. **Atmosphere turbidity:** This is one of the greatest environmental issues that are of great concern. The increasing rate of atmospheric turbidity is overwhelming. Industries produce hundreds of millions of tons of air pollutants annually and released directly into the atmosphere causing atmospheric turbidity.

iv. **Solid and hazardous wastes:** Solid waste refers to waste resulting from domestic, commercial, industrial and institutional activities in an urban area. Hazardous waste on the other hand, is the one that possess a substantial hazard to human health or the environment when improperly treated, stored, transported, disposed off or mismanaged. In most cities in developing countries like Nigeria, the volume of solid waste seen either at the city junctions or at the entrance or exit of the city emitting ammonia gas producing pungent or irritating odors and causing aesthetic nuisance is a measure of the extent of the problem.

v. **Increasing human population:** Global population increase has eventually put pressure on the level of natural resources consumption such that the needs for future generation are being threatened. Increasing human population has also resulted to unsustainable agricultural practices and pressure on land thus leading to desertification, erosion, pollution, etc. examples of unsustainable agricultural practices include: deforestation, overgrazing, use of heavy tillage machines, continuous fertilizer application, indiscriminate bush burning, chemical weed control, etc.

vi. **Food shortage and famines:** This problem is acerbated by other environmental problems such as population growth, soil erosion, desertification, climate change and draught.

3.2 Components

An ecosystem consists of the biological community (biotic) and the physical and chemical factors (abiotic) that exist in the environment. The study of the ecosystem consists of the study of certain processes that link the living or biotic components to non-living or abiotic components. Energy transformations and bio-geochemical cycling are the main processes that comprise the field of ecosystem in ecology. To understand the ecosystem more cogently, ecologists primarily divided all participatory elements into two basic sub-divisions: biotic and abiotic components.

I. The Biotic Components

These are living things or component of a community. It includes all living organisms that follow the process of birth and death. Examples of biotic components are man, plants, animals including (reptiles, rodents, insects, birds, fishes, etc), micro-organisms (including parasitic, saprophytic bacteria and fungi which feed primarily upon other living or dead organisms.

Of these organisms, plants produce their own food with the help of other biotic components like soil, nutrients, water and sunlight. This process of food production in plant is called "photosynthesis". All other biotic components depend directly or indirectly on plants (autotrophs or producers) for their own food (hetertrophs) including all living things that directly ingest food (phototrophs or consumers).

There are some creatures called "osmotrophs" which secrete digestive enzymes on their food that help to break it down to tiny parts which they absorb. The basic distinction between phagotrophs and osmotrophs is that the former eat their food directly while the latter convert their food into simple components and then absorb. Micro-organisms belong to this category. They play a very important role in the decomposition of dead organic matter. This is why they are called "decomposers".

II. The Abiotic Component

These are non-living components of nature or environment. Examples are land, water, air, etc. Abotic components are also said to be non-living chemical and physical factors in the environment which affect ecosystems. The role played by the air, water, soil, gases, etc, are equally important for the birth and growth of the living things. Like the life cycle, the non-living aspects of nature form a complex interrelationship among each other, and with the biotic components. The abiotic components of the earth consist of the following three main elements:

- the solid matter of the earth starting with topsoil or dust and all its solid components
- the water in the ocean and the rivers, lakes, ponds including marshes and wetlands
- the gaseous compounds around us including nitrogen, oxygen and water vapour called the atmosphere.

The radiant energy reaching the earth from the sun is also considered as abiotic element. It sis this constant flow of energy from the sun that allows the maintenance of ambient temperature on

the planet that makes life possible. It also enables photosynthesis or the food-making process of plant that is at the root of the food chain.

The rotation and revolution of the earth and the gravitational forces are the other factors that are responsible for seasons and create wind and tides. The bio-geochemical cycles of nature helps the growth and development of biotic elements and their inter-links with abiotic elements.

4.0 CONCLUSION

In this unit, you have been introduced to the meaning and basic components of the environment and environmental challenges or issues.

5.0 SUMMARY

In this unit, we have learnt that:

- Environment is the summation of all external conditions that affect the growth and development of living organisms

- Environmental issues or challenges occurs as a result of modification of the environment to cater for the increasing population and demand for quality environment
- Biotic and abiotic factors are the environmental components of an ecosystem

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the term environment.
2. List some biotic and abiotic factors that affect the environment

7.0 REFERENCES/FURTHER READING

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UNIT 2: MEANING AND IMPORTANCE OF ENVIRONMENTAL ECONOMICS

1.0 INTRODUCTION

In this unit, the student will be made to know the meaning and importance of environmental economics. Efforts will be made to discuss the relationships between environmental economics and other fields.

2.0 OBJECTIVES

In this unit, the student is expected to know:

- meaning of environmental economics
- importance of environmental economics
- relationship between environmental economics and other fields

3.0 MAIN CONTENT

3.1 Meaning of Environmental Economics

i. Environmental economics is an aspect of economics which focuses on how and why people make decisions that have environmental consequences and the role of economic institutions (organization, public or private, laws, etc) and policies influencing these decisions.

ii. Environmental economics is a sub-field of economics that is concerned with environmental issues.

iii. Environmental economics undertakes theoretical or empirical studies of the economic effects of national or local environmental policies around the world. Issues of particular interest include: the cost and benefits of alternative environmental policies to deal with air pollution, water quality, toxic substance, solid waste and global warning.

iv. Environmental economics can be defined as that "part of economics which deals with interrelationship between environment and economic development and studies the ways and means by which former is not impaired or decreased". It is thus a branch of economics which discusses about the impacts of interaction between men and nature and finds human solutions to maintain harmony between men and nature.

v. Environmental economics deals with the impact of economic activities on the environment, the significance of ecosystem to the economy and suggest the appropriate ways by regulating economic activity, so that cosmic balance is achieved in the society.

3.2 Importance of Environmental Economics

i. Environmental economics teaches us how to promote economic growth of nations with least environmental damage. Classical and neo-classical school of thoughts underestimated the environmental issues of production and consumption, since they considered these issues merely as social issues. When environmental goods gets transformed into economic goods, the problems of environmental damage crop up, and therefore the need to interact with economic principles.

ii. To restore harmony, to reconcile the interest of human beings and nature – an ecological reorientation of the economic policy is required. Environmental studies would help to create this awareness among the people.

iii. It is required for the collection of environmental taxes and charges. This is now used extensively in Organization for Economic Cooperation and Development (OECD) nations; and is spreading to developing nations. Tradable environmental property rights are used for air pollutants, fisheries, water allocation and water pollutants as well as biodiversity banks. Emissions trading are increasingly being used as the main policy measure to reduce regional and global pollution.

iv. Environmental economics is used to address issues concerning individual (micro) and local or national (macro) decisions that have environmental implication.

v. It is essential in environmental policy decision making and forward planning. Some of the important decisions include: marked failures and externalities (not considered by classical and neoclassical economists), optimum environmental management, environmental inventory and cost decision, etc.

vi. Environmental economics is essential in collecting, interpreting and analyzing data of environmental issues. A better understanding of the correlation between a country's Gross Domestic Product (GDP) and its environmental quality involves analyzing the environmental issues including market failures, externalities, demand for quality environment, and willingness to pay that may tend to complicate the particular problems facing the country, such as political issues, inadequate infrastructure, or inadequate financing tools, etc. The knowledge of environmental economists therefore required in this respect

vii. It is required for the formulation of suitable environmental policies that are applicable to each nation and also at the same time to address transnational environmental issues. It means that to solve environmental issues that cropped up off and on and also to avert the local or regional environmental threats that are likely to take place, a suitable environmental policy is essential.

viii. Studies of environmental economics are used to determine the role or what role environmental economics can play to minimize environmental damages. There are a few methods by which this can interfere

- Assign environmental costs to resource under use
- Use price as a tool to avoid waste of resources
- Allocation of environmental resources based on true costs and real benefits
- Resource conservation through environmental management

Though these methods are basically economic in nature, due to internal and external factors, or socio-political reasons nations are constrained to accommodate economic principles in valuing resources. Environmental economics plays a crucial role in assigning true costs to scarce resources as well as popularization of environmental management.

3.3 Relationship of Environmental Economics to other Fields

I. Environmental and Ecological Economics

The insights into sustainability provided by mainstream economics are taken much further by environmental and ecological economists. The main areas of contribution include the following:

- A classification of sustainability views according to assumptions about the conservation of natural resources.
- Extending the analysis of externalities to provide a basis for designing anti-pollution policies and deciding on the resources it is desirable to devote attention to avoiding pollution.

- A range of methodologies for evaluating the services provided by environmental assets and social capital to extend the inclusiveness of Cost Benefit Analysis (CBA).
- Models for projecting the pricing and depletion of finite resources.
- Assessments of the implications of various access regimes governing the harvesting of renewable resources.

There is considerable overlap in the subject matter of ecological and environmental economics. The key difference is one of orientation.

Environmental economics tends to embrace the Neo-classical paradigm as an analysis of economic system and seeks to incorporate environmental assets and services. Ecological economics on the other hand gives priority to the health of complex interrelated ecological systems and consider how economic behavior can be modified to that end.

Central to environmental economics is the concept of market failure. Market failure means that markets fail to allocate resources efficiently. A market failure occurs when the market does not allocate scarce resources to generate the greatest social welfare. A wedge exists between what a private person does given market prices and what society wants him or her to do to protect the environment. Such a wedge implies wastefulness or economic inefficiency, resources can be re-allocated to make at least one person better off without making anyone worse off (parato optimality). Thus, environmental economics apply the tools of economics to address the environmental problems, many of which are related to the so-called market failures – circumstances wherein the "invisible hand" of economics is unreliable. However, ecological economics consider the impacts of human and their economic activity on ecological systems and services and vice versa. This field takes as its premise that economics is a strict subfield of ecology.

II. Environmental and Resource Economics

- Environmental economics is concerned with the impact of economic activities on the environment, the significance of ecosystem to the economy, and suggests the appropriate ways of regulating economic activity, so that cosmic balance is achieved in the society.
- Resource economics does not bother about the environmental impact of production and consumption but environmental economics deals with this aspect.
- Environmental economics point out the "right volume of pollution" which the society can bear. In order to attain this "balanced" level of production and pollution, economist recommended economic tools like market mechanism principles. This is so because, in the case of environment, market fails to bring equilibrium. Market fails because environment is a public good. But by assigning true values to the environmental goods it is possible to apply market mechanism principles. These aspects are covered in environmental economics which distinguishes it from resource economics.

III. Environmental Economics and Environmental Policy

Concerned with the environment is brought on in large part by coincidence of high income and high population density. If there were a few people in the world, earth's environment would be capable of absorbing most of the waste that they throw at it. The demand for environmental quality is income elastic. This implies that small price change in income will lead to a more proportionate change quantity demanded for environmental quality. This is one of the reasons for higher levels of environmental damage and this is quite dominant in developing economies. The higher income groups treat environment as luxury good. The relationship between income and environmental quality is shown in figure 1.1

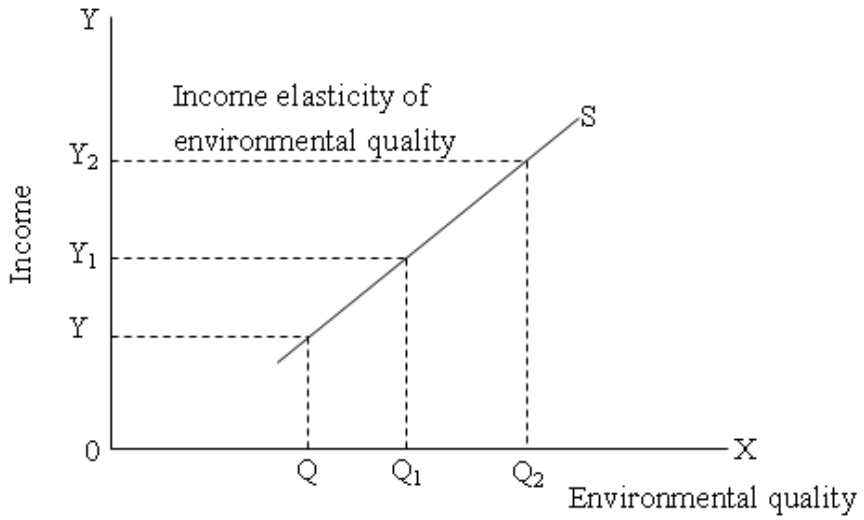

Fig. 1: Relationship between income and environmental quality

The relationship between income and environmental quality is thus:

- There exists a positive correlation between income and demand for environmental quality.

- Higher the demand for environmental quality will result in higher levels of environmental damages. This implies that as income (Y) increases, damages to the environment also increase. However, this theory is not found suitable to developed economy. In such countries, higher levels of income bring about higher levels of environmental protection. But this theory need not be through always.

- When the rich nations grow substantially, they depend on other developing nations for resources. In such dependent economies there will be higher levels of environmental damages.

- Figure 1.1 shows that when income of people increases from OY to $OY_1$and then to OY_2, the demand for environmental quality increases from OQ to $OQ_1$and then to OQ_2,

correspondingly. Thus there exists a positive correlation between income and environmental quality. Income and environmental damages are also positively correlated.

Environmental economics employs environmental friendly policies to minimize the environmental damages.

3.4 The Law of Thermodynamics

The natural law which govern the environment and which are, therefore, of interest to us is the first two laws of thermodynamics. These relates to closed systems. Strictly speaking, the earth is not of closed system as it receives energy from the sun but it is almost a closed system.
Thermodynamics deals with the study of the transformation of energy from one form to another.

I. First law of thermodynamics: Law of conservation of matter and energy:

The first law of thermodynamics states that the total energy of the system remains constant. That is energy is neither created nor destroyed but may be transformed from one from into another. For example, if energy supplied to heat energy is Q_1, the heat flow from the system is Q_2. If the work done by the system is W, then according to the first law of thermodynamics;

$$Q_1 = Q_2 + W.$$

Thus, whenever energy is converted in form, its total quantity remains unchanged. In other words, energy (or matter) can neither be created nor destroyed. Example can be drawn using a coal-fired electricity generating plant. The coal is heated which produces electricity. A by-product of this process is waste heat that is transported away as cooling water or gases. In addition, various waste gases are emitted into the atmosphere, which cause pollution such as acid rain. The first law of thermodynamics stresses that the total amount of energy created through production and consumption activities must be equal to the total sum of initial energy created from nature.

II. Second law of thermodynamics

The second law of thermodynamics states that the energy transformations which occur in doing work are never completely efficient and that some energy must escape as heat energy. In other words, energy must be unavoidably lost in all systems involving energy transformations. In an ecosystem, every time heat is lost from a food chain, high complex organized food molecules are broken down i.e. disorganized. A measure of the degree of disorganization is called entropy. Every time chemical energy is transformed from one tropic level in a food chain to the next higher tropic level, the entropy of the ecosystem increases. Entropy could also be described as a measure of the disorderness of energy. For instance, ordered energy is useful and an example of this is the energy stored in battery. However, disordered energy is not useful, and an example is the energy dispersed into the environment by a fire.

When a piece of coal is kept idle, there is low entropy but when it is burnt up, the same piece is subjected to high entropy since heat and carbon (iv) oxide are released but sometimes un-available for use. Economic activity helps to convert low entropy resources and energy into high entropy waste i.e. resources into wastes. Economic activities cannot be stopped on account of high entropy, but at the same time through recycling and waste management, it is possible to

bring into economic system low entropy value. Use of natural resources, but at the same time with minimal waste or damage to the environment is considered the key theme to sustainable development.

Entropy is a thermodynamic property of matter and is related to the amount of energy that can be transferred from one system to another in the form of work. For a given system with a fixed amount of energy, the value of the entropy ranges from zero to a maximum. If the entropy is at its maximum, then the amount of work that can be transferred is equal to zero, if the entropy is at zero, then the amount of work that can be transferred is equal to the energy of the system. During an irreversible process, the entropy of a system always increases.

The key points to remember from the above are that, because of these natural laws:

- Increased extraction of minerals by production process leads to an increase in waste,
- There is a limit on the substitutability,

- Since production and consumption lead to the dissipation of matter, scarce energy is needed for recycling.

The importance of these two laws relates to the use, re-use and recycling of the environment after interactions with the environment.
Recycling is referred to s the 3Rs of resource use – reduce, re-use and recycle. The final and last appealing option after resource use is to dispose of any remaining waste.

There are now many materials which are routinely recycled and re-used. For example, glass bottles have been collected and re-used by a number of drink companies for many years. Other examples include paper, metals, glass, plastic, textiles and garden waste. In some countries, this practice is encouraged by the use of deposit-refund schemes.

There are clearly limits to what resources can be re-used and recycled. These limits are not only dictated by the laws of thermodynamics but also by the costs associated with re-using and re-cycling many items.

3.5 Links between environment and the economy

The environments and economy interacts in many ways and are interdependent for example, agriculture and the environment. Society has become very aware of the environmental impact of agriculture over the last few decades because of the increased understanding of the negative consequences of certain agricultural practices. At the same time, it has become apparent that

many of these practices have resulted from the policies introduced to encourage farmers to produce agricultural output. Examples of the negative consequences of agriculture include water pollution (both surface and ground water), soil erosion and compaction, loss of wetlands because of drainage, air pollution such as acidification of soil as a result of livestock activity, and loss of biodiversity because of clearance for more agriculture as well as the adoption of new technologies. These outcomes have resulted because of demand for agricultural produce resulting from population explosion.

The relationship between the environment and the economy for a better understanding is explained here using two approaches:

- A two sector economy
- Material balance models

A Two Sector Economy: The underlying assumption here is that the economy is divided into two sectors: production and consumption. These sectors use the environment in three different ways:

- as a supplier of natural resource inputs
- as a supplier of environmental or amenity or service of goods
- in its capacity as waste sink

Using the environment in one of these ways may affect the other uses.

Supplier of resource inputs: Land, water and stocks of raw materials re important inputs for production. These resources are frequently used and vary between countries and so will affect the country's economy. Some countries will have large stocks of minerals while others have good arable land. Natural resources are either renewable (e.g. trees) or non-renewable (e.g. crude oil). This distinction is important as it influences the way the resources have to be managed in production. These resources are used by production sector to create goods and services for use by consumers or as inputs for another part of the production sector, but in the process, waste products are also produced.

Supplier of environmental or amenity goods: Economic benefits (i.e. increased utility) may be directly derived from the consumption of the flow of services that are forthcoming from a stock of environmental goods. For example some countries may enjoy beautiful landscape and the public benefit from these through their associated recreational services and tourism. Environmental stocks of tree can offer global services such as climatic regulation because the trees absorb carbon (iv) oxide, which might otherwise contribute to climatic change. Many people derive pleasure or get enjoyment from the biodiversity that exist in the world, and this can also be considered as a form of public consumption of environmental good.

Waste sink Capacity: This is the capacity of the environment to assimilate the waste products of production and consumption and convert them into harmless or ecologically useful products s. the environment is not only affected by waste products but also by international releases of

chemicals, such as pesticides, wood preservatives, paints and lubricants. For example, during photosynthesis, carbon (iv) oxide is taken up by green plants (autotrophs) from the air and water to produce complex organic molecule (glucose) and oxygen. The later is used by man. The physical capacity of the land, water and the atmosphere to absorb wastes and determined by the physical factors such as the climate, rainfall, wind patterns and geographical location is called the physical assimilative capacity of the environment. Some wastes are degradable pollutants while others are non-biodegradable pollutants.

Degradable pollutants are waste materials that can be broken down naturally through biological (micro-organisms), chemical and physical process. They are not harmful except when present in large quantities. Examples of degradable pollutants are: sewage, paper products, vegetables, juice, seed, leaves and e.t.c. Degradable pollutants are often used as fertilizer.
Non-biodegradable pollutants are waste materials that are not easily broken down and are harmful to man. Examples include: plastics, metal, rubber, glass and e.t.c.

Most waste materials within landfills are non-biodegradable. When thinking about waste, we need to distinguish between degradable and cumulative pollutants. With cumulative pollutants, we need to know or understand if there are any important thresholds that need to be avoided. The figure in 2.1, below is used to illustrate the importance of assimilative capacity for threshold and non-threshold cumulative pollutants.

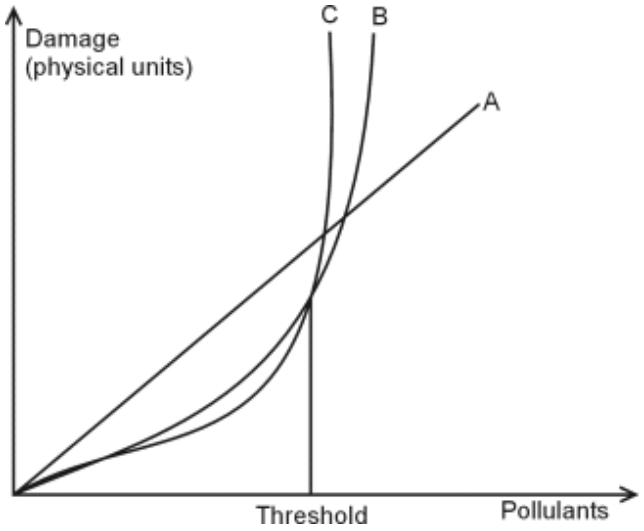

Fig. 2.1 Pollution damage functions
Source: adopted from Hanley *et al* (2007).

Figure 2.1 represents a three damage function. Function A shows a simple linear damage function, function B an exponential damage function, and function C a damage function with a threshold. The important issue captured by function C is that there is a point beyond which a pollutant has a significantly increased impart on the environment. An example is the pollution that reduces the level of oxygen in water, which if it falls below a particular level becomes extremely dangerous for fish.

The waste assimilation capacity of the environment is mathematically stated as:

Stock of degradable pollutant (S^a_t) at time t is given by:

$S^a_t = F_t - A_t$

Stock cumulative pollutant (S^c_{t*}) at time t is given by

$(S^c_{t*}) = {}^{t-t^*}E_{tl}\, F_t$

Where F_t = positive flow in a year

A_t = the amount assimilated in a year

T_l = the starting date for emissions

Environmental management can require that we take actions to prevent further pollution because we think that any important threshold might be breached. The term used to describe this type of environmental management is the **precautionary principle.** The precautionary principle states that actions to prevent or restrict environmental damage should not be delayed just because there are uncertainties about how the damage is caused or the level of damage.

Material Balance Models

Material Balance Models was developed by Alen Kneese and R.V. Ayres. The material balance models are based on the first and second law of thermodynamics. These models consider the total economic process as a physically balanced flow between inputs and outputs.

Inputs are bestowed with physical property of energy which is received from the sun. The resulting output from input carries the same level of energy. Similar to this, there are wastes resulting from consumption activities. Materials and energy are drawn from the environment, which are used for production and consumption activities and returned to the environment as wastes. So far as the balance is maintained, there are no environmental issues. The material balance model of the economy is shown in figure 2.2.

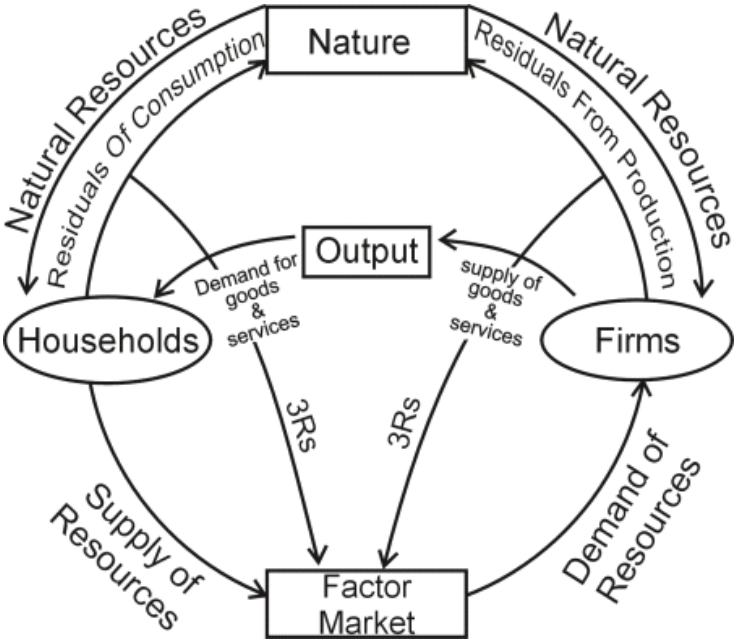

Fig. 2.2 The material balance model: interdependence of economics and environment.
Source: Callen and Thomas "Environmental Economics and Management Theory, Policy and Application.

3Rs: Recovery, Recycling and Reuse.

Fig 2.2 indicates that environment is the supplier of all forms of resources like renewable and non-renewable, and it is also acting as sink for cleaning up of wastes. Households and firms are connected to environment, and they are interconnected too. Household and firms depend on nature for resources. Both households and firms send out residuals of consumption and production respectively to nature.

Nature has the power to assimilate all forms of waste. But this power is conditional, so long as earth is not being disturbed by the excess amount of wastes, the earth can clean up natural wastes. When the earth fails to respond to 3Rs, the symptoms of environmental damage appears. Thus, there is a rhythm in the use and reuse of resources for men by men. Earth cannot respond properly to men-made or artificial wastes. Main-made wastes are piling up around us, and therefore, the extent of damage to the environment has been on the rise. All the wastes that being sent out cannot be cleaned up by the sink earth. As long as earth can discharge this function of cleaning up of pollution due to wastes, there would not be any environmental issue. But earth has reached at the saturation point of this process and it is helpless in cleaning up of several types of wastes resulting in major environmental issues in the world over.

4.0 CONCLUSION

In this unit you have been introduced to the meaning and importance of environment, relationship of environmental economics to other fields and Law of thermodynamics. You have also been introduced to the Links between environment and the economy

5.0 SUMMARY

In this unit you have learnt that:

- Environmental economics is a sub-field of economics that is concerned with environmental issues.
- It focuses on how and why people make decisions that have environmental consequences and the role of economic institutions and policies influencing these decisions.
- Environmental economics is important determining the role or what role environmental economics can play to minimize environmental damages.
- There is considerable overlap in the subject matter of ecological and environmental economics.
- Thermodynamics deals with the study of the transformation of energy from one form to another.
- The environments and economy interacts in many ways and are inerdependent.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is environmental economics? Show the relationship between environmental economics and environmental policy, resource economics and ecological economics.
2. Explain the term thermodynamics? State the law of thermodynamics.

7.0 REFERENCES/FURTHER READING

Callen, S. J and Thomas, J. M (2012). Environmental Economics Management: Theory, Policy and Application

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UNIT 3: NATURE OF ENVIRONMENTAL ECONOMICS

1.0 INTRODUCTION

Environmental economics is a science applied to decision making. It focuses on how and why people make decisions that have environmental consequences, the implication of such and the role of economic institutions and policies in influencing these decisions. Environmental economics is considered both as positive and normative science. It also covers both micro and macro aspects of different pollution problems. In this unit, the student will be made to understand the nature of environmental economics, positive, normative, micro and macro aspects of environmental issues. Efforts will be made to discuss briefly the static and dynamic versus social science in relation to the environment as well as environmental pollution as an economic problem.

2.0 OBJECTIVES

At the end of this unit, the student is expected to

- Know the difference between positive and normative economics
- Understand the micro and macro aspects of environmental economics
- Have a full knowledge of environmental economics as a static and dynamic area of study as well as a social science
- Identify environmental pollution as an economic problem.

3.0 MAIN CONTENT

3.1 Positive versus Normative Economics

3.1.1 Positive Economics:

Positive economics is concerned with "what is" and how the economy works. Positive analysis in economics is used to forecast the impact of changes in economic policy or economic conditions on such things as production, sales, prices and income to determine who wins and who losses as a result of those charges.

Positive economics can therefore be defined as a body of synthesized knowledge concerning "what is". It is concerned with description of economic events and formulation of theories to explain them. It tries to follow scientific principles and devise objective test of these theories. Robbins regards economics as a pure science of what is which is not concerned with moral or ethical questions. Economics is neutral between ends.

The economists have no right to pass judgment on wisdom or folly of the end itself. Economists are simply concerned with problem of resources in relation to the ends desired. For example, the manufacture and sale of cigarettes maybe considered injurious to health and morally unjustifiable. The economist however, has no right to pass judgment on these as both satisfy human wants and involve economic activity.

Environmental economics is application of scientific theories and general application of welfare economics. When we study the cause and effect relationship, it covers the positive aspect. For example, the laws of thermodynamics are equally applicable to economic process.

3.1.2 Normative economics

This is concerned with what goals of economy should be. Normative analysis in economics is used to evaluate the desirability of alternative outcomes according to some underlying value judgments or opinions about what is good or bad. Normative economics develop criteria for what ought to be. It is also concerned with describing what should be the things.

Normative economics is also called prescriptive economics. What price for a product should be fixed, what wage should be paid, how income should be distributed and so on fall within the preview of normative economics? Normative economics value judgment. Hence, environmental economics are of the opinion that environmental economics is normative and prescriptive in nature. If the problem is related to policy measures, then it is considered as normative aspect. Therefore environmental economics is a normative science because it prescribes the goals of environmental policy.

3.2 Environmental Economics: Micro and Macro Aspects.

Economists have formulated their models in relation to individual firms and natural resources. Therefore, it covers the micro and macro aspects of the pollution problem. There are many examples of micro and macro aspects of environmental problems in the present times. We generally observe crowded market places, industrial units and even residential areas in cities and urban areas. These areas do not have sufficient fresh air. Thus environmental quality fresh air is a scarce commodity in these areas. Its solution lies in the micro level planning. On the other hand, when pollution problems are related to the economy as a whole such as rise in temperature, then it is related to macro aspect of environmental planning. Environmental economics draws more from micro economics than from macroeconomics. It focuses primarily on how and why people make decisions that have consequences for the natural environment. It is concerned also with

how economic institutions and policies can be changed to bring these environmental impacts more into balance within human desires and needs of the ecosystem.

3.3 Static and Dynamic Approaches versus Social Science Approach to Environmental Economics:

3.3.1 Static and Dynamic Approaches

Classical and Neo-Classical economists have applied both static and dynamic approaches in relation to environment. They have applied economic welfare approach to environment which is static in nature whereas under dynamic approach, they focus on forests, minerals, fossil fuels, water resources among others.

3.3.2 A social Science Approach

Environmental economics deals with economic and managerial aspects of pollution and natural resources. It interacts between human beings and their physical surroundings. It studies the impact of pollution on human beings and suggests national utilization of resources in a proper way so that there may be an increase in social welfare or maximization of social costs.

Environmental economics is also concerned with the natural environment, but not exclusively so. For example, man-made and cultural or social environments may also be a part of the nature of environmental economics.

3.4 Environmental Pollution as an Economic Problem

Environmental pollution is an economic problem because it requires us to make choices and to resolve conflicts of interest. It is an economic problem because the means by which pollution can be reduced are themselves scarce resources.

Furthermore, it also reduces the value of some resources that society has at its disposal. It means that pollution is a problem of scarcity in terms of waste disposal capacity. The main problem of choice is how to utilize the scarce resources in relation to society's needs. The market forces will be helpful in determining this scarce resource in most rational manner. The equilibrium will be attained at the equality of demand and supply of environmental quality.

Since resources are scarce, they cannot be used to produce all types of goods simultaneously. Therefore, if they were used to produce one thing, they have to be withdrawn from other uses. The problem of choice facing a modern society is whether to maintain environmental quality or to increase industrial production (i.e. auto mobiles). It creates conflicts of interest between potential gainers and potential losers.

The problem of externality is an important aspect of environmental quality. The external effects of industrial production may affect the environmental quality. Therefore, the economic problem is the optimal allocation of resources in the context of externalities.

One of the objectives of environmental quality is to restrict these production activities which enhance social costs to society. Environmental quality is largely influenced by human activities in terms of excess exploitation of resources and the production of waste. How much environmental quality is affected by exploitation of resources and production of waste depends on ecological conditions of the economy. More exploitation of it means more pollution.

Figure 2.3 below is used to explain environmental pollution as an economic problem.

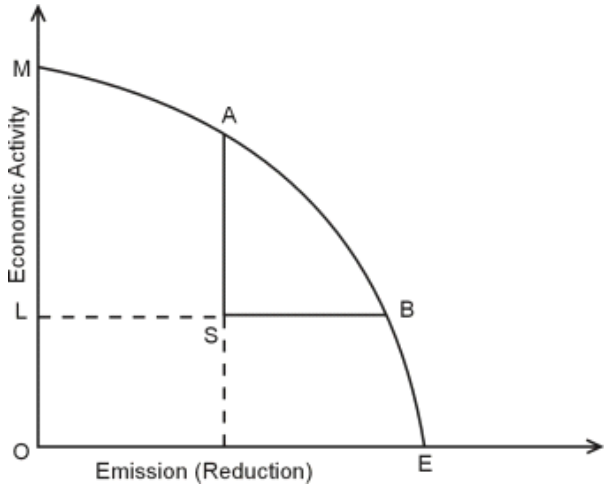

Fig. 2.3 Environmental Pollution as an economic problem

From figure 2.3, it is assumed that the economy is producing two sets of goods, a composite good (M) which is the aggregate of all existing goods and services, and second, an environmental quality good which also represents certain quantity of emission reductions. The ME curve represents a production frontier which explains the trade-off between economic activity and emission reduction. If the economy moves from point S to point A on the ME curve, it means more production with increase in economic activity without increased emission.

On the other hand, if the economy moves from point S to point B on the ME curve, it means more emission reduction without reducing the economic activity level (L) because point S and point B lie in the same direction. In this connection, what we will find is that choices made about the environment depend upon similar factors as do choices made in other areas of economics.

Our views of changes in environmental quality depend (as do all prices) upon supply and demand factors: how much of the environment is supplied for particular purposes and how much

is demanded. Thus, the factors of supply (production) and demand (preference for clean environment) and market instrument used by the state are important issues in environmental policy.

Economic growth can affect environmental quality under different situations. Environmental quality can increase with economic growth, thus increased incomes; for example, provide the

resources for public services. With availability of these services, individuals can devote more resources for conservation. Secondly, environmental quality can initially worsen but then improve as the growth rate rises. Thirdly, environmental quality can decrease when the rate of growth increases.

4.0 CONCLUSION

In this unit, we have discussed the difference between positive and normative economics, micro and macro aspects of environmental economics, environmental economics as a static and dynamic area and as a social science as well as environmental pollution as an economic problem.

5.0 SUMMARY

In this unit, we have been able to understand:

- The difference between positive and normative economics
- Micro and Macro environmental economics
- Environmental economics as a static and dynamic area of study
- Environmental economics as social science and environmental pollution as an economic problem

6.0 TUTOR-MARKED ASSIGNMENT

Briefly explain the following:

a. Micro environmental economics

b. Macro environmental economics

c. Environmental economics as a static and dynamic area of study

7.0 REFERENCES/FUTURE READINGS

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UNIT 4: SCOPE OF ENVIRONMENTAL ECONOMICS

1.0 Introduction
2.0 Objectives
3.0 Main content
- 3.1 Economy-Environment analysis
- 3.2 Eco-development
- 3.3 Welfare approach
- 3.4 Dynamic and stock flow analysis
- 3.5 Environmental values
- 3.6 Clean technology
- 3.7 International cooperation
- 3.8 Conservation policy
- 3.9 Multi-disciplinary base

4.0 Conclusion
5.0 Summary
6.0 Tutor-marked Assignment
7.0 References/Further reading

1.0 INTRODUCTION

In unit 1, you will read about economy-environment analysis, eco-development, and welfare dynamic and stock flow analysis. You will also read about environmental values and clean technology. This unit will be devoted to discussing international cooperation, conservation policy and multi-disciplinary base.

2.0 OBJECTIVES

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

- identify the scope of environmental economics
- describe the scope of environmental economics

3.0 MAIN CONTENT

3.1 Economy-Environmental analysis

Environmental economics is primarily concerned with the impact of economic activities on environment and its implications for the individual firm, industry and the economy as a whole. Economists have formulated economy-environmental models to explain the various economic activities and their external effects. For example, the material balance model and the Leontief Abatement model explain these externalities.

3.2 Eco-Development

The main objective of environmental economics is to maintain a balance between economic development and environmental quality. In order to achieve it, environmental economists have to explore the various socio-economic possibilities to reduce pollution and uplift the standard of living of the people. This objective gained momentum after the publication of the reports on limits to growth.

3.3 Welfare approach:

Environmental economics has emerged as a discipline to tackle environmental problems from an economic welfare framework. The welfare framework covers scarce resources and market failures due to property rights and ethical aspects of different problems of pollution. Thus it suggests the best possible measures to tackle environmental problems.

3.4 Dynamic and stock-flow analysis:

The mainstream economics is largely confined to the static problems of market behavior. But environmental management issues are about resources and are dynamic in nature. Moreover,

resources have a stock and they have a rate of depletion and replenishment such as oil, minerals, and forests. Thus there is the inevitable stock-flow dimension to environmental issues.

3.5 Environmental Values:

Environmental issues are about resources. The neo-classical economists have analyzed the use of various resources like fisheries, forests, fossil fuels and water in a rational manner and with environmental values. In fact, environmental values are economic values. It is important for the society to conserve its limited resources in the interest of economic efficiency and welfare.

3.6 Clean Technology:

Presently, environmental pollution is caused by misuse of existing technology and failure to develop better one. Environmental economists are in favour of appropriate and clean technologies which provide the most rational use of natural resources and energy and to protect the environment.

3.7 International Cooperation:

There are many international issues like hazards of trans-boundary shipments, unwanted substances and common property resources which need international cooperation among nations. There are many negative effects of inadequate toxic waste generated within countries and hazardous goods exported to other countries. Most countries of the world are insisting on uniform standards and environmental regulations for all nations. Other issues are related to international common property resources, especially the share of river water and forest land among others.

3.8 Conservation Policy:

The longstanding foundation of environmental economics lies in conservation economics which tends to emphasize the impact of economic activities on demand for productive resources and energy resources. It suggests the optimal strategy in the utilization of natural resources in a rational manner.

3.9 Multi-disciplinary base:

Environmental economics is inherently a multi-disciplinary subject. It consists of an integration of many varied disciplines such as biology, ecology, physical sciences and main stream economics. Therefore, it has a wide scope.

4.0 CONCLUSION:

In this unit, we have discussed the scope of environmental economics. From the discussions, it is concluded that environmental economics has a wide range of scope. It cuts across so many fields of study.

5.0 SUMMARY

In this unit, we have learnt that:

- environmental economics is basically concerned with impact of economic activities on environment and its implications for the individual firm, industry and economy as a whole
- the main objective of environmental economics is to maintain a balance between economic development and environmental quality
- environmental economics is used to tackle environmental problems
- there is stock-flow dimension to environmental issues
- it is important to conserve scarce resources for the interest of economic efficiency and welfare;
- appropriate and clean technologies that will ensure rational use of natural resources and energy to protect the environment should be employed;
- environmental economics is a multi-disciplinary subject.

6.0 TUTOR-MARKED ASSIGNMENT

1. Outline the scope of environmental economics
2. Mention the different field of studies that interrelate with environmental economics

7.0 REFERENCES/FUTURE READINGS

Callen, S. J and Thomas, J. M (2012). Environmental Economics Management: Theory, Policy and Application

Pavithran K. V (2008). A Text Book of Environmental Environmental Economics. https://book.google.con.ng/books?isbn=812242802

MODULE 3: AGRICULTURAL PRODUCTION AND THE ENVIRONMENT FOR SUSTAINABLE AGRICULTURAL PRODUCTION

Unit 1 Theory of production
Unit 2 Agricultural production decision and theory of production function
Unit 3 Resource productivity and efficiency
Unit 4 Resource and environmental sustainability

UNIT 1: THEORY OF PRODUCTION

CONTENTS

1.0 INTRODUCTION

Production does not mean fabrication of material goods alone as the term generally connotes. The term production is used in economics to comprise such numerous activities as: playing professional sorcery, frying akara on the road side, dressing hair at the saloon, writing a feasibility report on a proposed project, fabrication of engine and motors and hawking goods on the streets and motor parks. It also includes, managing a bank, driving a taxi, selling an insurance policy, teaching in a KG class, selling newspapers at newsstands, repairing a car, bicycle or any equipment and so on.

Production therefore does not simply refer to the process of fabricating commodities, but also covers any activity involved with the packaging, storage, transportation or marketing of these products as well as the rendering of personal and commercial services of all kinds. In fact, any activity that gives utility and economic value is termed production.

2.0 OBJECTIVES

At the end of this unit, the student is expected to know:+

- The meaning of production
- Meaning of resources and important resources involved in agricultural production

3.0 MAIN CONTENT

3.1 Meaning of Production

Production is the process by which resources otherwise known as inputs are transformed into output in output producing units. Producing factors of production are called resources while the products or outcomes are called output. The output producing units include farm and factories.

Production therefore implies changing of either the form of something or its situation in space of time, or provision of a service of any kind. Examples include: the transformation of pepper into tomapep (canned pepper), cassava into cassava flour, maize into either maize flour. On the other hand, when for example a maize farmer produces maize from his land using labour and his skills as a farmer, his inputs are land, labour, capital (hoes, seeds, fertilizers, cutlasses) and his skill. His output (product) is maize. The farmer is said to be involved in production. Similarly, for a poultry feed mill however, the maize (the output in earlier case) is one of the inputs, while poultry feed will be the output. For a poultry farmer on the other hand, the feed is one of his inputs, while eggs or chicken (poultry meat) or both are his output.

3.2 Agricultural Resources (Inputs)

The major resources used in agriculture are free and economic resources.

- The free resources are termed free because they are relatively abundant in supply and hence have no cost implication but are very important in agricultural production. Examples include air, heat, light, water (in form of rain) and so on.
- The economic resources are scarce in supply and limiting in production. They have high economic value. They are land, labour, capital and management. The economic resources come into agricultural production in different disaggregated forms to give a more specific set of resources for example, land of different types, different categories of capital expenditure and labour of different categories such as hired labour, family labour, skilled or casual or unskilled labour.

3.3 Agricultural Production Resources

Land: Land implies natural resources which include the soil itself, water, minerals and forests. Land was regarded as being different from other resources in that it was not be created by man and its total supply was perfectly inelastic. This however is not true today as they have been reclaimed plots of land in Nigeria and Holland.

Land contributes to economic growth in that it is from it that our food and raw materials for industries are produced. The characteristics of a nation's natural resources affect the amount of her Gross Domestic Product (GDP). Countries may have natural resources, but if they are not harnessed or exploited, they are of no use.
The supply of land is said to be relatively fixed but it can be expanded slightly by drainage of swamps, reclamation from sea bodies and water, and chemical or biological improvement of non-cultivable land. Land (farm size) is measured in hectares but the local farmers sometimes, refer to the size of their farms in number of heaps.

Capital: The term capital is used to describe all those instrument of production deliberately made by man to be used to carry on production function. Capital is man-made, and its presence is as a result of past human effort. Capital resources come into farm production in three forms, namely:

- Farm machinery, such as tractors and various farm implement and tools
- Biological capital such as fertilizers, pesticides, herbicides, improved seeds and breeding stock
- Feed for livestock

Also, capital can be categorized on the basis of their construct, that is:

- Depreciation cost on building which are farm improvement
- Maintenance and running cost on machinery and equipment, livestock and feed expenses, feed and fertilizer purchases
- Depreciation cost on machinery

If the productive capacity of capital is to be maintained, increased capital accumulation is necessary. Capital accumulation involves two related processes – saving and investment. Capital accumulation occurs if output exceeds consumption, and if the margin between output and consumption is re-invested as the opportunity cost of consumption. For example, if a man buys a spade today because he went without his lunch for some days, the consumption foregone enables him to invest in a productive aspect – a spade. Investment could be made through savings. Saving is defined as the difference between disposable income and consumption. Saving therefore is a means of accumulating assets that perform specific function for the saver. It is also the setting aside of some items for future use.

Investment on the other hand is the large amount of money that is used to set up a business (capital fund). It is a process of adding to capital while capital accumulation is the process of building up capital stock through positive net investment.

Capital accumulation is low in developing countries such as Nigeria due to low levels of income and low saving level. Capital accumulation is very difficult because with low income, very little savings or investment occur out of existing income. Lack of capital has some economic implication. It produces the vicious circle of poverty. This is represented in figure 3.1

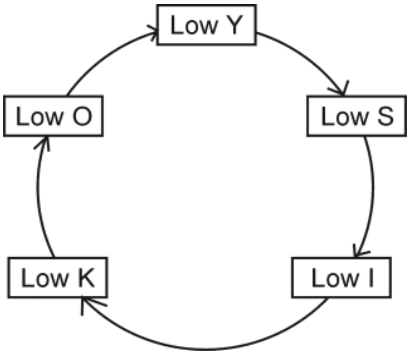

Fig.3.1. Vicious circle of poverty

Y

Y= Income
S = Savings
I = Investment
K = Capital stock
O = Productivity = output per unit factor input

In developing countries like Nigeria, national income is generally low. Since savings are low, investment is low. Since investment is low, capital stock is low. Since capital stock is low, productivity is low and since productivity is low, output and income are low, thus completing the vicious circle.

Each of the variables impinges on the other. The vicious cycle implies a circular flow of forces tending to act and react with one another in such a way as to perpetuate certain conditions. Hence, the vicious circle of poverty refers to the circular flow of forces which tend to act upon one another in such a way as to maintain and sustain the state of poverty. If capital injunction is the means through which the vicious cycle of poverty could be broken, then conditions favourable to savings and investment have to be created. There must be political stability and sound monetary and fiscal policies (including tax policy to investors).

Labour: The term labour refers to the efforts of human beings (including that of farmers and their families) and labourers, and not individuals (or people) themselves. If four men work for four hours, we have four-man hours. Therefore, labour is the effort of human being that is used in making things happen in production process. It is the second most important resource next to land in agricultural production.

Labour availability is a function of the economically active proportion of the population released for agricultural activities. Farm labour on peasant farms could be from both family or hired sources depending on the size of the farm and type of operation to be performed, but in large

commercial farms, farm labour is purely hired and categorized as casual, unskilled, semi-skilled and skilled labour. The quality of labour is used as a function of the level of education and training in relevant agricultural production, that is, the higher the level of training in the cultivation and management of any crop the higher the productivity and efficiency.

Labour is measured in terms of adult male equivalents where one man-day is the work done by one adult male in eight house, and one woman is equivalence of two-third (2/3) of a man-day while a juvenile is half (1/2) of a man-day. Labour productivity can be increased through specialization.

Labour specialization increases productivity in the following ways:

- Through the application of modern technological method and capital equipment,
- Through development of skill. By concentrating on a particular job or line of production, the productive power of labour is increased. In a food processing company, for example, the majority of worker do fairly routine job over and over working with specialized machinery and thereby developing a particular skill which increases productivity,
- Through the saving of time; since workers by concentrating on a particular line of action, does not waste time switching from one job to another,
- Specialization allows labour to make maximum use of tools and equipment, thereby avoiding idle equipment. Suppose a man is all a bricklayer, a carpenter and a fisherman, some of his tools will be lying idle when he is performing one of his activities. He will make more efficient use of his scarce resources if he specializes in one of the activities.

Managements: Management or entrepreneur or coordinator is the most important factor of production. In this input, resides the decision making power in farm business. It is concerned with efficient mixing of resources in the production process. An efficient resource planning and utilization ensures attainment of the objective of the production function. Management is therefore concerned with planning, implementation and control of the farm business.

Technology: Technology of recent is being classified as a factor of production. The reason for classifying technology as a factor of production is because we are in a jet age. Technology refers to new, better and cheaper ways of doing things. It means improvement in the efficiency of capital stock that result from technological and organizational changes, and improvement in the quality and productivity of labour force that results from improved training and efficiency of workers. Technology has made it possible for man to utilize more efficiently the resources at his disposal. It increases the quality of other factors to which it is applied. By applying technology (i.e. better use of existing labour, capital, land and management) production function moves upward (figure 3.2)

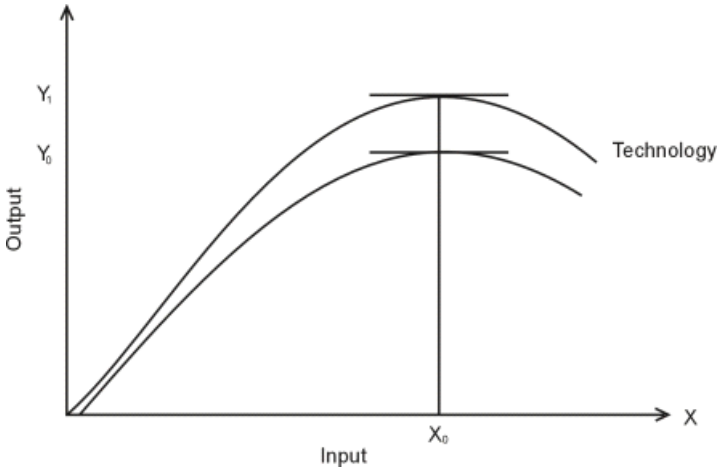

Figure 3.2: Production function

4.0 CONCLUSION

Production is the transformation of resources into output. Agricultural production resources are land, labour, capital, water, entrepreneur and technology.

5.0 SUMMARY

In this unit, we have learnt that:

- Production involves transformation of inputs into outputs
- Agricultural resources are of two types: free and economic
- Agricultural production resources include land, labour, capital, water, entrepreneur and technology.

6.0 TUTOR-MARKED ASSIGNMENT

1. Briefly explain the term production
2. List and discuss the different types of agricultural resources

7.0 REFERENCES/FUTURE READINGS

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UNIT 2: AGRICULTURAL PRODUCTION DECISION AND THEORY OF PRODUCTION FUNCTION

CONTENTS

1.0 INTRODUCTION

In this unit the student will be made to understand the meaning of agricultural production and decision, types of production relationship, meaning of production function, assumption of production function and types of production function

2.0 OBJECTIVES

In this unit, the student is expected to know the

- Meaning of agricultural production and decision
- Types of agricultural production and decisions
- Meaning of production relationship
- Assumption of production function
- Types of production

3.0 MAIN CONTENT

3.1 Meaning of Production and Decision

Agricultural production is the process of transforming agricultural resource into a form that will give maximum utility. Agricultural production decisions on the other hand are decision taking in the allocation of scarce resources. Agricultural production requires various resources. These resources are scarce and therefore a choice has to be made in their use. One of the production decision farmers have to make is that of the quantity of a commodity e.g. maize that must be produced. Making this decision will lead to knowing the production function.

3.2 Factor – Product Relationship

Factor – product relationship describe the transformation of a given product like maize. Here we are interested in the effect of variation of only one input like labour or fertilizer holding other factors or inputs fixed. Many farm decisions always fall within this frame of reference and are analyzed using this production relationship. Factor-product relationship is important especially when it involves the problem of determining the intensity with which the given variable input is to be combined with fixed quantities of other essential inputs to achieve the profit maximization objectives.

Factors- product relationship is not true to life since production always involve more than one variable in the short run and all inputs are variable in the long run. It is only used for diagnostic purpose where one basic input is the limiting input e.g. labour or capital in developing economy.

The input functional form of factor product relationship is stated as

$Y=f(X1/X_2$ ---------- $X_n)$, or $Y= f(X_1)$

Where Y= output in specified unit

X_1= Variable input

X_2-X_n= Fixed quantities of the other input

3.3 Factor – Factor Relationship

Another type of production decision farmers have to make is the decision on what method of production to use. This type of decision involves factor – factor relationship and factor substitution. Factor – factor relationship shows the level of choice between different combinations of two or more resources. This level of choice must be that which is economic for production of given output.

In other words, how many tons of fertilizer can be combined with unknown man- days of labour, and unknown capital – input service to give certain amount of grain per acre of cultivated land. This relationship is important in attaining the cost minimization objectives. Substitution of one factor to another factor in the production process is a familiar practice among farmers. Some farmers produce beef by using more maize and little pasture. Milk can be produced entirely by hand labour or by means of a milk machine with little hand labour. Pigs can be reared with feed concentrates or with carbohydrate such as cassava.

Assuming a livestock farmer has two variable factors hay and maize and a fixed factor, cow.

Assuming also that he has to produce 100kg of milk he can combine these two variable factors in

a number of ways to produce the same output of 100kg of milk. In figure 3.0 , there six different ways.

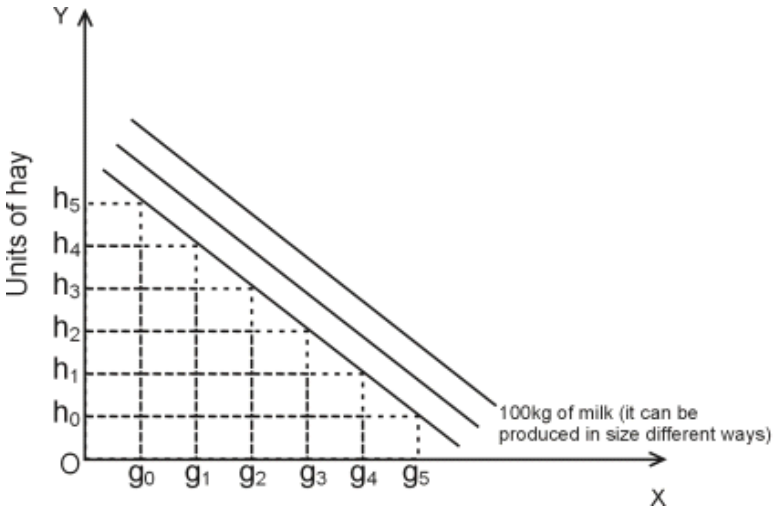

Figure 3.0: *Equal product curve or*

When these six different ways that can be combined to produce the same output of 100kg of milk are plotted on a graph, we shall get a contour line or an iso-line. Such a contour line is called iso-curve or equal product curve or iso-quant. An equal product curve is a curve which indicates all possible combinations of two variable inputs yielding the same level of output. With an increase in the quantity of the variable input there will be higher level of output resulting to a series of iso-quants (figure 3.0). If either hay or maize or are increased, there will be increase in milk production and quantity there will be several iso-quants or equal product curves higher and higher on the production surface each representing a higher level of output.
Implicitly, a factor-factor relationship is defined as

$Y = f(X_1, X_2/X_3 \ldots\ldots\ldots\ldots X_n)$ or
$Y = f(X_1, X_2)$
X_1 and X_2 = Variable inputs
X_3 to X_n = Are fixed

Properties of Isoquants

- Negative Sloped: This downward slopes stems from the technical substitutability of one resource for another.
- Isoquants are convex to origin: this implies that the slope of isoquants decrease in absolute terms as we move along the curve from left to right. The marginal rate of substitute of the resources is diminishing.
- Two isoquants do not intersect each other: if they were to intersect, points of intersection will indicate that two different quantities of the product could be produced with the same combination of resources which are impossible.

- Isoquants do not intercept the X and Y axis: If they do, it implies that there will be a stage where two factor inputs combined in different proportions to produce a given output can no longer be so combined and only one of them and none of the other can now be used to produce the same level of output.
- The further away from the origin an iso-quant curve lies, the higher the level of output it denotes: quantity of products on a higher iso-quant is preferred by the rational producer.

3.3 Product-Product Relationship.

This type of relationship tends to establish the most efficient allocation of given resources. This relationship is particularly relevant to the problem of optimum enterprise combination that maximizes farm income. It is a relationship involving the production of two different enterprises such as oil palm and rubber with only one variable input such as land and labour. It involves substitution between the two enterprises given the variable input. In other words, to produce more hectares of oil palm with a given hectares of land will imply the production of less hectares of rubber and vice versa.
Implicitly, it is defined as.

$X = (Y_1, Y_2)$

Where X = Variable input
Y_1 = Enterprise 1 (oil palm)
Y_2 = Enterprise 2 (rubber)

3.5 Theory of production function

Production function is a technical or physical relationship between inputs such as fertilizers, herbicides, land labour, capital, agro-chemicals etc and output in any given production processes. It shows the rate at which inputs are transformed into output. Production function reveales the production possibilities open to the farmers. The relationship indicates that total output is a function of quantity and quality of inputs used in the production process. Any given input-output relationship specifies the quantities and qualities of resources required to produce a given level of output. Implicitly product function is defined as

$Y=f(x)$
It state that output Y is a function of input x

Where Y=output of product

X=input used

f=functional form
Production function can be expressed in different ways such as

(a) Arithmetically by means of tables.
Arithmetic expression of production function is shown in table below:

Table1 Arithmetic representation of production function

Fixed factor (land) (I)	Variable factor (labour in man hours) (II)	Total product (kg maize) (III)	Average product (kg of maize) (IV)	Marginal product (kg of maize) (V)
¼ hectare of land all through	0	-		-
	1	30	30	30
	2	90	45	60
	3	177	58	84
	4	244	62	70
	5	270	54	26
	6	240	40	-30

The second and third columns whose values are given represent production function. The value of the forth column are derived by dividing total product by the corresponding labour values, while the marginal product are the difference between successive total product.

(b) Graphical expression of the product function

If the second and third columns are shown on a graph, the result would be the factor product pair, a relationship (figure 3.1)

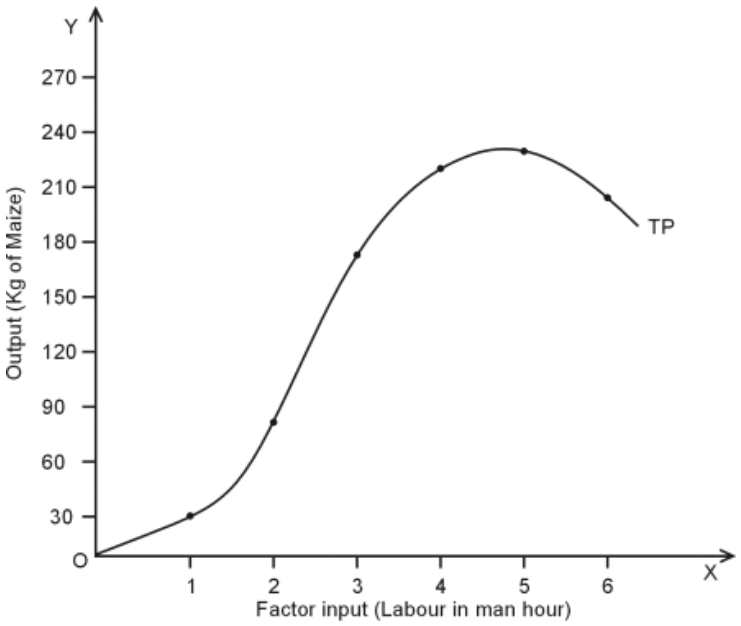

Figure 3.1: Factor-Product Relationship

(c) Algebraic expression of the production function

In the implicit function, X is the independent or the explanatory variable while Y is the dependent or the explained variable. This is expressed as

$Y=f(x)$

However, the product output is not dependent upon only one factor hence an algebraic expression is more accurately represented as

$Y=f(X_1, X_2, X_3, X_4 - - - - - - - - X_n)$.

If we put a bar between X_1 and $X_2, X_3, X_4 - - - - - - - - X_n$, it shows that X_1 is variable while the other factors are assumed constant or fixed. For simplicity, the general formula, for explicit function is shown as

$Y=a+bx$

Where a = constant

b = elasticity of response of Y to a unit change in X. a is the value of Y when there is no change in X, and it is 25 by substitution. b is the coefficient of elasticity, and it is 4 by substitution, which is also the slope of the line (figures 3.2 and 3.3).

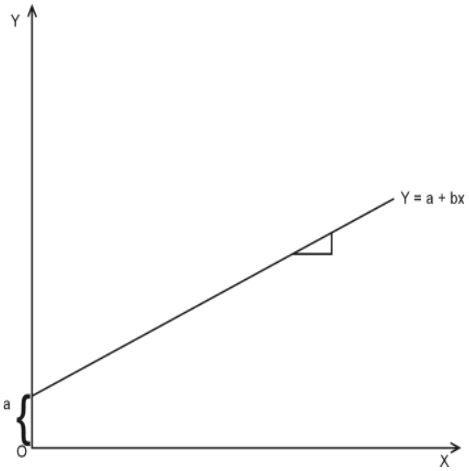

Fig. 3.2: Explicit Production Function (unsubstituted)

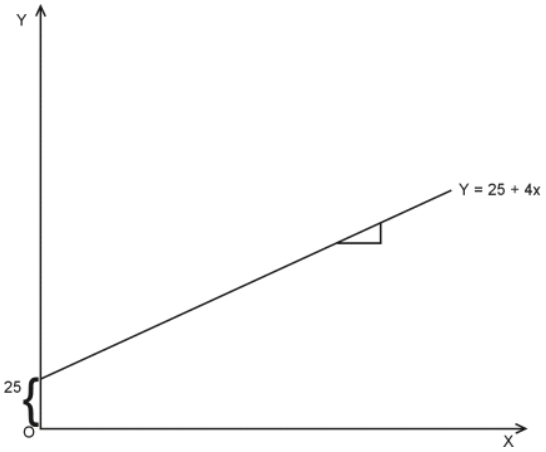

Fig. 3.3: Explicit Production Function (substituted)

This implies that for every one unit change in X, Y changes by b. It is important to know that both input and output must be homogeneous. Production and resource relationships are meaningful if they refer to input and output that are homogeneous. Assuming the initial input of labour refers to the labour of an adult and the additional input of labour refers to that of a child, it does not make any meaning because it will be difficult to refer to the amount of labour uses. To be meaningful, the additional amount of labour employed must be that of an adult as this will

enable us make assumption about their output. Similarly, the output must refer to the same type of product.

Assumptions of production function

- Inputs and outputs are perfectly divisible
- Factors of production (resources) can substitute each other's to extent certain
- Technology of production is known and it is constant
- Supply of variable factor is elastic in both sort-run and long run, while the supply of fixed factors is inelastic in the short run.

The general form of production function can be classified as:

- Constant returns
- Increasing returns
- Decreasing or diminishing returns

a. Constant returns

This occurs when all units of variable factors of production applied to a fixed factor bring about a proportionate or constant to the output. This implies that the marginal physical product is constant. For example, if a pig is given a deworming peel and it increases its body weight by 10kg, it is expected that the weights of other pigs of the same species will increase by the same weight. The graph showing constant return is represented in figure 3.4

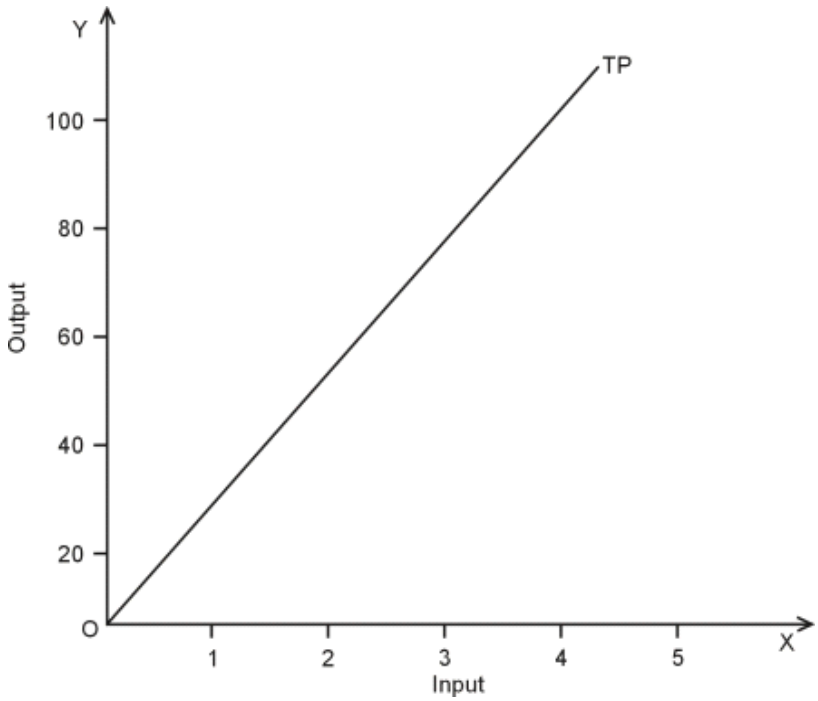

Figure 3.4: *Constant returns*

b. Increasing Returns

Increasing return is said to occur when each additional unit of variable inputs adds more to the total product than the previous unit. For example, if additional bags of fertilizer are applied to a limited area of land, the marginal increase in total output of a crop like maize is more than the increase in total product as a result of previous unit of fertilizer. Figure 3.5 shows the graph of increasing return.

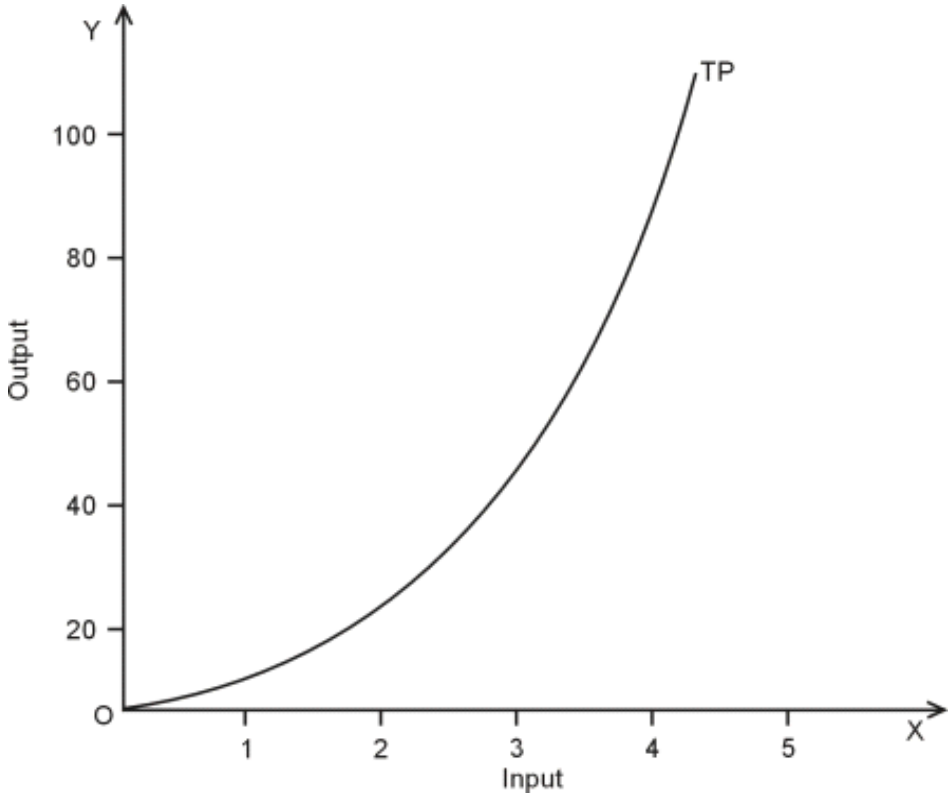

Figure 3.5: *Increasing Returns*

c. Decreasing or Diminishing Return

When each successive unit of variable input applied to a fixed factor adds less to the total product than the previous unit, it is regarded as decreasing or diminishing returns. The graph showing decreasing or diminishing returns is represented in figure 3.6

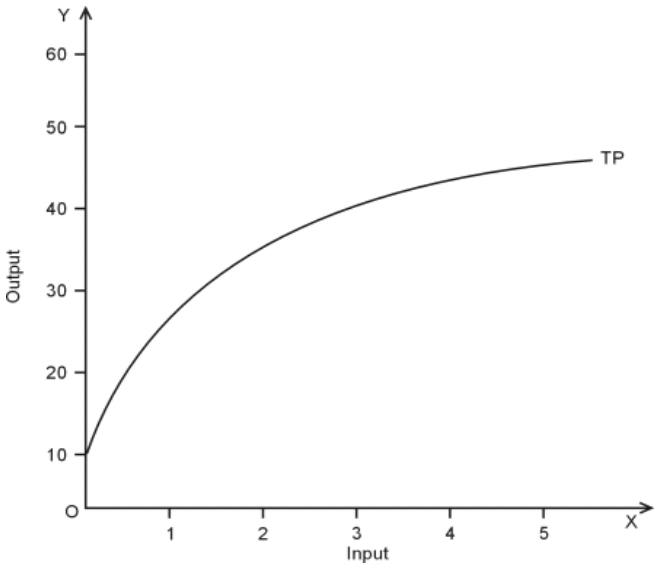

Figure 3.6: *Decreasing or Diminishing return*

The concept of decreasing or diminishing return boarders on a general principle or law known as law of variable proportion or diminishing marginal returns. Simply put the law of diminishing returns state that as successive quantities of a variable factor are applied to a fixed factor total output initially increases, remains constant and diminishes as more units of the variable factors are applied. Hence it can be alternatively be defined as; if the qualities of other resources are held constant, the increment to the total product first increase at an increasing rate, then increases at a decreasing rate, reaches a maximum and then decreases henceforth. The law of diminishing return can also be expressed in terms of Average Physical Product (APP) and Marginal Product (MPP). The average physical product is given by the total product divided by the input used at that point. This implies that;

$APP = {}^{TPP}/_{X}$

Where x = quantity of variable input used

The MPP is given by the change in output (▲TPP) divided by change in the input (▲x) i.e. MPP = (▲TPP)

(▲x)

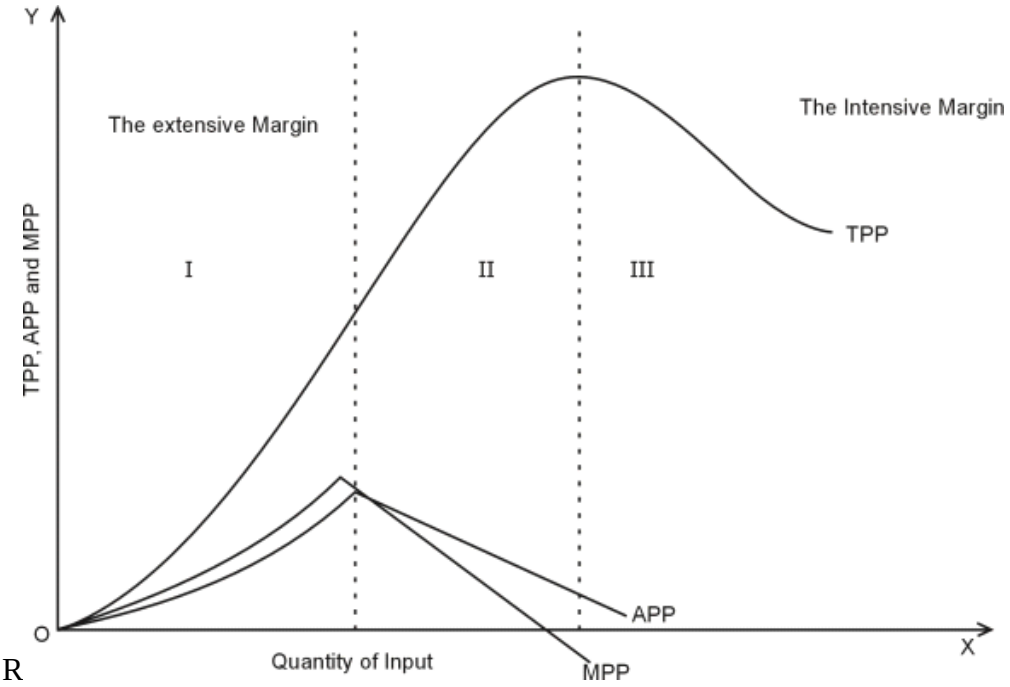

Figure 3.7: comprehensive production functions

Figure 3.7 is used to represent a comprehensive production function expressing the law of diminishing return in terms of APP, TPP and MPP.

Here it can be seen that as the successive equal amount of variable inputs are added to a set of fixed inputs, the MPP first increases at an increasing rate, reaches a peak and then decreases to zero. For APP as the successive equal units of the variable inputs are added to the fixed inputs, APP first increases, reaches a maximum where it is equal to MPP and then decreases.

The law of diminishing return is important in the following ways:

- Decision making process. The law of diminishing return is useful in decision-making as it shows the best combination of factor inputs that will yield maximum output.
- It is an important tool in resource allocation; hence it makes for efficiency in resource use.

3.6 Stages of Production

Three stages of production can be identified as shown in figure 3.7 above.

Stage I

This stage is characterized by increasing return to factor input. This is as a result of proportionate increase in total output arising from successive application of a unit of factor input. Total output increases in this portion due to the spreading effect of output on fixed cost. In this stage, as

indicated in figure 3.7, APP is increasing while MPP reaches a maximum and begins to drop indicating that TPP is increasing at an increasing rate and increases at a decreasing rate.

Stage II

In stage II, the TPP is increasing at a decreasing rate and reaches its peak while APP reaches a maximum and begins to decline thereafter with the employment of each additional unit of variable input. In this stage, MPP is decreasing faster than APP and reach zero. This is the best stage of production. This is called the ration stage of production.

Stage III

At this stage, additional unit of variable input (labour) to a fixed input (land) results to a decrease in total output. It is a stage of negative returns to factor input. It begins from where TPP is at maximum and MPP is negative. In this stage, TPP is decreasing; APP is decreasing while MPP is negative.

In stage I, the quantity of variable input is small in relation to fixed input hence the ratio of variable input to fixed input is small. In the same way, as long as MPP is greater than APP as in stage I, one would continue to add more of the variable input to the fixed input MPP does not equate APP and APP is at maximum at the beginning of stage II (extensive margin).

In stage III, the quantity of variable input is large compared to the fixed input hence the ratio of variable input to fixed is large and reaches a maximum at the beginning of stage III (intensive margin). As from the beginning of stage III, where the ratio of variable input to fixed input is maximum, the limiting factor is no more the variable input but one or more of the fixed inputs which might have been stretched beyond their limits. Additional variable input produces no yield advantage. MPP becomes negative and makes no economic sense; this implies that it is not technically efficient to keep adding more of the variable inputs in the intensive stage. Thus, stage II is the most technically efficient stage of production.

Quantitatively, three stage of production can be interpreted thus:

Stage I

- MP > AP
- MP is maximum at point of inflection
- MP = AP at boundary of stages I and II

Stage II

- MP < AP or AP > MP
- MP is falling
- AP is also falling
- MP is zero at boundary of stage II and III
- AP is positive

Stage III

- AP > MP
- AP > 0 i.e. Positive
- MP < 0 i.e. negative
- Both MP and AP are falling

3.7 Types of Production Function

Production functions are classified into based on time period. They are short run and long run production functions.

4.0 CONCLUSION

Agricultural production decisions are decisions taking in the allocation of agricultural scarce resources. These resources are scarce; hence choice has to be made in their allocation. Making this decision leads to knowing the various production function relationships.

5.0 SUMMARY

In this unit learnt that:

- Agriculture production is the process of transforming agricultural resources into a form that will give maximum satisfaction.
- Agricultural production decisions are decisions taking in the allocation of scarce resources.
- Factor-product relationship is essential in determining the intensity with which a given variable could be combined with other essential resources for the attainment of profit maximization objectives.
- Factor-factor relationship is important in attaining cost maximization objectives.
- Product-product relationship is particularly relevant to the problem of optimum enterprise combination that maximizes from income.

6.0 TUTOR-MARKED ASSIGNMENT

1. What do you understand by: (a) agricultural production (b) agricultural production decision and (c) Iso-curves.
2. State the properties of isoquants.
3. Briefly explain the following relationships.
   i. Factor-product relationship
   ii. Factor-factor relationship
   iii. Product-product relationship

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UNIT 3: AGRICULTURAL RESOURCE PRODUCTIVITY AND EFFICIENCY

CONTENTS

1.0 INTRODUCTION

In this unit, the student will be made to know the concept of agricultural resource productivity, the definition and meaning, types and importance of efficiency.

2.0 OBJECTIVES

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

- explain the concept of agricultural resource productivity
- define and explain the concept of efficiency
- know and explain the various type of efficiency
- importance of efficiency.

3.0 MAIN CONTENT

3.1 Concept of Agricultural Resource Productivity

Productivity in economics is often used in relation with resources (inputs) used to produce goods and services (output). The basic objective of any society is to achieve maximum productivity using a given amount of the scarce and available resource. Any increase in productivity of inputs (labour land and capital) in production process amounts progress in the economy.

Agricultural productivity may be defined as the index of the ratio of value of total product (output) to that of the value of total resources (inputs) employed in production process. Optimal agricultural resource productivity implies an efficient use of productive resources to attain a given amount of output. The concept of resources productivity analysis is important in agriculture as it:

1. serves as a measure of economic growth,
2. it is a parameter for adjustment of resource use,
3. provide the framework, for which formulation and evaluation of agricultural policies are made,
4. review problem areas that require further investigation.

Since optimal productivity implies efficient use of resources agricultural in this context is synonymous with production efficiency (using most efficient and best technology in reduction process). Attainment of economic growth as achieved when scarce resources are optimally used to the benefit of the society.

3.2 The Concept of Efficiency

The tem efficiency has a wide range of application. Efficiency (also called Pareto-optimality or Pareto efficiency) was named after Vilified Pareto (1848-1923). An economy is said to be pareto-optimal given all parameter if a change in policy that will make one person better of without making some worse off. Giving this condition it means that, production and exchange must be efficient. If otherwise, the need for reallocation of resources will arise. This is to ensure that scarce resources are utilised to produce a different combination of good or there could be reduction of goods among individuals that would improve at least one persons position without reducing the other person's utility.

Efficiency is simply concerned with the optimal production and distribution of scarce resources. It is the ratio of total useful output to total input. It is also defined as the minimization of waste of economic scarce resources in production for the attainment of optimally given level of output.

Efficiency can also be viewed as using optimal input combination to attain a given level of output (an input orientation) or attaining optimal output with a combination of a given set of inputs (an input orientation).

Under a given technology, say, output-output model is said to be efficient given that more of one product is combined with less of the other product.

Efficiency of production assumes that: marginal rate of transformation of goods A and B most be the same for all firms producing good A and B. This assumption can symbolically be written as:

(i) $MRT_{XYA} = MRT_{XYB}$

Where x and y represents two products

A and B are two firms producing both

(ii) Marginal rate of technical substitution for producing two goods must be the same in production of both. Notationally, this condition can be expressed as:

$(MRTSv_1v_2)_X = (MRTSv_1v_2)y$

Where v_1 and v_2 are the two elements of production

X and Y are the two products.

(iii) Marginal rate of transformation of that element into good must be the same for all firms producing these goods and using these elements. This condition can be represented mathematically as:

$(MRTv_1x)_A = (MRTv_1x)_B$

Where v_1 is the element of production
X is the product
A and B are the two firms.

Where this condition fail to exist, a transfer of some amount of v_1 from firm to the other could be necessary to increase the total output of one or both goods.

Graphically, the transformation curve (TC) or production possibility curve (PPC) as shown in figure 3.8 can be used to determine maximum efficiency

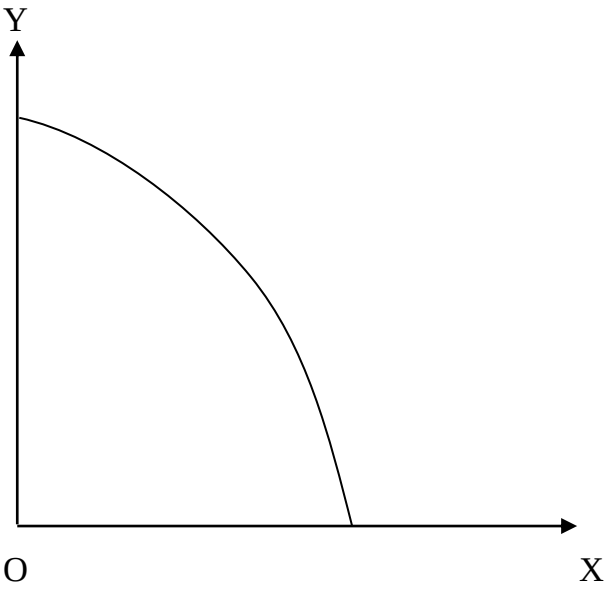

Figure 3.8: Production Possibility Curve (PPC)

Maximum efficiency is attained at any point on the PPC where allocation of economic resources satisfies the condition of $MRTS_ab^x = MRTS_ab^y$.

3.3 Types of Efficiency

There are different types of efficiency. Some of which include:

a. Technical Efficiency

Technical efficiency is the maximum combination of resources (inputs) in production process with a view to attaining a given level of output (an input orientation or obtaining optimal output using a combination of a given set of inputs (an input orientation). It is also maximization of inputs to produce a given amount of a good or service or maximizing output with a givens et of inputs.

If a firm in a firm produces maximum output with a given minimum amount of inputs (labour, capital and technology), the firm is said be technically efficient. If otherwise, the firm would be said to be technically inefficient. For example, a maize farmer would be technically inefficient if he employ too many workers than required. A cassava process or may also said to be technically inefficient if spend more resources (overutilization) and time in producing garri (bye-product) of cassava.

Similarly, a poultry farmer using outdated and upsolate capital, tools and technology is said to be technically inefficient technique implies obtaining maximum physical product

from a given set of resources, an inefficient technique implies that maximum output cannot be attained with a given set of limited resources (figure 3.9).

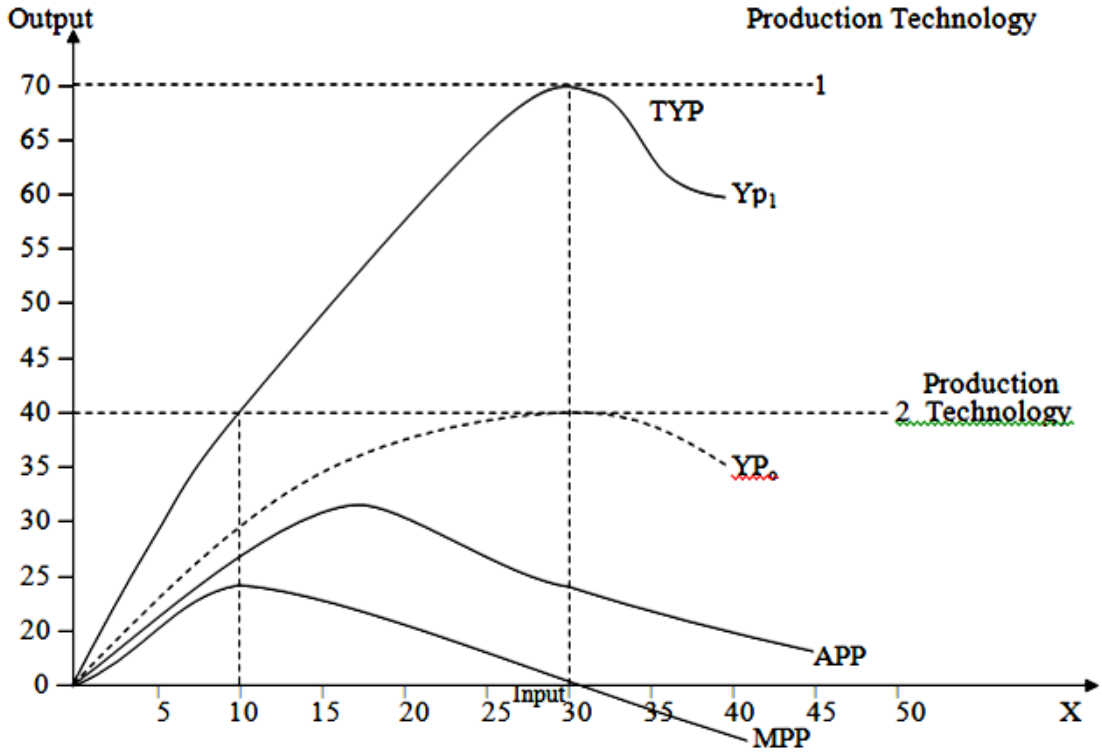

Figure 3.9: Technical Efficient and Technical Inefficient Production Technology (Production Frontier Function)

The graphs (Figure 3.9) represents a production frontier function for a combination of variable inputs for the production of a outputs using two production technologies Yp_1 in the graph represent on efficient production technology. At that point using production technology (1), 30 units of variable inputs was combined to obtain 70 units of output. On the other hand, using the same level of variable inputs (i.e. 30 units), only 40 units of output was obtained, employing production technology (2). To produce 40 units of output using production technology (1) will only require combination 10 units of variable inputs against technology (2) that will require a combination of 30 units of variable input. There production technology (1) is technically efficient while production technology (2) is said to be technically inefficient.

Efficient and inefficient production technology can be established if only and if two production technologies employ the use of the same quality, kind and form of input in production process. Otherwise, inefficiency may not exist. If for example in the production process, production technology (1) employed the use of modern (improve)

and intricate machinery and production technology (2) could not use such, production technology (2) therefore cannot be said to be technically inefficient. This because the cost of machinery for production technology (1) might be high enough to outweigh any increase in output of the variable factor.

The concept of technical efficiency is related to productive efficiency. Productive efficiency means producing at the lowest point on the short run average cost curse. Hence productive efficiency requires technical efficiency.

The concept of technical efficiency is also related to x-inefficiency. X-inefficiency occurs when a firm is technically inefficient (i.e fails to be technical inefficient). Example is a monopoly using inefficient production techniques as a result of no incentives to cut costs.

Technical efficiency is a necessary condition for allocative efficiency to be attained. Nevertheless, allocative efficiency also requires optimal allocation of resources.

3.3.1 Conditions for Attainment of Maximum Efficiency

(i) Marginal rate of transformation of input in to product must be the same for all firms producing the same product using the same factor inputs.
(ii) Marginal rate of technical substitution for producing two goods must be the same in production of both.
(iii) Marginal rate of transformation of elements into goods must be the same for producing this goods and using the same element.
(iv) Marginal rate of substitution between two factors must be the same for every product is which they are used.
(v) Marginal rate at which two crops substitute as product on one farm must be equal is the marginal rate at which they substitute as inputs on another.
(vi) Marginal rate of substitution must be equal between income and direct utility of input employed in production, income and direct utility of an input employed in consumption for any one input owner and between input owners.
(vii) Marginal rate of substitution of outputs in time or inputs in time must be equal for all farms to produce or use both.
(viii) Prince ratio must equate transformation and substitution rate in all cases.

3.3.2 Causes of inefficiency

(i) Inadequate knowledge available alternative production technology and input organisation.
(ii) Constraints arising from risk uncertainty and inadequate resources with net product of labour with respect to capital.

(iii) The believe that inputs returns in primary or extractive industries as in case agriculture, always put pressure on those of the secondary industries such as manufacturing industries.
(iv) Institutions (like government terms) acting as basis for judgement may bring about inefficiency.
(v) Low income nature of farm families, mature of rural life and household nature may bring about inefficiency.
(vi) Labour supply function in agriculture in respect to non-agricultural sector and the level of investment in human capital.
(vii) Degree of market competition.
(viii) Structure of costs and returns society arising from regional differences resource productivity.

3.3.3 Ways of Minimizing Inefficiency in Production

(i) Minimizing risk and uncertainty enterprise.
(ii) Enlightenment campaign with a view to increasing production and adoption of modern and improved production technologies.
(iii) Provision of credit facilities to enhance capital acquisition with a consequent increase in farm size.
(iv) Provision of employment output.
(v) Steps that will reduce and or eliminate differences in costs and returns for individual and community should be introduced.
(vi) Proper integration on primary and secondary production sectors into agribusiness framework and also encouraging corporate and part-time farming.

(b) Productive Efficiency

Productive efficiency is said to occur when a given set of inputs are used to produce maximum amount of goods and services. This will occur on the production possibility curve (PPC). From the curve it will be seen that it will not be possible to produce more of a particular goof without producing less of another good. Productive efficiency of a firm will occur at the lowest points on the firm's average cost curve.

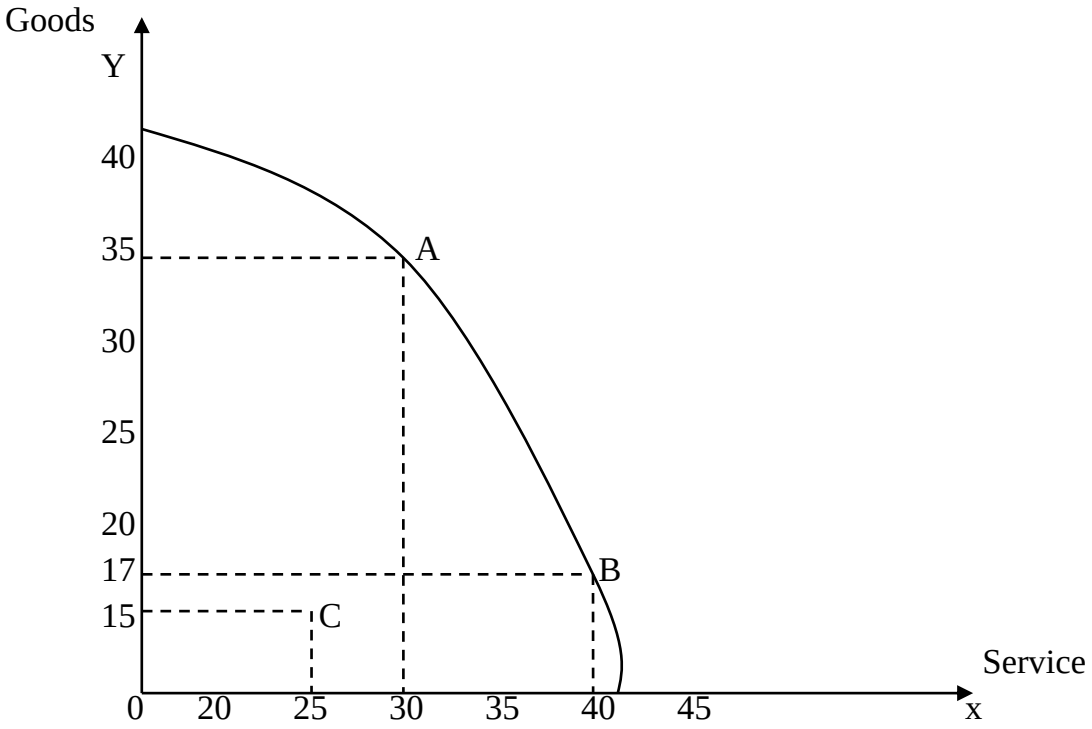

Figure 3.9.0: Productive Efficiency, PPC

From the PPC graph points A and B are said to be productively efficient while point C is said to productively inefficient. This is because more goods or services could be produced without any opportunity cost.

At point AC_1 and Q_1, the firm is producing at lowest cost curve where MC meets average cost (figure 3.9.1).

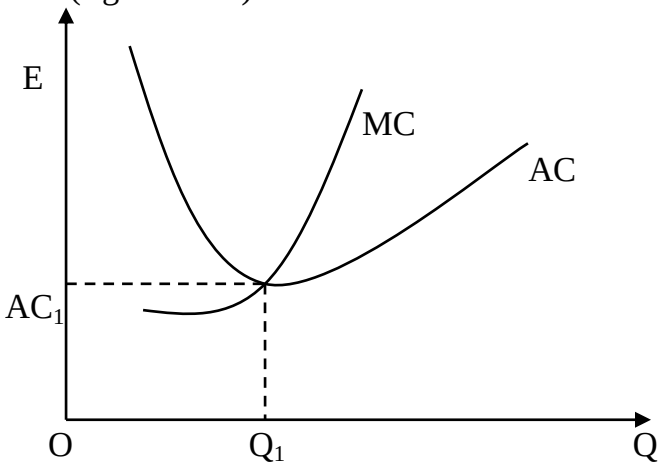

Figure 3.9.1: AC, MC cost curve for Productive Efficiency.

Productive efficiency is closely related with technical efficiency. Technical efficiency is concerned with optimal combination of a given amount of resources (labour and capital)

to produce maximum amount of output. In this regard, it is not possible to produce more of a good without more input.

When output is produced at minimum average cost, it implies that:

- Least costly resources are used,
- The use of most efficient and least technology in production process,
- There is economics of scale (i.e close to minimum efficient scale),
- Wastes of resource are minimized in production of goods and services.

(c) Allocative Efficiency

Allocative efficiency is said to occur when there is maximum distribution of resources. An economy may be rich and may be productively efficient but have poor allocative efficiency. For example, if 90% of the country's GDP is devoted to health, the country could be productively efficient. However, this would be a very imbalanced economy. For economy to be allocatively efficient, available resources must be distributed in line with consumer preferences. Otherwise, the economy would be said to be productively efficient and allocatively inefficient.

Precisely, allocative efficiency occurs at a point where the level of output is equal to the marginal cost of production. At that point, the marginal utility (of a consumer) derived from the consumption of a particular good and service is equal to the price the consumer is willing to pay for the particular good and service. Thus, maximum distribution is achieved when marginal utility is equal to marginal cost of production as shown in figure 3.9.2.

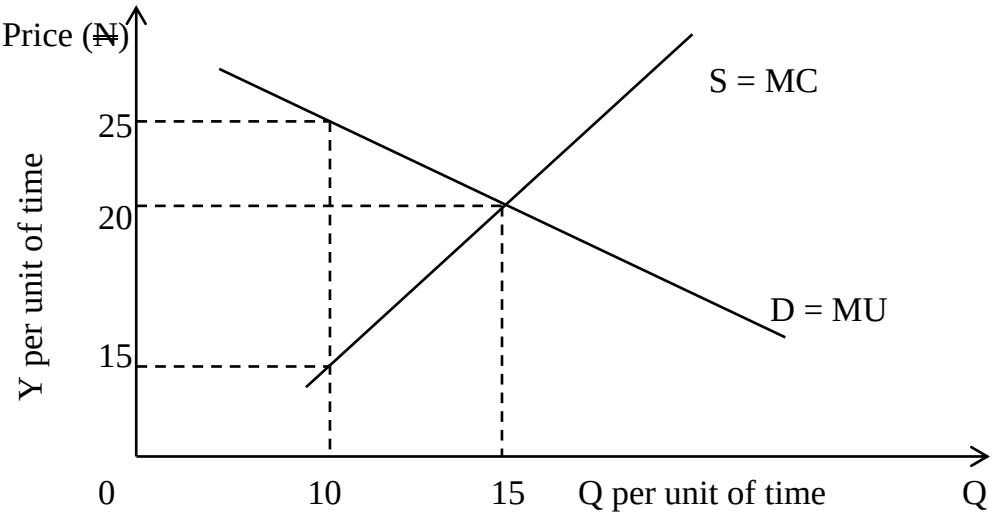

Figure 3.9.2.Equilibrium price and quantity determination

From the graph (figure3.9.2), at a marginal cost of ₦25, consumers were only willing to purchase the good (output) for 10 unit of time. At this point, it is allocatively inefficient.

This is because the utility derived by (10 unit of time) is less than the cost of production. Thus, the cost is greater than the utility derived. So it is inefficient.

Assuming the marginal cost of production was ₦10, and price ₦25, than price (MU) will be greater than MC-implying under- consumption. On the other hand, if output increased and there is a fall in price, then the society will gain from enjoying more of the good. Allocative efficiency (figure3.9.2.) is said to occur at a point where price (₦20) and output (15 unit).

(i) Perfect Competition – Allocatively Efficient

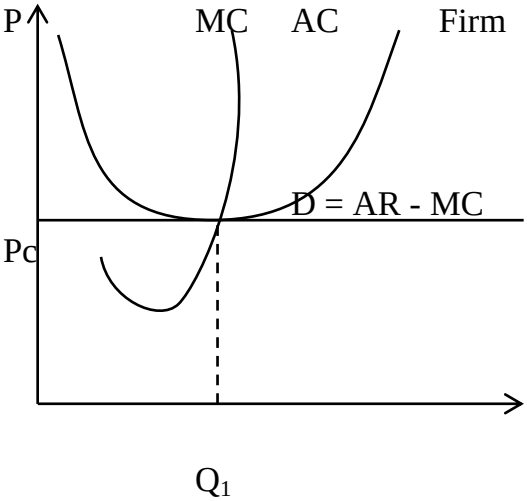

Figure 3.9.3: AC, MC Cost Curve

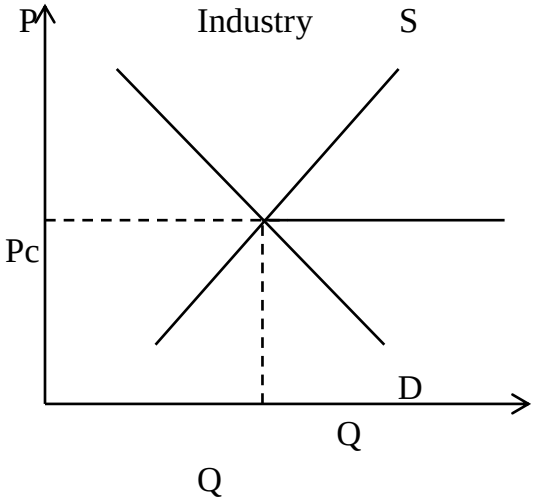

Figure 3.9.4: Equilibrium Price and quantity determination

Firms in perfect competition are said is be allocative efficient at a point Q_1,P=MC

(ii) Monopolies – Allocatively Inefficient.

Monopolies are allcatively in efficient. They can afford to increase price above the marginal cost of production and become allcativelyin efficient. This is because they have the market power and increase prise to reduce consumer surplus.

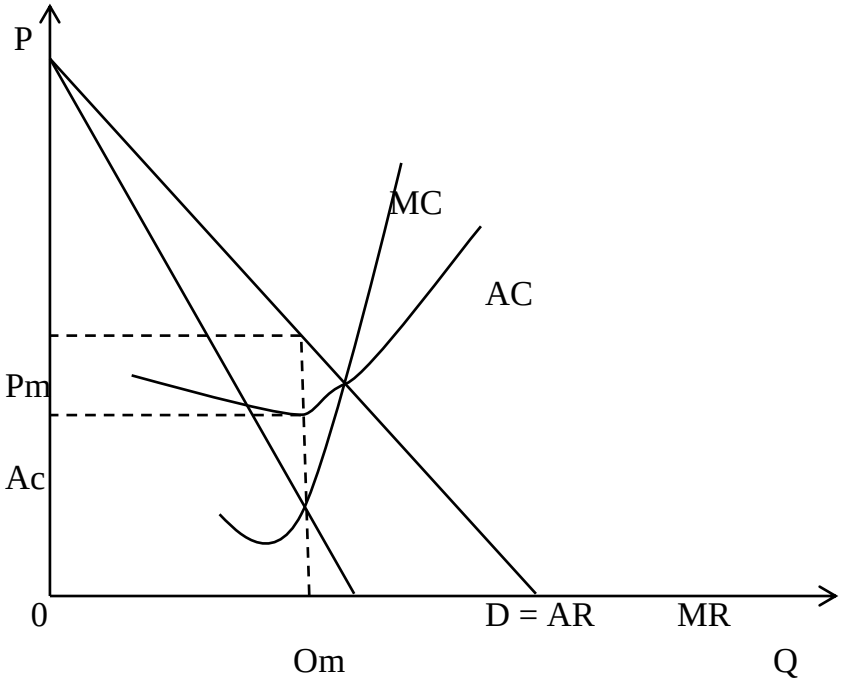

Figure 3.9.4: AC, MC cost curve (Efficiency Determination).

At price PM, it is allocatively inefficient. The reason is that price is greater than the marginal cost (MC). Allocative efficiency will occur at the point where MC cuts the demand curve i.e. where the price of good is equal to marginal cost of production [P=MC].

When allocative efficiency occurs, it implies that:

- Price the consumer is willing to pay is equal to the marginal cost of production.
- Resources are allocated to the production of goods and services that are of great importance as valued most in the society or economy.

(d) Pareto Efficiency

Pareto efficiency occurs when it is not possible min an economy to make one party better off without another party worse off. A Pareto improvement is said to occur in a society, it at least one person is better off without any other individual being worse off.

Pareto efficiency will occur on a production possibility curve. If an economy is operating on a simple production possibility frontier (e.g at point A), increasing the output of goods may not be possible without reducing output of services.

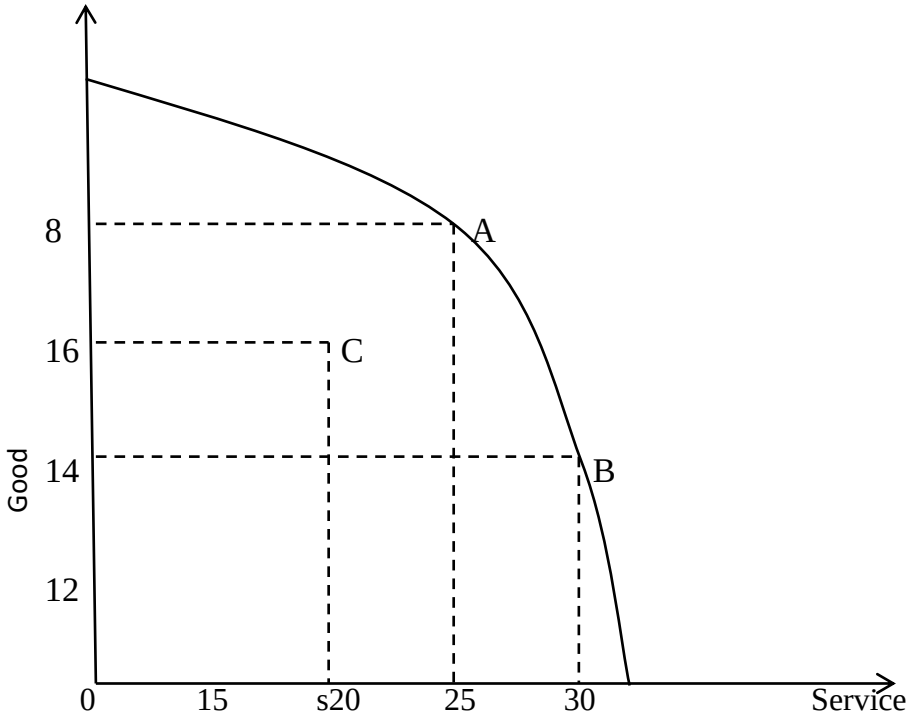

Figure 3.9.5: Production possibility Curve-Pareto efficiency Determination

At point C (16 goods and 20 services) increasing either goods or services may not necessarily lead to a decline in the output of the other. Point therefore is regarded as Pareto inefficient and such is not considered good for the economy.

Pareto efficiency is a concept that is closely related to the concept of productive efficiency. It is also conserved with allocative efficiency. To be Pareto efficient, resource distribution must be at point where it is not possible to make someone better-off without making some one worse-off. Example of Pareto efficiency can be drawn from the construction of airport. Constructing an airport is important in an economy as could lead to a higher increase in social benefit with a lower cost. This implies a net gain to the society. It is a worse-off to people living around the airport due to noise pollution and other impacts on the environment.

This situation or case not considered Pareto-improvement. If the people living around the airport are compensated in any form, it will be considered as Pareto improvement. Similarly, if the extraction of oil leads to a greater social benefits that thn the social cost, it will be considered as Pareto efficient since there is a net gain to the economy or society. However, people living around area of oil extraction and production are likely to be worse-off as they are likely to suffer the hazardous effects of environmental pollution, degradation and climatic change resulting from oil spillage and gas flaring. To achieve

Pareto improvement in this situation, the communities around need to be compensated. In practice, compensating losers from a particular project is often very difficult and with a high fractional costs.

(e) Pareto Efficiency and Equity

An outcome may be seen as a Pareto improvement, there could still be inequality after a pareto improvement. A society may have pareto efficiency with large degrees of inequality. Assuming 3kg of groundnut is shared among three people, it is most equitable to divide it into three parts. Assuming it was divided into half and shared and shared among two people, it would be seen as pareto efficient as the third person did not lose out (even though he did not share in the groundnut).

In taking decision, it is important to take into consideration more factors like social efficiency, total welfare, and issues like diminishing marginal utility of money.

(f) Social Efficiency

Social is achieved when externalities are considered. It occurs at an output point where social marginal cost (i.e social cost of production benefit) is equal to social marginal benefit (i.e social benefit). It is important to know that:

- Social benefit equals private benefit plus external benefit.
- Social cost equals private cost plus external cost

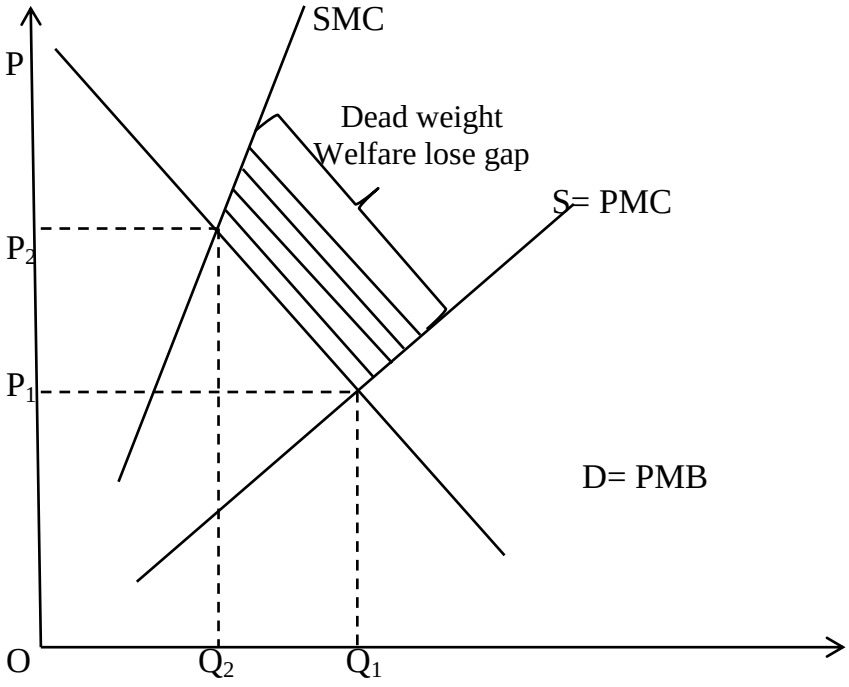

Figure 3.9.6: Graphical Representation of Social Efficiency

Social efficiency is achieved where the marginal social benefit (MSB) equates marginal social (MSC). In a free market condition, consumers tend to ignore the external cost of consumption (e.g harvesting fish with dynamite) without considering the effects on the people and environment. Thus, the free market equilibrium is attained at Q_1 (i.e where supply equates demand). At point Q_1, however, MSC is greater than MSB. Therefore, consuming at this point implies that the cost to the society is greater than the derivable benefits. Example consider pollution and toxicity effects in the river as source of water supply and toxicities on micro aquatic organisms and the environment resulting from the use of toxic substances.

At this point, it can be said that there is deadweight welfare lose - indicated in the graph. In a situation where output is less than equilibrium, than the MSB will be greater than MSC. Increasing output implies that addition to the social welfare (MSB) will be greater than the cost of an extra unit, hence net social welfare increases. The implication of social efficiency is that it considers externalities (positive or negative). Although it is often very difficult to measure externalities, efforts need to be made.

Attaining social efficiency implies:

- Maximization of social welfare.
- Social marginal benefit of production/consumption equates social marginal cost.
- Markets for social welfare to occur, markets need to take into consideration market externalities.

(g) Efficiency of Scale

This is the situation when firms tend to produce on the lowest point of its long run average cost and derive the full benefits of economies of scale.

(h) Dynamic Efficiency

This is concerned with the introduction of new technology and techniques to reduce costs over time. For example a rice farmer in 1910 would be very efficient at that time frame but by comparison would now be inefficient. Thus, dynamic efficiency occurs in a market over a given time period. It relates to changes in the amount of consumers choice available in the markets in line with the quality of the available quantity of goods a services.

Dynamic efficiency can be boosted by:

- Research and development, spending and faster pace of innovation and invention

- Investment in human capital development of labour force with a consequent increase in product quality.
- Greater market competition with technological and knowledge transfer across countries.

(i) Distributive Efficiency

Distributive efficiency occurs when goods and services are utilized by consumers that have great desire for such goods are services. Distributive efficiency is therefore concerned with an even distribution of limited resources as it relates to the law of diminishing utility which states less marginal utility is derived as the consumption of particular good increases.

For example, if an individual already has 20ha of land and get an additional 5ha, the additional 5ha can only increase his net utility by a little amount. On the other hand, if a low income individual is able to acquired 2ha of land, the marginal utility will be higher.

A society is therefore said to be distributively efficient when there is equitable distribution of resources. A monopoly condition may lead to distributive inefficiency. This is so because the monopolist is able to use its market strategies and power to set high prices. Thus a monopoly can gain a higher share of the GDP while consumers are faced with higher prices with a decline in consumer surplus.

(j) X – Inefficiency

X – Inefficiency occurs when forms do not have the required incentives to cut down costs. A monopoly for example may make supernormal profits but may have little incentives to get rid of the surplus labour. Examples of x-inefficiency may be seen a state and local government institutional firm where workers that are necessarily not productive are employed. This results to too many people doing very dew work with a consequent loss in man-hours.

A state owned firm may be more concerned about the political implications of making workers redundant than getting rid of surplus workers. X-inefficiency implies:

- Business uses unnecessarily more inputs for the production of a given level of output.
- Potential cost inefficiency resulting from lack of effective competition within a market e.g companies that face little or no competition often allow their fixed cost of production to raise.

X-inefficiency could be cause by

- Monopoly power: Monopolists face little or no competition. This is why it is possible for the monopolist to attain super moral profits. Since there is no competitive pressure, the monopolist may not try hard to cut costs.
- State control: Government owned firm may have little or no incentives to make profit. Hence little or no incentives to control costs.

3.4 Technical Efficiency versus Economic Efficiency

- Technical Efficiency is said to occur when it is not possible of increasing output without increasing input.
- Economic Efficiency occurs when cost of production of a given output is al low as possible.
- Technical Efficiency is said to be a condition for economic efficiency. To achieve economic efficiency, technical efficiency must have been achieved.
- An economic efficiency is a state of minimizing inefficiency and waste using the available resources.
- Once economic efficiency is attained, a change to assist any individual will make another individual worse-off.
- Economic efficiency is a factor of prices in relation to factors of production
- Technical Efficiency is considered as an engineering issues.

3.5 Distributive Efficiency versus Economic Efficiency

- It is often very difficult to ensure an equitable distribution of resources (especially in developing countries) as this may cause discentives. For example people of very high income may see very high rate of marginal tax and may tend to stop working or choose to work in another country. The society may therefore achieve less output.
- There is a trade-off between increasing equity and cause discentives to work and take risk.
- It is generally assumed that a free market requires a degree of inequality to enhance some incentives for entrepreneurship.

3.6 Importance of Efficiency in Agricultural Production

- Efficiency is a means by which farm success and performance are measured and productive units are evaluated.

- In periods of financial strees, efficiency study is on important tool as most efficient farms are likely to generating more income. Such farms have more chances of surviving and prospering.
- Efficiency analysis could be used to determine cost effectiveness of different poverty-linked programmes of government.
- It is a determining factor for the survival of small holder farms.
- Efficiency analysis is an important determinant of input – output relationship.
- It is employed in determining farm progress.
- Efficiency analysis is useful in measuring attributes of farms operating close to the production possibility frontier and those operating faraway.
- The ability to quantify efficiency provides the farmer the check and balances to maintain the performance of the product system.

By measuring efficiency and separating its effects from the effects of production, environment, hypothesis with respect to efficiency differentials can then be explored.

4.0 CONCLUSION

In this unit, we have learnt the concept of agricultural resource productivity, efficiency and types of efficiency. We have been able to distinguish between technical efficiency and economic efficiency as well as distributive efficiency versus economic efficiency and the importance of efficiency in agricultural production.

5.0 SUMMARY

- Agricultural productivity is the index of ratio of the total value of total output to the index of the total value of inputs used in production.
- Efficiency is the ratio of the total useful output to total input. It is the maximization of waste of economic scarce resources in production is attain optimal given level of output.
- There different types of efficiency. Some of these include, technical efficiency, pareto – efficiency, distributive efficiency and productive efficiency. Others include: allocative efficiency, social, dynamic and efficiency of scale.

6.0 TUTOR-MARKED ASSIGNMENT

i. Given X units of inputs with a Y unit of output with equal amount of technology in maize production, what are the conditions that will enhance maximum production efficiency of the maize farmer?

ii. How can maximum efficiency be determined graphically?

iii. Differentiate between technical efficiency and economic efficiency.

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MODULE 4: LAND, WATER AND FOREST RESOURCE MANAGEMENT FOR SUSTANABLE AGRICULTURAL PRODUCTION

Unit 1 Land Resources and sustainable Management
Unit 2 Forest Resources
Unit 3 Water Resources
Unit 4 Conservation and Management of Natural Resources

Unit 1: LAND RESOURCE AND SUSTAINABILITY

1.0 Introduction
2.0 Objective
3.0 Main content
- 3.1 Meaning and characteristics of land
- 3.2 Agricultural land policy objectives and strategies
- 3.3 Land use decree and the implication
- 3.4 Uses of land and factor affecting land availability use
- 3.5 Importance of land use decree
- 3.6 Demand and supply of land

4.0 Conclusion
5.0 Summary
6.0 Tutor- marked assignment
7.0 References

1.0 INTRODUCTION

In this unit, the student will be made to understand the meaning of characteristics of land agricultural land policy objectives and strategies, land use degree and the implication. The student, after reading this unit is expected to understand familiar and be with the following: uses of land and factor affecting land availability and use, importance of land use decree, demand and supply of land sustainable land management practices.

2.0 OBJECTIVE

In this unit, the student is expected to know

2.1 Meaning and characteristic of land
2.2 Agricultural land policy objective and strategies
2.3 Land use decree and the implication
2.4 Uses of land and factors affecting land availability and uses
2.5 Importance of land use decree
2.6 Demand and supply of land
2.7 Sustainable land management practices

3.0 MAIN CONTENT

3.1 Meaning and characteristic of land

Land is an important natural resource for both primary production and secondary production. It is a free gift of nature that includes all renewable and non renewable resources available on the earth surface and under the earth. Land resource when effectively and efficiently combined with other inputs will lead to a greater output. Characteristics of land as a production factor include:

- Land is not manmade. It is a free gift of nature. Man simply found them around him and started using them
- Agricultural land is subject to the diminishing returns.
- Land is not mobile. It is geographically fixed. This Implies land cannot be move from one place to another. Example oil deposited discovered in okapi, Ndokwa East local Government Area, Delta State cannot in any form be moved to any part of Katina state. Similar mineral deposits discovered in any part of Katina state cannot be moved to any part of delta state therefore land is location fixed.
- Rent is the reward for land
- Land resource is unique or homogenous in nature. This implies that the characteristic features of land are not the same everywhere. For example, the nutrient component of a soil may vary from one place to another. Species of plant and animals in a forest land in Edo state Nigeria or Ondo state may not be the same with their in cross river state or Benue state
- Demand for land of derived demand

3.2 Agricultural land policy objectives and strategies

Agricultural land policy objectives include:

- Ensure a land tenure system that is nationally accepted with access to use for productive and profitable purposes without any necessary fragmentation.
- Ensure that lands are used for the purpose to which they are allocated and protect bad land resources against further damages or degradations.
- Promote the conservation land so as to improve the potential of land resources for sustainable productivity.
- Achieve a sufficient level of enlightenment of the masses on land issues so as to ensure that objectives of land policies are achieved and hence appreciated by the general public.

The above objectives can be achieved by a adopting the following strategies:

a. Land acquisition processes to be controlled by government (as to where the land is located) such that small holder farmer may not be worse off while the commercial or large scale farmer are better off. In such a way, acquiring and existing farm land alternative purpose demand that the government pay compensation for the improvement on the land including the economic trees and valuable assets and agricultural activities on the land. It is the government should

also provide alternative farmlands to the displaced famers to ensure a continuous source of livelihood and income generation

b. A reform of existing land tenure use decree (act) is a necessary vehicle to ensure the control use and management of land in each state of the federation.
c. Government should carryout mass enlightenment campaign to ensure free flow information and to educate the masses a greater extent on the land use degree act land use policies and objectives as well as sustainable land management practices
d. The government should have a bench-mark and also harmonize compensations for economic crops and valuable assets on land to be acquired or acquired land including cost of land cultivation.

3.3 Land use decree and the implication

The land use decree was prorogated in March 29 1978 and became the land use act of as provided in constitution of the federal republic of Nigeria. The land use act as provided in federal ministry of justice land use act chapter 202, part ii section ii(power of governor or public officer to enter and inspect land and improvement) "the governor or public officer duty authorized by the governor in that behalf shall have the power to enter upon and inspect the land comprised in any statutory right of occupancy or any improvement affected thereon at any reasonable hour in the day time and the occupier shall permit and give free access to the governor or such officer to enter and inspect" the land use act came into being as a result of the demand associated with land ownership patterns in Nigeria precisely, the law state that:

- All land in the country is vested in the federal government to be hold in trust for the people. This means that the acquisition and use of land for whatever purpose, are to be controlled by the federal government of Nigeria
- It empowers each state to act on behalf of the federal government in any issue relating to land in their state.
- To be legally recognized as rightful owner of any piece land the person must have appealed to the government and approval is given thereafter, certificate of occupancy on the acquired land will be issued
- Every Nigerian is qualified to acquire land for use having attained 21 year of age
- It is aimed essentially, to encourage proper, efficient and productive use of land

The implication of the land use act

- Any individual that requires land and has the capacity to develop and make maximum use or is assured of it this means that enough land will be available for both primary and secondary production the decree does not dispose any individual of his/her legally acquired land that is optimally utilized.
- The decree tends to prevent hooding and speculation of land among individual especially in developed and developing areas and among the few wealth individuals the decree ensure

their individual above 21 year of age can apply for certificate of occupancy. It only restrict individual that are below the age of 21 years.

- The land use decree has some negative implication among which include: Bureaucratic and administrative processes involved often make it so difficult to acquire land from the government.
- It may give room for some wealthy and influential individual to acquire land in the expense of the less privileged individual (making the poor worse off and the rich better off),
- When there is competing and conflicting public interest, government can revoke acquired land (ownership),
- The consent of the government is required in mortgage of right of land,
- Politically place individuals and their associates tend to canners and abuse the act,
- There is land insecurity as it relates to land ownership in heritance. This is so because the titled deed to land is certificate of occupancy.

3.4 Uses of land and factors affecting land availability and uses

Uses of land can be classified into two broad heading: (a) agricultural and (b) non- agricultural use

Agricultural uses of land

The agricultural uses of land include but not limited to the following:

- Crop production
- Animal production
- Pasture and grazing
- Zoological and botanical gardens
- Forestry wild life conservation and fishery

Non - Agricultural uses of land

- Road construction, transportation and communication.
- Social service such as houses, schools, churches, hospitals and mosques.
- Construction of stadium, civil centers and parks.
- Building of business offices.
- Construction of airports and railway lines.
- Building of markets hotels, industries and other secondary production activitie**s.**

Factors affecting land availability and use

- Land tenure system
- Population pressure
- Industrial development
- Urbanization
- Topography
- Culture and trading

- Conflict over land

3.5 Importance of land use decree

The importance of land use decree includes:

- It enhances agricultural and real estate development
- It is a vehicle for commercial agricultural production
- The act tends to promote land availability
- Only qualified individuals can acquire land
- Bank loan can be obtained with the acquired certificate of occupancy as collateral
- Land use act makes it possible for individuals to acquire land anywhere in the country.

3.6 Demand and Supply of land

The demand for land means the demand by an individual farmer, industry or by the economy as a whole. The term demand for is used to show the functional relationship between the marginal willingness of individuals to pay for land and the land purchased. Demand for land therefore is the marginal willingness of an individual to pay for land at an ongoing price.

Aggregate demand of land on the other hand is the summation of individual farmer, and industry demand for land. The demand for land depends on the marginal revenue productivity [MRP]. This is indicated as

$$MRP = \frac{\blacktriangle \text{in input}}{\blacktriangle \text{in output}}$$

The demand for land is derived demand. Farmers will pay rent equal to the MRP of land which falls as more land is used due to the law of diminishing return or variable proportion.

The demand for land is negatively sloped or slopes downwards. This implies that all things being equal, land will only be used by farmers as low rent is paid. The demand curve of land for industry is the summation of the demand curve of firms. The summation of the demand curve of land for the industries is the society demand curve.

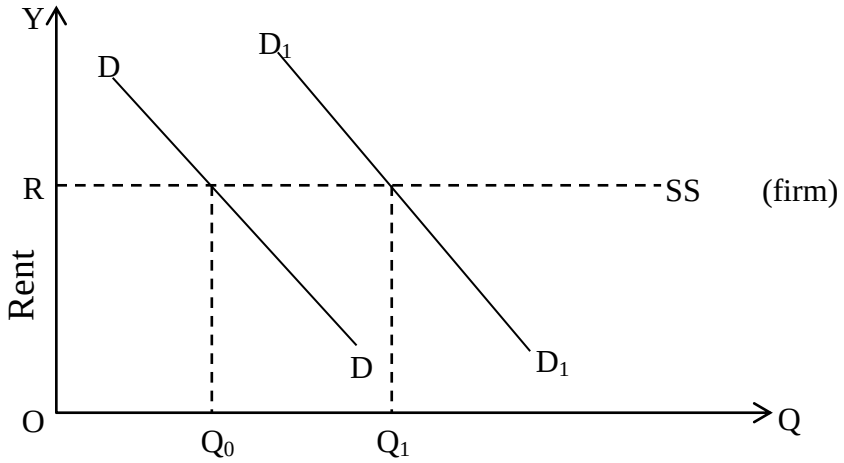

Figure 3.9.7: Equilibrium Demand curve for land.

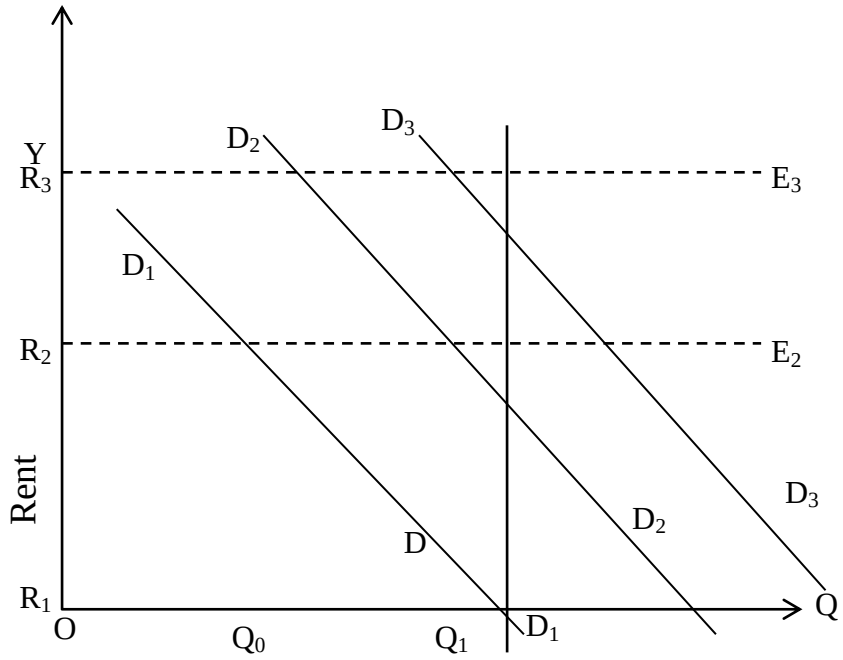

Figure 3.9.8: Shift in Demand for land.

Here we assume a condition of perfect competition. At demand D, land is assumed to be rent free. As production increases to D2 or D3, rent increases from zero to R1 or R2 as determined by the interaction of demand and supply. Since the quantity of land is fixed, it implies that only the price [rent] is determined. This is known as pure scarcity rent.
In the supply side for firm, the supply curve is horizontal to the x-axis [perfectly elastic] for rent is fixed by the industry. By paying the current rent, the farmer can farm as much land as he desires.

Agricultural industries growing the same crop, the supply of land is perfectly elastic and the shape of the supply is the usual one. The implication of this is that by fixing [offering] higher land can be withdrawn from other uses, hence the supply of land is perfectly elastic meaning whatever the rent is ie low, high, zero, the supply remains unchanged.

4.0 CONCLUSION

In this unit, you have learnt the meaning of demand for land, characteristics of land, agricultural land, agricultural land policy, objectives and strategies, use of land, factors affecting land availability and use. You have also learnt about the importance of land use decree. You have also learnt the from the land use decree that government is the custodian of any land and the need to obtain a certificate of occupancy for any acquired land.

5.0 SUMMARY

We have learnt in this unit that:

- Land is a free gift of nature and it includes all renewable and no renewable resources available on the earth and beneath the earth.
- When land is effectively and efficiently combined with other productive resources, optimum output will be attained.
- Agricultural land is subject to diminishing return, it is fixed, demand for land is rent, and land resource is homogenous.
- Agricultural land policy is to assure a nationally accepted land tenure system with access to use for productive and profitable purpose without any fragmentation.
- Ensure that land is used for the purpose it is meant for and to promote conservation of land in other to achieve sustainable productivity.
- To achieve agricultural land policy and strategies that land acquisition process should be controlled by the government. Are form of the existing land tenure use decree is a vehicle to ensure the control, use and management of land in each state of the federation.
- Land could be used for agricultural and non-agricultural purpose.
- The marginal willingness of individual to pay for land is the demand for land.

6.0 TUTOR-MARKED ASSIGNMENT

1a. What is demand for land?

b. Outline the factors that affect the availability of land for use.

2. Your friend Musa, a student department of English does not know what land is. As a 500 level student of environmental economics, explain to Musa the meaning and characteristics of land.

3. What are the consequences of the land use act?

4. Outline the uses of land.

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UNIT 2: FOREST RESOURCES

1.0 INTRODUCTION

In unit 1, you read about land resources, the characteristics of land, agricultural land policy objectives and strategies. You also learnt that land is a free gift of nature that was provided by God and that Land is not limited to the top soil and the earth crust but also include; mineral deposits, forest, water, among others. Unit 2 will be devoted to discussing forest as a resource, contributions of forest in economic development, deforestation and the consequences of deforestation and the constraints to forest development.

2.0 OBJECTIVES

By the end of the unit, you should e able to:

- define forest
- explain the role of forest in economic development,
- know the meaning of deforestation and the consequences of deforest
- ascertain the constraints to forest development

3.0 MAIN CONTENT

3.1 Meaning of Forest

In most developing countries, it is easy to find large areas of uncultivated land that are covered with naturally or artificially developed trees. This provide for a complex interaction in the environment between climates, soils, and rocks, water, animals (including insects, fungi, earthworms and so on) and plants as the defining elements of natural forest.

Simply put, forest is a complex eco system that is made up of trees that boost the earth and give support to different life forms. The trees not only provide shade, they provide special environment that affect the kind of plants and animals that are found in forest. The trees in the forest act as wind break and help to prevent erosion by wind. Plants in the forest also provide a protective canopy that lessens effect of rain drops on the soil and reduce soil erosion. The leaves fall, form layers on the soil and prevent water runoff. This allows the water to percolate in the soil. The roots help to hold the soil together. The dried leaves, plants and animals decompose to

form humus, organic matter that holds water and provides nutrients to the soil. Animals live in the forests. Birds build their nests on trees and branches of trees. Other animals such as giant rats, earthworms, crickets, insects and other organisms that burrow into the soil live in the forest. Some animals live in burrow of trees. These interact in different ways in the environment.

The burrowing effect of micro and macro animals help to turn the soil, allow water percolation and penetration of air into the soil. Environmental interaction in the forest leads to production of large quantities of oxygen and take in of carbon (iv) oxide. Thus purifying the air. Transpiration from forests affects the relative humidity and precipitation in a place. There is a continuous movement of water (water cycle). In Nigeria, different forms of forest could be found in parts of Oyo, Edo, Delta, Ogun, Ondo and Rivers States. Others include: Lagos, Bayelsa, Cross River and Akwa Ibom States.

Forest could either be developed naturally or artificially. Natural forests are forests that are majorly made up of indigenous trees not deliberately planted or established. Artificial forest is forest stands established by planting or seeding or both, or afforestation or reforestation with the desire of driving the benefits associated with forest. Artificial established forest could also be called plantation forests. Types of forest include:

i. **Mangrove (salt water) Swamp forest:** Majorly found in parts of Edo, Delta, Bayelsa, Rivers, Cross River and Akwa Ibom States. The characteristic features of mangrove swamp forest are the presences of the red mangrove plant *(Rhizophora racemosa)*. The plants are adapted to the environment by developing prop roots and breathing roots. Other examples of trees found in mangrove swamp forest include coconuts and reeds that are found in sand beaches along seashores. Animals found include tilapia, angel-fish, blody clam (Arca), Oysters, barnacles, mangrove crabs, lagoon crab, hermit crab, mudskipper fish, mosquitoes and birds.

ii. **Fresh Water Swamp Forest:** This is characterized by shrubs and climbing plants that form chumps of thick bush. Plants found include water lettuce, lemna and Salvina. Others are raffia palm, sword grass, ferns and trees such as *alstonia* and *spondiiathus*.

iii. **Tropical Rain Forest:** In Nigeria, tropical rain forest is found in major parts of Oyo, Edo, Delta, Ogun, Ondo and Rivers States. Examples of trees found include: mahogany, African walnut, African cedar, iron wood, opepe, iroko and among others. Animals include: monkeys, squirrels, lizards, antelopes, birds, frogs and insects.

3.2 Role of forest in economic development

Forest is important in economic development of a nation. The importance of forest includes:

a. **Energy Supply:** Most rural households depend on forest for energy supply. Woods produced in the forests serve as a source of fuel (firewood) for cooking as well as processing of some food items. The use of charcoal as a source of fuel is gaining ground

even in urban areas. Some of the forest woods are converted into charcoal and used for cooking and for providing heat: at home and poultry houses.

b. Raw materials for industries: Various species of forest plants, animals and bye products serve as raw materials for industries. Most of the World's paper is used as packaging materials, in communications and scores of other uses. There is no really satisfactory substitute paper as it concerns it uses. Forest provides soft fibers and hard fibers that are used to make rope and fabrics. For example, jute (soft fiber) is produced from the stems of the plant. Fabrics for various applications are produced from the leaves of hemp and sisal (hard fiber). Coir, another form of fiber, derived from the fruit of coconut is used to make rope. Timber derived from the forest is used by timber-based industries such as plywood; saw milling, paper and pulp and particle boards. Bamboo is commercially used as substitute to timber, fodder and raw materials for basket, paper and pulp and other small scale industries. Cane or rattans are derived from climber plants. They are used in production of large number of house hold items including walking sticks, polo sticks, baskets, pictures frames, screens and mats.

c. Human survival and income generation: The basic necessities of life (food, clothing and shelter) are derived from forest. Forest provides trees and fruits that are important sources of income and food for not only the rural households but also for the urban dwellers. It is practiced in other areas, the field boarders and around the wells of forest. Mango, coconut, orange, pear, jack fruit and among others. grow wild in the forest short lived crops are also grown in artificially developed forest to provide food and income. Resources from the forest are used by the textile and allied industries to produce textile materials while forest wood are used for the construction and building of houses. Logging of forest wood as an income generating enterprise.

d. Grasses: Several species of graces exist in the country. These are used for a number of purposes including feeding of livestock. Lemon grass, palm rose grass, *bhabbhar* and *khus* grass are some of them. Legumes with root nodules), not only involved in soil nitrogen fixation, are used for feeding animals. Fodder and the forest form an important source of food for cattle and other grazing animals.

e. Essential oils: Certain forest grasses and trees are sources of oil for domestic and forest uses. Tropical grasses such as lemon grass, citronella and *khus* are the source of essential oils. Oil is distilled from the wood of various species such as sandalwood, agar and pine from the wood and various species such as eucalyptus, campour, water green and pine. These are used for the production of soaps, cosmetics, incense, pharmaceuticals and confectionary.

f. Medicinal use: Various species of plant leaves, fruits, roots and barks derived from the forest are used for cure of different ailments. Forest provides herbs and plants to fight against diseases. For example, the *neem* plant is used in many pharmaceutical companies in Nigeria to produce drugs. Leaves bark and other part of many other trees also have medicinal value and are used to make various ayuredic medicines, quinine is the most important drug derived from the forests.

g. **Habitat, ecosystem and biodiversity:** Forest is a home for both micro and macro organisms (other species of plants and animals) that are useful to man. Rabbit, grass cutter, antelopes, snakes, squirrel, insects are found in the forest. They form source food and income to man. Their interaction accounts for the existence of an ecosystem. The different species of plants and animals interacting in an ecosystem are called biodiversity.

h. **Source of water supply:** Forest provides clean water for drinking and bathing and other house hold needs. It serves as buffer in natural disaster like flood and rainfall.

i. **Tans and Dyes:** Tans and dyes are derived plant tissues as secretions. Tanning materials are used in leather industries. Tanning materials derived from mangrove, amla, oak, hemlock, anwal, wattle, myrobalans, ratanjol, flower of dhawri, babul, avaram, e.t.c. are the most commonly used. Dyes are derived from red sander (bright red), Khir (chocolate), flowers of palas fruits of mallotus phillipensis, bark of wattle and roods of morinda tinctonia are some of the important dyes.

j. **Gums and resins:** Gums are derived from stems or other parts of different trees either as natural or by inflicting injury on the bark of wood or blazing the tree. Karaya is the most important gum obtained from either *sterculia urens* or *S.villosa* trees of dry deciduous forests. It is often in textiles cosmetics, confectionary, medicines, inks, pastes, eigar and e.t.c. resins derived from forests are important raw materials for industries involved in production of paper, paint, vanish, soap, rubber, water proofing, linoleum, oils, greases, adhesive tape, phenyl, plastic and e.t.c. it is also used in pharmaceutical preparations, wax, boot polish and industrial perfumes.

k. **Animal products:** The most important animal product obtained from the forest is lac secreted by minute insect *(Laceifer lacca)*. It feeds on the sap of a large variety of forest trees such as palash, peepul, kusum and e.t.c. The use of this product is common in medicines, plastic, electrical insulation materials, dyeing silk, making bangles, paints, sealing wax, gramo phone records, leather, wood finishing, ornamental articles and e.t.c. Other animal products include: honey, wax, silk moths, horns and hides of dead animals, ivory, antters of deer, e.t.c. All these will increase the revenue base of the government if properly harnessed.

Indirect significance of forest in an economy includes:

a) **Soil Improvement:** Certain species of forest trees have the capacity to return nitrogen to the soil through nitrogen fixation process. This helps to improve the nutrient status of the soil. Dried leaves, dead forest plants (branch or whole) and animals are decomposed through the action of micro-organisms to add humus to the soil. Similarly, some forest plant species have the ability to return nitrogen to the soil through root decomposition or fallen leaves. Such species of forest trees are deliberately planted to provide nitrogen to the soil. Thus forests help in increasing the fertility of the soil.

b) **Water shade:** Forests are source of water shade. This is so because nearly all water comes from rivers and lakes and from forest derived water tables. Some rivers running

through forest are also kept under control such that the rivers are kept cool and from drying off.

c) **Effect on climate change:** Forest helps to mitigate climate change. Harmful greenhouse gasses that produce climate change are absorbed by forest. Carbon (iv) oxide is a by-product of respiration, carbon (ii) oxide released in process of burning harmful materials from heavy duty vehicles are stored in above and below ground biomass (large ecosystems). Forests help to ameliorate the extremes of climate. It reduces the effects of heat and cold. The amount of rain fall is also influenced by forests. Through transpiration, they tend to lower the temperature of the moisture ladder within thereby increasing the humidity of the air. The surface velocity of winds is reduced and the process of evaporation is retarded.

d) **Prevention and control of soil erosion:** Forests are important in the prevention and control of soil erosion caused by water or wind. Heavy forces like wind are lowered by the existing forest trees. This action tends to prevent and control the spread of wind erosion. The increased nutrient capacity o the soil and the binding effects as provided by forests helps to checkmate water erosion. But the destruction of forest cover leads to increased run off of rain water and its reduced seepage and storage in soil. The structure of the soil suffers, runoff increases and lessens the soil which is carried away to other regions. The fertility of the soil is thus lost, and becomes barren and unproductive. Erosion by water is very common in the south-eastern parts of Nigeria. The most effective way to check soil erosion is to avoid unguided and indiscriminate falling of trees and to plant more trees. Erosion if not checked, can impact negatively on the economy of the country.

e) **Flood control:** Forests helps to regulate the flow of water and hence control flood. Rain water is absorbed by the roots and as much as possible; they are gradually used during the dry season. By so doing, much flow of water is reduced. Tick forest cover acts as rain-holder and rain banker. Trees also act like millions of painting dams and check the flow fof water like a barrage. Increased deforestation has led to increased intensity and requency of flood in different parts of the country. Where forest does not exist, there is usually increased runoff along with sand and silt especially after heavy rain. This in most cases is sudden rushes that tend to block silted streams and causes devastating flood effects.

f) **Checks on spread of Deserts:** In the deserts, sand particles are blown and carried away over long distances by strong wind. This results in the spread of deserts. The plant roots and plants help to bind the sand particles thereby preventing easy transportation by wind therefore, forests are vehicles to check the spread of deserts. On the long run, forests are a great instrument in adding humidity to the atmosphere. Through the process, the spread of deserts is checkmated.

3.3 Deforestation and Consequences of Deforestation

Deforestation leads to climate change. The demand for fibre and wood products is increasing due to world population explosion. The resultant effect of this is a net release of high quantity of carbon (iv) oxide into the atmosphere which bring about climate change. Climate change and biodiversity losses have a negative effect on wood and fibre

- as well as agricultural production. Increased amount of rainfall, temperature and atmospheric concentration of carbon (iv) oxide can affect forest growth and productivity.
- Continuous large-scale destruction of forest leads to soil erosion, higher frequency and intensity of flood, continuous and heavy siltation of soil, costly dams and river banks. It also causes change in climatic conditions and ecological imbalance
- Unguided exploitation of forest tree and deforestation alters the rate of water flow over and within the soil. Deforestation reduces rate of evapotranspiration..
  The consequent effect of this is that the organic matter and structure of the soil degenerate shortly after deforestation since there are no tree regenerates naturally.
- Deforestation may lead to the direct elimination of other species through harvesting or indirectly through destruction of habitats.
- Deforestation can lead to interruption of the migration routes of other species that travel through the forests.

3.4 Forest Conservation

Forest conservation is the summation of all the efforts made to ensure continuous existence of forest. Due to consistent increase in human activities, forest are fast dwindling as a result of indiscriminate and unguided felling of various species of forest trees and fibres. Bush burning, air pollution and climate change are also major disaster to forest depletion. To ensure continuous existence and derive maximum benefits from forest it is imperative to conserve them. The success of forest conservation or management could be achieved through the following:

a. Afforestation

This is the creation of forest by planting new tree or large scale plantation. Trees may be planted to derive the socio-economic values of trees. Tree planting may serve as wind break, shelter belt, field boundary demarcation, field fence, and groves in other vacant land. In Nigeria today, tree planting campaign has been on. It is advocated that when you remove one tree, plant two. This is to ensure that forest is not totally depleted.

ii. Forest Laws

Establishment and enforcement of laws to regulate the felling of tree and use of forest resources is essential. Laws guiding the falling of immature trees should be enforced and offenders should be prosecuted. Permission to fall any timber tree should be obtained from Department of Forest, Ministry of Agriculture and Natural Resources.

iii. Selective Cutting of Tree

Only trees that are fully matured should be allowed to be felled for timber use. Young and immature trees should not be tempered with to ensure and continuous existence and avoid deletion of trees.

iv. Forest Guards

Forest guards, usually civil servants should be well trained a equipped to guard and protect the misuse of forests and forests products.

v. Forest Reserves

Misuse of forest reserves, indiscriminate felling of trees, farming and hunting in government acquired forest (known as forest reserves) should be avoided except by permission and such should be monitored.

vi. Prohibition of Bush Burning

Law establishing the prohibition of bush burning should be established and enforced. Anyone caught should be made to face the law. As much as possible, indiscriminate bush burning should be avoided.

vii. Government Policy Development

Policy to reduce the cost of cooking gas, coal and electricity to a level where the poor can afford should be developed and put in place. This will discourage de much dependence on firewood as a source of fuel for cooking.

4.0 CONCLUSION

In this unit we learnt the meaning of forest and role of forest in economic development. This unit also discussed the meaning of deforestation, consequences of deforestation and conservation or management of forest.

5.0 SUMMARY

We have learnt in this unit that:

- Forest is a large uncultivated area that developed either naturally or artificially. Artificially developed forest is also known as plantation forest.
- Types of forests were identified to include: mangrove (salt water), fresh water and tropical rainforest among others.
- Forest is a source of energy supply, provides raw materials for industries, employment and income generation.
- Deforestation is a deliberate, continuous and unguided loss of vegetation cover due to excessive use and over exploitation of forest and forest products by man.
- Soil degradation, erosion, climate change and loss of biodiversity are some of the negative consequences of deforestation.

- Forest conservation is the summation of efforts of man to ensure the continuous existence of forest. Some forest management techniques include: afforestation, establishment of forests laws, selective cutting of trees and prohibition of bush burning.

6.0 TUTOR-MARKED ASSIGNMENT

i. a. Explain the meaning of forest
   b. Why would you encourage Nigerian Government to carryout afforestation programme.

ii. Identify the negative consequences of deforestation.

7.0 REFERENCES/FURTHER READING

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UNIT 3: WATER RESOURCES

CONTENT

1.0 INTRODUCTION

Water resource is becoming an important component in resource economics. Water is important in a diverse range of productive, environmental, social purposes in agriculture and the economy in general. Suppliers and consumer of water have a role to play to ensure that proper measure are put in place to achieve effective socially, economically beneficial and efficient outcome in an environmentally effective and sustainable manner.

In this unit, the students will be made to understand the importance of water, physical properties of water and sources of water use in agriculture. The students will also be made to know water resource planning, Lindh multi objective approach and sustainable water management.

2.0 OBJECTIVES

At the end of this unit, the student should to be able to know:

- importance of water
- physical properties of water
- sources of water use in agriculture
- water resource
- Lindh multi-objective approach to water planning and
- sustainable water management

3.0 MAIN CONTENT

3.1 Importance of Water

Water is a source of income and wealth generation. It is a basic determinant and a major indicator of quality life.

- It is an important economic input in agriculture and economic activities. A sink for waste and supports living systems including man.
- Water is a medium in which all living process occurs. The water content of an adult human is about 65-70%.
- It provides natural environment for some living organisms.
- Water is one of the necessary conditions required for seeds to germinate.
- It helps to regulate body temperature.
- Water is required in the body to dissolve nutrients and distribute them to all cells and supports structures.
- Water is required to remove waste products from the body of living organisms
- Water in the form of water vapour is a greenhouse gas that is required to regulate the temperature of the earth's surface.
- Most aquatic flowering plants require water for pollination to be achieved.
- Water availability determines the nature, types, composition, abundance of terrestrial life and habitat.
- Rain water is essential to regulate the atmospheric temperature.

3.2 Physical Properties of Water

- Water is colourless, odourless and tasteless substance that boils at a temperature of 100^{o}c and freezes at 0^{o}c with an atmospheric pressure of 760 mmHg.
- The maximum density of water is $1gcm^{3}$ at 4^{o}c (277k). This implies that the density of ice is lower than liquid water.
- Water is a universal solvent. Most solutes dissolve in water.
- Water is the most common solvent in nature. The polar nature (hydroelectrical constant) is usually positively and negatively charged ie one side of the water molecule is positively charged while the other side is negatively charged.

3.3 Sources of Water use in Agriculture

The main sources of water supplies for agricultural production or use in Nigeria are: (i) rainfall, (ii) Stored sources (rivers, streams, lakes, pond and wetland) and ground water.

i. Rainfall

Water is derived from the atmosphere in the form of rainfall. The atmosphere is one of the smallest major sources of water reserviours of the earth with respect to the volume. Rainfall distribution determines the growth and performance of crops and the main vegetation belts or biomes. It affects living organisms in different ways with a consequent effect on animals that feed on the planets. A very high amount of rainfall will bring about water logging, leaching and erosion. These have negative effects on plants and animal production. For optimal production (output), moderate amounts (1500 – 2000mm) of rainfall are required.

ii. Stored sources

iii. Stored sources of water resources use in agriculture includes: rivers and streams, lake and ponds as well as wetlands.

Rivers and Streams: Are surface water resulting from precipitation that does not evaporate or infiltrate into the ground and runs off over the surface, drawn by the force of gravity back towards the sea. The accumulation of rivulet leads to the formation of streams while stream join to form river. Most rivers may begin to diminish if not constantly replenished by precipitation. Examples of rivers in Nigeria are rivers Niger and Benue, river Ethiope and river Adofi among others.

Lakes and ponds: These are regarded as small temporary or permanent shallow bodies of water that support the growth of plants. Lakes are inland depressions that permit the existence of fresh water year round. Lakes and ponds have temporary characteristics on the landscape that are eventually filled with silt or emptied by cutting of an outlet stream through the barrier that creates them. The Oguta lake and Agwulu Lake are good examples of lake in Nigeria. Lakes and ponds support the growth and performance of plants and animals.

Wetlands: These includes: swamps, mashes, wet meadows and bogs. They play important role in the hydrological (water) cycle. The growth of plant here helps to stabilize year the soil and retain surface runoff, giving time for infiltration into aquifers and giving rise to long flow of stream. The disturbance of wetlands will lead to a reduction in the natural water-absorbing capacity and surface water runoff with a consequent effect of soil erosion and flood during the raining season.

Ground Water (Shallow and deep aquifers): In some countries agriculture may draw part of its water supplies on the main water supply distribution network (mainly used by urban and industrial consumers). This however could be an expensive option. For some countries sharing surface and ground water across national boundaries is important (eg. Mexico-Us, Portugal-Spain). In regions where water resources are intensive and scarce, there is a growing interest in water recycling for agricultural production.

Recycled water come mainly from processed drainage water or sewage water and desalinated water. Desalinated water is largely derived from seawater as well as saline aquifers. Both recycled and desalinated water supply a very small quantity of water and highly localized for agriculture.

Use of recycled water has raised health concerns with its application in agriculture especially in crop production. Desalinated water was once a costly source of water in agriculture, it is now a much lower-cost option with improvement in technology leading to reduced cost and energy required to produce desalinated water.

3.4 Water Resources Planning

The classical economists considered water as a free good with zero cost at point of consumption or supply. Water consumers usually pay for transfer cost which is related to transport, water quality treatment and disposal of used water. Thus, ignoring the opportunity cost of water. The

result of this is that consumers have little incentive to ensure that water is optimally or efficiently utilized. Economic efficiency of water requires two conditions:

i. Marginal benefits of water consumption must be greater or equal to marginal cost of supply
ii. .Marginal benefit per unit of resource must be equal across all consumers.

There are three measures of economic efficiency that must be maximised. They include:

a. The Net Benefit Efficiency Ranking Function: This is expressed as the total value of benefits less the cost. In the case of multipurpose projects, benefits are the summation of the willingness and ability of the individual beneficiaries of the project to pay for the different uses of the development. These include benefits derived from water supply, sanitation, improved water quality, waste assimilation or reduced soil lost and environmental impact assessment.

The selection of best alternative is therefore a function of maximization of efficiency-ranking function subject to the constraints imposed on the system. The efficiency ranking function is most efficient for large project.

b. The Benefit-Cost Ratio: The benefit cost ratio is mathematically derived by the maximization of the efficiency ranking function. The effectiveness of a project is determined is the benefit-cost which must be greater than one. This implies that for a project to be considered effective, the benefit-cost ratio must be greater than one. The maximization of benefit-cost ratio will yield optimum return per unit of investment.

c. The Rate of Return: This is defined as the discount rate (inherent time rate) required for total stream of cost (or total cost-outlay) to be equal to total stream of benefits.

3.5 Lindh Multi Objective Approach to Water Resource Planning

The multi-objective system approach to water resource planning was proposed G. Lindh. This system analysis process considers some socio-economic variables as important in water resource planning. These include: benefit-cost ratio, capital outlay, environmental and social impact and manageability aspects.

Benefit-Cost Ratio: In project preparation or planning the project planners must select from a number of proposed project alternatives. The physical feasibility of each of these projects must be considered. This is then followed by the test of the economic feasibility to ascertain the alternative projects with the highest benefit-cost ratio. The benefit-cost ratio is the most widely used and reliable method of analyzing and ranking of alternative projects. Intangible goods would include the project's effect on social harmony, aesthetic and ecology among other must be considered. Although, these may not easily be quantified in monetary terms, they involve values that are beyond economic and did not exhibit even likely dimension for measurement while others may involve non-economic values.

Capital Outlay: This test is carried out to determine the financial feasibility of alternative projects. It is mostly carried out when sufficient funds are raised to pay for project installation and operation. It may be possible for a project to be economically feasible but at the same time may be financially infeasible. Similarly; it may be possible for a project to be economically infeasible and financially feasible. This is because someone may be willing to pay for the achievements of non-economic goals.

Environments Impact Assessment (EIA): The environmental impact assessments is used to access or analyze the impact or outcome of proposed projects on air, water, land noise, biological, cultural and socio-economic environment. In applying the environmental impact assessment method, only meaningful variables maybe included and quantified while the irrelevant variables are spotted and not included in decision making process. The environmental impact assessment method includes certain socio-economic variable among pre-determined ecological and environmental pollution ones. The most important step for this development appears to be the modified input-output analysis as it involves the application of environmental impact assessment matrix methodologies.

Manageability of the Project: This is another multi-objective approach in water resource planning. It is mostly employed to determine the ranking order of project alternatives involving several countries. It considers economic, environmental and social factors. Input showing the level of technology country's resources and governmental policies influenced by these factors are indicated. Manageability is an important factor in assigning weight to a particular country's technologies or preferences as shown by manageability, resource use and other general characteristics of alternative projects considered.

3.6 Sustainable Water Management

Agricultural sector is often characterized by inefficient use and wastage of water resources leading to depletion of the resources. It is necessary to plan or implement measure that could ensure that water resources are effectively and efficiently used. Sustainable water management is a strategic measure that would be adapted to reducing the adverse impact or effect on water resources and ensure that water resources are efficiently utilized. The basic strategy in sustainable water resource management demands the integration of water management objectives to include physical, social and economic planning. This involves agricultural management, total land use planning, forest resource use, protection of coastal zones and marine environments from land based activities. This can help economic planners in achieving a more efficient use of water resources. Sustainable water resource management measures include:

a. **Water conservation strategy:** Efficient use of surface and ground water resources should be encouraged to reduce the water use and subsequently reduce degradation of water and soil resources. Some technologies for ground water recharge include: use of dug wells, ponds, water harvesting structures in drains and rivers should be studied for feasibility.

b. **Rainwater Harvesting:** This is the process used to induce, collect, store and conserve local surface run-off for use in agriculture within arid and semi-arid areas. This process involves vegetation management, surface treatment and chemical treatment. In areas with rainfall of more than 280 mm, the vegetation management is more effective. Where there is scarcity, shortage or problem of water, water irrigation is often used to augment. It is necessary to have an efficient drainage system to ensure a favourable salt balance for crop growth and development.
c. **Irrigation Management:** This artificial supply of water in agricultural production for optimum growth and performance of crops. It provides the necessary and required water for agricultural production in areas with water shortage. The irrigation management includes all measures involving improvement in irrigation management. These include lining canals with high efficiency system. This is to overcome problem leading to land degradation, salinization and water logging.
d. **Watershed Management:** Watershed management is a way of improving both water supply management and the quality of water. It involves the protection of watershed through the maintenance of naturally vegetated shield along streams, river channels and around lakes. Watershed management should take into consideration a process involving participatory planning, monitoring and evaluating the various courses of actions of natural, human and other resources. A good and general soil conservation and watershed management system should put into consideration the physical, socio-economic and institutional relationships that exist between upstream and downstream of a river basin or watersheds.
e. **Wetland Preservation:** This is an important component of watershed protection. Gains arising from water quality and natural water shortage are capable of reducing the need for and the costs of water treatment and storage downstream.
f. **Establishment of Effluent Treatment Plant (ETP):** Effluent (otherwise known as waste, sewage, discharge, emission, over flow, run off or run-off) treatment plant is used to control pollution. A major step to control industrial waste is the establishment of effluent industrial plant. Industrial waste treatment is based on certain standard such as rivers standards, inland water bodies and sewer standards. This however is a function of where the treated water is to be drained to.
g. **Community Participation:** Community effort is required in carrying out activities that will support the village organizational levels. Some of these activities include construction, operation, maintenance and funding of water system.

4.0 CONCLUSION

In this unit you have been exposed to understanding the importance, physical and sources of water use in agriculture. You also learnt about water resource planning, Lindh approach to water resource management and sustainable water management.

5.0 SUMMARY

- Water is an important factor in resource economics.
- It is essential in income and wealth generation, provides natural environment for some living organisms, important for crop animal development, a major component of the body among others.
- Water is colorless, odorless and tasteless with a boiling point of $100^{o}C$
- Major sources of water in agriculture include rainfall, stored sources and ground water.
- Water resource planning involves strategic efforts geared towards achieving maximum efficiency in water use.
- Measures of economic efficiency include; the Net benefit Efficiency Ranking Function, Benefit – Cost Ratio and the Rate of Return.
- Lindh multi-objective approach to water resource planning considers some socio-economic variable as important in planning.
- Sustainable water management relates to the strategic measures adopted to ensure maximization of water resource use.

6.0 TUTOR – MARKED ASSIGNMENT

1) Explain the strategies to be adopted to ensure the maximization of water resource use.
2) Outline the importance of water resource development.

7.0 REFERENCES / FURTHER READINGS

Jhingan, M.L and C.K Sharma (2008). Environmental Economics: Theory, Management and Policy. 2nd Edition. Vrinda Publications (P) Ltd.

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UNIT 4: CONSERVATION AND MANAGEMENT OF NATURAL RESOURCES

CONTENT

5.0 Summary
6.0 Tutor-Marked Assignment
7.0 References/Further Reading

1.0 INTRODUCTION

Man is an important factor in the environment whose activities interfere positively or negatively with the environment. The various activities of man lead exchange of material within the environment in a continuous cycle. With the increase in population, urbanization, industrialization and agricultural production activities much pressure is exacted on the environment leading to environmental degradation. This calls for efficient use, conservation and management of the environment and natural resources in general.

In this unit, the students will be made to understand the meaning and objectives of conservation, energy conservation, mineral conservation, conservation of renewable resources, fish and biodiversity conservation.

2.0 OB JECTIVES

At the end of this unit, the student should to be able to know:

- Meaning and objectives of conservation
- Energy conservation
- Mineral conservation
- Conservation of renewable resource
- Fish conservation
- Biodiversity conservation

3.0 MAIN CONTENT

3.1 Meaning and Objectives of Conservation

Conservation is the summation of efforts made by man to achieve environmental friendliness and reduce loss of biodiversity and biosphere to the advantage of all life including that of man. Jhingan, and Sharma (2008) defined conservation as management for the benefits of mankind, biosphere to ensure sustainable benefits to the present generation and maintaining its potential with a view to meet the needs and aspirations of the future generation. The objectives of conservation include:

i. ensure environmental protection through conservation
ii. efficient and rational use of natural resources
iii. proctect the earth to ensure a sustainable living and lifestyles.

3.2 Energy Conservation

The purpose of energy conservation is to:

i. improve the efficiency of energy supply systems,

ii. decrease the energy intensiveness of a given standard of living through a life style that is acceptable. For instance, thermostat settings, lighting levels or smaller cars and car-polling,
iii. shifting from gas or electricity to solar energy system.

Optimum energy conservation means a long run efficient use of energy for benefit of mankind and short run effect. Energy conservation requires that:

i. value of energy saved must be equal or greater than the additional operating cost or investment at a discounted rate required to achieve it,
ii. there must be an increase in energy supply when compared with an alternative energy source of supply,
iii. the alternative conservation option must be superior in terms of cost implication (including capital investment, price
iv. of energy, socioeconomic and environmental impacts) of non-exhaustive energy source.

3.3 Mineral Conservation

Mineral conservation involves the efficient use of mineral resources. Some energy resources like non-renewable energy resources cannot be recycled or reused; therefore, they require efficient and proper management. Environmental pollution emanating from mining activities can be reduced through efficient methods. Examples of non-renewable mineral resources that cannot be recycled or reused include: coal, oil and natural gas. Some examples of mineral resources that can be recycled or reused to some extent include: copper and aluminum.

3.4 Conservation of Renewable Resource

Land, soil, minerals, water, vegetation and wildlife are important resources that support the growth and performance of plants and animals that are beneficial to man. It is there important to conserve these resources to avoid misuse and depletion. Soil conservation involves several measures aimed at sustaining the soil and preventing soil degradation. Some these measures include: erosion control measures, planting of trees and cover crops, strip cropping and crop rotation methods.

Water conservation measures involve efficient water use (avoid wasting of water), encourage water recycling, reduce water pollution (this involves treating sewage and industrial waste before disposing them) and adopting good technologies for groundwater recharge (like use of dug-wells and pounds. Efficient use of water or management is essential in human development, water availability and sustenance as improvement of water cycle and crop production.

Forest conservation is important as provides among other things raw material, income, employment, fuel, coal and provide home for both micro and macro animals. It is also essential in regulating the amount of rain fall, erosion control, silting of streams and floods. Forest control measures include: avoidance of indiscriminate felling of trees, deforestation and bush burning. Use of pesticide and insecticide that can destroy insects in the forest but may pollution and harm to other organism should be avoided.

3.5 Fish Conservation

Fish is an important natural resource that is useful in supplementing the existing food resource. Therefore, there is the need to ensure increased yield of this important resource. For increased yield of fish, it is important to pay attention to artificial breeding under controlled conditions in lakes, ponds, rivers and seas. Fish conservation practices involves the regulation of fishing and of fish production, prohibition of overfishing, ensuring that only fully matured fish is harvested and increased rate of fish breeding should be done.

3.6 Biodiversity Conservation

Increasing search of wide life for food, income generation and human sustenance has lead to extinction or disappearance of some wildlife species. Some important animal species have gone into extinction as a result of over-exploitation for either domestic or commercial purposes. For example, the selling of the skin of leopards, tigers and other animal have drastically reduced the existence of these animals. Animals like lion are almost going into nonexistence.

Biodiversity conservation measures requires: positive incentive measures that will encourage require individuals, private organizations and government to protect biodiversity. This positive incentive could be in the form of monetary terms or alternative form. Introduction of internalization of the cost of use and damage to biodiversity should be adopted. This measure will not only help to reduce but discourage measures that lead to depletion of biodiversity resources. Another conservation measure is to encourage eco-label for the biological resources.
An effective and practical approach involving local task force in monitoring should be implemented. Government should ban the exploration and export endangered animal and plant species. Other measures include: well planned and coordinated efforts for sustainable use of biodiversity within forestry, fisheries and agricultural system. There should be equitable sharing of biodiversity using social and economic instruments.

4.0 CONCLUSION

In this unit you have been made to understand the meaning and objectives of conservation, energy conservation, mineral conservation, conservation of renewable resources, fish conservation and biodiversity conservation.

5.0 SUMMARY

Conservation is the summation of all human efforts aimed at preventing environmental degradation.

- It is focused on relative aspects to environmental protection through conservation, rational use of mineral resources and protection earth for sustainable life.
- Energy conservation involves the various measures used to improve the efficiency of energy supply systems and decrease the energy intensiveness of a given standard of living through a life style that is acceptable.

- Mineral conservation involves the efficient use of mineral resources. Some energy resources like non-renewable energy resources cannot be recycled or reused; therefore, they require efficient and proper management.
- Land, soil, minerals, water, vegetation and wildlife are important resources that support the growth and performance of plants and animals that are beneficial to man.
- Efficient use of water or management is essential in human development, water availability and sustenance as improvement of water cycle and crop production.
- Forest conservation is important as provides among other things raw material, income, employment, fuel, coal and provide home for both micro and macro animals.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define the term conservation and state why it is important to conserve natural resources
2. Briefly explain energy and mineral conservation

7.0 REFERENCES/FURTHER READING

Jhingan, M.L and C.K Sharma (2008). Environmental Economics: Theory, Management and Policy. 2nd Edition. Vrinda Publications (P) Ltd.

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MODULE 5: ECONOMICS OF IRRIGATION AND WATER USE IN AGRICULTURE, MEASUREMENT OF ENVIRONMENTAL DEGRADATION AND COST-BENEFIT ANALYSIS OF ENVIRONMENTAL CONSERVATION

Unit 1 Economics of irrigation and water use in agriculture
Unit 2 Measurement of environmental degradation
Unit3 Cost-benefit analysis of environmental conservation

UNIT 1: Economics of Irrigation and water use in Agriculture

1.0 Introduction
2.0 Objective
3.0 Main Content
  3.1 Need for irrigation
  3.2 Importance of irrigation
  3.3 Sources of irrigation
4.0 Conclusion
5.0 Summary
6.0 Tutor–Marked Assignment
7.0 References

1.0 INTRODUCTION

Water is an important component in agricultural production and development. The issue of water shortage or insufficient water for agricultural production is addressed using irrigation. Irrigation is the artificial application of water on land in absence of rainfall or where natural water is scarce or unavailable. Irrigation facilitates multiple and increase crop productivity.

In this unity the student will be made to understand the need for irrigation, importance of irrigation and sources of irrigation.

2.0 OBJECTIVE

At the end of this unit the students should be able to know and understand:

- The need for irrigation
- Importance of irrigation and
- Sources of irrigation

3.0 MAIN CONTENT

3.1 Need for Irrigation

Agriculture to a large extent depends on rainfall. Most of the cropped areas in Nigeria depend exclusively on rainfall. The rainfall pattern determines the type of crop and animal produced as well as the productive efficiency in agriculture.

When rainfall is scanty, it becomes very important to make water available to farmers through irrigation. Uncertain nature of rainfall increases the need for water irrigation in agriculture.

Irrigation is mostly needed in areas where natural water supply is of a great problem. The need for irrigation arises due to its enormous advantages to the soil, sunshine and climate. More water is required is in a sandy soil than a loamy or alluvial soil. In dry season, there is little or no enough residual soil moisture available to support the growth and performance of crops and multiple cropping. Hence, it is imperative to irrigate the land.

It is also necessary to have adequate irrigation facilities because there are certain crops that requires a very large quantity of water while certain crops require water for a long period of time. Grain crops for example cannot grow well if water availability in the soil is low. Sugar can also not only require water in large quantity but also for a long period. Irrigation is therefore necessary due to different water requirements of different crops.

The need for irrigation also emerges as a result of its employment potentials to the poor farmers. It provides micro employment to the farmers and farm families. Irrigation is capable of increasing both the employment, yield and income capacity of land with a consequent increase in the standard of living of the farm families. It is capable of even transforming the average unit of cultivation into a viable unit.

The need for irrigation also arises in order to solve the acute problems of high inter-temporal, inter-regional rainfall and meet up with the requirements of higher cropping intensity and water loving crops like rice, sugarcane among others and improve yield, income and employment potentials of farming population.

3.2 Importance of Irrigation

The importance of irrigation in agriculture and farm families cannot be overemphasized. The areas of importance are x-rayed from the following point of view.

1) **Unequal Rainfall:** Most agricultural production activities are a function of natural water sources. This natural water source comes from rainfall. Rainfall pattern in Nigeria varies from one geo-ecological zone to another. In the northern parts of the country rainfall occurs for a period of 4 -5 months. The remaining parts of the year then experiences uncertainty of rainfall. It is very important artificial irrigation facilities to substitute for water shortage.
2) **Uncertain Rainfall:** It is uncertain that there will be rainfall within the expected period of time or the stipulated time period. The distribution is not also certain. It may come earlier before planting which may force farmers to plant thereafter there will be no rainfall for some time leading to death of crops. This variation is unfavourable to achieving good yield. There is drought at one time and flood at the other time; crop planning is possible with adequate irrigation facilities.
3) **Prosperity:** Adequate water supply has a great prospect for agricultural production in terms of income generation, employment opportunity, capital formation, general welfare and standard of living of the farm families.
4) **Source of Government Income:** Applying irrigation water to the farm will have a multiplier effect of increased output, high income generation to the farmer and the government in general.
5) **Increase in Production and Productivity:** Double or multiple cropping can be possible with the application of irrigation water. With adverse land-man ratio, very little may be expected from extensive cultivation. It is possible to achieve high yield from irrigated land since it is possible to apply other inputs such as fertilizers, growth inducing hormones, insecticides, pesticides and high-yielding variety of seeds among others in irrigation water.
6) **Increase Cultivable Land:** Uncultivated land resulting from acute water shortage could be put to use with the availability of irrigation facilities. Waste land can also be used for cultivation if there is irrigation water.
7) **Flood Control:** The problem of flood is often caused by lack of excessive over flow of river and rain water. River water if well channeled and controlled at proper places can be a source of electricity and irrigation especially when provisions are made for extraction of electricity.
8) **Intensive Cultivation:** Multiple cropping can be achieved if there is sufficient irrigation water. Double, triple or multiple crops can be produced in a given cultivable land with application of irrigation water. It is possible to produce certain crops such as maize two or three times in a year in a land if irrigation facilities are available. The intensive cultivation such as planting or sowing at the proper time, weeding, fertilizer applications and other agronomical operations may not be possible without sufficient irrigation water.

9) **Making Land Available for Non Crop Use:** More food production through irrigation implies that more land will be made available for non-crop sectors. Also inferior quality or non-productive land used for crops like food grains can be to use where better returns could be attained. Land could also be made available for nonagricultural usages such as roads, railways, houses and recreational centers among others.
10) **Commercial Farming:** The development of irrigation facilities and application of irrigation water can lead to commercial agricultural production.
11) **Employment:** Development of irrigation facilities can provide job opportunities as agricultural production activities will be increased with double, triple or multiple cropping systems. With sufficient irrigation water, land reclamation can be achieved paving way for

3.3 Sources of Irrigation

The main sources of irrigation are discussed below.

i. Well Irrigation

In most countries of the world, well form a very good source of water irrigation. Wells can successfully be dug to supply water in areas where there is adequate water in sub-soil. Water irrigation with wells has been practiced in Nigeria from ancient times. Well irrigation among farmers has become important because of its economic and environmental values.

Advantages

- Well irrigation does not require technical know-how of the farmer.
- The operational cost is nominal which can easily be afforded by the farmer.
- Water from wells contains some chemical properties that help in increasing soil fertility.

Disadvantages

- It is noted consider suitable for use all over the country.
- At areas well water table is too high construction of wells is expensive and troublesome.
- In certain parts of the country well gets dried during the dry season.
- It is not suitable as source water irrigation in large and commercial farms.
- Engine and pump sets may be required to generate water from wells in case of large farms otherwise several wells may be required to achieve the purpose.

ii. Tube wells

Tube wells are considered to be an important component of green revolution which provide assured source of water irrigation.

Advantages

- The tube are not only cheaper compared to surface wells but they also help to relieve our weak and over worked cattle of great strain of working at the wells.
- Tube wells have the advantage of irrigating a large field in a short time.

- It can easily be used by farmer especially in situation where grants are to farmers by government.

Disadvantages

- The major limitation of tube wells is that it cannot conveniently be used in the absence of electricity.
- Tube wells cannot be used where there is insufficient water supply.

iii. Tanks

Tanks form important source of water irrigation. This is commonly used in places where the availability of underground water is poor as rocks do not suck up water. In such conditions it often very hard or difficult to construct wells. Water can easily be stored in tanks which may be easily available either in the natural or artificial forms in constructed tanks. The basic limitation of method of irrigation is that of administration and improvement in means to raise water to the field. There is also the issue of maintenance.

iv. Canal Irrigation

This is the most important source of water irrigation in the present day. Canal irrigation accounts for about forty percent of the net irrigated land. There are two major types of canal irrigation. These include: inundation canals and perennial canals.

Inundation Canals: This is constructed to allow water free flow of water from the river without any bank or dam at the head. During the rainy season when the water flow from the river is high, the canals overflow with the flooding of the river and thus irrigating the field. But during the off season as the river gets dried, the canals also get dried. This makes water availability for irrigation uncertain. Thus type of irrigation may not be very useful during the drought where water is mostly needed.

Perennial Canals: In this method, water is reserved at the site the dams that are built at higher levels. Water is being supplied throughout the year with or without the fact that the river are in spate. These types of canals are usually regarded as the most suitable since they are permanent in nature and also there is regular water supply. Water is assured even in the period of drought.

Limitations: There are several limitations of canal system of irrigation. Some of these include:

a. Canal irrigation cannot conveniently be constructed in everywhere.
b. They go dry when the river source goes dry.
c. There could be loss of water resulting from seepage evaporation and pilferage.
d. Water seepage from canals may lead additional problem of flooding.
e. Water wastage may occur as a result of water rate system, irrational demand for water and insufficient service by the irrigation department.

4.0 CONCLUSION:

In this unit, you have been exposed to understanding the need for irrigation, importance of irrigation and sources of irrigation.

5.0 SUMMARY

- Water is an important component in agricultural production and development.
- Agriculture to a large extent depends on rainfall. There is need for irrigation account for rainfall uncertainty.
- Irrigation is important in the provision of income to the farmer and government, income generation, flood control, making land available for non-crop production, intensive cultivation, increased production and productivity among others.
- Sources of irrigation include: wells, tube wells, tanks and canals.
-

6.0 TUTOR – MARKED ASSIGNMENT

1. Explain the importance water irrigation in agricultural development.
2. State the various sources of irrigation.

7.0 REFERENCES / FURTHER READINGS

Jhingan, M.L and C.K Sharma (2008). Environmental Economics: Theory, Management and Policy. 2nd Edition. Vrinda Publications (P) Ltd.

Lekhi, R.K and Joginder Singh (2016). Agricultural Economics: An Indian Perspective. Eleventh Edition. Diamond Agencies PVT Ltd., B – 125, Sec – 63 Noida

UNIT 2: MEASUREMENT OF ENVIRONMENTAL DEGRADATION

1.0 INTRODUCTION

The environment performs some basic functions that are important for man to survive. These basic functions are

(i) provision of 'natural goods' such as air, solar energy, lakes, landscape, and wildlife;
(ii) supplying natural resources such as land, water, forests, and minerals, which are used to create economic goods;
(iii) functioning as a 'sink' into which the byproducts of economic activities are dumped/discarded; and
(iv) (iv) providing environmental services and amenities such as the maintenance of a habitable biosphere, including the stratospheric ozone layer, climate stability and genetic diversity, and recreation and aesthetic appreciation.

By the end of this unit, the students will be made to understand the meaning of environmental degradation, causes and effects or consequences of environmental degradation.

2.0 OBJECTIVE

At the end of this unit the students should be able to know and understand:

- Meaning of environmental degradation
- Causes of environmental degradation
- Types of environmental degradation
- Effects or Consequences of environmental degradation

3.1 Meaning of Environmental Degradation

Environmental degradation is the gradual break down or deterioration of the environment as a result of the depletion of natural resources such air, water and land. When natural resources are destroyed or depleted, the environment is degraded. Environmental degradation results to the destruction of the habitat, ecosystems, extinction of wildlife and pollution. Environmental degradation is also said to occur when the environment and the natural resources become less valuable. in a situation where the natural habitats are destroyed, biodiversity are lost and natural

resources are depleted, environmental degradation is also said to occur. Environmental degradation may occur naturally or by the various actions of man. It is also the reduction it the capacity of the environment to meet up with the socio-economic and ecological needs and objectives.

3.2 Causes of environmental degradation

The major cause of environmental degradation is man and his activities. Some of the causes of environmental degradation include:

- overpopulation
- air and water pollution
- deforestation
- global warming,
- unsustainable agricultural and fishing practices
- overconsumption
- misdistribution of wealth
- Third World debt crisis, and militarization and wars.
- Mining is also a destructive development activity where ecology suffers at the altar of economy. Scientific mining operations accompanied by ecological restoration and regeneration of mined wastelands and judicious use of geological resources, with search for eco-friendly substitutes and alternatives must provide sensational revelation to the impact of mining on human ecosystem.
- destructive logging of forests
- overgrazing and over-cropping of arable lands
- strip mining etc. This may be extended to include oil exploitation, industrialization, improper disposal of domestic solid waste and human excretal including liquid waste,
- over-utilization of non-degradable materials for packaging among others.

Other causes of environmental degradation

- Solid waste
- Oil pollution
- Urban poverty
- Global warming
- Ozone layer depletion
- Land degradation
- Flooding
- Chemicals and toxic substances
- Drought
- Desertification
- Water scarcity

Causes of land degradation

- Improper resources management

- Destructive logging of our forest
- Overgrazing and over – cropping of arable lands
- Flooding and wind erosion menace
- Strip mining in some parts of Nigeria
- Land degradation with pesticides and fertilizers
- Some known natural landslides etc.
- Destruction of wetlands and marches for development.

Causes of environmental pollution

- Modern urbanization
- Industrialization,
- Over-population growth
- Deforestation
- Flooding
- Water and air pollution

Causes of Air Pollution

- Pollen grains
- Fungus spores
- Salt spray
- Smoke from finest fires
- Dust from volcanic eruptions
- Play ash
- Automobiles industrial processes
- Aircraft, ships, railways and other combustion engines
- Domestic fires, domestic refuse incineration and bush burning.
- Dust from the air

3.3 Types of environmental degradation

Some types of environmental degradation include:

- Land and soil degradation
- Water degradation
- Biodiversity degradation
- Wildlife degradation

3.4 Effects or Consequences of environmental degradation

Consequences include

- Increased poverty
- Overcrowding
- Famine

- Weather extremes
- Species loss
- Acute and chronic medical illnesses
- War and human rights abuses
- Increasingly unstable global situation that portends Malthusian chaos and disaster
- Reduction in the quantity and quality of natural resources
- Unemployment
- Low income generation to individual and the country at large
- Slow economic growth and development

4.0 CONCLUSION

In this unit, you have been to able to understand the meaning of environmental degradation, causes, types and effects or consequences of environmental degradation

5.0 SUMMARY

- Environmental degradation is the gradual break down or deterioration of the environment as a result of the depletion of natural resources such air, water and land.
- Environmental degradation results to the destruction of the habitat, ecosystems, extinction of wildlife and pollution.
- Causes of environmental degradation include: overpopulation, air and water pollution, deforestation, global warming, unsustainable agricultural and fishing practices and overconsumption.
- Some variables that can lead to land degradation include: improper resources management, destructive logging of our forest, overgrazing and over – cropping of arable lands, flooding and wind erosion menace, strip mining in some parts of Nigeria, land degradation with pesticides and fertilizers, some known natural landslides, destruction of wetlands and marches for developments among other.

6.0 TUTOR–MARKED ASSIGNMENT

1. Outline the causes of environmental degradation
2. Explain the meaning of environmental degradation.
3. List the types of environmental degradation

7.0 REFERENCES / FURTHER READINGS

Jhingan, M.L and C.K Sharma (2008). Environmental Economics: Theory, Management and Policy. 2nd Edition. Vrinda Publications (P) Ltd.

UNIT 3: COST-BENEFIT ANALYSIS OF ENVIRONMENTAL CONSERVATION

1.0 INTRODUCTION

The purpose of the cost benefit analysis (CBA) is to help decision makers make informed choices on whether to invest in projects, which are designed not only to increase the elasticity of the facility to the impact of hazards, whose effects have been exacerbated due to climate change, but to also implement climate alleviation measures by reducing or ensuring efficient consumption of energy and water resources to enhance a healthy living condition. Conducting a cost benefit analysis of a project can be costly and cumbersome or difficult to undertake. However, this is a factor of the range of input data used to verify a project's costs and benefits. Hence, these are recommended for use in projects where the potential costs of the project(s) are significant enough to give good reason for the allocation of resources to predict measure and calculate anticipated benefits, costs and impacts.

2.0 OBJECTIVE

At the end of this unit the students should be able to know and understand:

- Meaning of Cost-Benefit Analysis
- Types of Cost-Benefit Analysis

3.0 MAIN CONTENT

3.1 Meaning of Cost-Benefit Analysis

Cost-benefit analysis (CBA) is a scientific procedure or method used to analyze social or societal issues or projects in different fields like agriculture, environment, health, education, transport, among others. The cost benefit analysis is essential in estimating the benefits and costs of an investment with a view to:

- determine the viability of the project ie to know if the project is a good investment to embark on.
- Make comparison between one project with other competing projects, to ascertain which one is more viable.

Analyzing cost-benefit of a project investment will enable decision makers to evaluate projects in a reliable and similar way. Cost-benefit analysis requires certain assumptions and decisions to be made in other to find out some of the input data and there are definite questions that will be raised. It is necessary to make sure that the assumptions and methodological approach are reliable for the various projects being compared. Likely questions that may be asked include:

1. What baseline will the benefits of the project(s) be estimated?
2. What is the order and spatial level of project impact(s)?
3. Which particular elements of the project / activities are most relevant to the cost-benefit analysis?

3.2 Types of Cost-Benefit Analysis

This shows the different methods, ways or analytical or tools that are used to determine economic efficiency of a project. Some of these methods include

a. Benefit Cost Ratio (BCR)
b. Incremental Cost Benefit Ratio
c. Net Present Value (NPV)
d. The Payback Period
e. Accounting Rate of Return
f. Internal Rate of Return

a. Benefit Cost Ratio: This is the ratio of project benefits to the project costs or the ratio of the value of future cash flow (benefit) at the required rate of return to the initial cash outflow of the investment. It involves summing the total discounted benefits for a project over its entire period and dividing it over the total discounted costs of the project. This is mathematically represented as:

$$BCR = \frac{[\sum B / (1+d)]}{[\sum C / (1+d)]}$$

BCR = summed over 1 = 0 to n years

Where:
Bi = the project's benefit in year i, where i = 0 to n years
Ci = the project's costs in year i, where i = 0 to n years
n = the total number of years for the project duration/ life span
d = the discount rate

This can also be represented as:
PV of Cash inflow
PVof Cash outflow
i.e

$$\frac{\sum \text{PV of Revenue}}{\sum \text{PV of Cost}} = 1$$

$$\sum_{t=1}^{n} \frac{\text{At}}{(1+\text{k})t}$$

NPV = ∑PV of Revenue = ∑PV of Cost

Steps in calculating BCR

1. Determine the discounted benefits for each year of the project
2. Determine the discounted costs for each year of the project
3. Sum the total discounted benefits for the entire project duration
4. Sum the total discounted costs for the entire project duration
5. Divide the total discounted benefits over the total discounted costs

Decision or Acceptance Rule

If BCR < 1, do not continue with the project
If BCR = 1, the project should be allowed to continue. However it has little viability
If BCR > 1, accept the project and so should be allowed to continue. This implies that the project is viable.
This method however does not give the total projected gains or losses compared with another

b. Incremental Benefit Cost Ratio (IBCR)

This method is useful in determining the level or margin by which a project is more profitable or costly than another project. It is used to compare the available alternatives and determine the most feasible project.

Steps in calculating IBCR

1. List the projects from the least costly to the most expensive in ascending order.
2. Take the least costly project and compare it to the second cheapest option by subtracting the total discounted benefits for each project and dividing this by the difference in the total discounted costs for each project. IBCR is represented as

$IBCR = (\sum B_1 - \sum B_2) / (\sum C_1 - C_2)$

Where:
ΣB1 = total benefits for project '1'
ΣC1 = total costs for project '1'

3. If the incremental BCR obtained is higher than the target incremental BCR, then discard the lower-cost option (project 1 in this case) and use the higher-cost option (project 2) to compare with the next project on the ascending cost list.

4. If the incremental BCR obtained is lower than the target incremental BCR, then discard the higher-cost option (project 2 in this case) and use the lower-cost option (project 1) to compare with the next project on the ascending cost list.
5. Repeat these steps (2-4) until all of the project options have been analyzed.

The project with the highest cost and an incremental BCR equal to or greater than the target incremental BCR.

c. Net Present Value

This method considers the difference between the total discounted benefits minus the total discounted costs, which gives the Net Present Value of a project. Projects with positive net benefits are considered to be viable and a project with a higher NPV as compared with another project with a lower NPV is measured to be less lucrative. In other words, the higher the NPV, the greater the calculated benefits of the project. NPV can be derived as:

$NPV = [\Sigma Bi / (1+d)i] - [\Sigma Ci / (1+d)i]$ summed over 1 = 0 to n years

Where:

Bi = the project's benefit in year i, where i = 0 to n years

Ci = the project's costs in year i, where i = 0 to n years

n = the total number of years for the project duration/ life span

d = the discount rate

Alternatively, NPV can be derived using the formula below

$NPV = \sum (B(t) – C(t) / (1+d)t$

This alternative will give the same result as the one above.

Decision or Acceptance Rule

If NPV > 0, accept the project proposal

If NPV < 0, reject the project proposal

If NPV = 0, the project will have no effect whether it is accepted or not.

d. Payback Period (PBP)

This is the time period required for the total discounted costs of a project to be surpassed by the total discounted benefits. It is the total number of periods or years required for a project to recover the total cost or amount invested in the project. This can be easily done, say in excel, by calculating the cumulative discounted benefits and cumulative discounted costs of a project for each consecutive year of a project.

The year that the cumulative benefits exceed the cumulative costs is the payback period year of the project. In other words, the year following the project payback period will see net profits or benefits to the project.

If the annual income generated from the project is constant, then the pay bact period can be calculated by dividing the total cash outflow from the project by the total annual cash inflow. This can be represented as:

PBP = Cash outflow (investment)
Annual cash inflow

$$PBP = \frac{C}{A}$$

Consider the example blow.
If a project requires an outflow of #150,000 and yields an annual inflow of #40,000 for a given period of 7years, what will the payback period of the project?

Solution

$$PBP = \frac{\text{Cash outflow}}{\text{Cash inflow}}$$

$$= \frac{150000}{40000}$$

= 3. 80

This implies that the project will return the initial money invested within three years, eight months indicating that the project is viable.
In a situation where the cash inflow is not constant or unequal inflow, the payback period can be calculated by adding all cash inflow until the total is equal to total cash or final cash outflow.
Let us now consider the example below.
Calculate the payback period for a project that will cost a total of ₦130,000 and generate cash inflow of ₦50,000, ₦40,000, ₦30,000 and ₦20,000.

Solution
Adding up all the cash inflow will show that the project will be able to recover the total sum of #120,000 within the first three (3) years. Assuming that the cash inflow occurred evenly within the period or years, the time required to recover the balance of ₦10,000 will be:

$$= \frac{10000}{20000} \text{ x } \frac{12}{1}$$

= 6months

From the analysis or calculation above, the payback period is three (3) years and six (6) months.
Another way to calculate the payback period is by ranking. The ranking method gives the highest ranking to the project with the shortest payback period. Consider the example below.
Calculate the payback period of project A, B and C each requiring cash outflow of #100,000. Which of these projects will you recommend to be accepted by the management?

Solution

Ranking of Payback Period for Projects A, B and C Cash inflows

Year	Project A	Project B	Project C
1	25,000	40,000	10,000
2	25,000	30,000	20,000
3	25,000	20,000	30,000
4	25,000	10,000	40,000
5	25,000	-	-

The payback period can calculated as shown below.

Project A$= \frac{100,000}{25,000}$

= 4years

Project B = 4years

Project C = 4years

The payback period for each of the project is 4years. As at the end of the 4^{th} year the initial cash outflow of each of the project was recovered. Based on the analysis, all the projects are viable and are therefore recommended.

Decision or Acceptance Rule

Accept the project if the payback period calculated is less than the maximum payback set up by the management. If otherwise reject.

Advantages

1. It is quick, simple and easy to calculate and understand.
2. It is less expensive than most of the sophisticated techniques that requires much time of the analyst and the use of computer.
3. It saves the management the trouble or problem of having to forecast cash flow over the whole period of the project life span.
4. Another advantage of the payback period is that it is thought by managements to lead to automatic selection of the less risky project in mutually exclusive decision conditions.
5. It is a convenient method to use in capital rationing situations

Disadvantages

1. It takes into account only cash inflow within the payback period. All cash inflow after payback periods are not considered. For example, from the illustration above, the payback period considered project A at par with project B and C as having the same payback

periods. But a careful analysis would review that project A is most profitable than projects B and C as it yields cash inflow even after the payback period.

2. It is not a good measure of profitability index of project investment as it does not consider the entire cash inflow yielded by the projects.
3. It does not consider the timing and level of cash inflows.

e. Accounting Rate of Return (ARR)

The accounting rate of return investment criterion involves the use of financial statements in measuring the profitability of a proposed project. This method is achieved by dividing the average income after taxes by the average investment. The average investment is the original investment plus the salvage value (if any) divided by two.

$$\text{ARR} = \frac{\text{Average income}}{\text{Average investment}}$$

Decision or Acceptance Rule

Accept the project whose ARR is higher than the minimum rate set by the management. Reject the project whose ARR is less than the rate established by the management.

Advantages

1. It is simple to calculate, understand and use.
2. It can easily calculated using the accounting rate
3. The entire stream of income is used in calculating the accounting rate of return.

Disadvantages

1. It does not consider the time value for money. Profits accruing from different time period are valued equally.
2. It does not consider the project the length of the project life span.

f. Internal Rate of Return (IRR)

The internal rate of return is the rate at which equates the present cash inflow with the present value of cash outflow of any project. This is the thing as the rate at which the Net Present Value (NPV) equals zero. Internal rate of return provides information that are not available directly from the present value method. The actual rate of return of an investment having proper accounting for the time value of money is the internal rate of return. This is also known as marginal efficiency of capital or yield on investment. Internal rate of return can be derived as

$$NPV = \frac{\text{P1}}{(1+\text{i})1} + \frac{\text{P2}}{(1+\text{i})2} + \ldots\ldots\ldots\ldots\ldots + \frac{\text{Pn}}{(1+\text{i})\text{n}} - \text{C}$$

Where NPV is set equal to zero and the equation is solved for the discount rate. The IRR may be obtained using trial and error methods in absence of computers or sophisticated calculators with some approximation.

Decision or Acceptance Rule

Accept the project if the IRR is higher or equal minimum required rate of return. This is also known as the firms cost of capital. Reject the project if the IRR is less than the cost of capital.

4.0 CONCLUSION

In this unit, you have been able to know the meaning of cost benefit analysis. You were also made to understand that types of cost benefit include: Benefit Cost Ratio (BCR), Incremental Cost Benefit Ratio, Net Present Value (NPV), Payback Period, Accounting Rate of Return and Internal Rate of Return

5.0 SUMMARY

- Cost-benefit analysis (CBA) is a scientific method used to analyze social or societal issues or projects in different fields like agriculture, environment, health, education, transport, among others.
- The cost benefit analysis is essential in estimating the benefits and costs of an investment.
- It used to determine the viability of the project ie to know if the project is a good investment to embark on.
- It is comparison between one project with other competing projects, to ascertain which one is more viable.
- The ratio of project benefits to the project costs or the ratio of the value of future cash flow (benefit) at the required rate of return to the initial cash outflow of the investment is called benefit cost ratio.
- It involves summing the total discounted benefits for a project over its entire period and dividing it over the total discounted costs of the project.
- Incremental Benefit Cost Ratio (IBCR) is the method used in determining the level or margin by which a project is more profitable or costly than another project.
- It is used to compare the available alternatives and determine the most feasible project
- The accounting rate of return investment criterion involves the use of financial statements in measuring the profitability of a proposed project.
- The internal rate of return is the rate at which equates the present cash inflow with the present value of cash outflow of any project.

6.0 TUTOR – MARKED ASSIGNMENT

1. Calculate the payback period for a project that will cost a total of ₦130,000 and generate cash inflow of ₦50,000, ₦40,000, ₦30,000 and ₦20,000.

2. If a project requires an outflow of ₦150,000 and yields an annual inflow of ₦40,000 for a given period of 7 years, what will the payback period of the project?
3. State the advantages and disadvantages of payback period and accounting rate of return

7.0 REFERENCES

Jhingan, M.L and C.K Sharma (2008). Environmental Economics: Theory, Management and Policy. 2nd Edition. Vrinda Publications (P) Ltd.

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