NATIONAL OPEN UNIVERSITY OF NIGERIA

SCHOOL OF SCIENCE AND TECHNOLOGY

COURSE CODE (ESM 104)

COURSE TITLE: INTRODUCTION TO ENVIRONMENTAL SCIENCE

INTRODUCTION TO ENVIRONMENTAL SCIENCE (ESM: 104)

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UNIT 1: ENVIRONMENT

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1.0 INTRODUCTION

Now that you have gone through the guide, you should have acquired a general overview of what this unit is all about, and how it links specifically to the course. This unit will help you acquire basic understanding of the meaning and types of environment, and environmental science.

Before we do this, let us have a view of what you should learn in this unit, as indicated in the unit objectives below.

2.0 OBJECTIVES

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

- Define the term environment
- Identify the different types of environment
- Highlight what is new in environmental science
- Describe the nature of man-environment interaction

3.0 MAIN CONTENT

3.1 Meaning of Environment

The term “environment” according to Alan Gilpin (1976) in his book entitled “Dictionary of Environmental Terms” is the region, surroundings or circumstances in which anything exists; everything external to the organisms.

The environment or an organism according to him includes:

i. The purely physical or abiotic milieu in which it exists, e.g. geographical location, climatic conditions, and terrain.
ii. The organic or biotic milieu including non-living organic matter and all other organisms, plants and animals in the region including the particular population to which the organism belongs

Strictly speaking, the effective environment is everything external to the organism which effects the fulfillment of that organism.

The environment of the human being includes: the abiotic factors of land, water, atmosphere, climates, sound, odours, and tastes; the basic factors of animals, plants, bacteria and viruses and the social factor of aesthetics.

In Nigeria, in spite of much published speeches, there is no legislation that clearly defines environment. In the U.S.A and Canada, the general pattern adopted is that of National Environmental Protection Agency (N.E.P.A) 1969. Accordingly, in Section 1 (c) of the Ontario Environmental Assessment Act (1971), the environment is defined as follows:

i. Air, land and water
ii. Plant and animal life, including
iii. The social, economic and cultural conditions that influence the life of man or community
iv. Any building, structure, machine or device or thing made by man
v. Any solid, liquid, gas, odour, heat, sound, vibration or radiation resulting directly or indirectly from the activities of man, or
vi. Any part of combination of the foregoing and the inter relationships between any two or more of them (in or of Ontario)

In this definition, the biophysical and socio-cultural systems are not dichotomized. They are viewed interactively. In this course, therefore, our definition and

conception of the term “environment” is in accord with that given by Ontario Environmental Assessment Act (1971).

3.2 Types of Environment

There are two types of environment. We have natural or physical environment, and man-made or cultural environment. The natural environment refers to non-cultural and non-social environment before the advent of man on earth. It is all environment apart from man and all the things created before man. While man-made or cultural environment is the environment modified by man, culture, technological and population density determine the degree of modification of the natural environment. That is people of high technology will modify the environment than those of low level of technology.

In the past 25 – 30 years, there was the public and academic interest in environmental problems. This increasing interest has resulted or led to the birth of a new discipline called Environmental Science. Actually, the contents or composition of this discipline are not new as such, since they are drawn from the existing area of science such as physics, chemistry, biology and geosciences.

3.3 What is New in Environmental Science?

What is really new about environmental science is its view points. The view points can be seen in three ways:

i. In environmental science, the orientation is towards global problems
ii. Its conception of the earth as a set of interlocking and interacting system
iii. Its interest in man as part of this system

These are the three ways in which environmental science is different from the present science like physics, chemistry and biology.

According to Strahler and Strahler (1972) environmental science can be defined as the study of all systems of air, land, water, energy and life that surrounds man. Environmental science also includes all science directed towards the understanding of the environment particularly, as system. And this environmental system contains complex processes which must be understood in order to be able to solve several problems. And such problems include:

i. The maintenance of renewable resources such as timber and fish;

ii. The conservation of the non-renewable resources such as fuels. Fossil fuels take long time to form and therefore non-renewable.
iii. How to reduce the effects of natural disasters such as tornadoes, floods and earthquakes
iv. How to alleviate chronic damage to the environment formed by such things as erosion and drought;
v. How to abate the problem of pollution by man and this include smoke; and
vi. How to cope with natural pollution such as volcanic dust and allergens

3.4 Man-Environment Interaction

The study of environmental science will stress the understanding of the natural system and the processes of the earth, their implication on man, and their impact on man as the impact of man on these processes. Two areas of interaction between natural system and man have been recognized within environmental science.

i. Geosciences
ii. Eco-science

In Geoscience, interaction is on the realms of physical phenomenon. Here, we are concerned with the component and processes of the atmosphere, lithosphere and hydrosphere.

In Eco-Science, interaction is on the realms of biological phenomenon. The emphasis is on the function and component of the biosphere. The interaction of man on the natural systems can be looked at from two view points:

a. The impact of natural environmental forces on man. For example, floods, earthquake and landslides
b. The impact of man upon the environment. For example, the air and water pollution, extinction of certain species of animals, and accelerated rate of erosion.

In the broadest sense, the environment which is the focus of study of environmental science consists of all matter and energy capable of influencing life forms. The four realms of the environment are:

i. Lithosphere
ii. The atmosphere
iii. Hydrosphere
iv. Biosphere

4.0 CONCLUSION

In this unit, you have learnt what environment is, the types of environment, and what is new in environmental science. You have also known the nature of man-environment relationships.

You should at this point be able to define what environment is in your own words. You should be able to describe the nature of man-environment relationship in your locality.

5.0 SUMMARY

This unit has focused on the meaning of the environment, types of environment, the new things in the discipline of environmental science, and the nature of man-environment interaction.

6.0 TUTOR MARKED ASSIGNMENT

1. Using your own words, define the term “environment”.
2. Mention two (2) things that are new in environmental science

7.0 REFERENCES AND OTHER RESOURCES

UNIT 2: ENVOLUTION OF ENVIRONMENTAL EDUCATION

Table of Contents

1.0 INTRODUCTION

Having gone through the guide, you should have acquired a general overview of what this unit is all about. This unit will help you to know the evolution of environmental education, and history of global concern for human environment.

Before we do this, let us have a view of what you should learn in this unit, as indicated in the unit objectives below.

2.0 OBJECTIVES

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

- Identify the chronological phases in the development of environmental education
- Tell the major issue in the global concern for human environment
- Mention the major objectives of environmental education

3.0 MAIN CONTENT

3.1 Evolution of Environmental Education

Kirk (1985) has tried to analyse how two separate movements, namely the conservation/nature study movement and the outdoor education movement have acted as the foundation of modern environmental education in the

United States. He has described a few major chronological phases. Developments in each phase have contributed to the evolution of the Next phase. The four phases and a brief description of each follow:

i. Awareness Phase (1860 – 1890): This was the initial phase in which various powerful writers awakened many to recognize that man was not a single and solitary figure above all other living and non-living systems, but rather an integral part of the system
ii. Preservation Phase (1890 – 1910): in this phase, several writers popularized a need for the conservation of natural resources. The National Conservation Commission of the USA was established. Forests were conserved not merely as resources for their products, but also resources for recreation, relaxation, research and study.
iii. Nature study phase (1910 – 1932): The greatest catalyst during this period was the establishment of the American Nature Study Society (1908). In this phase, efforts were made to develop an understanding and appreciation of the beauty, majesty and mystery of nature. Valuable materials were also prepared which served as a tool and guide for teachers and aspiring naturalists.
iv. Education phase (1937 – 1950): In this latest phase, the Civilian Conservation Corp was established in which many young people had an opportunity to learn the value of forests and woodlands.

3.2 Global Concern of Human Environment

The global concern for human environment started in 1949 according to Cook and Weidner (1977) when the Commission on Education of the International Union for Conservation of Nature (IUCN) was established. This body was charged with the major responsibility of promoting environmental conservation education; and has been able to do this through several conferences and symposia on Environmental Education and renewable resources held in places such as Lucerne, Switzerland in 1966; Bariloche; Argentina in March 1968, Nevada in 1970; Ruschlikon, Switzerland in December 1971 and London and Ontario in Canada among others.

In 1968, the Swedish delegation to the United Nations drew the urgent attention of member nations to the rapidly growing crises in the human environment. It took four years, during which a working paper was prepared reconciling the contradictory views and positions of various nations, and

then to formulate a comprehensive document reflecting global aspirations and the imminent environmental threat (Lahiry et al 1988).

On June 5, 1972, the First United Nations Conference on the Human Environment was opened at Stockholm. The Conference was attended by 113 nations, UN agencies, and NGOs. The Conference discussed the various aspects of environmental problems, and adopted the Declaration on Human Environment and other action plan.

One of the major achievement of Stockholm Conference was the formulation of a special agency, known as the United Nations Environmental Programme (UNEP). The Stockholm Conference also provided the foundation of and framework for cooperative effort in International Environmental Education; which later resulted in the formation of the International Programme in Environmental Education.

The major activities of IEEP include the following among others:

1. Setting up pilot projects on Environmental Communication System;
2. The publication of a newsletter called Connect in five languages
3. Conducting a worldwide study of needs and priorities in environmental education;
4. Studying trends in Environmental Education;
5. Study, trial and development of innovations in Environmental Education; and
6. Sponsorship of discussion on Environmental Education and training of individuals throughout the world on Environmental Education.

In October, 1975, an International Workshop on Environmental Education was held in Belgrade. This meeting was well attended by experts and leaders of thoughts in academics from 65 countries. This was followed by regional and sub-regional meetings which covered the major regions of the world (Simpson et al 1988). The major achievement of the Belgrade workshop and other subsequent meetings was that it provided the groundwork for the Intergovernmental Commission on Environmental Education to be held in Tbilisi in October, 1977.

UNESCO in cooperation with the United Nations Environmental Programme (UNEP) established the UNESCO – UNEP International Environmental Education Programme (IEEP) which organized a number of regional conferences and seminars, each contributing to a Pluto supply and a body of knowledge concerning

world needs and a perspective of Environmental Education. These meetings led, eventually, to the world's first Intergovernmental Conference on Environmental Education, organized by UNESCO in cooperation with UNEP. The conference was convened in Tbilisi Georgia (in former USSR) in October of 1977. This conference was attended by 66 Member States and observers from two non-member states (Hungerford et al 1994).

The Tbilisi Conference resulted in unanimous agreement concerning the important role of environmental education in the preservation and improvement of the world's environment. From this conference come a document (the Tbilisi Declaration and 41 Recommendations) which delineates a substantive structure for Environmental Education and recommends policies and strategies to be followed worldwide (Connect, 1978). This document, without a doubt, is one of the most important single contributions to Environmental Education (Hungerford, et al, 1994).

The Tbilisi Recommendations provide a substantial forting for the decision making in Environmental Education. They communicate criteria for developing environmental education programs, goals for Environmental Education, categories of Environmental Education objectives, and guiding principles.

The goals of Environmental Education according to Tbilisi Declaration are:

- To foster clear awareness of, and convene about, economic, social, political and ecological interdependence in urban and rural areas
- To provide every person with opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect and improve the environment
- To create a new pattern of behavior of individuals, groups, and society as a whole towards the environment

Objectives of Environmental Education

It is important to note that Agenda 21 programme areas for Environmental Education are based on the fundamental principles established by the Tbilisi conference.

1. Awareness: to help social groups and individuals acquire an awareness of and sensitivity to the total environment and its allied problems
2. Knowledge: to help social groups and individuals gain a variety of experience on, and acquire a basic understanding of the environment and its associate problems.

3. Attitudes: to help social groups and individuals acquire a set of values and feelings actively participating in environmental improvement and protection
4. Skills: to help social groups and individuals acquire the skills for identifying and solving environmental problems
5. Participation: to provide social groups and individuals with an opportunity to be actively involved at all levels in working towards resolution of environmental problems (UNESCO, 1978)

Some of the guiding principles for Environmental education recommended by the Tbilisi Conference were that it should:

1. Consider the environment in its totality – natural and built, technological and social (economic, political, technological, cultural, historical, moral, aesthetic);
2. Be a continuous lifelong process, beginning at the preschool level and continuing through all formal and non formal stages;
3. Be interdisciplinary in its approach, drawing on the specific content of each discipline in making possible a holistic and balanced perspective;
4. Examine major environmental issues from local, national, regional, and international points of view so that students receive insights into environmental conditions in other geographical areas;
5. Focus on current and potential environmental situations, while taking into account the historical perspective;
6. Promote the value of necessity of local, national and international cooperation in the prevention and solution of environmental problems;
7. Explicitly consider environmental aspects in plans for development and growth;
8. Enable learners to have a role in planning their learning experiences and provide an opportunity for making decisions and accepting their consequences;
9. Relate environmental sensitivity, knowledge, problem solving skills and value clarifications to every age, but with special emphasis on environmental sensitivity to learners own community in early years
10. Help learners discover the symptoms and real cause of environmental problems;
11. Emphasise the complexity of environmental problems and the need to develop critical thinking and problems solving skills
12. Utilize diverse learning environments and a broad array of educational approaches to teaching/learning about and from the environment with due stress on pratical activities and first-hand experience.

In 1992, the United Nations Conference on Environment and development, held in Rio de Janeiro, the capital of Brazil emphasized Environmental Education as an Tbilisi.

In conclusion, it can be said that the Stockholm – Belgrade – Tbilisi (1972 – 1977) phase is neither the beginning nor the end of Environmental Education or a concern for the environment. Without prejudice, it can be said that Tbilisi Conference was the beginning of a worldwide movement on Environmental Education (Hungerford and Peyton, 1994).

4.0 CONCLUSION

In this unit, you have learnt the four phases in the evolution of environmental education, the major issues in the global concern for human environment and the major objectives of environmental education. You should at this point be able to trace the history of the global movement for environment education and management.

5.0 SUMMARY

This unit has focused on the evolution of environmental education, the major issues in the global concern for human environment, and the major objectives of environmental education.

6.0 TUTOR MARKED ASSIGNMENT

1. Discuss the major objectives of environmental education
2. Mention three (3) major issues in the global concern for human environment

7.0 REFERENCES AND OTHER RESOURCES

UNIT 3: THE ATMOSPHERE

Table of Contents

1.0 INTRODUCTION

Having gone through the guide, you should have acquired a general overview of what this unit is all about. This unit will help you to know the composition, structure and functions of the atmosphere. Before we do this, let us have a view of what you should learn in this unit, as indicated in the unit objective below.

2.0 OBJECTIVES

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

- Describe the atmosphere
- Identify the major constituents of the atmosphere
- Explain the factors influencing the composition of the atmosphere
- Mention the various structures in the atmosphere
- List the functions of the atmosphere

3.0 MAIN CONTENT

The Composition and Structure of the Atmosphere

The atmosphere can be described as a gaseous envelope held to the earth by gravitational forces. The composition of the atmosphere is fairly

homogenous from the earth surface upward to an altitude of about 80km. it is fairly homogenous because there are internal variations in the composition even within the range.

This fairly homogenous part of the atmosphere is referred to as the homosphere. From the altitude of 80km upward, the composition of the atmosphere is no longer uniform and this layer is referred to as the heterosphere.

3.1 Composition of the Homosphere

The composition of the homosphere consists of many gases which are shown in Table 1. They are perfectly diffused among one another to form:

Name of Gas	Composition by Volume
Nitrogen (N_2)	78.08%
Oxygen (O_2)	20.95%
Argon (Ar)	0.93%
Carbon Dioxide (CO_2)	0.03%
Neon (Ne)	0.001%
Helium (He)	0.0005%
Krypton (Kr)	0.0001%
Xenon (Xe)	0.00009%
Hydrogen (H_2)	0.00005%
Methane (CH^4)	0.00002%
Nitrous oxide (N_2O)	0.00005%

In addition to the above, we also have those gases whose proportion by volume varies from time to time. It varies temporally and spatially depending on the condition of the atmosphere. These gases are: water vapour (H_2O) 10^{-5} to 10^{-1}; sulphur dioxide (SO_2) 10^{-4}; Nitrogen dioxide (NO_2) 5 to 10^{-6}.

3.2 Factors Influencing the Composition of the Atmosphere

a. Altitude: the dense gases are found at the lower layer of the atmosphere especially at a distance of up to 15km from the earth surface. The lighter gases such as hydrogen and helium are found at the upper layer of the atmosphere. It should be noted that turbulence can bring a distortion in

the atmospheric composition since the atmosphere is not static but rather dynamic

b. Latitude and season: gases that varies with latitude and season include ozone, water vapour and carbon diocide. Ozone concentration is lower around the equator and densely concentrated over latitudes 50^0N and S of the equator
c. Time: gases such as carbon dioxide present in the atmosphere varies with time. The period of time when changes takes place in a society that is urbanized and industralised to the time it achieves a high level of urbanisation and industralisation is referred to here as "Time". It has been observed that the carbon dioxide content of the world's atmosphere increased by 9% between 1900 and 1935 arising from urbanization and industralisation all over the world.

3.3. The Structure of the Atmosphere

The structure of the atmosphere refers to stratification or division of the atmosphere using the factors of temperature. In other words, it refers to the division of the atmosphere into temperature zones

The various layers or division in the atmosphere are: troposphere, stratosphere, mesosphere and thermosphere.

The Troposphere

This is the lowest layer of the atmosphere. It extends to a height of 16 – 18km over the tropical region, and 8 – 10 km over the polar region, although an average of 15km is often adopted as the vertical extent of this layer. The major characteristics of this layer include:

i. Uniform decrease in temperate with increase in height. This rate of temperature decrease with increasing height is called Environmental Lapse Rate. This decrease of temperature takes place at a rate of 6.5^0C per kilometer.
ii. Increase wind speed with increase in height
iii. Higher quantity of moisture at the lower part of this layer
iv. Considerable movement of air vertically. There is considerable atmospheric instability or what we call air turbulence arising from alternating heating (during the day and cooling at night) of the earth surface. The upper boundary of this layer is called tropopause.

The Stratosphere

This is the second layer of the atmosphere. It extends from an average of 15km to 50km from the earth surface. It has the following characteristics:

i. Horizontal air movement
ii. High wind speeds
iii. Low concentration of water vapour and consideration nuclei
iv. Absence of clouds (except for cirrus clouds) at the lower parts
v. Temperature is constant at the lower part about 2-3km, but begins to rise with height from the height of 20 km
vi. This is the layer that has ozone
vii. Maximum temperature is about 7^0C at the upper limit of the layer. The combination of stratosphere and troposphere constitute what is referred to as the lower atmosphere.

The Mesosphere

This is the third layer of the atmosphere and this extends from about 50km to 80 km.

General characteristics of the mesosphere

i. Temperature generally decreases with increase height or elevation to a minimum of about 90^0C at its upper limit
ii. It is also characterized by very high atmospheric pressure
iii. Some clouds-like particles believed to be a layer of ash produced by the oxidation of meteors are found in this layer.

The Thermosphere

This is the fourth layer. Temperature increases with elevation or height up to a maximum of about 1232_0C at its upper limit of 480km.

3.4 Functions of the Atmosphere

i. It serves as a medium for the exchange of water and heat between the earth and the atmosphere
ii. It provides the oxygen for breathing by man and other living organisms

iii. It provides the gas (ozone) that shields the earth from the ultra violet radiation of the sun.

4.0 CONCLUSION

In this unit, you have learnt about the description of the atmosphere, the composition and factors influencing the composition of the atmosphere, structure and functions of the atmosphere.

5.0 SUMMARY

This unit has focused on the description composition, structure and functions of the atmosphere.

6.0 TUTOR MARKED ASSIGNMENT

1. List the major constituents of the atmosphere
2. Describe the structure of the atmosphere

7.0 REFERENCES AND OTHER RESOURCES

UNIT 4 THE LITHOSPHERE

CONTENTS

1.0 INTRODUCTION

Having gone through the outline, you should have acquired a general overview of what this unit is all about.. This helps you to know the structure and the mineral composition of the lithosphere, as well as utilitarian value of lithosphere to man. Before we do this, let us have a view of what you should learn in this unit, as indicated in the objectives sector.

3.1 The lithosphere

The lithosphere otherwise known as the earth's crust is made up of two parts. The upper part is made up of granitic rocks, and forms the continent.. This part is rich in minerals such as silica and alumina and is collectively called' SIAL'. While the lower part, made up of basaltic rocks forms the oceanic crust. This part is rich in silicon and magnesium, and the two collectively form what is known as 'sima'. The SIAL has an average density of 2.7gicm3 while 'sima' has a density of 3.0g/cm3. The SIAL continents, of a lighter material than the 'sima', tend to float upon it like icebergs in the sea.

Beneath the outer skin (that is the lithosphere), are the mantle and the core. Generally speaking, the lithosphere is often erroneously regarded as a passive factor in the environment.. The fact it provides a solid table platform for life supports this belief. But the lithosphere is not passive. It is just the process going on in the lithosphere operates at a very slow rate when compared with the process operating or going on in the atmosphere, biosphere and hydrosphere.

Unlike the biosphere and hydrosphere, the energy of the lithosphere is largely independent of solar energy system which dominates the atmosphere and hydrosphere. The most important source of energy in the lithosphere is the radioactivity. This is the energy generated through the decay of certain mineral elements known as radio isotopes.

Generally, the radio isotopes are concentrated in the outer layer of the lithosphere. The heat generated by this radio isotopes is responsible for the molten-nature of the inner core. Of all the energy system, the energy system of the solid earth (earth crust), is the least subject to alteration which is about 16 -44 km thick. This is the portion of the lithosphere that is in contact with the atmosphere, hydrosphere and biosphere. This outer layer contains all the relief features on earth; it also contains the continent and ocean, soil, gases and water. The most important mineral elements of the earth crust are as follows: in the order of importance.

Element	**% Weight**	% By **Volume**	
O_2	46.6	' 93.8	Silicate elements
As far as bios here is concerned			
S_i	27.7	0.9	Basic elements
Al	8.1	0.5	
Fe	5..0	0.4	
Ca	3.6	1.0	
Na	2.8	1.3	
K	2.2	1.8	
Mg	2.1	0.3	

These minerals combine to form rock. Most of the rocks in the earth's crust are Igneous in origin. The most abundant mineral in the earth's crust are the silicate minerals. Silicate compounds are compounds which contain combination of silica and oxygen to one or more metallic elements. This silicate minerals fall into two (2) groups:- the felsic group and the mafic silicate group.

(1) The felsic consists of quartz and felspars. A good example is Sj02.

3.2 Man and the Lithosphere

Man interacts with the lithosphere in several ways, and the result of the interaction may be positive or negative. As far as man is concerned, the lithosphere provides the resources as well as the resistances and environmental hazards. On the other

hand, man modifies the lithosphere in many ways. Unfortunately, most of the impacts of man on the lithosphere are destructive.

As far as the resources provided by the lithosphere are concerned, they are either in the form of minerals or in the foml of landforms or process which man can take advantage of. For example, the lithosphere provides man with minerals, soil as well as water stored in water bearing rocks. The minerals provided by the lithosphere can be divided into three (3) types:

(1) Matalliferous minerals e.g. Iron, Copper and Bauxite.
(2) Precious minerals like gold, silver and diamond
(3) Non-metallic minerals especially the structural materials, building sands, stone, gravel, etc.

Apart from these, there are also salts like sulphur salts, chlorides and phosphate, even fossil fuel such as coal, liquid, petroleum and gas. In some parts of the world, we have nuclear fuel such as Thorium and Uranium. In addition, the lithosphere also provides the non- renewable resources. These are resources whose rate of exploitation is several times greater than the rate of replenishment. Most of these non-renewable minerals continue to increase everyday. Perhaps, the most important resource provided by the lithosphere is the soil. Soil is formed from weathered materials, organic matter, air and water. It is the medium of plant growth, and is therefore very crucial to man's food supply. The physical, chemical and biological characteristics of soil determine tour important qualities of land.

(1) It determines the ability of land to provide nourishment to plants and animals.
(2) It also determines the ability of land to provide water for plants, lakes and streams.
(3) Also the ability of land to give mechanical support to plants, animals and buildings.
(4) These characteristics provide materials for construction purposes.

As far as the landforms are concerned, the landforms provided by the lithosphere have aesthetic value, and very good educational resources e.g. Volcanoes, mountains, warm springs, inselberg, rivers, water falls, etc. Despite all these resources provided by the lithosphere, it also provides resistance. For example, mountains, gullies, waterfalls and gorges are most of the time obstacles to the movement of communication lines. Similarly, earthquakes, mudflows, landslides,

floods are environmental hazards where they occur. Finally, as far as man's impact is concerned, we discover that most of their impacts are largely negative.

(1) Man extracts minerals from the lithosphere and this may result in serious environmental consequences. For example, it could lead to what is known as despoliation of land surface. Scars are created on the landscape when minerals are exploited.
(2) Extraction of minerals may also lead to subsidence, which may eventually lead to mudflow.
(3) Extraction could also lead to water stream channels.

When minerals are exploited by sophisticated means, it can lead to air pollution. In some cases, when extraction is very near the sea, like extraction of fossil fuel, it could lead to ocean pollution.
Finally, man is an agent of erosion when he carries out deforestation through cultivation or building purposes. These are the complex interrelationship between man and the lithosphere.

UNIT 5 THE HYDROSPHERE

CONTENTS

1.0 INTRODUCTION

This unit will help you understand the various components of the hydrosphere, and the concept of the hydrological cycle. Before we do this, .let us have a view of what you should learn in this unit, as indicated in the unit objectives below.

2.0 OBJECTIVES

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

- Explain the hydrosphere and its components
- Understand and describe the concept of hydrological cycle.

The Hydrosphere

It is a term used to' describe the sum total of all water on earth, and it includes oceans, seas, lakes, streams and rivers, underground water, soil moisture, water vapour in the atmosphere, glaciers and ice sheets. Water is the only element which occurs naturally in three states - gaseous, liquid and solid state. The chemical formula for water is H2O. The freezing point is O°C, while the boiling point is 100°C. Three quarters of the surface materials on the crust of the earth consist of water. Water also forms the largest part of most living matters. For example, an average man is two-thirds (2/3) water; and plants manufacture carbohydrate with water. Plants also take their nutrients in solution.

In fact, water is a universal solvent i.e. dissolves many substances, and the solubility of water increase with increasing temperature. Water is also a very remarkable catalysts as many chemical reaction are slowed down or totally prevented when water is not available. Water is also a geomorphic agent important for the process of weathering. Also, important in the process of weathering, modification and formation of landforms (as water is an erosional agent).

Water is the basis of life itself. It occurs in varying location in the earth's atmosphere system. It is also involved in rain processes taking place within the earth atmosphere system. Because of the ubiquitous nature of water, we find out that water is studied by various disciplines. Some of the discipline which study aspect of water include:

(1) **Hydrology:** This is defined as the scientific study of water especially inland water both surface and underground, including its properties, distribution, movement and utilization. (Inland water occurs over the land).

(2) **Hydrography:** Is concerned with the description, survey and charting of the oceans, sea and coastlines together with the study of tides, currents and winds especially from the point of view of navigation.

(3) **Oceanography:** Is the scientific study of all phenomena associated with ocean. There are two branches of oceanography:
   (a) Physical and
   (b) Biological Oceanography

   Physical oceanography studies the extent and shape of the ocean basin, the structure and relief of their floors, the movement of sea water, its temperature and salinity.

   Biological oceanography is the study of life forms in the ocean including plants and animal's lives.

(4) **Limnology:** Is the scientific study of lakes, fresh water and ponds. It deals with the various physical, chemical and biological conditions and characteristics of water bodies. These four disciplines deal directly with water.

The level at which the troposphere gives way to the stratosphere is known as the Tropopause. The height of the tropopause from the earth surface varies from about

10 km around the poles to about 17 km at the equator. Stratosphere starts from 10 km to 17 km above the earth surface and extends to a height of about 35 km. In this layer, air temperature increases gradually with increasing height.

Finally, the mesosphere gives way to the thermosphere at the boundary between the two layers referred to as the mesopause. Temperature within the thermosphere varies between
1100o and 1650oC.

Energy System in the Hydrosphere

Composition of the Hydrosphere

	Components	**Volume in 000 cu.km**	**Proportion in % 1.**
1	World Ocean	1,370,323	93.93 2.
2	Underground water	60,000	4.12 3.
3	Glaciers	24,000	1.65
4	Lakes	230	0.40
5	Soil moisture	83	
6	Atmospheric vapour	14	
7	Rivers	1.2	

The Major Ocean

S/NO	Oceans	Areas	% Ocean Surface'
1	Pacific	179.7	49
2	Atlantic	93.4	26
3	Indian	76.0	21
4	Arctic	14.0	04

The Hydrological Cycle

This is also known as water cycle. This is the term used to describe the endless interchange of water between the ocean, air and land. The cycle has no beginning nor an end. The hydrological cycle consists of two phases, the land and the ocean phases.

In the land phase of the cycle, water is evaporated from the oceans and most of the moisture is advected inland as vapour by air masses. The vapour later condenses to give precipitation on the land. The falling precipitation is disposed of in various ways including -percolatin (that is seepage into the ground); runoff (that is flowing through channels, and interception and reflection -which will be sent back to the atmosphere, or will eventually slide down to the surface. Also, precipitated water finds its way to surface water, ground water or oceans and seas, where the process of evaporation begins allover.

The ocean phase is much shorter phase. Over the oceans, water is being evaporated from the ocean surface into atmosphere, the condensation of the vapour and finally, the precipitation falling on the ocean surface.

Over the oceans; evaporation exceeds precipitation. The excess water vapour is therefore transported towards the land masses by atmospheric advection currents. Whereas, over land, precipitation exceeds evaporation; the surplus land water is therefore transported to the oceans in the form of surface run off through streams.

Fig. 4.1 The Hydrological Cycle

4.0 CONCLUSION

In this unit, you have learnt what is meant by hydrosphere and the components of the hydrosphere. You should be able to describe and explain the concept of hydrological cycle.

5.0 SUMMARY

This unit has focused on the various types and composition of the hydrosphere, and the description and explanation of the land and oceanic phases of the hydrological cycles.

6.0 TUTOR MARKED ASSIGNMENTS

1. Mention the various discipline concerned with the study of water as a discipline.
2. List the composition of the hydrosphere
3. Describe the land and oceanic phases of the hydrological cycle.

7.0 REFERENCES AND OTHER RESOURCES

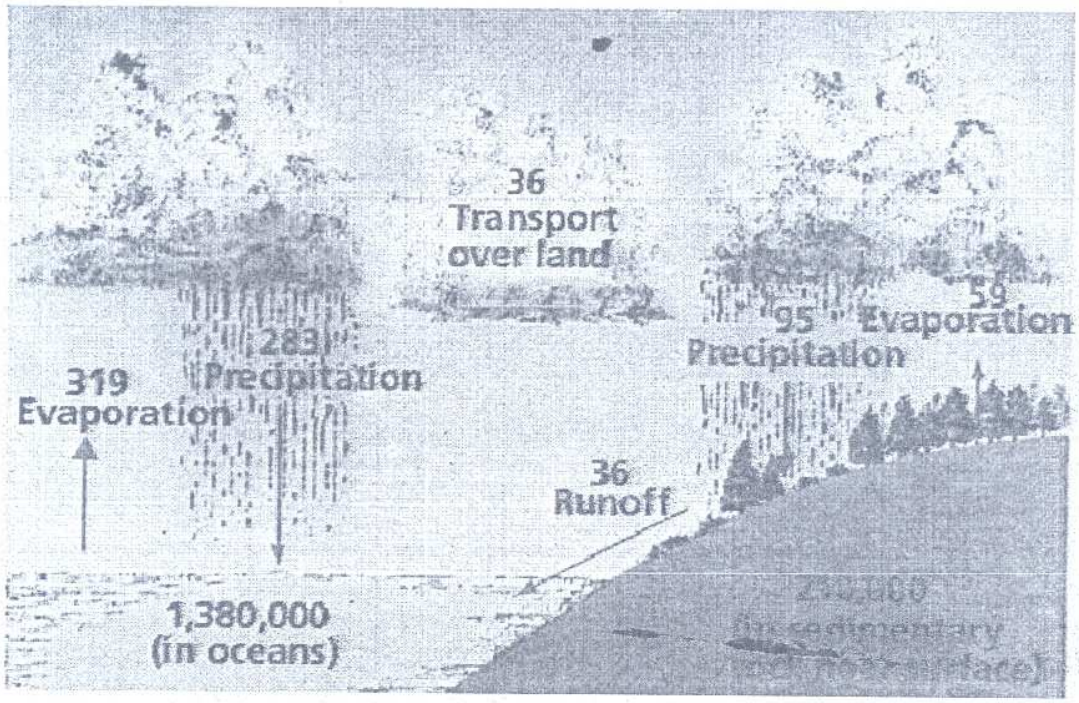

Fig. 4.1 Hydrological Cycle

UNIT 6 THE BIOSPHERE TABLE OF CONTENTS

CONTENTS

1.0 INTRODUCTION

This unit will help you to understand the energy system in the biosphere, the ecosystem concept, the functioning of the ecosystem. The unit will also discuss the concept of biogeochemical cycles.

Before this, let us have a. view of what you should learn, as indicated in the unit. objectives below:

2.0 OBJECTIVES

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

- Define the biosphere
- Explain the characteristics of a species
- Group the biosphere
- Explain the ecosystem concept
- Explain the biogeochemical cycles.

3.1 Energy System in the Biosphere

The biosphere is also referred to as the organic world, and it is a very small world when compared to the atmosphere or the lithosphere. However, the biosphere is densely populated with living organisms, and these living organisms vary from microscopic to unicellular plants and animals, and to the big and the complex life forms of plants and animals. The microscopic life forms are greater in number than the large or visible life forms (plants and animals). It has been estimated that a gram of rich top soil may contain as many as one million Algae, 16 million mould (fungi) and several million bacteria.

Individual organisms in the biosphere are grouped together to form a specie, and the members of the same specie population have certain characteristics in common.

(1) Their forms or external appearance are similar.
(2) Members have the ability to interpret one another, and the ability to interact freely between members of other species population.
(3) They are the same ecological requirements and tolerance. Generally, the organic world can be divided into two parts:
    (1) Plants
    (2) Animals

(1) The plants are self nourishing and that is why they are referred to as Autotrophes. In addition, the groups are immobile.
(2) The animals are Heterotrophic in nature. They are mobile. They cannot provide nourishment for themselves.

A better system of grouping the biosphere is one which recognizes four (4) different groups in the biosphere.

(1) The Monera
(2) Protista
(3) Metaphyta
(4) Metazora

1. The first group are mostly primitive organisms. They are basically unicellular. Examples are bacteria, blue-green algae. These groups are found in aquatic environment.

2. Protista posses complete set of cellular parts but they lack inter-cellular organization and specialization. Example includes fungi, protozoa and the algae.

3. The metaphyta -They are aquatic and at the same time live in terrestrial environment e.g. tree plants, mosses, and other vascular plants such as ferns.

4. Metazora -These are the true animals including man, and we have wide variations of those groups. Man, insects, worms and those whose cells are organized and specialized.

3.2 The Biosphere

The biosphere consists of the following:

(i) The weathered surface layer of the lithosphere which is more commonly referred to as soil.
(ii) The lower layer of the lithosphere which is more commonly referred to as soil.
(iii) The bodies of water on the earth's surface including ponds, lakes, rivers, streams and the seas.

The biosphere lies at the interface of the lithosphere, atmosphere and the hydrosphere. The non-living things or abiotic component of biosphere form the physical environment in which organisms live. The functional interactions between organisms and their physical environment result in distinctive entities called ecosystem.

3.3 The Ecosystem Concept

An ecosystem is any area on the earth's surface consisting of organisms interacting with one another and with the physical environment. Most ecosystems consist of plants and animals interacting with one another and with the physical environment in such a way that there is circulation of nutrients between the living and non-living components of the ecosystem and flow of energy through the entire system.

Ecosystems have two basic components:
(a) The non-living or abiotic component, and
(b) The living or biotic component

The living or biotic components can be divided into three, namely (i) the producers, (ii) the consumers, and (iii) the decomposers.

The producers -are those organisms that are able to manufacture food from simple organic substances, and energy from sunlight in a complex process known as photosynthesis. They are mainly green plants.

The Consumers -These are all the organisms which depend on the producers for food, either directly or indirectly. They can be divided into: (i) the herbivores; (ii) the carnivores; (iii) the omnivores.

4.0 CONCLUSION

In this unit, you have learnt what is meant by biosphere, and the groupings of the biosphere. At this stage, you should be able to explain the flow of energy and the cycling of matter in the ecosystem.

5.0 SUMMARY

This unit has focused on the energy flow in the biosphere, the various components and the biogeochemical cycles.

6.0 TUTOR MARKED ASSIGNMENT

1. In your own words, define the biosphere.
2. Differentiate between autotrophes and Heterotrophes. 3. What are biogeochemical cycles.

7.0 REFERENCES AND OTHER RESOURCES

UNIT 7 CONCEPT OF MAN-ENVIRONMENT INTERACTION: ENVIRONMENTALISM AND POSSIBILITIES

CONTENTS

1.0 INTRODUCTION

This unit will help you to understand the three major concepts used to explain the nature of the relationship and interrelationship between man and the environment. Before we do this, let us have a view of what. you should learn in the unit objectives below:

2.0 OBJECTIVES

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

- Explain the concept of environmental determinism
- Explain the concept of possibilism and probabilism

3.0 MAIN CONTENT

3.1 Environmentalism

Essentially, the concept of environmental determinism was developed as a general theoretical framework to explain the pattern of human activities in the earth surface. That is, the way human activities are arranged and how they vary in space.

The essence of determinism is that every effect has a cause, and as far as human activities and human behaviour are concerned, all first causes lies in the physical

environment. In other words, the concept of environmental determinism poses or regards the physical environment as the primary determinant of human behaviour and human activities. In fact, three components of the physical environment were particularly singled out in this regard as the principal factors. These include: topography, climate and soil.

The doctrine or concept of environmental determinism is an idea among geographers, and is usually traced to Ratzel. But the widespread adoption of the concept is primarily associated with the three of the Ratzel disciples -Semple, Hunting Tin, and Demolins. These three popularized the case of this concept in the field of geography. In the early time, the concept was largely abused because scholars tried to explain variations in human character, human behaviour and human physique in term of physical environment. For instance, Aristotle regards the inhabitants of the colder countries of Europe as brave, but lacking in thought, technical skills and political organization. The Asiatic people were seen by him as thoughtful and skillful but without spirit. The Greek who occupy the region in-between Europe and Asia were seen by him as combining the best qualities of both.

Many other scholars made such sweeping generalization in the name of environmental determinism. The common factor to most of these work is that their primary concern was to understand the variation in human nature. And given these objectives, the earth as such is not their focus of interest except where it shed some light on some possible reasons for human variations. Their approach was therefore not systematic and their conclusion was not consistent. Each scholar drew conclusion based on personal experience and imagination (This conclusion was not based on scientific procedure).

It became clear later or subsequently that the physical environment cannot be as important as the early proponent of the concept of determinism would have us to believe. In their thinking, man was seen as a Passive agent in the man-environment system. That is, the environment was seen as a dictator. In other words, man was not seen as an active agent of geographic change. This position can be faulted on many grounds.

The first is that similar environment would not necessarily evoke the same response from man. This means that the environment is not dictatorial. That man has a say in the choice of activities. Even human physique and physical types vary in the same geographic settings. In other words, different human types and different activities are not generally found in the same environment. Secondly, that

man- environment relationship is reciprocal; a kind of two-way relationship. The interaction between man and the environment is intricate, and it is sometimes difficult to know when the influence of one seizes and the other begins. It is difficult to demarcate. It is therefore impossible to stick one's neck out that the environment is the most important factor.

Thirdly, man's impact in the environment is not temporary or transitory but permanent. F or cities and most other forms of human settlements are permanent features of the landscape and their impact on local climatic conditions, local vegetation, patterns, local soil properties and local hydrology are more or less permanent.
Fourthly, that men's decision and tastes are becoming increasingly important in determining the pattern of agriculture, industrial location and production. Government policy and tariffs on the location of industrial estate, tax concession and so on can create spatial pattern of industries completely out of harmony with environmental factors.

The fifth ground is that environmental factors by themselves can hardly provide adequate explanation of the distribution of population. Invest which is a human factor is becoming more and more important in this regard.

There is also the factor of culture and technology. These can insult man from the direct impact of the environment, that is, through technology, man can protect himself by modifying the environmental dictates. Also, like irrigation, man has been able to extend the frontiers of cultivation and human settlement. Air condition makes life comfortable in desert environment.

Finally, towns site or the location of settlement in general are increasingly negating dictates of the natural environment. The migration of settlements to new roads, and the creation of new cities or national capitals are cases in points and examples of negating dictates of the environment.

All these other weaknesses in the concept of environmental determinism led to the development of new concept relating to the influence of environment on man. One of the new concepts to take into account some of these shortcomings is the concept of possibilism. Essentially, this concept of possibilism maintains the position that the / environment offers mall a number of alternative options from which he can choose; that within the possibility, man tries to find which one suits him most. This concept accepts the fact that man is an active agent of geographic change.

3.2 Possibilism

Possibilism does not say that environmental factors are not important; but that environmental factors only set the broad limit within which man can find choice among alternative options. Possibilism emphasizes the scope of man's freedom of action rather than the limit sit by the physical environment. The core or essence of the possibilism philosophy is that nature is not mandatory but permissive. It is more of an adviser than a dictator. Environment; offers a lot of opportunities from which man is free to choose. However, the environment places a limit to the number of these options and opportunities. The limit set by the environment varies on human activities, as well as in term of time a:nd space. In marginal environment (swamp, desert, ice-cap and fairly difficult environment), the opportunities and options are very restricted. That is taking the world as it is today, opportunities are better in the humid environment than the desert or arid area. This is in term of spatial, dimension.

Talking about time dimension, in the past, these opportunities and options were more limited than now, owing to the low level of cultural and technological development. It is true today that in primitive society, the options and opportunities are limited. Certain factors are limiting the range of possibilism of options in any given area. In this regard, the possibilist emphasizes the inhibiting power of custom, belief, habit and prejudices. All of these place atifiiir on tlie extent to which man can utilize or fully exploit the potentialities of his environment. That is the environment still places kind of limitation on the choice of opportunities available to man in his environment in spite of the technological attainment.

The range of options can be limited by the price man is willing to pay. F or instance, changing economic circumstances along with some technological development can lead to the exploitation of economic resources that could otherwise be very costly to exploit e.g. In the North Sea, when the price is very low for crude oil, it is not economic to exploit oil but when the price of oil is high, it becomes economic to prospect oil in the North Sea.

Finally, the level of technology is another important factor that can limit the range of options available to man in an area. Technological development can lead to the discovery of new resources, to the exploitation of hitherto inaccessible resources or to the development of new uses from existing resources. E.g. Livestock is formerly used as a beast of burden, later it is used for milk and skin, etc. The collective effects of all these factors is the broadening of the resource base of an area. Some authors identified the shortcomings of the concept of possibilism and these

shortcomings have to do with the fact that possibilism implicitly assigned the same probability of adoption to alternative options available to man. That is, each of these adoptions is equally good and equally attractive to man, and that the options are not equally good, this are more attractive than others.

One of the criticisms is that all options or alternatives are not equally good. Some of the options are better than the others. This means that the probability of adoption is not all the same for all the options. It is on the basis of this that the concept of probabilism was formulated.

3.3 Probabilism

Essentially, possibilism and probabilism are not the same but are very close. Probabilism argues or admits that it is possible that man has choice and some are more likely to be adopted than others. We know therefore that the move from determinism to probabilism represents a retreat from ideal situation to one in which determinate solution are available for all problems to at recognition that the total of man's environment is far too complex for a determinate answer to be detected in all cases.
This move from determinism to probabilism is one of the main reasons why the development of statistical techniques have become very important in geography in recent time. For example, the use of regression model to explain variation in agricultural system. Even in pure Science like Physics, explanation is more in probabilistic term.

4.0 CONCLUSION

In this unit, you have learnt what is meant by the concept of environmental detenninism, the major features of the concept an the problems with the concept. You should also be able to explain the concept of possibilism and probabilism.

5.0 SUMMARY

This unit has explained the main features of the concept of environmental detenninism, possibilism and probabilism.

6.0 TUTOR MARKED ASSIGNMENTS

1. List 3 major reasons for the modification of the concept of environmental detenninism.

2. List the 3 major components of the environment useful in determining the human behaviour.

7.0 REFERENCES AND OTHER RESOURCES

UNIT 8 DROUGHT

CONTENTS

1.0 INTRODUCTION

This chapter will discuss drought as an environmental problem, the causes, effects and control measures of drought. Before we do this, let us have a view of what you should learn in this unit.

3.1 What is Drought?

Different scholars have given the term "drought" different interpretational interpretations, but notwithstanding this, there is still a fair amount of consensus that drought is said to occur whenever the supply of moisture from precipitation or stored in the soil is insufficient to fulfill the optimum water needs of plants (Ayoade, 1988). And there are different types of drought. There is hydrological drought, agricultural drought and meteorological drought.

In meteorology, a period of at least 15 consecutive days, none of which is accredited to 0.2 mm constitutes what is called absolute drought. Partial drought is said to occur in meteorology if we have a period of at least 29 consecutive days, the mean daily of which does not exceed 0.2 mm. To the hydrologist, drought is defined in terms of river discharge, when it falls below critical minimum. Agricultural drought occurs when we have insufficient precipitation for the growth of crops. The crops start to show side effects ranging from wilting to decrease in yield.

Climatologists tend to define drought in different ways in terms of deviation from long term mean of rainfall in a given area. If deviation from the long term mean is:

11-25% -slight drought

26 -45% -moderate drought.

46 -50% -severe drought

> 50% -disastrous drought

Another way of defining drought in climatic term is to define it in terms of disposition curve of rainfall. Other types of droughts which have been recognized in climatology according to Ayoade (1988) include:

1. What is called permanent drought found in desert. It is a permanent feature of desert.

2. Seasonal drought, with well defined wet and dry season. It happens in the tropics.

3. Contigent drought occurs when rainfall is irregular and variable and unpredictable. It is a characteristic of humid and sub- humid area.

4. Invisible drought is less easily recognized unlike others where we can see the evidence. This occurs when the water need of crops are not met for daily basis. It occurs in the humid areas.

So, within the scope of this study, the term "drought" will be conceptualized to mean a situation when the supply of moisture from precipitation or stored in the soil is insufficient to fulfill the optimum water needs of plants (Ayoade, 1988).

3.2 Causes of Drought

According to Barry and Chorley (1984), drought is associated with one or more of the following:

1. Increase in area and persistence of the subtropical high pressure cells such as in the West African Sahel.

2. Changes in summer monsoonal circulation, causing a delay or failure of incursions of maritime tropical air mass as in the Sahel of Indian sub continent.

3. Lower ocean surface temperatures produced by changes in currents or increased upwelling of cold waters as occurs in Chile, California and Northeast Brazil, and

4. The displacement of mid-latitude storm tracks associated with either an expansion of the circumpolar westerlies into lower latitudes or with the development of persistent blocking patterns of circulation.

The Sahelian drought of 1972/73 and, indeed subsequent droughts according to Ayoade (1977) can be ascribed to three main factors. These are:

1. Climatic factors
2. Disruption in the ecological system .as a result of improper use of land by man and the increasing pressure of human and animal populations on the available land resource and
3. the failure of the area concerned to develop adequate water control projects owing to ignorance and lack of expertise and/or capital.

Different writers have tried to advance reasons for the causes of drought in West Africa and by implication Nigeria. But it is generally agreed that the continuous decrease in vegetal cover due to over- cultivation, over-grazing and over-population is a potent factor causing drought and eventually desertification. Let us come down to West Africa, the 1968 -73 Sudano -Sahelian drought for instance have generated a great deal of interest among scientists and efforts were made to answer the causes and effects of the drought in its local and global contexts.

One of the causes of the drought according to Oguntoyinbo (1982) has to do with the changes in the radiation regime attributed to changes in the albedo brought about a rapid depletion of the natural vegetation. Charney (1975) developed a model which showed that the high albedo of a desert surface contributes to a net radiative loss relative to its surroundings. Increasing the albedo from 14% to 35% had the effect of shifting the boundary between the two major air masses, known as the Intertropical Discontinuity (ITD), several degrees of latitudes south and decreasing the rainfall in the Sahel by about 40% during the rainy season. He further argued that a reduction of the vegetation with consequent increase in albedo

in the Sahel region at the southern margin of the Sahara would cause sinking motion, additional drying and would therefore perpetuate the arid conditions.

Taking into consideration Charnoy's Theory, Oguntoyinbo (1982) argues that human activity in Nigeria and indeed, in the whole of West Africa, has increased the surface albedo of the solar energy by about 5%. Such phenomeno according to him is bound to follow the over population, over-cultivation and over-grazing that is characteristic of our (i.e. Nigeria and West Africa) land use practices. An analysis of the seasonal shift of the Intertropical Discontinuity (ITD) during the 1968 -73 period according to Oguntoyinbo and Richard (1978) revealed a definite southwards shift. The implication of this southward shift according to them is that the moist maritime air mass which is the rain bearing wind in West Africa could not penetrate as far inlands as expected and its vertical extent was also decrease; thus reducing the convective activities associated with the formation of clouds and rain in West Africa.

3.3 Effects of Drought in Northern Nigeria

Drought is not a recent phenomenon in Nigeria. Historical records and evidence indicate that drought induced famine occurred in different parts of Northern Nigeria in the year 1835 -37, 1847, 1855, 1863 -64, 1873, 1888 and 1889 -90. Although similar drought induced famines occurred in different parts of Southern Nigeria in the 19th century (Ayoade, 1988b).

According to the Annual Report on Northern Nigeria (see Hill, 1972) there was serious famine in 1903, caused by drought, which hit most parts of the country. Available records according to Aperdoorn (1981) indicate that rainfall was generally below average not only in 1903 but also in 1914. In fact, 1913 and 1914 were the worst years. Harvest was poor in 1918, 1920, and 1921 and in all the drought years mentioned above and there was mass migration to the southern parts of the country. Drought was also recorded in 1934 -35 especially in Nupeland and 1943 -46 in Hausaland and Yorubaland. The most widely documented is the famine of 1927 known as the year of scarcity and called "Mai Buhu" by the Hausa, hit Kano, Katsina and Western Kano (Apeldooorn, 1981). Rainfall was generally good all over the country in the fifties and sixties until the beginning of the 1970 when the rainfall progressively -decline, started in 1968 in several places but peaked in the 1972/73 period.

It was noted at the end of the United Nations Conference on Desertification held in Nairobi (1977) that more than 16 million people in sub-saharan Africa were in

areas undergoing severe desertification and by implication drought, and that 19% of this *were* urban based, 37% cropping based and 44% animal based. It was also observed that a total areas of 6,850,000 km2 was involved and that on the global scale, the process of desertification threatens 628 million people or 14% of the world's total population. Also, that between 50 and 78 million people living in arid and semi-arid lands are affected directly by decreases in productivity associated with the desertification and drought processes.

Oguntoyinbo and Richards (1978) examine the impact of 1968 -73 Sahelian drought on Nigerians, and their result showed that:

(a) output of groundnut in 1972/73 dropped below 5% of the 1968/69 production (see table I).

Table I: Estimates of groundnuts graded in the Northern States of Nigeria 1968/69 -1972/73

Year	Output (Tons)
1968/69	765,000
1969/70	660,000
1970/71	400,000
1971/72	250,000
1972/73	25,000

Source: Federal Office of Statistics, Lagos.

(b) that there is loss of livestock, reaching about 2Q% of the total in Sokoto in 1972/73 (See table 2); and 60% in Dagacheri village in North-Eastern Kano .State (Mortimore, 1981).

Table 2: Estimate of Livestock Mortality in the North-Western State 1972/73

Division	Cattle		Sheep & Goat		Horse and Donkey'	
	Population	Mortality	Population	Mortality	Population	Mortality
Sokoto	1,007,100	201,420	3,384,693	676,937	658,041	121,608
Argungu	147,270	29,454	263,769	52,744.	46,544	9,111
Gwandu	356,455	712,289	769,588	145,918	163,169	32,58.1
Total	1,510,825	302,163	4,378,050	875,599	867,854	16,300
Mortality	-	19.9	-	19.9	-	18.8

Source: Local Administration Estimate (Adapted from Oguntoyinbo 1982).

It should be emphasized that apart from crop failure and loss of livestock as well as mass emigration of people out of drought-prone areas, underground and surface water was also seriously affected. There was drastic lowering of water table in many places. The level of Lake Chad receded several metres during the drought episodes of 1968, 1972 and 73 periods. There was also considerable drop in the level of River Niger and Benue. The smaller rivers almost ceased to flow. This invariably affected river transportation on Benue and Niger. Also, the seasonally cultivable land called Fadama in the North especially in many parts of Sokoto, Borno and Kano States become uncultivable. All this and others are some of the affected of drought in Nigeria.

3.4 Control Measures

The role of man has to be re-examined. Control of human activities like over cultivation, felling of trees for fuel and overgrazing. It should be emphasized that drought is an indication that the carrying capacity has been exceeded. Hence, there is need to reduce the animal and human population within the area under pressure of human activities.

Since drought is a condition in which water need is ill excess of available moisture, one of the most effective ways of combating drought in Nigeria and West Africa therefore is by the provision of water through the use of boreholes and irrigation schemes. Unfortunately, provision of water through boreholes has not been effective because of the fact that most boreholes got dried up after a while and some left or abandoned uncompleted altogether. Aside from this, available data also indicate that the country is comparatively deficient in ground water resources than in surface water resources (Aycade and Oyebande, 1978). This comparative

deficiency of groundwater and surface water resources has been attributed to the fact that over half of the country is underlain by crystalline rocks of the basement complex which are generally poor acquirers. These basement complex rocks are neither porous nor permeable, except where they are deeply weathered or have zones of' weaknesses such as cleavages joints, fissures and shelterbelts (Ayoade and Oyebande, 1978). So for many successful borehole project therefore, the ability to locate successfully weathering zones or basin in a sine qua non. These zones occur in perched and discrete fashion in Nigeria.

On 15th June, 1976, the Federal Government established eleven river basin authorities, it was increased to nineteen in 1984 and later reduced to nine in 1986. Unfortunately in many of these schemes, there is completely lack of proper management of water resources (Udo, 1982).

Aside from this, there is the need for afforestation programme to restore and maintain vegetation cover and to stabilize and protect soils in denuded areas. Ojo (1987) argues that for this aim to be achieved, knowledge of the plants or tree in relation to a climate of an area must be studied and established before they are introduced. He observes that bad planning and inadequate knowledge of the environment, particularly, the hydro climatic characteristics is responsible for the failures of most afforestation programmes in Nigeria (and this is also common to other West African countries).

The possibility of inter-basin water transfer has been proposed (see Adeniyi and Gadzama, 1985). The problem with this option is that there is no part in Nigeria and even West Africa where the hydroclimatic characteristics show enough evidence of so much water that can be transferred from one part of the country to another. Desalination and weather modification strategy are expensive. Apart from this, the clouds suitable for seeding are virtually non-existent during drought periods in drought prone areas of Nigeria and other West Africa countries.

This paper believes that there is need for inter-disciplinary research on climatic hazards especially drought and desertification. Such climate research Institute should be able to predict and forecast drought. The rainfall characteristics or the drought prone areas should be carefully analysed, monitored and studied.

Research on drought prediction should be explored. The aim is to be able to forestall the adverse effects of severe droughts. A lot of methods has been tried or attempted in the past but none of the methods is without some criticisms. Statistical technique (e.g. correlation) has been one of the earliest techniques. The

shortcoming of this technique is the shortness of variable data needed to allow for reliable prediction (Eddy and Cooter, 1978).

According to Oguntoyinbo (1984) the use of periodicities of climatic phenomenon has been explored. But the problem with this approach has to do with the lack of physical theory which explains the suggested link between drought and, for example, sunspot cycles.

Moreover, the use of time-lagged tele-connections have predictive value because of the fact that they are overridden by other effects.
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Finally, Numerical General Circulation Models appear to offer man some level of optimism for the prediction of drought. The use of this technique has even been facilitated by the use of computer facilities. So we can say that each of the techniques discussed here is not devoid of criticism and so the search for a better and a more reliable drought prediction still continues. Agro-climatic research that will focus on the problem of fitting crops to climate adoption of drought resistant types of crops as well as proper faming practices with emphasis on moisture conservation should be established and professionals such as climatologist, meteorologist, hydrologist, ecologist or expert in other environmental related disciplines. Finally, the populace should be given environmental education so as to know the danger inherent in harming the environment.

4.0 CONCLUSION

In this unit, you have learnt what is meant by drought, and you should be able to explain the causes and soocio-economic implications of drought and the control measures.

5.0 SUMMARY

The unit has focused on drought, causes effects and control measures using Nigeria as a case study.

6.0 TUTOR MARKED ASSIGNMENTS

1. In your own words, define droughts.
2. Mention two consequences of droughts in Nigeria.
3. List two controlling measures of drought in Northern Nigeria.

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UNIT 9 ACID RAIN POLLUTION

CONTENTS

1.0 INTRODUCTION

This chapter is a continuation of our discussion on environmental problems. The course will discuss acid rain pollution in eastern and Western Europe and Scandinavian countries. It will also consider environmental Policy in Africa. Before we do this, let us have a view of what you should learn in this unit.

2.0 OBJECTIVES

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

- Give historical background to acid rain pollution in Europe
- Analyse the environmental and socio-economic implications of acid rain pollution
- Examine the implication for environmental policy in Africa.

3.1 Acid Rain Pollution

Before the landmark 1972 Stockholm Conference on Human Environment, all efforts by environmental campaigners and pressure group to draw the attention of the public and policy makers to the presence and persistence of environmental problems such as soil erosion, drought, deforestation, toxic waste dumps, declining

wildlife, ozone layer depletion, green house gases, air and water pollution, and more, had not yielded any result. In fact, these environmental problems were considered in the early 1960s and early 1970s as local issue of concern to the individual countries affected. Nobody saw any rationale or justification why an average British should care about dead forests in Germany? Or why an average Lagosian should care about acid rain in Sweden? Why should the average New Yorker care about clearance of tropical forests in the Amazon basin? Or why should the average Kenyan or Sri Lankan or Nigerian or Ghanian care about sulphurous smogs in Los Angeles or Athens? Is it not a problem of the developed world or the price the developed world should pay for development?

Today, it has been discovered that one can no longer dismiss these environmental problems so easily as local or of minority concern. The environment does not recognize political boundaries; it affects everybody irrespective of region, nation, class, age, sex, religion or political philosophy. It was after the 1972 Stockholm Conference that the issue of environmental problems became internationalized, and all the countries of the world are now made to look at the whole world as a system of a global village.

The acute problem of acid rain in Europe has become a major concern in recent time. More worrisome is the devastating effects on species and ecology of the areas affected. This paper derives its relevance from this premise that as Africa presses on in her development strides, it has become imperative that she has to learn from historical experiences elsewhere so as to ensure sustainable development. Europe, a developed region, provides ample opportunities from which Africa can learn to mirror her development along the path of sustainability while the negative consequences are avoided.

It is within this matrix that this paper has the major objectives of examining the consequences of acid rain pollution in Europe and its implication for environmental policy in Africa. The paper is in three parts: First, the paper examines the issue of acid rain pollution in Eastern and Western Europe, and Scandinavian countries; the second part identifies the control measures while the third part examines the implication of acid rain pollution on environmental policy in Africa.

Acid Rain Pollution in Eastern Europe

The former Soviet Union is the world's largest producer of sulphur oxide (S02)' The United Nations in 1987 published an annual emission of 11.1 million tones for 1985 (United Nation, 1987). In addition to domestic pollution, the former Soviet

Union is also assailed by $S0_2$ brought on South-Westerly winds from Poland, former East Germany, Czechoslovakia and Hungary. It receives an estimated five to ten times more pollutant than it sends out to her Western borders

Data on environmental deterioration of any kind in the former Soviet Union are variable, and Western assessments of Soviet acid pollution have to date had to rely largely on balancing official and unofficial reports.

Poland has about 8.6 million hectares (21.2 million acres) of forest, covering a quarter of the total land area. According to Engeniusz (1983) as cited in McComick (1990), about 6% of the forest (50,000 hectares/l.23 million acres) is thought to be damaged, and trees over an area of 200,000 hectares (500,000 acres) are thought to have through acid rain. Hungary, Bulgaria, Romania and former Yugoslavia also feel the effect of acid pollution. Bulgaria and Romania are the least industrialized countries in the Eastern bloc, but this has not spared them. An estimated 170,000 hectares (420,000 acres) of Romanian forest have been damaged by acid rain (McCormick, 1990). Forest damage has been reported in the former Yugoslavia too, but figures are very imprecise. According to Elsworth (1984) as cited in McCormick (1990), an estimated 450,000 hectares (1.1 million acres) of forest damage was recorded in 1984 in the former Yugoslavia.

Over half of Hungary's air pollution originates in neighbouring countries -primarily (West and East) Germany and Czechoslovakia. Conversely, more than 10% of Romania's SO_2 is Hungarian in origin. Hungary also sends out much of its annual SO_2 production of 1.2 million tones to Austria, Czechoslovakia and former Yugoslavia (United Nations 1987).

3.2 Acid Rain Pollution in Western Europe

The United Kingdom produces about 3.5 million tones of SO2 per year, making it the fourth biggest producer in the world (United Nations 1987). It also produces about 1.7 million tones of Nitrogen dioxides (NO2), making it one of the five biggest producers in the world (see table I and II for details). It derives 92% of its energy needs from fossil fuels and most of the balance from nuclear power. Most of the energy comes from coal -: fired stations, which are the major producers of 802. The acidity of United Kingdom rain varies from PH 4.7 -4.4 in the West to 4.3 -4.1 in the East (U.K. Review on acid rain, 1984). A 1987 survey research conducted by United Nations (1987) shows that 67% of the United Kingdom's conifers were suffering slight to severe damage, and 28.9% had moderate to severe damage due to acid rain.

Little research on acid rain has been investigated in Belgium and Denmark. About 70% of the forest cover is reportedly damaged in Belgium. In France, not less than 35,000 hectares of forest are affected, and damage to cultural heritage is very substantial as about 2,600 sculptures in Rheims Cathedral have lost their features (McCormick, 1990). In the case of Italy, he further observed that about 70% of its' emissions are re-deposited within its borders, thus, making acid rain a public issue. For example, lake acidification and forest damage have been reported in Northern Italy and around PO Valley.

Reports from Luxemberg show that 30% of mature trees have been damaged due to acid rain. In her own case, a survey of 70 lakes in 1982 in Netherlands found 56 acidified and 1.5% of the woodlands irreparably damaged. In Portugal, prospect of acid rain is greatest in the North because it has 75% of all the industries (McCormick, 1990).

Table I: Annual 802 emission (in thousand tones)

	Deposition (%)	**1980**	**1983 -1986 (Average)**
Former	USSR	25000	24000
	USA	23200	20800
	China	-	1800
	Poland	4.100	4.300
Former	East Germany	4.000	4.000
	Canada	4.650	3.727
	U.K	4.670	3.540
	Spain	3250	3.250
	Italy	3800	3150
	India	3200	-
	Czechoslovakia	3100	3050
Former	West Germany	3200	2400
	France	3558	1845
Former	Yugoslavia	1175	1800
	Hungary	1633	1420
	Bulgaria	1034	1140
	South Africa	1000	–
	Greece	800	720
	Belgiunl	799	467
	Finland	584	370
	Denmark	438	326

	Netherlands	487	315
	Portugal	266	305
	Turkey	-	276
	Sweden	483	272
	Austria	354	170
	Ireland	219	138
	Romania	200	-
	Norway	141	100
	Switzerland	126	63
	Luxembourg	23	13
EC	**Total**	**21510**	**16469**

World Total approx. 120 million tones in 1980

Source: United Nations, United National Strategies and Policies for air Pollution Abatement, New York, 1987.

Table II Annual NO2 emission (in thousand tones)

	Deposition (%)	**1980**	**1983 -1986 (Average)**
	United States	2300	19400
Former	West Germany	3100	2900
Former	USSR	2790	2930
	U.K.	1916	1690
	France	1867	1693
	Canada	1725	1785
	Italy	1550	1537
	Czechoslovakia	1204	1100
	Spain	-	1122
	Poland	-	840
	Netherlands	535	522
	Belgimn	442	385
	Sweden	328	305
	Hungary	-	300
	Finland	280	250
	Austria	216	216

Norway	-	215
Switzerland	196	187
Portugal	166	192
Bulgaria	-	150
Greece	127	150
Ireland	67	68
Luxembourg	23	22

No figure is available for former East Germany, Romania, Turkey, Yugoslavia.

Source: United Nations, United National Strategies and Policies for Air Pollution Abatement, New York, 1987.

3.3 Acid Rain Pollution in Scandinavian and other Western European Countries:

Swedish and Norwegian scientists were the first to successfully draw international attention to the problem of acid rain based on the research they undertook in the chemistry of acid pollution during the 1960s (McComick, 1989); and that was why these two countries campaigned vigorously during the 1970s and 1980s in order to win international attention and agreement on the control of acid pollution. The outcome of their campaigns led to the birth of the first United Nations' Conference on Human Environment held in Stockholm in 1972 and another one again in Stockholm in 1982.

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Sweden according to United Nations (1987) receives about 58% of its sulphur from abroad, (mainly from the United Kingdom, Belgium, the Netherlands, Germany, Poland and the former Soviet Union). This has affected Sweden 23 million hectares (57 million acres) of forest, and forest products which are Sweden's largest source of export earnings and for about 100,000 jobs (McComick, 1990). According to McCormick (1990) there were 18,000 acidified lakes in Sweden in 1982; and that in the winters of 1979 -80 and 1983, snow in the far north of these regions was acid, and sensitive waters were damaged; and that recent estimates show that 90,000 km of running waters have PH value low enough to cause ecological damage and finally, the annual cost of damage from acid groundwater has been estimated at $120 million.

In Norway, McCormick further argued that 63% of the sulphur dioxide (SO2) is brought through trans-boundary air flux; and domestic SO2 emission figure of 100,000 tonnes was produced in 1985.

Finland is the most heavily forested country in the world with about 70% (23 million hectares/57 million acres) of its land made up mainly of coniferous -forest. Forest products account for 53% of its export earnings and for more than 500,000 jobs. A survey research in 1984 revealed that out of 107 lakes investigated, half of them, mostly small forest lakes, were found to be either suffering from sever acidification or to having a low buffering capacity. In the case of Austria, about 16% (600,000 hectares or 1.48 million acres) of her .forest was reportedly damaged by acid rain and this is estimated to cause annual loss of$166 million in 1985 (McConilick, 1990).

In Switzerland, a study in 1983 shows that a quarter of its first and 10% of the spruces died, while 8 -14% of Swiss forests were thought to be damaged. Also, a survey of 27,000 trees in mid 1984 by the Swiss Forestry Research Institute revealed that one-third of Swiss trees were damaged and 8% critically damaged or dying (McCormick, 1990).

Control Measures

One of the control measure being adopted is the reduction in amount of SO_2 and NO_2 emission by individual countries. In pursuance of this measure, McCormick (1990) identified a number of Conferences, treaties and agreement that have been initiated, some of which are enumerated below:

The United Nations Conference on the Human Environment held on Stockholm in 1972 discussed the issue of trans-boundary air pollution. Sweden at the Conference was very vociferous in its campaign because the increasing acidity of her territory was caused by pollutants from neighbouring countries. One of the achievement of the conference was the acceptance of the principle 2l of the Declaration of the Stockholm Conference which pointed out that States have an obligation to ensure that activities carried out in one country do not cause environmental damage in other countries, or the global common.

(ii) The Convention on large Range Trans-boundary Air Pollution signed in Geneva in November, 1979 by thirty five countries was the first environmental agreement ,involving all the nations of the East and West of Europe and North America. A resolution was adopted at Geneva requesting signatories 'to start implementing the provisions of the Convention on a

voluntary base, starting with sulphur emission, until the time the Convention could enter into force.

(iii) The Conference on the Acidification of the Environment held in Stockholm in June, 1982 was a response to the lukewarm attitude to the earlier Conventions by some of the Europe's biggest polluters, and the prevailing lack of public awareness about acid pollution.. The Stockholm Conference had one major effect; the process of ratifying the Convention was speeded up, and within months, all the European countries (EC) had ratified and the Convention came into force in early 1983. Another substantive was the Nordic proposal for a mutual 30% reduction of S02 emissions in the ten years from 1983 to 1993, calculated from emission levels in 1990.

(iv) The Ottawa Conference held in March 1984, where members from ten of the countries that supported the Nordic concept of a 30% reduction in 802 met to sign their own agreement. It was this Ottawa Convention that witnessed the birth of what is known today among environmentalists as the "30% Club". One major success of the Ottawa Conference was that it puts N02 emissions for the first time on the international agenda.

(v) The Multilateral Conference on the Environment held in Munich from 24 to 27 June, with the partial aim of encouraging more countries to join the 30% club; especially the East European countries.

(vi) The Helsinki Conference of the East European of July, 1985 binds its members to a 30% reduction of SO_2 at source by 1993 based on 1980 levels. (The same terms as the 30% club).

(vii) The International Conference on Acidification and its Policy Implications held in Amsterdam in May 1986 took up the call made Helsinki for accelerated research on N02. The Conference allowed countries to choose any year as the baseline provided they carried trans-boundary flows at 1987 levels within ten years. At a meeting in Sofia in November, 1988, 25 countries finally signed the protocol. The Agreement on the protocol marked an important new step in progress towards solving acid pollution.

(viii) The 'Rio 92' popularly called the Earth Summit also made provision for the cutting of S02 and N02.

3.5 Implications for Environmental Policy in Africa

Industrialization and acid rain pollution are twin brothers that always go together; and that is why many people believe that the problem of, acid rain pollution is an European and North American problem. This paper is of the view that this is not so as there are growing speculations of acid rain pollution in many parts of Africa.

Although it should be stated that as at present, there is no empirical or scientific evidence to prove the substantial existence of acid rain pollution in Africa, nonetheless, there are growing indications from oral reports of dying crops and forest, and the ,existence of acidified water bodies in the oil mineral producing communities of Nigeria (Ologunoris, 1996). As at present, we have little or no information on how much sulphur dioxides (SO_2) and nitrogen dioxides (NO_2) being generated in most African cities or environment. Only cases of oil spillage ~ (see Odu, 1977; Ikporukpo, 1983, 1986, among others) and environmental implication of gas flaring has been reported in the literature (Datubo -Brown and Kejeh, 1989; Egbuna, 1987; Obioma, 1985 and Ologunorisa, 1996, 1995); and the totality of such environmental damage has informed the Ogoni uprising (see Saro-Wiwa, 1992) and other pocket of civil disturbances in the oil producing communities of Nigeria, which have accused the Nigerian government of genocide. The issue of genocide is the argument that the pollution of the environment results in irreparable damage to the means of livelihood (soils and rivers/creeks) of the people. Consequent on this, there may come a time when life cannot be sustained in the area (Ikporukpo, 1993). Even though the destruction of life and property is also another dimension (see Human Rights Watch/Africa, 1995). Data on the rate of production of industrial pollutants such as 802 and N02 for African cities or countries are not readily available.

Despite this, it can still be said that most African Countries including Nigeria have a sound legislative and regulatory framework for controlling industrial pollution. What are left to be done are the monitoring and the strict enforcement of the regulations (Faboye, 1997). Industrial pollution control in Nigeria for instance, is under the Federal Environmental Protection Agency (FEPA) which the former government of Olusegun Obasanjo converted to the Ministry of Environment. This Ministry is charged with the task of keeping track of all industries in the country, establishing the volume and types of waste generated by each industry and monitoring their waste disposal cultures. According to a World Bank Report published in 1993, there were about 3000 industries in Nigeria, with 85% of them being small scale. The 1993 report further pointed out that over 80% of the industries discharge solid, liquid and gaseous effluents directly into the

environment without prior treatment, 80% of these industries are based in four states -Lagos, Rivers, Kano and Kaduna (Faboya, 1987).

There is now growing evidence that while consumption of energy seems to be stabilizing in the industrialized countries, its rate of growth is very rapid in developing nations. For example, in 1988, energy use increased by about 1 % in Western Europe, 3 % in Latin America, 4.1 % in Africa, and more than 11 % in the Industrializing countries of South East Asia. There is indeed a growing concern that the rapid growth in consumption of oil in some African countries is both economically and ecological unsustainable and thus the need for conservation and for finding alternative sources of energy (Salau, 1990).

The potential pollution zones in Africa and by implication acid deposits include Libya, Algeria, South Africa, Cameroon, Nigeria, Egypt, Zimbabwe, Congo, Mauritania and Zaire. Some of these countries are major producers of fossil fuel and fossil fuel combustion is the primary cause of acid deposition and pollution, with coal accounting for the release of more sulphur dioxide and aside from the above environmental policy recommendations. In African Continent, evidence of growing environmental awareness has been manifested through the Cairo Plan (or the African Ministerial Conference on the Environment, (AMCEN) started in 1985. It has become a major forum for cooperation among African nations on matters affecting the environment (Baba, 1994). To achieve its goal, AMCEN has put in place its own institutional outfit, or network structures, including Regional Coordination Units (RCUS) and six centres for Environmental Education and Training Network (ETNET) of which two are in Nigeria, at Obafemi Awolowo University, Ile Ife, and the Federal University of Technology, Minna. The purpose of ETNET is to create and develop centres of excellence in environmental training for all categories of decision makers and practitioners.

3.6 Conclusion

The conclusion that can be drawn from this study is that there is a need tor Africa to evolve a sound environmental policy that is development sustainable if she is not to pay the price the developed countries and other European countries are paying today in terms of acid rain pollution, air, land, water pollution and solid waste, industrial waste and all other forms of environmental degradation and biodiversity loss.

Also, the fact that the rate of energy consumption (fossil file I) in Africa is on the increase is a pointer that African countries are potential zone for acid rain pollution

and she must therefore brace up to protect her lakes, rivers and l1Ch continental shelves from being acidified, forest from decay and soil from acidity.

In view of this growing fossil fuel combustion in African cities and environment, there is therefore the urgent need to formulate effective environmental policy for solving air, water and land pollution and all other forms of environmental degradation issues in Africa. Such environmental policy on African environment, to be sustainable, should be based on the following among others:

- Strict enforcem.ent of Environmental Impact Assessment (EIA) In the planning of Industrial Policy);
- Religious adherence to the practice of regular conduct of environmental audits of company activities.
- Strict compliance with the standards for pollution emissions based on the best available technology.
- Monitoring stations for industrial pollutants especially CO2, SO2 and NO2; so that reduction value could be advocated.
- Adopt and implement an ecological approach to human settlements planning;
- Identify hazardous industries, and locate and operate them with stringent safeguards;
- Commit every business or industry to environmental sustainability;
- Reduce the use of fossil fuels, wastage in distribution, and pollution from commercial energy generation.
- Publicity campaigns towards energy conservation should be undertaken;
- The need to introduce (a) the polluter pays principles (b) the users pays principle; and (c) the precautionary principle.
- The waste of natural gas through gas flaring during oil extraction should stop or be discouraged;
- The development of alternative source of energy that is pollutant free (relatively speaking) should be encouraged e.g. promotion of solar energy development; and hydropower after EIA.
- Finally the need for the establishment of Environmental Protection Agencies in each African State to monitor the environment; and the Agencies should also draw the attention of the population especially importers and users of industrial, agricultural and ozone depleting chemicals to the requirements of international treaties, protocols and guidelines to which most African Countries is a party. (Nigeria through Federal Environmental Protection Agency, FEP A is already doing this).

- There is also the need to regard the environment as a common property, and the need for legitimate mechanism for collective decision-making through which an individual or a community can enforce its rights.

4.0 CONCLUSION

In this unit, you have learnt what is meant by acid rain pollution and you should be able to explain the environmental and socio-economic implications of acid rain pollution in Europe and Scandinavian countries.

5.0 SUMMARY

This unit has focused on acid rain pollution in Europe and Scandinavian countries as well as the policy implications for environmental management in Africa.

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UNIT 10 CLIMATE CHANGE AND ENVIRONMENTAL IMPLICATION

CONTENTS

1.0 INTRODUCTION

Now that you have gone through this guide, you should have ac a general overview of what this unit is all about, and how i1 specifically to the course. This unit will help you acquire understanding of the meaning of climate change and its environmental implications. Before we do this, let us have a view of what should learn in this unit, as indicated in the unit objectives below

2.0 OBJECTIVES

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

- Define the term "Climate" and "Climate Change"
- Tell how climate varies over the ages
- Understand variability of climate over time
- Identify the role of man in climate change
- Know the implication of the present global warming.

3.0 MAIN CONTENT

3.1 Meaning of Climate and Climate Change

The term "Climate" can be defined as a synthesis or an amalgam weather. In other words, it is the mean expectation of weather given period over a location or area. It can also be regarded statistical abstraction of actual weather experienced in an area long period of time. This is why man sees climate as the average weather condition. This notion of climate is not strictly correct is because climate includes not only the average conditions but the study of weather extremes and deviations from those a conditions and the probability of occurrence or re-occurrence particular weather event (Ayoade, 1988). The changeability weather is a common phenomenon; this is because weather Variation occur frequently, often on a time scale of a few hours. Climate variations are not a common occurrence because they occur they occur much less frequently on a time scale of several years or hundreds of years. Climate is a variable phenomenon with variations occurring on varying time scales. And that is why various terms are use describe variations or fluctuations in climate and these are valid reference to some appropriate time scales at which the variations or fluctuations are considered.

The term "climatic variability", "variations" and "climate fluctuations" are used to express the inherent variability of c Climate is not fixed or static but rather dynamic and cha Climatic trends occur only when fluctuations or variations in (follow a trend over a period of time. The fluctuation may 2 cyclical in nature to give rise to climatic cycles. Over a long period time, climatic fluctuations may be such that a shift in type of climate over a given area occurs; we then say there is a change or climate change.

3.2 Climate Through the Ages

Although the earth is estimated to be over 4 billion years 0 study of past climate, which is called Paleoclimatology extends only to 500 -600 million years before present. Table 10.1 summarizes variations in global climate from the pre-Cambrian era to the present.

Not much about past climate could be studied during this era. This is because pre-Gambrian rocks hardly contain an evidence of past climate. Instrumental observations of weather began less than 200 years with the invention of the thermometer in 1593 by Galileo the Mercury Barometer in 1943 by Toricelli (Oguntoyinbo, 1982) Our knowledge of past climate dating to pre-instrumental

period is therefore based on the imprints of the climate in those periods on the landscape, soil, vegetation and later on, human activities.

TABLE 10.1: Summary of Paleoclimatic History of the Earth

Era	Period	Age by radio-activity in Million Years	Climate
Pre-Cambrian		560	Glacial
Paleozoic	Cambrian	510	Cold" becoming warm
	Ordovician	400	Moderate to warn
	Silurian	340	Warn
	Devonian	310-340	Moderate becoming warm
	Carboniferous	260-300	Warm at first becoming warn
	Permian	210'- 240	Glacial at first becoming moderate
Mesozoic	Triassic	190	Warm and equable
	Jurassic	155	Warm and equable
	Cretaceous	110	Moderate
Tertiary	Eocene		Moderate becoming warm
	Oligocene	60	Moderate to warn
	Miocene	30	Moderate
	Pilocene	13	Cool
Quaternary	Pleistocene	1	Sequence of glacial and interglacial period
	Holocene		Present inter- glacial 12,000 to 10,000 years before present and reached climatic optimum about 5,000 years before present mild climate 800-1000 A.D. Worldwide warming of about 0.60C from 1880’s to 1940’s, relative cooling with several trend reversal since, then. Warming since 1980’s.

Source: (Modified after Brooks, 1949)

The details of these indications of past climates as given by *A* (1988) include.:

A. Biological Indicators
   i. Pollen
   ii. Fossils
   iii. Tree rings

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B. Lithogenetic Indicators
   i. Varves
   ii. Salt deposits or evaporates
   iii. Laterites

C. Morphological Indicators
   i. relic Landforms -old beaches and sand and glacial landforms such as moraines and eskers.
   ii. River terraces

D. Archeological/Documentary Indicators
   i. Artifacts
   ii. Cave draining
   iii. Evidence of large scale migration
   iv. Abandonment of settlements
   v. Records of famines.

The summary of variations in global climate given in Table based on various studies of the Paleoclimates in various parts world using a variety of indicators of past climate. These studies show that the global climate has oscillated between cold (glacial) and warm (non-glacial) phases since the Pre-Bambrian era. oscillation according to Ayoade (1994) has been on varying scales with the larger time scale ones affecting larger areas globe than the smaller time scale oscillations. Apart from the ice ages during the Pre-Cambrian 560 million years ago, there a Permian ice age, this occurred 210-240 million years ago, a Pleistocene ice age, which occurred less than a million yea] Significant ice ages have occurred every 100,000 years termination period of 10,000 years. Minor ones have occurred over 20 to 30,000 years. The last period from 7,000 to 5,000 years have been characterized by declining temperatures with very cold in some 28,000 and 350 years ago. The latter cold interval between 1550 and l850AD has been referred to as the little ice age. this period vineyards disappeared from England and European

glaciers grew. It is generally believed that we are at present] through an interglacial period. Since the advent of instrumental records, data have indicated a warming trend in the N Hemisphere from the 1880's to the 1940's and a warming trend early 1950s in the southern Hemisphere.

The warming trend in the Northern hemisphere terminate in the 1940's when cooling set in, but this cooling has been reversed part since the 1970's. Studies have shown that since the ad' instrumental records, a serried of drought has been recorded in parts of the world. In West Africa, for instance, major d occurred in 1913-14,1943-46,1972-74,1982-83 and 1987. Severe drought were experienced in the United States in 1993 -94, in the 1930's and in 1975. The major cause of drought in this part tropics and indeed elsewhere, is the failure of the seasonal monsoon rains. The floods on the other hand are caused by cyclones. Bryson (1975) summarized the lessons of climatic history as follows:

(i) Climate is not fixed.

(ii) Climate tend to change rapidly using geologic time scale rather than gradually;

(iii) Cultural changes usually accompany climatic changes; normal in the longer perspective of centuries.

(iv) When the high latitudes cool, the tropical monsoons tend to fail

(v) Cool periods of the earth's history are periods of greater than normal climatic instability.

3.3 Variability of Climate Over Time

In order to understand why climate varies, we have to examine mechanisms that give rise to climate. Climate depends on the general circulation of the atmosphere, which is determined by a complexity of factors and processes that constitute the global c system. The global climatic system according to Ayoade 1988, 1993), includes the atmosphere, the hydrosphere (water biosphere (Living organisms), the lithosphere (land) an cryosphere (ice and snow) and they interact with one another influence of solar energy. He observed that the climatic sta1 place at any given period is determined by three crucial factors are:

(vi) The amount of solar energy received by the climatic s which depends on the solar output, the extent of radiation in space before reaching the earth's atmosphere, the dist, the earth from the sun and the angle of tilt of the earth's rotation.

(vii) The way this energy is distributed and absorbed over the surface, which depends on the earth's atmospheric composition, its topography, extent of ice and snow cover and distribution of continents and oceans.
(viii) The nature of the interaction processes between the comp making up the global climatic system.

3.4 The Role of Man in Climate Change

All the theories of climate change attempt to account for variations the amount of solar energy received by the earth and the spatial temporal distribution of this energy over time. In the la: decades, research findings have indicated that man can influence climate through various activities. The causes of climatic variation ascribed to human activities are:

(i) Increase in the CO2 content of the atmosphere as are; bush burning and burning of fossil fuels such as coal, g. especially in urban areas;
(ii) Artificial generation of heat as a result of human ac1 especially in urban areas:
(i) Interference with the ozone layer by pollution deriving human activities; (See Table 2).
(iv) Alteration in the earth's albedo as a result of deforestation, land clearing for cultivation or construction and animal grazing.

The most important pollutants as far as climate modification concerned are CO2, fluorocarbons, sulfur compounds and dust (aerosols). Other causes of atmospheric pollution apart from industrialization and urbanization are bush burning and deforestation. Man estimates the CO2 content of the atmosphere to have increased by 11% from 294 ppm in 1870 to 321 ppm in 1970 owing to the b of fossil fuels. It is estimated that by 2,000 A.D. the CO2 atmosphere will be 370 ppm. It is believed that the increase have been more were it not for the removal of CO2 fro atmosphere by the biosphere and hydrosphere. If all things I equal, CO2 will raise global temperature because it absorbs and reemits radiation from the earth and the atmosphere.

Table 10.2: Man's Impact on Climate

Elements	Comparison with Rural Environs
Dust Particles	10 times more
S02	5 times more
CO2	10 times more
Radiation	15 or 20% less
Sunshine Duration	5 to 15%
Cloud Cover	5 -10% more
Fog	30 to 100% more
Precipitation	5 to 1 0% more
Temperature	0.5 -1.0 degree cent more
Relative Humidity	6% less
Wind Speed	20 -30% less

Source: (after Landsberg, 1970)

Aerosols have a cooling effect on the temperature of the lower atmosphere. Aerosols are known to counteract or model warming effect of CO2. This is probably one of the reasons, observed global warming of about 0.6°C between the 1880s early 1940s was followed by a net cooling of 0.2 to 0.3°C 1: presumably as a result of increases in man-made particulate (Ayoade, 1993); another atmospheric constituent whose concentration can be influenced by human activities in ozone. Ozone is mainly between 30 and 60 km from the earth's surface but concentrated mainly between 15 and 35km in the atmosphere. is a tri-atomic form of oxygen (0_3), highly unstable and formed under the influence of ultra-violet radiation, and during thi oxygen molecules break up and the separated atoms indiv combine with other oxygen molecules as follows:

O_2 + Ultraviolet rays $\longrightarrow$ 0 + 0
Then, 0 + O_2 $\longrightarrow$ 03

Once formed, ozone itself is unstable and may be destroyed action *of* radiation on it or by collision with monatomic oxygen recreate oxygen (Oz) as follows:

$0_3 + 0 \longrightarrow O_2 + O_2$

Ozone performs two important functions in the atmosphere. I absorbs ultraviolet radiation harmful to living things including Second, it plays some role in the energy balance of the atmosphere and so can influence climate. Man can damage the Ozone I, two ways. First, is through the production of fluorocarbons 1 refrigerants, and aerosol propellants. Second, is through nitrogen oxides produced form exhaust of high flying aircraft (SST) and perhaps from fertilizers. When fluorocarbon (also kilo' chlorofluoromethanes e.g. CCI3F and CCI2F2) reach the stratosphere the absorption of ultraviolet radiation causes the molecules t chlorine atoms (CI) which then react with ozone (0_3) as follows to produce chlorine oxide and oxygen.

$$CI + 0_3 \longrightarrow Clo + O_2$$

The chlorine oxide (Clo) in turn reacts with atomic oxygen (O) to regenerate chlorine atom (CI) and oxygen as follows:

$$Clo + 0 \longrightarrow CI + O_2$$

The regenerated chlorine atom then reacts with another molecule and the destruction of ozone continues. The chlorine atom (Cl) thus acts as a catalyst which in itself unchanged at the end reaction. Ozone may also be destroyed by nitrogen oxides. Nitrogen oxides are produced by chemical reactions from natural Sources as well as man-made sources such as atomic bombs and exhaust (flying aircraft. Nitrogen oxides notably nitrous oxide (N_2O) are produced by bacterial activity on nitrogen fertilizer. When the: oxide gets to the stratosphere, it is converted to nitric oxide (NO) by reaction with ultraviolet radiation. The nitric oxide reacts with to produce nitrogen oxide and molecular oxygen as follows:

$$NO + O_3 \longrightarrow NO_2 + O_2$$

A molecule of nitrogen dioxide then reacts with a free oxygen a regenerate a molecule of nitric oxide and molecular oxygen follows:

$$NO_2 + O_2 \qquad NO + O_2$$

The regenerated nitric oxide (NO) is available to react with a ozone molecule and the process of ozone destruction continues. It should be noted that the reaction of ozone with chlorine atom re from fluorocarbons is six times more rapid than that involving oxide. So most efforts at conserving the ozone layer has been area of reducing the amount of fluorocarbons released in atmosphere. The major climatic

effect of depleting the ozone layer to raise the earth's temperature and consequently bring about warming. It is believed that such global warming will cause:

(a) More violent storms in the tropics
(b) A shift in climatic belts, and
(c) Melting of polar ice and glaciers and a rise in sea It

3.5 Implication of the Present Global Warming

Variations in climate will no doubt have planning implications Appropriate long term planning must be put in place to enable man live successfully within the limit of his variable climatic res. Ayoade (1993) illustrated this scenario with a few example argued that if there is cooling on a large scale, decreased agric length of the growing season would result, similarly, there would be increased space heating and consequently greater demands in generation activities. New strains of crops and animals may t be developed to withstand the harsher climatic conditions. Cooling will also affect precipitation adversely particularly in the tropic the monsoons tend to fail when there is cooling. Prolong and intense cooling may lead to a fall in the level of rainfall t moisture withdrawn from the sea is not returned but locked up as ice on the land. Polar ice will therefore increase. Many of the present port cities may become hinterland cities as the sea retreats. On the other hand, global warming may result in melting of polar glaciers with consequent increase in sea level and the submergence of coastlands. The growing season in the temperate region will increase.

UNIT 11 FLOODS

CONTENTS

1.0 INTRODUCTION

You have just gone through this guide, and you should have acquire a general overview of what this unit is all about, and how it link: specifically to the course. This unit will help you understand the meaning of floods, causes, beneficial and negative effects and mitigation strategies. Before we do this, let us have a view of what you should learn in this unit, as indicated in the unit objective below:

2.0 OBJECTIVES

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

- Define floods
- Identify the types of floods
- Mention the benefits and negative effects of floods
- Understand the flood mitigation strategies

3.0 MAIN CONTENT

3.1 Floods

In everyday usage and in the ordinary hydrologic literature, a flood is referred to as "any relatively high flow that over-tops the natural or artificial banks in any reach of stream" (Chow, 1964). It is also regarded as "an overflow or inundation that comes from a river or other body of water and causes or threatens damage" (Leopold an Maddock, 1954; Alli, (1979) or simply a "deluge or inundation (Wright, 1978).

Floods can also be defined as the highest value of the stage or discharge of a stream during the water year (Gumbel, 1941; Cicioni et al, (1972). This common view implies the distinction between floods of the same magnitude, but there might exist several different inundations in a year, the greatest one will be a flood but a flood need not be an inundation, even a dry year has a flood (Gumbel, 1941).

It is necessary to state here that these definitions do not contradict themselves. The latter is necessary only because of the technical exigency of including at least one flood for every year in the computation of flood magnitudes and their probable frequencies of occurrence.

3.2 Types of Floods

Floods have been divided into: River Floods and Coastal Floods (Chow, 1964).

River Floods: are caused by precipitation acting either directly by rainfall, or indirectly by snow or ice melt, and those resulting fofll1 dam collapse and earthslides (Ward, 1978). Floods resulting from melting of snow or ice, with or without an additional increment from rainfall, are a major component of the hydrological region in the high latitude areas of Canada, the United States and Russia, and parts of Europe and at high altitudes in the major mountain areas of Europe and Asia (Ward, 1978). Such floods normally occur only once a year.

In view of the markedly varying flood response to different rainfall conditions, many attempts have been made to classify rainfall floods on the basis of the storm event itself. Thus, Ward (1978) recognized two types of river floods related to different causal factors:

(i) Flash Floods, and (ii) Long Rain Floods. Flash floods are often the results of convection storms; while long rain floods are associated with the several days or even weeks of low intensity rainfall and are the most common cause of major flooding.

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Ward (1978) studied the characteristics of long rainfall floods, and on that basis identified four types. These are: "flash floods" of few hours duration; "Single event floods" of longer duration; "Multiple event floods; and finally, "Seasonal floods" which are often simply an extended form of multiple event floods. It should be noted that apart from the four discussed above, another type called "flood pondages" occur on surface depression on urban and other surfaces (Omuta, 1988).

Coastal Floods

They are of three kinds:

(i) those caused by meteorological disturbances such as hurricanes and other disturbances at sea (typhoons, cyclones, tsunamis, etc.).

(ii) those caused by seismic disturbance such as submarine earthquakes, landslides and other disturbances of the sea (Langbein, 1978).

(iii) Lakeshore floods (Hewitt and Burton, 1971)

The combination of these different types of floods accounts for 40% of the world's natural disasters. Earthquakes cause 15 per cent of natural disasters but are over-estimated while droughts are under-estimated probably because it is a non-event (Burton et al, 1978). Apart from the high frequency of flood occurrence, most of the world's population and property are located on lands subject to the overflow of rivers or seas. For example, flood prone lands comprise about 5% of .the area of the United States, more than 10 per cent of the Hwang Ho Basin in China, almost al the Netherlands and nearly all of the Southern part of Vietnam (Langbein, 1978). There is therefore an imperative need for a proper and comprehensive understanding of floods if the safety of flood plain occupancy and coastal areas are to be guaranteed.

3.3 Causes of Floods

Wisler and Brater (1959) have discussed seventeen factors which ma) influence runoff and hence floods in any stream. These they divided under three broad categories viz: climatic factors such as precipitation interception and evaporation; physiographic factors including basil characteristics and physical factors; and channel characteristics including types and efficiency. These factors are in

complete agreement with those discusses in detail by Ward (1968). The most exhaustive list is however that Chow (1964). According to him runoff, and by extension floods, may be affected by:

(i) Climatic factors, these include: (a) precipitation form: such as rain (rainstorm floods), snow (snow melt floods), floods due to ice jams, floods due to glaciers, floods due to earth-slides, types of precipitation, intensity, duration, time distribution, area distribution, frequency of occurrence, direction of storm movement, antecedent precipitation and soil moisture.

(b) Interception: vegetation species, composition, age and density of stands, season of the year, size of storm.

(c) Evaporation and

(d) Transpiration

(2) **Physiographic factors which include:**

(a) Basin characteristics such as size, shape, slope, orientation, elevation, stream density.

(b) Physical factors such as land use and land cover, surface infiltration condition, soil type, geological conditions such as the permeability and capacity of ground water formation.

(c) Topographic factors such as the presence of lakes and swamps

(d) Artificial drainage

3. Channel Characteristics including:

(i) Carrying capacity such as size and shape of cross sections shape, roughness, length, tributaries, types and efficiency.

(ii) Storage capacity such as breakwater effects.

The effects of all these factors are fairly accurately known except for the effect of lance use. Wisler and Brater (1959) contend, f01 instance, that of all the many physiographic factors that affect the runoff of any area, one of the most important is land use and land management. Ward (1967) agrees completely that "it is largely the human that apparently increased severity of flood during recent times: Langbein (1978) asserts, however, that the effects of all these factors (land use) are small and in themselves along insufficient". He has the backing of Waltham (1978) who concludes the discussion of the Hwang Ho basin floods by saying that floods will always occur with or without the presence of man. .

Few scholars have discussed the causes of the most dangerous floods of all. That is the coastal floods. Coastal floods are the most dangerous because they almost always result in compound hazards (Hewitt and Burton, 1971). A hurricane for instance causes damage by the direct action of wind on property, by the accompanying heavy rainfall that causes rivers to flood. Hence, the damage is from three sources, each potentially destructive in its own right, collectively, they are catastrophic.

Floods may also be caused by the encroachment of hydraulic structures and cities on floodplains and coastal lands (Darling, 1959): and by blocking of river channels. The Ogunpa river flood in Ibadan on August 30, 1980 for instance was wholly due to the blocking of the river channel with waste deposited by the residents of Ibadan Eventually, it was as if the river "decided" that it had created the channel and should therefore have the "right of way". The entire channel was cleared in one swift flood along with over 200 residential buildings, over 200 lives and inestimable property (Oyo State Diary of Events, 1981).

3.4 Beneficial Effects of Floods

Of all the extreme events, none is more paradoxical than floods. This is because it is the most frequently occurring natural hazard that causes the greatest damage as well as the most beneficial effect. It is probably safe to attribute the rise and growth of the early civilizations to the occurrence of floods. Civilization hereunder used loosely refers to the period when man settled and embarked on cultivation of agriculture. Naturally, these early settlements (later to be the foci of civilization), thrived along the valleys and floodplains of the Nile Tigris, Euphrates, Indus and Hwang Ho (Langbein, 1978).

All these rivers have over the years built expensive and ferti1 floodplains that were ideally suited to tiling with the crud instruments possessed by the early man. Hence, Tarhule (1988) ha observed, "since the beginning of recorded history and probably predating that, man has always had an infinity for floodplains an riversides". This is because there is lack of road and rail network: and hence, greater affinity for rivers and ports affinity.

Perhaps, the best example of the benefits of floods and floodplains presented by the river Nile and its valley. The River Nile fed on its upper course by heavy tropical rainfall and from the Blue and White Nile Floods between June and September in its lower reaches. It covers and fertilizes large area of land. This resulted in the early occupancy and subsequent rise of civilization, in the Nile

valley. The Nile Valley indeed has been a human anthill since very ancient time (Tarhule, 1990). Today, the Nile Valley with about 900 persons per square kilometer is one of the most densely settled parts in the African Continent. Farming is so completely reliant on flooding that to ensure that the River Floods, the river channel is artificially narrowed in some stretches by the construction of levees. These hold back the excess flood water after the floods has receded. This dependence has given rise to such popular saying like "Egypt is the Nile and the Nile is Egypt". "No Nile, no Egypt" and the Nile gives life to the Egyptian desert. (Burton, et al, 1989). Burton et al (1978) also found that some farmers along the lower zones of floodplains have adopted their crop pattern to annual overflow and they would be disappointed if flooding were to fail. Here then are examples where floods are not only beneficial, but also desirably necessary for the sustenance of life Other examples of floodplains giving rise to civilizations are the earl) West African Empires of Ghana, Mali and Songhai whose most value possessions were the floodplains formed by the Colonization of the River around the region of present day Bamako. The Nok cultures also developed on the floodplains of the Niger.
Today, the Gang Delta and the Hwang Ho floodplains are some of the most densely settled parts of the world while valuable forest resources continue to be harvested on the Amazon floodplains.

The sites on riverbanks have always been attractive locations for towns because they act as a focus of routes at bridging points. Town tended to develop first on bluffs or terraces close to the river. Consequent expansion forces them to spread out on the floodplains, e.g. London, Paris and Washington D. C. In Nigeria, examples of such towns include Makurdi, Jebba, Lokoja and Onitsha.

Floods may also have other beneficial uses if they can be properly controlled and managed. The excess floodwater, for instance, may be held in reservoirs and used to provide water for homes and' industry in the dry season and generate hydro-electric power. For example, the Naser dam in Egypt and the Hydro-Electric Power works at the Kainji Dam in Nigeria rely on high floodwater to be efficient. The floodwater may also be used to reduce stream pollution and provide opportunity for fishing and recreation, and agricultural expansion schemes.

3.5 Negative Effects of Floods

Flood has been known to cause damage to lives, landed property household property, business, traffic, drains and surface and underground water (Ward, 1987). For an in-depth comprehension 0 flood effects, it is preferable to review a few

catastrophic floods. The causes of floods are essentially the same, differentiated only it magnitude and the diversity of the victims (especially in their nature and response capability).

On August 31, 1980, the Ogunpa River flowing through the city 0 Ibadan overflowed its banks and all features encroaching on it floodplains. Over 2000 persons perished in that flood (Oyo State Year Book, 1981, p2). The series of floods which hit the city of Kano between August 6 and 13, 1986 culminating in the collapse of he Baguda dam estimated to have claimed a total of over 100 lives.

No discussion of the loss of lives will be complete without mention of the Hwang Ho River (translated from Chinese to mean "Yellow River"). This amazing river is responsible for more human deaths than any other individual feature of the world's surface (Langbein, 1978; Walthan, 1978). In 1887, a massive flood on this .river killed over 2 million people (by drowning or starvation). In 1931, the wors1 flood ever claimed a total death toll of 3,700,000 people (Waltham: 1978). Hence, within a time span of only 44 years, the Yellow River had depleted the Chinese population of by million people or more~ which is about the population of the entire Niger Delta. No wonder then, that the river is more popularly referred to as "Chinese Sorrow".

In 1970, a cyclone initiated a flood in the coastal areas surrounding the Bay of Bengal in Bangladesh which killed about 225,000 people crops worth about 63 million dollars were destroyed and 280,000 herds of cattle were washed away (Burton et al, 1978). These weather events ranged from hurricane in the Americans to heavy rains resulting in flash floods an avalanches in other parts of the globe India had the worst disasters with 3,320 dead avalanches followed b) China (2500 dead) arising from rain floods, typhoons and snows Nigeria (14) and Republic of Benin (7), the two African countries listed ranked low not necessarily due to the mild nature of rainstorm which did the havoc but more to lack of networking system through which reliable records can be compiled.

WMO (1997) has confirmed that the 1995 figures were very close to 8,300. The number of countries which reported weather-related deaths was also similar -44 in 1996 and 42 in 1995. It is important to note that the largest fatalities are associated with floods resulting from rain. The most largest fatalities are associated with floods resulting from rain. The most striking feature of these severe rain events is the amount per day which in India was about 12,00mmd-l for 12 consecutive days in August 1996). In the case of China, lives 10s1 within demolished houses have

not been fully accounted tor but abou1 2 million houses collapsed and 2,000 boats sank. (Adefolalu, 2000).

Adefolalu (2000) further observes that the "story" in other parts of the world was not different, as most fatalities had to do with flooding arising from heavy rains. The case of United States of .America deserves special mention if only to highlight that the low number of deaths (292) was not as a result of mild storms, snowstorms, or weak hurricanes and tornadoes but to the efficiency and high level of sophistication of early warning system (EWS) and the accuracy of the NEW-CASTING Techniques which connect over 1,000 Radar network to the Global Telecommunications System (GTS) from which India houses derive their'30-minute forecasts of the weather. Further, the underground shelter system allows for immediate evacuation of people rather than transporting them over long distances at great danger. It is noteworthy that only, 24 fatalities accompanied 1,200 tornadoes in 1996 -a figure that was five (5) less than in 1995 and less than 30% of the average annual deaths, (82). These go to prove that in terms of averting deaths, the United States of America is far ahead of the whole world in their EWS and public enlightenment/sensitization campaigns on extreme weather events.

Table 11.1 Number of Reported Fatalities from Weather Events in 1996

Country	Number	Principal Weather Events
India	3,320	Cyclone, Tornado, rain floods, snow rain, avalanches
China	2,500	Rain floods,typhoon, snow
USA	292	Snowstorms, hurricanes, floods, tornadoes
Brazil	234	Rained landides, rain floods
South Africa	155	Wind, cold, hail, lightning
Egypt	41	Rain floods, lightning
United Kingdom	26	Rain floods, sand storm, heat wave, thunderstorm, fog
Malagasy	21	Cold, fog, blizzards, cyclone
Nigeria	14	Rain
Benin	7	Storm rains
Algeria	5	Rain floods
Mauritius	3	Cyclone

Source: Adefolalu, 2000.

Table 11.1 summarises the absolute number of persons reportedly killed or missing during sever weather events in 1996 -1995 (where available) as a function of indexes, N, defined by Conford (1996) cited in Adefolalu (2000) which measures the proportional impact on those at risk (i.e. total country's population), it expresses the number of fatalities (from 11.2) as one person in every N of each country's population.

Despite their ranking as numbers 1 and 2 world population, China and India tend to lead in rating catastrophic losses of life in weather- related event.

Nigeria has a fair rating lout of every 7.7 million at risk of dying in any major weather disaster. This, of course, does not represent the total picture, as reports cannot be said to be complete due to lack of reliable (reporting) network; for instance, air disasters and multiple road accidents Occurring in bad weather for in Table 11.2 however the rate of fatalities occurring due to sever weather events in Africa is amplified by the other rating for Egypt, Ethiopia and Malagasy.

Table 11.2: Number of Fatalities in Weather Events 1996

Country	N(1996)	(1995)
India	275,000	600,000
China	480,000	900,000
USA	890,000	300,000
Brazil	680,000	1,200,000
South Africa	260,000	100.000
Ethiopia	800,000	600,000
Egypt	1,400,000	300,000
Malagasy	620,000	-
Nigeria	7,700,000	-
Rep. of Benin	760,000	-

Source: Adefolalu, 2000

4.0 CONCLUSION

In this unit, you have learnt what is meant by floods, types of floods beneficial and negatives of floods. You should have also known the various flood mitigation strategies.

5.0 SUMMARY

This unit has focused on the meaning of floods, types of floods causes of floods, beneficial and negative effects of floods, as well a: flood mitigation strategies.

6.0 TUTOR MARKED ASSIGNMENT

1. Using your own words, define the term "floods" 2. List two flood mitigation strategies.