COURSE GUIDE

EMT 511
ECOLOGICAL DISASTERS AND CONTROL

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MAIN COURSE

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MODULE 1

UNIT 1 DEFINITION, CONCEPT AND TYPES OF NATURAL RESOURCES

CONTENTS

1.0 INTRODUCTION

Everything humans use in their physical environment to meet their needs and wants come from natural resources supplied by the earth and sun. Since the 1980s there's has been growing concern over resource availability and use, environmental consequences of resource exploitation and the relationship between the environment, poverty and economic change. Natural resources is seen by many as plentiful and it is been exploited as cheaply as possible in quantities which did not acknowledge resource frontiers. Little thought was given to the amounts of minerals used or forest cleared or the capacity of the air land and water to absorb pollutants. Using natural resources to meet society's wants and needs requires wise management and stewardship of the resources. How wisely society develops the land and the impacts on natural resources will determine what is available in the future.

2.0 OBJECTIVES

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

- Explain explicitly the meaning of resources
- Differentiate between renewable and non-renewable resources with concrete example.
- Discuss the use of natural resources

3.0 MAIN CONTENT

3.1 Definition and Concept of Natural Resources

A resource is a material or an ingredient required as life support system for living organisms on the earth's surface. It is also considered as anything that can be used to satisfy the wants of man. A resource can be viewed in terms of material e.g. raw material, land or in abstract terms e.g. Human Knowledge, attributes of labour.

In general, resources depend on importance attached to it. Resources are therefore man-made. They are created because someone wants something, a goal and hence means of achieving the goal. If man does not make use of something, that thing is not a resource. A resource is therefore employed to meet certain defined objectives.

The attribute of labour is because someone wants to hire it. The attribute of land also is because it can be used for certain purposes and someone is willing to use it or take advantage of its fertility, topography, accessibility, scenery e. t. c.

Homo sapiens first appeared on earth nearly 200 thousand years ago. And since, then, we have depended on Mother Nature for things needed by us to survive. Humans require air, water, food from plants and animals, sunlight, minerals, land, soil and fossil fuels to exist. All these useful raw materials are called natural resources.

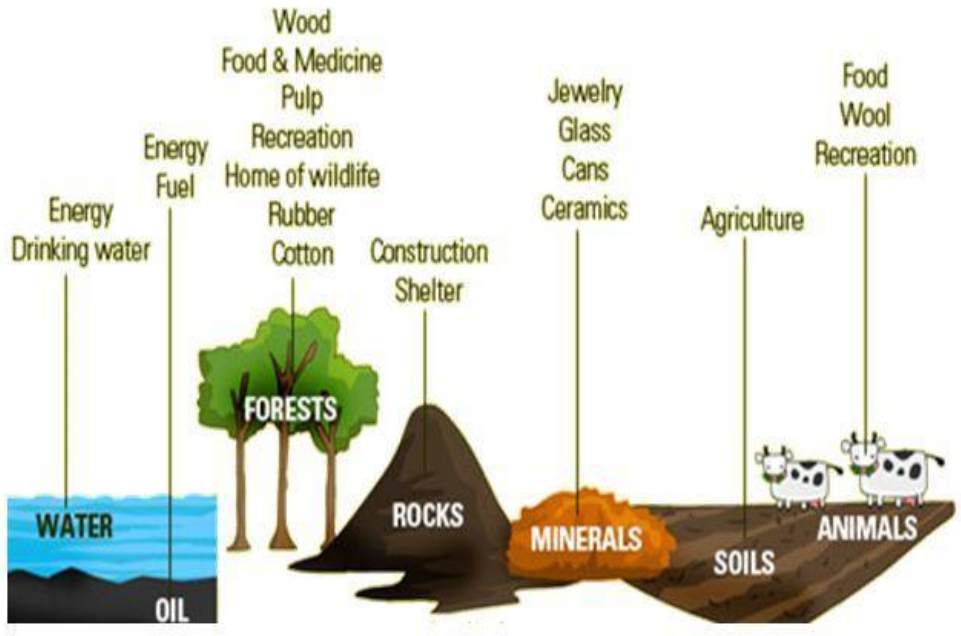
Natural resources are the raw materials supplied by the earth and its processes and include things in the physical environment used for housing, clothing, heating, cooling and transportation and to meet other human wants and needs. For example, trees are used for shelter, animals for food and clothing, plants for medicine, minerals and fossil fuels for power, transportation, heating and cooling. These resources include soil, air, water, sunshine, forests, wildlife, fish, fossil fuels, metals and minerals produced by the earth's natural processes. Using natural resources to meet human needs and wants has an impact on the global environment. Each time raw materials are used to produce goods there

are ecological, social, and economic impacts. Managing these natural resources and utilizing conservation techniques is necessary to help societies meet present and future needs. The primary economic value of a matured resource derives from the services it provides humans.

The value of resource hence depends on the context in which man takes it. For example, it is the context of forest estate, inland water fisheries, lakes, oceans, mineral resources in the country that really matters. The context in which resources are taken also influenced by social, economic, and cultural backgrounds as well as technological know-how. Therefore, nothing is independent and nothing may be regarded as unmanageable in a vacuum. The concept of a resource therefore varies in time and space due to technological advancement and human wants. For example, the use of saw dust as cooking fuel was not appreciated in some part of the country until the scarcity of the conventional sources such as kerosene and cooking gas sequel to the industrial actions by the Petroleum and Natural Gas Workers.

After the Second World War, attentions focused on the subject of natural resources such as timber, fishes, petroleum, e. t. c. This is because they are important resources that constitute the basis of wealth and are indicators of the developmental potentials of a nation.
The unusually high rate of natural resources exploitation and misuse could result in irreversible disequilibrium of ecosystem and environment.

The picture below gives us a few examples of the numerous things we obtain from natural resources.



Types of natural resources

3.2 Types of Natural Resources

There are many ways of classifying these natural resources. They can be biotic or abiotic (that is derived from organic materials or inorganic materials). Another way of classification of resources is by the amount of resource available for human consumption. Through this, resources can be classified into renewable (inexhaustible) and non-renewable (exhaustible) and natural resources.

i. Inexhaustible natural resources:

These are resources which have the inherent capacity to reappear, replenish or regenerate themselves by quick recycling, reproduction and replacement within a reasonable time and to maintain themselves. Resources such as air, water, soil, forest, fishes, wildlife and sunlight are some examples of nature unlimited supply of inexhaustible resources also called renewable resources.

ii. **Exhaustible natural resources**:

These are resources that do not have the capacity to regenerate or replace stock extracted from the earth and are finite resources. Examples are fossil fuels (coal, petroleum, natural gas), metallic and non- metallic mineral (iron ore, gold, tin, limestone etc). These resources are also called non-renewable resources because they are not capable of regeneration

As human population is increasing at an astounding rate with world population estimates of 7.7 billion people (October, 2018), naturally, this means that we are utilizing more and more natural resources. If we go at this rate, we will soon reach a day when nature will not be able to provide us with resources such as plants and trees, animals, mineral ores, fossil fuels such as coal, petroleum and natural gas. Thus, resources renewability becomes hampered.

If the use of these resources is not monitored carefully, there will be no food for our predecessors to eat, no energy for them to power their machines and no material for them to build shelter with. This is why it is important to understand which resources are exhaustible and which are not, and to practice sustainable development. This is nothing but development that meets the needs of the present generations without compromising the ability of future generations to meet their own needs.

4.0 CONCLUSION

To ensure the continued existence of human life on earth, there must be rational use and consumption of natural resource by reducing the unsustainable use of natural resource which is essential requirement for human survival.

5.0 SUMMARY

In this unit, we have learnt:

- The various perspective of what a resource
- What mother nature provides for humanity is referred to natural resource
- Resources are exhaustible or inexhaustible
- Uses of natural resources
- Situations that hampers the renewability of a resource
- The need for sustainable development

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the term resources
2. Using specific examples attempt a classification of resources
3. Enumerate five natural resources and their uses

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UNIT2 WATER RESOURCES

CONTENTS

1.0 INTRODUCTION

Nigeria is blessed with a rich array of natural resources which provide the basis for national development. Consequently, the conservation and management of this wide variety of resources are crucial to sustainable development.

2.0 OBJECTIVES

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

- Explain the various pulls in which water exists and the total percentage of the earth's surface covered by water.
- Explain the importance of the hydrologic cycle in continuously collecting, purifying, recycling and distributing water over the earth's surface.
- State why water resource is the most polluted and poorly managed resources.
- Enumerate factors responsible for water scarcity.
- Explain the causes of water stress.
- Discuss approaches to addressing water demand leading to water stress.

3.0 Main Content

3.1 Water Resource

Water keeps us alive, moderates climate, sculpts the land, remove and dilutes wastes and pollutants and is recycled by the hydrologic cycle. Water covers 71% of the earth's surface. Of this, 97.5% is the salty water of the oceans and only 2.5% is fresh water, most of which is locked up. The remaining freshwater is found in glaciers, lakes, rivers,

wetlands, the soil, aquifers and atmosphere. Ocean circulation patterns have a strong influence on climate and weather and, in turn, the food supply of both humans and other organisms. It is used for household purposes, irrigation, transport, for producing tidal energy etc. Water is also used in many industries like textiles, iron and steel, paper etc. Tides result in rise and fall of sea water which can be harnessed to produce electricity.

Despite its importance, water is one of our most poorly managed resources. We waste it, pollute it and charge too little for making it available. This encourages still greater waste and pollution of this renewable resource, for which we have no substitute.

The world's fresh water supply is continuously collected, purified, recycled and distributed in the solar- powered hydrologic cycle. This magnificent water recycling and purification system works well as long as we do not over load water systems with slowly degradable and non-degradable wastes or withdraw water from underground supplies faster than it is replenished. In parts of the world, we are doing both of these things.

Over the years, rising population, increasing industrialization and expanding agriculture have pushed up demand for water. Efforts have, therefore been made to collect surface water by building dams and reservoirs and creating ground water structures such as wells, tube wells etc to tap ground water.

The precipitation that flows across the earth's land surface and into rivers, streams, wetlands, lakes and estuaries that does not return to the atmosphere by evaporation is called surface runoff. The region from which surface water drains into a river, lake, wetland or other body of water is called its watershed or drainage basin. Two- thirds of the world's annual runoff is lost by seasonal flood and it is not available for human use. Major water problem in arid and semi arid areas is shortage of runoff caused by low precipitation, high evaporation and recurring prolonged drought.

A 2003 study by the United Nations found that one of every six people does not have regular access to adequate and affordable supply of clean water. By 2050, this number could increase to at least one of every four people.

Poverty also govern access to water even when a plentiful supply of water exist as most of the world's 7.7 billion people living on less than $1 (U.S) per day cannot afford a safe supply of drinking water and so live in hydrological poverty. Most are cut off from municipal water

supplies and must collect water from unsafe sources or buy water often from polluted sources from water vendors at high prices. In water short rural areas in developing countries, many women and children must walk long distances each day carrying heavy jars or cans to get a meager and sometimes contaminated supply of water.

3.1.1 Water Scarcity Implications for Nigeria

Nigeria's current population is estimated at 197 million (*Demographics of Nigeria Wikipedia*) with annual growth rate at 2.5%. The climate is tropical with high temperatures and high humidity generally marked with two distinct seasons, wet and dry varying between north and south. The wet season is often short lasting 3-4months in the extreme north with precipitation from 500-1,00mm/year. The duration of the wet season is longer southwards up to 9months with precipitation varying from 1,500-4,000mm/year. Much of the rainfall is received in the months of June-September. The evaporation is high with mean value at 2,500mm/year.

Nigeria has abundant surface and ground water resources which if harnessed and managed properly, could meet demands for drinking, farming and industries. However, about 20% of its water resources are derived from outside the boarder, from Cameroon, Niger and Benin Republic.

Nigeria's total annual renewable water resources are estimated at 286.2bm^3. Estimated resources produced internally amount to 221bm^3, out of which, 214bm^3 constitutes surface water and 87bm^3 ground water. External water resources from Niger, Cameroon and Benin are estimated at 65.2bm^3/year. Total annual groundwater resources that can be extracted are 59.51bm^3.

Despite abundance of water resources, Nigeria like most other countries in the West African region, experiences difficulties in meeting demands, for agriculture, industries and drinking. This situation has led to low economic growth as its water resources have not been sufficiently developed to increase agricultural production that would in turn feed the economy of the nation.

At both national and local government levels, there are issues identified to be responsible for the situation. These are:

Rapid population growth increases stress on water resources and human activities which, in turn, contributes to pollution from fertilizers, pesticides and industrial effluents. In addition to pollution, there is

increased growth of water weeds and their subsequent migration to lower reaches of the river basins.

Weak political commitment by both national and state governments to fund new water projects, and low water tariffs to sufficiently maintain existing facilities much less, to expand them.

Low funding in the water sector and the non participation of private sector in financing water projects are other reasons.

Causes of Water Stress and Scarcity

Generally, there is distinction between physical and economic scarcity. In the case that water demand cannot be met with available supply, like in dry regions, then the region is considered to be facing physical water scarcity. On the other hand, where constraints are due to lack of investment, inadequate regulation or pricing, then this situation is considered to be affected by economic water scarcity. This is the situation in most developing countries, including Nigeria.

In general, factors that cause water scarcity are many but prominent ones are; shifting demographics, population growth, increasing urbanization and migration, changing consumption patterns leading to increased demand for water, changing hydrologic cycle, caused by anthropogenic activities, climate change and increasing demand and competition for water resources for food, energy, industries. A brief description is presented on how some of these factors increase demand for water resources.

Increased Population Growth and Agricultural Production

Water for agriculture water currently accounts for 70% of all water use and increase in population will lead to increased demand for water.

Changes in Diet

Dietary habits change with increase in prosperity. People with consume more foods with high water footprints like meat, vegetable oil. For example, compare one kilogram of beef requires 15,500 litres of water to produce, while the equivalent amount of wheat requires only 1,300 litres.

Industrialization

Globally, energy and industry account for approximately 20% of water use. Water is fundamental to industrialization and as a nation becomes

more industrialized, it will require more water. In addition to increased demand for water, the available fresh water gets depleted as industries become major source of pollution, releasing heavy metals, solvents, toxic sludge and other wastes and contribute to water stress.

Inadequate Water Supply Infrastructure and Poor Management

Ageing and poorly functioning water infrastructure with leakage rates often between 30-50% , all these pose a challenge for agricultural and urban water supply.
The ageing of costly irrigation infrastructure is a serious problem in Nigeria and this will result in water scarcity and security. Other contributing factors are, inadequate knowledge of both surface and ground water budgets and unsatisfactory representation of value of water in the economic models and lack of understanding of water rights.

Climate Change

Almost all climate change models predict increased precipitation in the tropics and high latitude zones and decreased precipitation in the sub-tropics and mid-latitudes. The pattern and distribution of precipitation will lead to increase in the frequency and intensity of extreme events namely, floods and droughts.

Addressing Challenges Caused by Increasing Water Demand

Thus, to deal effectively with increasing water demand leading to water scarcity and water security, multidisciplinary approaches are required, together with cross-sectoral policies to avoid tensions and conflicts.

1.0 Need for New and Better Technologies

New technologies will be required to increase water efficiency and reduce water pollution in the future water resources development. New and better tools are needed to support effective policy development and decision making and enable the effective and sustainable management of water resources. These include:

- Developing water system modelling techniques for use in the optimization of water resource allocation and the simulation of the reliability of the balance between supply and demand to the analysis of water needs and water use.
- The use of risk analysis and risk-based decision- making techniques, especially to address issues relating to the security and reliability of water supply, and the implications of uncertainty in developing sustainable water management plans.

- Technology will have an important impact on fresh water supply and demand in future but changes will be evolutionary, as assessed by scientific studies. Also, changes are expected in salt-tolerant crops and point-of-use applications for the safe human consumption of untreated water.

2.0 Developing New Sources

2.1 Water Recycling, Reuse and Rain Water Harvesting

There is scope for reuse and recycling of water in industrial and domestic settings. Also, rain water can be harvested and this together with recycled water can be used for flushing toilets, and irrigation, dust control and firefighting. Current patterns of water use involve excessive waste. However, there is great hope for water savings in agriculture, in industry and in domestic water supplies.

2.2 Water Desalination

Membrane and other nanotechnology applications that dominate the current desalination and water-purification industries are likely to account for the biggest advances and effects on fresh water availability. Although desalination may be economically feasible for household and industrial water, it is not currently feasible for agriculture. In providing new sources of water, any technology faces three hurdles: reducing energy consumption, lowering production costs, and eliminating the fouling of membranes and filters.

Because all desalination processes produce a saline concentrate, the environmental impact of using or disposing of this concentrate also poses a hurdle.

Given the low price of water charged in most regions of the world, users are less motivated to adopt technologies such as desalination and drip-irrigation systems. For industry and households, water prices in developed countries are found to vary from $0.60/cubic meter to more than $3/cubic meter; whereas, water for agriculture in most countries is priced at approximately $0.10/cubic meter. Recent reports indicate that desalination processes produce water at much higher costs: $0.61/cubic meter for reverse osmosis, and $0.72/cubic meter to $0.89/cubic meter for thermal processes.

3.0 Research in Water Treatment Process

Advances in large-scale drip-irrigation systems are the most likely means to address water shortages for agriculture. Research to develop

drought resistant crops has been conducted for several years, but no break-through has been recorded for commercialization to date. During the coming years, selected crops could be developed that require less amount of water used by current crops, but widespread cultivation of such crops would still likely to pose some problems.

Limited experiments are being conducted to develop food plants that can tolerate salt or waste water. The advances in biotechnology may result in new plants or genetically altered strains that can grow in salt water from the ocean or large saltwater aquifers. Point-of-use water-purification technology relies upon portable systems that tend to be self-contained. These systems are useful for recreational purposes and would be suitable for military personnel. Also, they may find application in rural communities in the developing countries who often rely on drinking water from untreated sources.

4.0 Managing Variability Through Surface Storage

Water can generally be stored in rivers, lakes, reservoirs and aquifers to provide a means of managing variability in available water, allowing stored water to be used during dry periods. Also, storage water in lakes and reservoirs can mitigate floods and improve aesthetics of the surroundings.

5.0 Conjunctive Use of Groundwater

Groundwater, where available can be used conjunctively with surface water. Also, excess surface water can be stored underground and later recovered for use during period of scarce water.

6.0 Water Efficiency in Agriculture

There is need for improved irrigation efficiency for more efficient use of water. New technologies like drip system of irrigation can be adopted. Also, there is need to adopt heat and drought resistant crop varieties while, improved irrigation practices and land leveling (to obtain an even distribution of water), are often the most convenient approach to meet increased demand from existing water supplies.

7.0 Water Efficiency in Industry

Water used by industries for cooling of plants is evaporated and not available for reuse in the basin. This water is non-consumptive and there is need for improving efficiency in the cooling process such as recycling to put the water to consumptive use.

8.0 Reducing Leakages in Water Supply and Distribution

There is need to improve on water supply distribution network to reduce leakages. It is estimated that water supply leakages could be reduced substantially by up to 30% if proper measures are put in place.

9.0 Improved Policy Development by Engaging the Public

Awareness raising is a vital part of a participatory approach to water resources management. Information, education and communication support programmes must be an integral part of the development process. The current uncontrolled rate of population growth, combined with the growing pressure on available water resources, Nigeria will be among the water-deprived countries in the world in less than ten years, if the available resources are not judiciously_and efficiently managed. There is need to formulate water policy to identify priority users, evolve appropriate water pricing policy to promote water saving techniques that will lead to efficient utilization of water. Participatory management, public awareness and education- Involve all stakeholders in the planning and development of water schemes through education, interaction and open channels of communication with communities.

10.0 Integrated Water Resources Management

Water is a vital part of the environment and a home for many forms of life on which the well-being of humans ultimately depends. Disruption of flows has reduced the productivity of many such ecosystems, devastated fisheries, agriculture and grazing, and marginalized the rural communities which rely on these. Various kinds of pollution, including transboundary pollution, exacerbate these problems, degrade water supplies, require more expensive water treatment, destroy aquatic fauna, and deny recreation opportunities. Integrated management of river basins provides the opportunity to safeguard aquatic ecosystems, and make their benefits available to society on a sustainable basis.

11.0 Developing Mechanism for Resolving Water Conflicts

The most appropriate geographical entity for the planning and management of water resources is the river basin, including surface and groundwater. Ideally, the effective integrated planning and development of transboundary river or lake basins has similar institutional requirements to a basin entirely within one country. The essential function of existing international basin organizations is one of reconciling and harmonizing the interests of riparian countries, monitoring water quantity and quality, development of concerted action programmes, exchange of information, and enforcing agreements.

In the coming years, it is expected that management of both, national and international watersheds will greatly increase in importance. A high priority should therefore be given to the preparation and implementation of integrated management plans, endorsed by all affected governments and backed by international agreements.

12.0 Managing Trans-Boundary River Basins

Trans-boundary disputes will be expected to emerge as water becomes scarce thus, increasing source of risk in the future, with conflicts over water. Where rivers, lakes, aquifers cross national boundaries trans-boundary agreements for water allocation and sharing need to be enshrined between countries within international treaties.

13.0 Capacity Building

We require well-trained and qualified personnel. We should identify, as part of national development plans, training needs for water-resources assessment and management, and take steps internally and, if necessary with technical co-operation agencies, to provide the required training, and working conditions which help to retain the trained personnel.
Governments at both national and state level must also assess their capacity to equip their water experts and other specialists to implement the full range of activities for integrated water-resources management. This requires provision of an enabling environment in terms of institutional and legal arrangements, including those for effective water-demand management.

4.0 CONCLUSION

There is abundance of both surface and ground water resources in Nigeria. At present Nigeria is experiencing water stress resulting from its rapid population growth, increased economic activities, population migration and climate change. Furthermore, Nigeria will likely face serious water scarcity by 2025 and Prolonged water scarcity will lead to unrests and likely conflicts in the near futures. There are many agencies involved in water resources development and there is need to evolve a means to allocate water resources, reduce wastages, improve utilization efficiency and above all, a coordinating policy to monitor and conserve resources as means towards addressing the impending water scarcity and security challenges.

5.0 SUMMARY

In this unit, we have learnt:

- The various pulls in which water exists and the total percentage of the earth's surface covered by water.
- The importance of the hydrologic cycle in continuously collecting, purifying, recycling and distributing water.
- Water resource is the most polluted and poorly managed resources.
- Factors responsible for water scarcity.
- Causes of water stress.
- Approaches to addressing water demand leading to water stress.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the importance of the hydrologic cycle in continuously collecting, purifying, recycling and distributing water over the earth's surface.
2. Enumerate five factors responsible for water scarcity in Nigeria.

    - Explain the causes of water stress.
    - Discuss five approaches to addressing water demand leading to water stress.

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UNIT3 FOREST RESOURCES

CONTENTS

1.0 INTRODUCTION

Forest and related land cover types (woodlands shrubland, degraded forest and forest fallows) are important terrestrial ecosystems. They account of over $52x\ 10^6\ km^2$ of the earth's land area, occupy three times the area of cropland and 75% of more area than grasslands. They are vital to the ecological functioning of the planet, producing 60% of the net productivity of all terrestrial ecosystems, of which tropical forests account for approximately two-third. They are also the habitat of a large proportion of the earth's plant and animal species, providing the basis for the biodiversity which is essential for the biosphere's future. They essentially support life on earth by absorbing carbon dioxide and releasing oxygen thereby maintaining the balance in the gaseous atmosphere and also in regulation of hydrological cycle and flood control. Forests are important for provision of a wide range of products such as timber, fuel wood, paper, food and fodder as well as ecosystem services like protection of soil and water resources and carbon sequestration.

2.0 OBJECTIVES

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

- Enumerate the importance of forest.
- Explain the causes of deforestation
- Explain the contributions of deforestation to global warming.
- State the objectives of the UN-REDD-plus initiative.

3.0 MAIN CONTENT

3.1 Forest Resource

The world's forests serve a series of vital environmental and ecosystem services (i.e. benefits people obtain from ecosystems), without which the functioning of the biosphere would be endangered. Woodlands and forest regulate water regimes by intercepting rainfall and regulating their flow. This is particularly important in areas with highly seasonal rainfall, as in the case of many tropical regions. Trees are vital to the maintenance of soil quality, providing organic matter through leaf fall, limiting soil erosion through the binding effects of root systems and protecting soil from the direct impact of rainfall. On a regional and global scale forest play a part in modulating climate and are the lung of the planet. Deforestation is believed to contribute as much as 25% of the increased carbon dioxide which is the principal cause of enhanced greenhouse effect and this occurs because heat-trapping gases are released by the burning of felled woodland and because the absorption of carbon from the atmosphere via photosynthesis is reduced.

Tree resources are of major economic importance and form the basis of a wide range of industries, notably timber, processed wood and paper including products such as rubber, fruits, nuts and coffee etc.

The world's forests are also the home of millions of people, many of whom live preindustrial lives and have unique cultural heritages. These ways of life depend totally on the survival of the forest, and are under threat from spectre of deforestation. Forest and woodland are also the source of many products which are vital to the viability of agricultural communities throughout the developing world, e. g. fuel, fruits, building materials, medicines and herb. These forest products provide diversity to the rural economy and security when times are hard. The loss of tree resources undermines the viability of agricultural economies and in particular makes the poor more vulnerable to environmental disruption. Deforestation, particularly in developing countries, is consequently not only an environmental problem, but also an ecological and developmental disaster.

3.1.1 Importance of Forest

In consideration of the importance of forest much of the deforestation currently taking place is undesirable for a number of reasons:

At the local scale forest and woodland canopy protects soil from rainfall, reducing erosion and regulating runoff. Forested areas produce more even water flow as the soil acts as major store in the hydrological cycle.

This buffering role is especially important in regions with irregular or strongly seasonal rainfall such as monsoon areas of Asia and semi-arid regions.

Forest creates local microclimates regulating temperature and humidity in their immediate vicinity. Generally, temperature is moderated, humidity is increased and wind speed reduced. Forest environments create ideal microclimate for a number of crops, although solar radiation can be limited by canopy cover. Such environments also provide habitats for many flora and fauna which add to the variety and durability of local environments.

On regional and global scales forest resources plays a major role in environmental regulation and preservation. Some local functions such as soil protection and regulation of the hydrological cycle also operate at a regional scale and deforestation is often cited as a major contributing factor to disaster such as downstream flooding of previously forested areas. Also the effects of droughts in arid and semi-arid areas are worsened by the loss of vegetal cover.

Forest performs two major environmental functions at global scale, both of which are seriously threatened by current patterns of deforestation. Firstly, their roles as carbon sink in the global carbon cycle and secondly as pools of biodiversity, i. e. as the home of a vast number of species of plant and animals.

The world biomass resources of which forests and woodlands are the largest component play a key role in global climate mitigation by providing sink for greenhouse gas that contribute to global warming. Their contribution to climate change takes place through the process of photosynthesis whereby plants absorbs carbon dioxide and release oxygen. The loss of a significant proportion of the world's biomass stocks through deforestation will consequently lead to a reduced capacity to absorb carbon dioxide and could in the long term causes other forms of disruptions to the composition of the atmosphere. Not surprisingly, the reversal of deforestation trends and a move to significant re-afforestation is seen by many as a key component in global efforts to mitigate the impact and speed of global warming.

3.1.2 Causes of Deforestation

Deforestation occurs as a result of outright destruction of woodland through fuel wood and timber harvesting and tree cutting for fodder and grazing. African closed forest has also been loss through steady expansion of hardwood logging. In tropical Asia closed forest destruction has been due to land clearance for agriculture, planned

migration and resettlement project. Urban development and expansion and construction activities also increased the tempo of logging activities. Unauthorized felling of trees in excess of what can be harvested normally from the forest to earn money from selling the forest resources is also responsible for deforestation. Practices in some culture to ward off witches and wizards by cutting down trees could also contribute to deforestation. Commercial logging and establishment of heavy industries also contribute to deforestation. In some coastal communities land conversion particularly the clearance of mangrove swamps to provide land for swamp rice cultivation. There is no doubt that in some areas growing population densities have had an adverse impact on forest resources, but this is mainly through land clearance for agriculture and greater demand for fodder from increasing livestock populations.

3.1.3 United Nation REDD- Plus Initiative to Combating Deforestation

Forests play a very important role in protecting the land from desertification and conserve biodiversity. They also provide ecosystem goods and services. However, despite their value, forest ecosystems are threatened by deforestation and land degradation. The degradation of forest ecosystems in drylands results in a loss of biomass and biodiversity, water resources and carbon storage capacity.

Deforestation and forest degradation have long been recognized as significant sources of greenhouse gas (GHG) emissions. The fifth assessment report of climate change causes and impacts published by the Inter-governmental Panel on Climate Change (IPCC), inferred that deforestation and forest degradation account for over ten percent of GHG emissions.

Reducing emissions from deforestation and forest degradation (REDD) is a mechanism that has been under negotiation by the United Nations Framework Convention on Climate Change (UNFCCC) with the objective of mitigating climate change through reducing net emissions of greenhouse gases through enhanced forest management in developing countries. The UN-REDD Programme was set up in 2008 to build on the convening power and technical expertise of the UN Food and Agriculture Organization (FAO), the UN Development Programme (UNDP) and the UN Environment Programme (UNEP), combining forces to support developing countries get ready to undertake efforts to mitigate climate change through the implementation of REDD+ activities agreed under the UNFCCC.

REDD+ is defined by the conference of parties (COP) to United Nations Framework Convention on Climate Change (UNFCCC) as reducing

emissions from deforestation and forest degradation, conservation of forest carbon stock, sustainable management of forests and enhancement of forest carbon stocks in developing countries.

The defined scope of REDD+ encourages developing countries Parties to contribute to mitigation actions in the forest sector by undertaking the following activities as deemed appropriate by each Party and in accordance with their respective capabilities and national circumstances:

- Reducing emissions from deforestation.
- Reducing emissions from forest degradation.
- Conservation of forest carbon stocks.
- Sustainable management of forests.
- Enhancement of forest carbon stocks.

It is increasingly apparent that REDD+ can make a significant contribution to sustainable development in the context of climate change. Some countries have launched ambitious climate change, green and sustainable development action plans, in which REDD+ is a major component of the effort to transform natural resource management and tackle poverty. The challenges were succinctly stated at the UN climate change summit in 2014, in a declaration on tackling deforestation and forest degradation:

"Forests are essential to our future. More than 1.6 billion people depend on them for food, water, fuel, medicines, traditional cultures and livelihoods. Forests also support up to 80% of terrestrial biodiversity and play a vital role in safeguarding the climate by naturally sequestering carbon. Yet, each year an average of 13 million hectares of forest disappear, often with devastating impacts on communities and indigenous peoples. The conversion of forests for the production of commodities accounts for roughly half of global deforestation. Infrastructure, urban expansion, energy, mining and fuel wood collection also contribute in varying degrees. Reducing emissions from deforestation and increasing forest restoration will be extremely important in limiting global warming to +2°C. Forests represent one of the largest, most cost-effective climate solutions available today. Action to conserve, sustainably manage and restore forests can contribute to economic growth, poverty alleviation, rule of law, food security, climate resilience and biodiversity conservation. It can help secure respect for the rights of forest dependent indigenous peoples, while promoting their participation and that of local communities in decision-making".

This substantial agenda defining the global effort to tackle climate change and keep temperature increase below plus two degrees Celsius above the pre-industrial levels, combined with supporting countries to make significant and transformative progress with respect to the UN

Sustainable Development Goals (SDGs), underpins the design of the UN-REDD+ Programme.

4.0 CONCLUSION

From the foregoing it is clear that the loss of forest and woodland cover affect the environment with some level of ecological consequences. Local communities in many places are heavily dependent on withdrawals from forests for sustaining their livelihoods. To address this unsustainable demand of forest goods and services, alternate clean sources of energy, like liquefied natural gas, promotion of agro-forestry component and withdrawals from forests within limit of sustainable harvests should be encouraged.

5.0 SUMMARY

In this unit, we have learnt that:

1. Forests are important terrestrial ecosystems and they provide ecosystem services that are vital to the ecological functioning of the planet.
2. Deforestation is caused by destruction of woodland, expansion of logging activities, urban development etc.
3. Deforestation reduces the capacity of forest to absorb carbon dioxide which is recognized as significant sources of greenhouse gas (GHG) emissions that enhances global warming.
4. The objectives of the United Nation Redd-plus in combating deforestation and reducing emissions.

6.0 TUTOR-MARKED ASSIGNMENT

1. Enumerate the importance of forest.
2. Explain the causes of deforestation
3. Explain the contributions of deforestation to global warming.
4. State the objectives of the UN-REDD-plus initiative.

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UNIT4 SOIL AND MINERAL RESOURCES

CONTENTS

1.0 INTRODUCTION

Soil is an important natural resource whose quality and management is essential to sustaining food production. Inadequate knowledge of soil ecology and its degradation is one of the greatest problems to sustaining food sufficiency and security.

In spite of the contribution of mineral mining and oil and gas production to the country's gross domestic product (GDP), it is noted to cause environmental degradation and health implications of various degrees in the host communities.

Attempts to improve and manage the impact of mining and oil and gas activities should go beyond the technical aspect of monitoring to ensure compliance with standard requirements.

2.0 OBJECTIVES

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

- Define soil and state its composition.
- Explain soil degradation and it causal factors
- Explain the environmental problems associated with artisanal and small scale mining
- Explain the ecological problems resulting from petroleum exploitation in Nigeria

3.0 MAIN CONTENT

3.1 Soil Resources

In its traditional meaning, soil is the natural medium for the growth of plants. Soil has also been defined as a natural body consisting of layers (soil horizons) that are composed of weathered mineral materials, organic material, air and water. Soil is the end product of the combined influence of climate, topography, organisms (flora, fauna and human) on parent materials (original rocks and minerals) over time.

Soils constitute the foundation for agricultural development, essential ecosystem functions and food security. The sustainable management of soils contributes to economic growth, biodiversity and food security which in turn are key to eradicating poverty. Soil health, therefore, is tightly linked to land use, food production as well as to the use of inputs, and to many other environmental and socioeconomic issues.

It must be highlighted that the doubling of global food production during the past decades has been accompanied by a massive increase in the use of inputs, such as synthetic nitrogen, phosphorus, pesticide applications and extensive use of irrigation and energy. The intensification of agriculture has also led to the degradation and exhaustion of soil. Unfortunately, people have been building and expanding their cities on the most fertile soils, thereby squandering such a valuable resource. This pattern is unlikely to change in the future. Continued urbanization will pose a further threat to agriculture production, along with the changing patterns of food consumption by the growing urban population.

Soil degradation represents a major threat to food production and environment conservation, especially in tropical and sub-tropical regions (where most of the future population growth will take place). Soil degradation has become a very serious problem in densely inhabited agricultural regions. Soil degradation is causing a decline in crop productivity and huge economic loss, putting the food security and livelihood of farmers at risk. In sub-Saharan Africa (SSA), soil degradation (nutrient depletion) is the primary form of soil degradation, is leading to a decline in crop productivity, and has been linked to hunger and poverty.

Soil degradation is defined as a change in the soil health status resulting in a diminished capacity of the ecosystem to provide goods and services for its beneficiaries. Soil degradation is a human-induced phenomenon and could be described as the deterioration of soil quality: the partial or entire loss of one or more soil functions. Soil degradation, therefore,

refers to a broad spectrum of changes in soil characteristics because of natural or anthropogenic factors that alter their structure and quality, including deforestation and the removal of natural vegetation, agricultural activities, overgrazing, overexploitation of vegetation for domestic use, and industrial activities.

Two categories of human-induced soil degradation processes are distinguishable: “The first category deals with soil degradation by displacement of soil material. The two major types of soil degradation in this category are water erosion and wind erosion. The second category of soil degradation deals with internal soil physical and chemical deterioration. In this category only on-site effects are recognized of soil that has been abandoned or is forced into less intensive usages”. Such alterations result in reducing the soil’s capability to function and its resilience (the capacity to recover from stressor events), that is, the soil’s ability to provide actual or potential productivity or utility (to produce economic goods and services) and to perform environmental regulatory functions.

Soil degradation can occur through the following processes: physical (i.e., erosion, compaction), chemical (i.e., acidification, salinization) and biological (i.e., loss of soil organic matter, loss of biodiversity). The factors that determine the kind of degradation are as follows: soil inherent properties (i.e., physical, chemical), climate (i.e., precipitation, temperature), the characteristics of the terrain (i.e., slope, drainage) and the vegetation (i.e., biomass, biodiversity).

Erosion is a process of soil degradation that occurs when soil is left exposed to rain or wind energy. Poor management of agricultural land induces soil erosion that leads to reduced productivity (which must be compensated with the addition of fertilizers), or, in extreme cases, to the abandonment of the land. Intensive conventional agriculture makes soils highly prone to water and wind erosion, which worsen when situated on a slope. Mild to severe soil erosion is affecting about 80% of global agricultural land. Soil erosion has been estimated to reduce yields on about 16% of agricultural land, especially cropland in Africa and Central America and pasture in Africa.

Salt-affected soils occupy an estimated 950 million ha of land in arid and semi-arid regions, i.e., nearly 33% of the potentially arable land area of the world. Soil acidity and the resultant toxicity caused by high concentrations of aluminium and manganese in the root zone are serious problems in sub-humid and humid regions. Soil compaction is a worldwide problem and can reduce crop yield by 20%–55%. Nutrient depletion is another significant process of soil degradation, with severe economic impact on a global scale. To cover the losses, more land

would have to be converted to agriculture and more inputs used to replace the reduced soil fertility.

Current intensive farming practices greatly deplete soil organic matter (SOM) and soil carbon stocks. The decrease in SOM reduces the resistance of soils to erosion agents (e.g., wind, water), lowers the water holding capacity of soils and affects overall soil health. This in turn reduces crop productivity, resulting in the need for more fertilization and irrigation, making soils a net source of carbon dioxide emissions.

Combating Soil Degradation

A main goal of sustainable agriculture practices is to preserve soil health, enhancing SOM content and limiting soil erosion to a minimum. Sustainable agriculture should aim at preserving the natural resource base, especially soil and water, by relying on minimum artificial inputs from outside the farm system and by offsetting the disturbances caused by cultivation and harvest, while being economically and socially viable. The domain of sustainable agriculture includes several practices such as agro-ecology, integrated agriculture, low input, precision agriculture and organic agriculture.

The resistance of soils to erosion is closely linked to the stabilizing influence of SOM and vegetation cover. High organic matter content inhibits erosion because SOM binds soil particles together, generating an aggregate that resists erosion. Most SOM is found in the topsoil (15–25 cm of the A-horizon) and is of key importance for soil fertility.

Practices such as no-till agriculture or minimum tillage, and organic farming can help reduce soil loss, increase SOM and restore soil fertility and biodiversity. No-till farming can slow soil erosion and pollution runoff, benefiting aquatic ecosystems, improving agronomic productivity, and achieving food security. No-till farming, however, may not suffice to properly protect the soil when other practices are not implemented alongside; for example, cover crops or appropriate rotation schedules, or when it is accompanied by the use of high amounts of agrochemicals.

It has also to be highlighted that low-input farming systems, such as organic agriculture, significantly increase the level of biological activity in the soil (e.g., bacteria, fungi, springtails, mites and earthworms).

Adopting agro-ecological and low input practices may allow us to preserve soil health while still increasing overall farm productivity, for example by adopting a more complex multi-cropping strategy. The adoption of agro-ecological practices is a necessary strategy for

degraded soils, in areas where farmers cannot afford to buy inputs, such as in sub-Saharan Africa.

Perennial crops are reported to be 50 times more effective than annual crops in maintaining topsoil. Experts maintain that perennial crops, with their roots exceeding depths of two meters, can also greatly improve ecosystem functions and services, such as water conservation, nitrogen cycling and carbon sequestration (more than 50% when compared to conventional crops). Management costs are also reduced because perennial crops do not need to be replanted every year, so they require fewer passes of farm machinery and fewer inputs of pesticides and fertilizers, thus reducing fossil-fuel use.

3.2 Mineral Resource

Nigeria's abundant solid minerals is made up of precious metals, stones and industrial minerals like coal, tin, gold, marble, limestone and others. The core of these mineral deposits scattered across the country remains a major attraction for informal and conventional mining activities.

The mining sector has been experiencing an ongoing resurgence with growing prospects as a result of the challenges posed by Nigeria's deeply troubled petroleum sector. With the current dominance of petroleum industry in the economy, informal miners and small holding companies have become very active in the production of solid minerals in the absence of a clearly defined policy, better standards and reforms. With the prevalence of artisanal and small-scale miners, recurrent hazard from thousands of abandoned mines, concentration of toxic residues and destruction of flora and fauna are some of major and widespread ecological impacts that mining communities are fraught with.

Artisanal and small-scale mining is practiced in Nigeria as a viable alternative source of rural livelihood however it led to devastating lead poisoning of children in addition to extensive mercury exposure and significant emissions of mercury into the air and soil.

Lead contamination continues to afflict large numbers of children and women commonly involved in the processing stage, which includes crushing, grinding, sieving, washing and panning. The practice of mercury amalgamation at mining sites has also resulted in widespread contamination of miners and others working near the mines. Exposure to mercury causes serious damage to the central nervous system, including respiratory failure, nausea, vomiting, diarrhea, increases in blood pressure or heart rate, skin rashes, eye irritation, and kidney damage.

For women, exposure to mercury positively correlates with an increase in malformations and miscarriages during pregnancy.

In addition to these health impacts, artisanal and small-scale mining is associated with significant environmental degradation, including toxic pollution of air, land, and water; destruction of flora and fauna; geological instability leading to landslides, flooding, erosion, and tremors; landscape degradation; and radiation hazards. Dredging and sluicing during mining also cause severe land degradation and river siltation. The increases in suspended sediment from river siltation hinder the penetration of light into the water and greatly affect the supply of nutrients. The suspended sediment also tends to carry high concentrations of mercury. During periods of heavy rain, the lead can leach into groundwater systems, contaminating them in the process.

Efforts to minimize the health and environmental impacts of artisanal and small-scale mining include basic practices such as moving operations outside of household areas and villages so as to reduce lead exposure for children and others, simple hygiene practice of hand and clothing washing before returning to their communities from the processing sites, the use of wet milling machines over dry machines to minimize the production of lead dust.

Oil exploration and exploitation has been on-going for several decades in the Niger Delta. It has had disastrous impacts on the environment in the region and has adversely affected people inhabiting that region. The Niger Delta is among the ten most important wetland and marine ecosystems in the world. The oil industry located within this region has contributed immensely to the growth and development of the country which is a fact that cannot be disputed but unsustainable oil exploration activities has rendered the Niger Delta region one of the five most severely petroleum damaged ecosystems in the world. The Niger Delta consist of diverse ecosystems of mangrove swamps, fresh water swamps, rain forest and is the largest wetland in Africa but due to oil pollution the area is now characterized by contaminated streams and rivers, forest destruction and biodiversity loss. This affects the livelihood of the indigenous people who depend on the ecosystem services for survival.

Oil exploration by seismic oil companies involves clearing of seismic lines, dynamiting for geological excavation, which affects the aquatic environment. It causes mortality in fauna, turbidity in the water that blockage of gills of the filter feeders in the benthic fauna, reduction of photosynthetic activity caused by the water turbidity that reduces the amount of sunlight penetration.

Oil and gas pipeline have been installed covering 7,000km to enhance the distribution crude oil products to other parts of the country. The installation of these pipelines involved clearing large areas of habitat to make pipeline tracks. These pipelines run across the rainforests and mangroves with incidences of leakage and rupture and accidental discharges. These discharges are caused by vandalism, failure of pipeline integrity due to aging and defects in material. Spillages also result from the process of drilling, transportation by petroleum tanker, oil bunkering and smuggling and leakages from filling station petroleum depots. Most incidences of the reported oil spillages have occurred in the mangrove swamp forest, which is one of the most reproductive ecosystems rich in fauna and flora.

Gas flaring is recognized as one of the main ecological problem facing the Niger Delta since 84.60% of total natural gas produced as a byproduct of oil is still being flared with 14.86% only being used locally. There are documented cases of fire incidence that engulfed local plant and animals within the mangrove forest of the Delta resulting in a large number of human fatalities as result gas pipeline leakage.

Acid rain is another problem within the Niger Delta region caused by gas flaring which has led to loss in biodiversity, with forest and economic crops being destroyed. The heat generated from gas flaring kills vegetation around flaring area, destroys mangrove swamps and salt marshes, suppresses the growth and flowering of some plants, induces soil degradation and diminishes agricultural productivity.

The cumulative environmental impact of these flaring activities result in contaminant build up on land, shallow ground water, greenhouse effect and general global warming and have also caused high concentration of acid rain within the region.

In terms of environmental changes occurring within the region, large areas of mangrove forest have been destroyed, oil spills spread over wide area affecting terrestrial and marine resources. Some past spills have necessitated the complete relocation of some communities, loss of ancestral homes, pollution of fresh water, loss of forest and agricultural land, destruction of fishing grounds and reduction of fish population, which is the major source of income for the Niger Delta people and pollution exposes people also to new risk of diseases.

The development of the petroleum industry and its activities have negative consequences on the environment, some of these negative effects can be reduced or prevented basically by taking some steps in terms of prevention and monitoring. The Federal Government

Has taken steps in this direction with the establishment of Niger Delta Development Commission (NDDC) and National Oil Spill Detection and Response Agency.

4.0 CONCLUSION

Soil degradation is increasing with many great challenges of population growth, the potential effects of climate extremes and fresh water scarcity which have impact on food security. Poverty alleviation should be a priority to reduce the human pressure on the environment.

Updating and revising the laws and legislations in mining and petroleum sector by reviewing fines will go a long way in ensuring compliance, even though the government cannot systematically or frequently monitor these sites Adoption of environmentally friendly technology that will minimize impacts of Mining and petroleum development on the environment should be encouraged.

5.0 SUMMARY

In this unit, we have learnt:

- The meaning, importance and composition of soil.
- Sustainable management of soil resources is essential to food security and other ecosystem services.
- Agricultural intensification depletes soil organic matter and promotes soil degradation.
- Dominant players in Nigeria solid mineral sector are the informal miners and small holding mining companies.
- Health and ecological problems resulting from artisanal and small scale mining activities.
- Environmental and health impact of oil and gas exploitation in Nigeria.
- Approaches to minimize the health and environmental implication of mining and petroleum operation in host communities.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define soil and state its composition.
2. Explain soil degradation and it causal factors
3. Explain the environmental problems associated with artisanal and small scale mining
4. Explain the ecological problems resulting from petroleum exploitation in Nigeria

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UNIT5 ECOLOGICAL CONSEQUENCES OF MISMANAGEMENT OF NATURAL RESOURCES

CONTENTS

1.0 INTRODUCTION

Natural resources play a special role in the life of the poor. More than 1.3 billion people depend on fisheries, forests, and agriculture for employment. According to the World Bank, in 2002, 90 percent of the world's 1.1 billion poor-those living on less than $1 per day-depended on forests for at least some part of their income.

Humans have altered the ecosystems in order to meet growing demands for natural resources, with recent decades experiencing more rapid and large scale changes due to increasing population pressure than any other period in human history. Misuse of natural resources contributed to degradation and loss of ecosystems and biological diversity. Land ecosystems is exploited at a much faster rates than ever before with negative implications for sustainable human livelihood.

2.0 OBJECTIVES

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

- Explain effects of agricultural intensification on soil productivity.
- Enumerate five effects of eutrophication in aquatic ecosystem.
- Discuss five environmental impact of mining operation.
- Discuss the ecological consequences of oil spillage.

3.0 MAIN CONTENT

3.1 Faming Activities

Soil is under pressure with declining quality and it is recognized that soil degradation is a serious problem which is driven by human activities such as inappropriate agricultural practices, urban and industrial sprawl, industrial activities, construction, and tourism. Alteration of soil characteristics by anthropogenic impact changes functional capacities of the soil. Agricultural technologies and current practices like mono cropping, residue management, mineral fertilization, overuse of pesticides, heavy agricultural machinery, inadequate management practices of soil and irrigation, can significantly affect the soil quality by changing physical, chemical, and biological properties. Long-term human impact (e.g. sealing), as well as short-term soil management (e.g. irrigation) modifies material and energy flows. Erosion, a decline in organic matter content and biodiversity, contamination, sealing, compaction, salinization, and landslides are major soil threats. Intensive use of pesticides and fertilizers is the main activity leading to deterioration of soil physical, chemical and biological properties. These modifications result in transformation of the soil processes to smaller or greater extent. It is important to be aware that soil is a finite and non-renewable resource, because regeneration of soil through chemical and biological weathering of underlying rock requires geological time.
Due to agricultural intensification over recent decades, vast amounts of fertilizers and agrochemicals have been applied to agricultural land in order to achieve maximum productivity. Excessive nutrient concentrations not recovered by the crop plants end up being washed into adjacent aquatic systems where they may cause problems such as eutrophication.

Agriculturally induced water pollution may occur from point sources e.g. manure storage tanks, feedlots, overflows, tile drains) as well as through diffuse pollution from farmed land. The nutrients and agrochemicals applied on the fields may reach adjacent water bodies via overland flows and subsurface flows during precipitation events or, at a slower rate, reach surface water bodies through groundwater discharge. Main flow paths differ between nutrient species. For example, phosphorus transport occurs mainly bound to soil particles as overland flow whereas dissolved agrochemicals and nitrogen can enter aquatic systems via overland flow, subsurface flows and groundwater flows.
An increased supply of nutrients, especially phosphates and nitrates, can cause algal blooms and excessive growth of aquatic macrophytes in both freshwater and marine ecosystems. The increased productivity due to substantial nutrient inputs leads to increased bacterial decomposition of

dead organic matter, which in turn, is the cause of declining oxygen concentrations.

Apart from nutrients and sediments, water quality may also be burdened by heavy metals which originate from organic and inorganic fertilizers, pesticide applications and irrigation water. Soil structure and chemistry determine heavy metal solubility and bioavailability. In general, plant uptake and leaching losses are small compared to the total heavy metal loads entering the soils. In the long term there is a potential for slow accumulation of toxic elements in the soil, which may lead to negative effects on plant growth and the function of soil organisms. Ultimately, heavy metal related changes to the quality of soils may lead to mobilization and leaching of the accumulated toxic elements to groundwater reservoirs and adjacent freshwater systems.

3.2 Mining Activities

Mining provides a variety of socio-economic benefits but its environmental disruption is massive in terms of land conversion and degradation, habitat alteration, water and air pollution. Mining activities generates high concentrations of waste and effluents. Mining impact can be direct through the value chain activities of prospecting, exploration, site development, ore extraction, mineral dressing, smelting, refining/metallurgy, transportation, post mining activities and indirectly through the impact of the degradation on the socio-cultural development of communities. In general, degradation arising from mining includes; air pollution, water pollution, land and forest degradation, noise pollution, solid and liquid waste disposal of toxic substances, as well as socio-cultural problems such as health complication and conflicts. The environmental impact of mining projects is summarized as follows:

Acid mine drainage and contaminant leaching

Acid mine drainage is considered one of mining's most serious threats to water resources. A mine with acid mine drainage has the potential for long-term devastating impacts on rivers, streams and aquatic life. Acid mine drainage is a concern at many metal mines, because metals such as gold, copper, silver and molybdenum, are often found in rock with sulfide minerals. When the sulfides in the rock are excavated and exposed to water and air during mining, they form sulfuric acid. This acidic water can dissolve other harmful metals in the surrounding rock. If uncontrolled, the acid mine drainage may runoff into streams or rivers or leach into groundwater. Acid mine drainage may be released from any part of the mine where sulfides are exposed to air and water, including waste rock piles, tailings, open pits, underground tunnels, and leach pads. If mine waste is acid-generating, the impacts to fish, animals

and plants can be severe. Many streams impacted by acid mine drainage have a pH value of 4 or lower-similar to battery acid. Plants, animals, and fish are unlikely to survive in streams such as this.

Acid mine drainage also dissolves toxic metals, such as copper, aluminum, cadmium, arsenic, lead and mercury, from the surrounding rock. These metals, particularly the iron, may coat the stream bottom with an orange-red colored slime called yellow boy. Even in very small amounts, metals can be toxic to humans and wildlife. Carried in water, the metals can travel far, contaminating streams and groundwater for great distances. The impacts to aquatic life may range from immediate fish kills to sub-lethal, impacts affecting growth, behavior or the ability to reproduce. Metals are particularly problematic because they do not break down in the environment. They settle to the bottom and persist in the stream for long periods of time, providing a long-term source of contamination to the aquatic organisms that live there, and the fish that feed on them.

Acid mine drainage is particularly harmful because it can continue indefinitely causing damage long after mining has ended. Acid drainage and contaminant leaching is the most important source of water quality impacts related to metallic ore mining. Due to the severity of water quality impacts from acid mine drainage, water treatment is required in perpetuity.

Acid mine drainage

Erosion of soils and mine wastes into surface waters

For most mining projects, the potential of soil and sediment eroding into and degrading surface water quality is a serious problem as a result of

large area of land disturbed by mining operations and the large quantities of earthen materials exposed at sites.

Erosion causes significant loading of sediments (and any entrained chemical pollutants) to nearby water bodies especially during severe storm events.

Sediment-laden surface runoff typically originates as sheet flow and collects in rills, natural channels or gullies, or artificial conveyances. Major sources of erosion/sediment loading at mining sites include open pit areas, heap and dump leaches, waste rock and overburden piles, tailings piles, haul roads and access roads, ore stockpiles, vehicle and equipment maintenance areas, exploration areas, and reclamation areas. A further concern is that exposed materials from mining operations (mine workings, wastes, contaminated soils, etc.) may contribute sediments with chemical pollutants, principally heavy metals.

The types of impacts associated with erosion and sedimentation are numerous, typically producing both short-term and long term impacts. In surface waters, elevated concentrations of particulate matter in the water column can produce both chronic and acute toxic effects in fish.

Sediments deposited in layers in flood plains or terrestrial ecosystems can produce many impacts associated with surface waters, ground water, and terrestrial ecosystems. Minerals associated with deposited sediments may depress the pH of surface runoff thereby mobilizing heavy metals that can infiltrate into the surrounding subsoil or can be carried away to nearby surface waters. The associated impacts could include substantial pH depression or metals loading to surface waters and/or persistent contamination of ground water sources. Contaminated sediments may also lower the pH of soils to the extent that vegetation and suitable habitat are lost.

Beyond the potential for pollutant impacts on human and aquatic life, there are potential physical impacts associated with the increased runoff velocities and volumes from new land disturbance activities. Increased velocities and volumes can lead to downstream flooding, scouring of stream channels, and structural damage to bridge footings and culvert entries. In areas where air emissions have deposited acidic particles and the native vegetation has been destroyed, runoff has the potential to increase the rate of erosion and lead to removal of soil from the affected area.

Overburden Drainage

Impacts of tailing impoundments, waste rock, heap leach, and dump leach facilities

The impacts of wet tailings impoundments, waste rock, heap leach, and dump leach facilities on water quality can be severe. These impacts include contamination of groundwater beneath these facilities and surface waters. Toxic substances can leach from these facilities, percolate through the ground, and contaminate groundwater, especially if the bottoms of these facilities are not fitted with an impermeable liner. Tailings (a by-product of metallic ore processing) is a high-volume waste that contain harmful quantities of toxic substances, including arsenic, lead, cadmium, chromium, nickel, and cyanide (if cyanide leaching is used). Most mining companies dispose of tailings by mixing them with water (to form slurry) and disposing of the slurry behind a tall dam in a large wet tailings impoundment. Because the ore is usually extracted as slurry, the resulting waste contains large amounts of water, and generally forms ponds at the top of the tailings dams that can be a threat to wildlife. Cyanide tailings in precious metals mines are particularly dangerous. Ultimately, tailing ponds will either dry, in arid climates, or may release contaminated water, in wet climates. In both cases, specific management techniques are required to close these waste repositories and reduce environmental threats.

During periods of heavy rain, more water may enter a tailings impoundment than it has the capacity to contain, necessitating the release of tailings impoundment effluent. Since this effluent can contain toxic substances, the release of this effluent can seriously degrade water quality of surrounding rivers and streams, especially if the effluent is not treated prior to discharge.

Dozens of dam breaks at wet tailings impoundments have created some of the worst environmental consequences of all industrial accidents. When wet tailings impoundments fail, they release large quantities of toxic waters that can kill aquatic life and poison drinking water supplies for many miles downstream of the impoundment.

Impacts of mining projects on air quality

Airborne emissions occur during each stage of the mine cycle, but especially during exploration, development, construction, and operational activities. Mining operations mobilize large amounts of material, and waste piles containing small size particles that are easily dispersed by the wind. The largest sources of air pollution in mining operations are particulate matter transported by the wind as a result of excavations, blasting and transportation of materials. Exhaust emissions from mobile sources (cars, trucks, heavy equipment) raise these particulate levels.

Large-scale mining has the potential to contribute significantly to air pollution, especially in the operation phase. All activities during ore extraction, processing, handling, and transport depend on equipment, generators, processes, and materials that generate hazardous air pollutants such as particulate matter, heavy metals, carbon monoxide, sulfur dioxide, and nitrogen oxides.

Mercury is commonly present in gold ore. Although concentrations vary substantially, even within a specific ore deposit. If the content of mercury in a gold ore is 10 mg/ kg, and one million tons of ore is processed at a particular mine (not unusual concentrations), 10 tons of mercury are potentially released to the environment. In some gold mining projects, gold-containing ore is crushed and then, if necessary, heated and oxidized in roasters or autoclaves to remove sulfur and carbonaceous material that affects gold recovery. Mercury that is present in the ore is vaporized, particularly in roasters, which are some of the largest sources of mercury emitted to the atmosphere.

Noise pollution associated with mining may include noise from vehicle engines, loading and unloading of rock into steel dumpers, chutes, power generation, and other sources. Cumulative impacts of shoveling, ripping, drilling, blasting, transport, crushing, grinding, and stock-piling can significantly affect wildlife and nearby residents. Vibrations are associated with many types of equipment used in mining operations, but blasting is considered the major source. Vibration has affected the stability of infrastructures, buildings, and homes of people living near large-scale open-pit mining operations. The animal life, on which the local population may depend, might also be disturbed.

Impacts of mining projects on wildlife

Wildlife is a broad term that refers to all plants and any animals (or other organisms) that are not domesticated. Mining affects the environment and associated biota through the removal of vegetation and topsoil, the displacement of fauna, the release of pollutants, and the generation of noise.

Wildlife species live in communities that depend on each other. Survival of these species can depend on soil conditions, local climate, altitude, and other features of the local habitat. Mining causes direct and indirect damage to wildlife. The impacts stem primarily from disturbing, removing, and redistributing the land surface. Some impacts are short-term and confined to the mine site; others may have far-reaching, long-term effects. The most direct effect on wildlife is destruction or displacement of species in areas of excavation and piling of mine wastes. Mobile wildlife species, like game animals, birds, and predators, leave these areas. More sedentary animals, like invertebrates, many reptiles, burrowing rodents, and small mammals, may be more severely affected. If streams, lakes, ponds, or marshes are filled or drained, fish, aquatic invertebrates, and amphibians are severely impacted. Food supplies for predators are reduced by the disappearance of these land and water species. Many wildlife species are highly dependent on vegetation growing in natural drainages. This vegetation provides essential food, nesting sites, and cover for escape from predators. Any activity that destroys vegetation near ponds, reservoirs, marshes, and wetlands reduces the quality and quantity of habitat essential for waterfowl, shore birds, and many terrestrial species.

The habitat requirements of many animal species do not permit them to adjust to changes created by land disturbance. These changes reduce living space. The degree to which animals tolerate human competition for space varies. Some species tolerate very little disturbance. In instances where a particularly critical habitat is restricted, such as a lake, pond, or primary breeding area, a species could be eliminated. Surface mining can degrade aquatic habitats with impacts felt many miles from a mining site. For example, sediment contamination of rivers and streams is common with surface mining.

Impacts of mining projects on social values

The social impacts of large-scale mining projects are controversial and complex. Mineral development can create wealth, but it can also cause considerable disruption. Mining projects may create jobs, roads, schools, and increase the demands of goods and services in remote and

impoverished areas, but the benefits and costs may be unevenly shared. If communities feel they are being unfairly treated or inadequately compensated, mining projects can lead to social tension and violent conflict.

Communities feel particularly vulnerable when linkages with authorities and other sectors of the economy are weak, or when environmental impacts of mining (soil, air, and water pollution) affect the subsistence and livelihood of local people. Power differentials can leave a sense of helplessness when communities confront the potential for change induced by large and powerful companies.

The displacement of settled communities is a significant cause of resentment and conflict associated with large-scale mineral development. Entire communities may be uprooted and forced to shift elsewhere, often into purpose-built settlements not necessarily of their own choosing. Besides losing their homes, communities may also lose their land, and thus their livelihoods. Community institutions and power relations may also be disrupted. Displaced communities are often settled in areas without adequate resources or are left near the mine, where they may bear the brunt of pollution and contamination. Forced resettlement can be particularly disastrous for indigenous communities who have strong cultural and spiritual ties to the lands of their ancestors and who may find it difficult to survive when these are broken.

When mining activities are not adequately managed, the result is degraded soils, water, biodiversity, and forest resources, which are critical to the subsistence of local people's livelihoods. When contamination is not controlled, the cost of the contamination is transferred to other economic activities, such as agriculture and fishing. The situation is made worse when mining activities take place in areas inhabited by populations historically marginalized, discriminated against, or excluded.

Mining projects often underestimate the potential health risks of mining activities. Hazardous substances and wastes in water, air, and soil can have serious, negative impacts on public health. Because of the quantity, concentration, or physical, chemical or infectious characteristics, hazardous substances may cause or contribute to an increase of mortality or an increase in serious irreversible or incapacitating illness, pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed.

Frequent public health problems related to mining activities include surface and ground water contamination with metals and elements;

microbiological contamination from sewage and wastes in campsites and mine worker residential areas, exposure to high concentrations of sulfur dioxide, particulate matter, heavy metals, including lead, mercury and cadmium and deposition of toxic elements from air emissions.

Mining activities can suddenly affect quality of life and the physical, mental, and social well-being of local communities. Improvised mining towns and camps often threaten food availability and safety, increasing the risk of malnourishment. Indirect effects of mining on public health can include increased incidence of tuberculosis, asthma, chronic bronchitis, and gastrointestinal diseases.

Mining activities can cause direct and indirect impacts to cultural resources. Direct impacts can result from construction and other mining activities. Indirect impacts can result from soil erosion and increased accessibility to current or proposed mining sites. Mining projects can affect sacred landscapes, historical infrastructures, and natural landmarks. Potential impacts include complete destruction of the resource through surface disturbance or excavation, degradation or destruction due to topographic or hydrological pattern changes, or from soil movement (removal, erosion, sedimentation); unauthorized removal of artifacts or vandalism as a result of increased access to previously inaccessible areas and visual impacts due to clearing of vegetation, large excavations, dust, and the presence of large-scale equipment, and vehicles.

3.3 Oil Exploration and Exploitation Activities

It is a fact that the Nigerian oil industry has affected the country's economy in a number of ways but the adverse effect of petroleum exploitation on environment in the form of oil spills, extensive deforestation, loss of farms, loss of soil fertility, erosion, gas flaring, contamination of streams and rivers, effluent discharge and disposal is what the host communities are plaque with.

The deliberate act of sabotage and vandalization of oil installations causes extensive contamination of soil and water. Frequent rains and a high water table allow the oil contamination to be carried further down the delta through the creeks contaminating surface water and river sediments. The contamination of soil, surface water and ground water in turn impacts agriculture and fisheries negatively. Nigeria also flares more natural gas associated with oil exploration than any other country in the world and it releases toxic components into the atmosphere and contribute to climate change. Gas flares have potentially harmful effects on the environment, health and livelihood of the communities as they release a variety of harmful and poisonous chemicals including nitrogen

dioxides, sulfur dioxide, and volatile organic compound such as benzene, toluene, xylene and hydrogen sulfide as well as carcinogens like benzapyrene and dioxin which can cause health complications.

4.0 CONCLUSION

The nature of ecological consequences of mismanagement of natural resources in this unit resound the effects as it relates to agricultural activities, soil health and the impact of mining and petroleum exploitation on the environment.

5.0 SUMMARY

In this unit, we have learnt:

- Impact of intensive agriculture on soil resources.
- Ecological consequences of mining operations.
- Implications of petroleum exploitation on the environment.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain effects of agricultural intensification on soil productivity.
2. Enumerate five effects of eutrophication in aquatic ecosystem.
3. Discuss five environmental impact of mining operation.
4. Discuss the ecological consequences of oil spillage.

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MODULE 2

UNIT1 DEFINITION AND IMPORTANCE OF GREEN BELT

CONTENTS

1.0 INTRODUCTION

Green belt is established as a large band of permanently protected countryside to serve both as a limit to unsustainable urban sprawl and as a means of preventing the further loss of valuable agricultural lands and other natural features. By providing this protection, the Green belt has the potential to act as a long-term safeguard for the valuable stock of natural capital within the Greenbelt, whose ecosystems offer a broad set of benefits including the provision of clean drinking water, improved air quality, and vital natural habitat. One of the important ecosystem functions of the Greenbelt is its potential to reduce greenhouse gases. The Green belt's forests, wetlands, and agricultural soils capture and store considerable amounts of carbon and, as such, can play a role in mitigating climate change.

2.0 OBJECTIVES

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

- Define at least four perspectives of green belt
- List and explain five importance of green belt

3.0 MAIN CONTENT

3.1 Meaning and Definition of Green belt

There are various perspectives to the definition of green belt:

- A green belt refers to a physical area of open space, e.g., farmland, forest or other green space, that surrounds a city or metropolitan area, and it is intended to be a permanent barrier to urban expansion.
- A green belt is a land use zone designation used in land use planning to retain areas of largely undeveloped, wild, or agricultural land surrounding or neighbouring urban areas. Similar concepts are greenways or green wedges which have a linear character and may run through an urban area instead of around it.
- A green belt refers to vegetation cover leading to conservation of biodiversity, retention of soil moisture, recharge of ground water and maintaining pleasant micro climate of the region and control environmental pollutants.
- Green belts are planned open spaces safeguarded from developmental activities such as construction of buildings and factories etc. Safeguarded in the sense that no infrastructural development will be allowed on such designated areas and these areas will only be used for growing vegetation cover on it. Green belts in and around urban and industrial areas are important to the ecological health of any given region.
- A Green belt is defined as a strip of natural or artificially created coastal vegetation designed to prevent coastal erosion, and mitigate the adverse impacts of natural coastal hazards on human lives and property.
- A green belt is also referred to as shelter belts which is a linear arrays of trees and shrubs planted to create a range of benefits and is been managed to alter environmental conditions in agricultural situations. Shelterbelts are called by different names such as windbreaks, hedgerows, fence rows etc. They protect crop fields by reducing wind erosion, improving crop water use and increasing crop yields and economic returns

The objective of Green belt varies from country to country and region to region. The common objectives are to protect natural environments such as biodiversity, improve air quality of the region, pollution control, to maintain micro climate of the region, combat desert encroachment etc. Green Belt Development is an important tool that aims at overall improvement in the environmental conditions of the region.

3.2 Importance of Green belt

The following are some of the benefits offered by green belt projects:
Providing access for informal recreation

With the increasing intensification of urban areas and the loss of open space, including playing fields, the Green Belt can play a very significant role in providing space for informal recreation activities, such as cycling, walking and picnicking.

Providing opportunities for outdoor sport and recreation
As with informal recreation, the Green Belt offers significant opportunities for formal sport and recreation.

Conserving and enhancing landscapes

Successful tree planting increases woodland thereby reducing erosional activities of wind and water on the landscape. In addition trees provide food, shade, wood-energy, building and fencing materials. They regulate micro-climates and rainfall patterns, hold soil to the ground, serve as habitats for other life forms and help to harvest and retain rainwater.

Preventing deforestation and increasing tree cover have a significant role to play in mitigation of global climate and improvement then livelihoods of local communities.

Improving damaged and derelict land

Securing improvement to damaged and derelict land through reclamation and greening projects are good environmental initiatives.

Contributing to urban renaissance

Active planning and management of open space can help to shape new development, create a strong urban edge, and provide a sense of place.

Enhancing peoples' understanding of place

Green Belt creates opportunities to improve people understanding of place as it provide potential for outdoor recreation.

Providing an education resource

With its great diversity, the Green Belt provides an invaluable educational resource. There is potential for organized events and school visits as well as individual exploration.

Helping to improve public health

There are tangible health benefits to be gained from exercising and relaxing in a natural open space. The benefits are particularly significant for elderly people, children and people with mental and social problems.

Responding to climate change

Green Belt offers the potential to contribute to limiting the effects of climate change, for example through vegetated areas acting as carbon sinks and through opportunities for accommodating renewable energy resources such as biomass energy crops. Where climate change is likely to exacerbate problems of water supply the Green Belt could provide space for water storage

A venue for holidays and tourism

Open green spaces are potentially attractive to tourists and visitors as holiday destinations.

4.0 CONCLUSION

This unit summarizes the different perspectives relating to the definition of green and benefits of establishing and maintaining a green belt.

5.0 SUMMARY

In this unit, we learnt:

- The definition of green belt
- The importance of green belt

6.0 TUTOR-MARKED ASSIGNMENT

1. Define at least four perspectives of green belt
2. List and explain five importance of green belt

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UNIT 2 GREEN BELT AND COASTAL ZONE PROTECTION

CONTENTS

1.0 INTRODUCTION

The diverse habitats that comprise the sea and coastal environment have historically provided invaluable tangible benefits to its inhabitants. Coastal green belt including mangroves and other coastal forests undoubtedly provided a strong line of defense against the impact of coastal surges and also prevented intrusion of sea water to greater depths. The protective role of green belts against the coastal hazardous effects of storms, cyclones, hurricanes and pollutants from discharges has raised considerable interest among policy-makers and planners and attempts have already begun in many countries to plant tree saplings on shores on a mass scale and to rehabilitate mangroves. Other benefits of coastal vegetation includes the conservation of biodiversity, providing livelihood support for coastal communities through agricultural and forestry crops, affording shade for various human activities, and in contributing to recreation and scenic beauty.

2.0 OBJECTIVES

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

- Define a coast.
- Explain the uses of coastal resources.
- Enumerate and explain the challenges to sustainable development in the coastal zones.
- State the benefits of coastal green belt in coastal zone protection.

3.0 MAIN CONTENT

3.1 The Coast

In the broadest sense a coast defined as the place where the waters of the seas meet the land. The coast represents a mosaic of rich and diverse ecosystems and resources and is important to the economic and social well-being and development of coastal region. The combination of freshwater and salt water in coastal estuaries creates some of the most productive and richest habitats; the resulting return in fishes and other marine life is of great value to coastal nations. The coasts are highly valued and greatly attractive as sites for resorts and as vacation destinations. In many locations, the coastal topography formed over the millennia provides significant protection from hurricanes, tropical storms, and their ocean-related disturbances. Hence, for most coastal nations, the coasts are an asset of incalculable value and an important part of the national heritage.

3.2 Coastal Zone

The coastal zone is the transitional area between land and sea. It is defined, as a strip of land and sea of varying width depending on the nature of the environment and management needs. It seldom corresponds to existing administrative or planning units. The natural coastal systems and the areas in which human activities involve the use of coastal resources may therefore extend well beyond the limit of territorial waters and many kilometers inland. Thus, for practical planning purposes, the coastal zone is a special area endowed with special characteristics, of which the boundaries are often determined by the specific problems to be tackled.

3.3 Utilization of Coastal Resources

Coastal resources generally supply major economic benefits and contribute significantly to the national economy of countries and states. The major uses of coastal resources are: fisheries, tourism and recreation, urban development, shipping and transportation, industrial and manufacturing and shoreline protection.

Fisheries and Mariculture

Fish harvesting practices involves the use of fish traps, gill nets, drag nets, trawlers as well as spear fishing. Over fishing and the removal of juveniles have resulted in the decline of fishable stocks. The issues and challenges facing the fisheries sector in include rapid population growth, growing demand for fish and fish products, pollution and degradation of

coastal and marine habitat, unregulated and illegal fishing by local fleets, natural disasters such as hurricanes, and resultant damage to infrastructure, global warming and accompanying sea level rise. Mariculture activities include oyster culture, Irish moss culture as well as marine cage culture of primarily tilapia and shrimp. The issues associated with mariculture activities within the coastal zone include conflicts over access, tenure and harvesting rights; pollution discharges and subsequent degradation of adjacent waters; reduction in the aesthetic appeal and the illegal cutting of mangroves.

Tourism

Coastal areas historically have served as tourist destinations and tourism activities ranging from ticket booking, accommodation, restaurant, craft and gift, sporting, medical etc provides employment to people directly and indirectly. The constant drive to increase the number of visitors to coastal resorts places additional stress on limited resources and existing infrastructure such as sewage treatment facilities, supply of domestic water and solid waste disposal. These changes trigger rising property values, competition for resources and conflicts with other sectors such as fisheries and agriculture.

The growing popularity of ecotourism has led to the increase in demand for nature-oriented recreational services and access to coastal protected areas and buffer zones.

Urban Development

In 1994, World Bank experts estimated that two-thirds of the population of developing nations would be living along coasts by the end of the twentieth century. The presence of large and growing populations in the coastal areas exercises increasing pressure on these areas; pressure that threatens to diminish or even obliterate the values of the coasts. With rapidly increasing populations comes the proliferation of infrastructure for the manufacturing, transportation, energy processing and consumption that these populations require, as well as the corresponding amount of the waste products.

Sand Mining

Beaches and dunes as well as river mouths are the primary sources of sand for building. Indiscriminate sand mining from rivers, dunes and beaches is a major problem affecting the stability of the coastal resources. This activity is illegal in many countries but despite the

existence of the relevant laws enforcement is ineffective. The main issues related to the illegal removal of sand are changes in river courses, diminished coastal protection, destabilization of riverbeds, beach erosion, increased turbidity and flooding.

Ports, Industrial Development and Shipping

Ports have traditionally served as a magnet for manufacturing and processing activities, often contribution to the urbanization and increased industrial character of the coastal areas. Port operations including maintenance dredging and the disposal of dredge material and ship borne wastes, have significant effects on the coastal environmental quality. Increasing traffic increase the likelihood of accidental spills placing the coastal environment at high risk. Maritime transport is also a source of ship-generated marine debris and ranges of solid waste particularly plastics.

Urban waterfronts support infrastructure such as processing and power plants, wastewater treatment facilities, refineries and other industrial facilities that use coastal area as receiving waters for treated and untreated effluent. Dependent on the prevailing currents as well as the volume and composition of the effluent, there can be an impact on other activities dependent on marine water quality.

3.4 Challenges to Sustainable Development in the Coastal Zone

Marine Pollution

Sources of marine pollution and contaminations include petroleum and its derivatives; minerals contaminants include those from mineral processing, urban and industrial contaminant and agricultural contaminants. Marine pollution prevails in many ports where marine sediment retains substantial concentration of heavy metals (such as copper, cadmium. chromium. lead, zinc and mercury) as a result of waste disposal activities and discharge practices. Dredging disturbs these contaminated sediments causing them to enter the water column where they are ingested by marine organisms such as shell fish, thereby entering the food chain. Pollution of coastal waters can greatly reduce the production of fish and contributes to degradation of coastal nursery grounds and other valuable wetland habitat. The storm protection afforded by fringing coral reefs and mangrove forests can be lost if the corals die or the mangroves are removed. Inappropriate development and accompanying despoilment reduce the attractiveness of the coastal environment and its tourism potential.

Waste Disposal

The growth in urban population, industrial activity and tourism has outstripped infrastructural capacities to handle waste. In the absence of adequate sewage collection systems, waste treatment has in many instances been undertaken in an ad hoc and unsanitary fashion. Septic tank effluent is sometimes disposed of in storm drains and in some instances directly into coastal waters. Where sewage treatment facilities have been installed, there are deficiencies in plant capacity, plant operation as well as maintenance and monitoring practices. Improper disposal of industrial waste water from refineries and petro-chemical plants, sugar factories, distilleries, breweries, abattoirs, tanneries, textile industries, detergents factories, power plants, paint manufacture etc has for some time been an important cause of marine pollution. The absence and non compliance with water quality standards in a number of countries also serves to exacerbate the negative environmental impact of industrial and agricultural wastes.

Degradation of Coastal Ecosystems

Beaches and dunes perform vital functions in protecting uplands from the effects of hurricanes-induced storm surges and coastal flooding. They provide the habitat for a wide range of flora and fauna and are particularly important as nesting sites for sea turtles. Sanding mining is a predominant cause of beach and dune destruction in most coastal states. Coastal construction also threatens beach and dune stability and the construction of groins, sea walls and jetties are often constructed without understanding the dynamics of localize ocean currents and have been detrimental to beach replenishment. Land conversion combined with the expansion of coastal infrastructure is contributing to the degradation of coastal habitats. Mangrove forests, which represent an important link in the primary and secondary productivity of near shore areas, have been degraded through careless harvesting of timber.

Hazards and Disasters

The coastal region in some part of the world is subject to a range of natural disaster that includes earthquakes, coastal flooding, volcanic eruptions, landslides and subsistence and hurricane induced storm surges. All these hazards cause displacement of settlements, destruction of lives and properties and other social and economic dislocation. There is also risk of damage to building, roads sewer and water systems, port facilities and other infrastructure due to rising sea levels, higher storm surges and more intense tropical storms. Flood damage from heavy

rains may also occur, and may increase with increased intensity of extreme weather events.

3.5 Coastal zone Protection

There is a growing understanding of the importance of coastal green belt to mitigate damages along the coastline. The main aim of coastal green belt project is to act as windbreaks to reduce the harmful effect of dry winds, coastal waves and storms, protect the beautiful natural sand dunes, and act as a barrier to seawater salt spray and coastal stabilization. Mangrove and other trees of coastal forests have a variety of environmental and protective functions including:

- serve as the first line of defense against the impacts of tsunamis, hurricane and cyclones,
- stabilizing soils and protecting against erosion
- acting as natural barriers preventing debris from flowing inland during high tides
- reducing the force of high waves
- reducing energy of winds from the sea and helping to create sand dunes
- providing a habitat for a variety of wildlife
- add aesthetic beauty to the landscape
- offer opportunities for ecotourism and income to benefiting local population
- supply of biomass fuel to the coastal population.
- beach trees also provide a number of economic benefits.

4.0 CONCLUSION

Coastal greenbelt is important in the protection of coastal environment against natural hazards. Also natural vegetation in the coastal green belt would improve the scenic value of the coastal environment which in turns attracts more tourists. Therefore increased awareness and education on the potential benefits of green belt will help to build up positive attitudes among coastal people.

5.0 SUMMARY

In this unit, we have learnt:

- Definition coast.
- Delineation of coastal zone
- Uses of coastal resources.
- The challenges to sustainable development in the coastal zones.

- Benefits of coastal green belt in coastal zone protection.

6.0 TUTOR-MARKED ASSIGNMENT

- List and explain five uses of coastal resources.
- Enumerate and explain three challenges to sustainable development in the coastal zones.
- State five benefits of coastal green belt in coastal zone protection.

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UNIT3 BENEFITS OF URBAN GREEN SPACE

CONTENTS

1.0 INTRODUCTION

City planning in developing countries have recognized the need and importance of urban green space to support healthy living in urban areas. Links between urban green space and health have been recognized throughout history, and were one of the driving forces behind the urban parks movement of the 19th century in Europe and North America. Urban green spaces include public green areas used predominantly for recreation such as gardens, zoos, parks, and suburban natural areas and forests, or green areas bordered by urban areas that are managed or used for recreational purposes. It also includes specific types of urban greenery, such as street trees, and may also include ‘blue space’ which represents water elements ranging from ponds to coastal zones. Typical green spaces in urban areas are public parks where human control and activities are not intensive so that a feeling of naturalness is allowed to predominate.

2.0 OBJECTIVES

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

- State the objectives green spaces in urban and city planning.
- List and explain five health benefits of urban green space.

3.0 MAIN CONTENT

3.1 Green Space Concept in Urban Planning

Urban green space is increasing adopted as an important concept in urban planning aimed at containing sprawl and protecting cities. The idea of urban green space was founded in England in 1898, with Ebenezer Howard’s idea of a new garden city to ensure the accessibility

to nature and size of such cities was restrained by an agricultural and recreational zone, called a green belt. The initial function then was to ensure open space for agriculture near urban settings and to limit urban growth and preserve rural areas. However, the roles of these green spaces have changed and become more significant. Garden cities as a planning concept, was widely spread in the turn of the 19th century but the urban green space strategy peaked among planners from the early 1950s to the 1970s during high modernism. The adoption of urban green space was seen as a way of imposing a rural-urban polarity on the landscape of outer urban suburbs and as a tool to secure the preservation of a beautiful surrounding landscape. Sometimes the urban green space strategy is referred to as the "blanket prohibition" because of a strict regulation of development. With the urban green space concept promoted as a universal solution to urban growth, it was soon being deployed around the world regardless of the contingencies that affect urban growth in different cities.

On a global outlook, urban green spaces are seen around large cities such as Moscow, Bangkok, Tokyo, Seoul, Ottawa and Paris, to name a few. These green spaces, however, may showcase different structures and patterns; the ambitions are more or less similar to the goals of the green belt in the Garden City. Based on the global experience, the main objectives of urban green space can be summarized as:

- Mitigation of urban sprawl and improvement of landscape patterns.
- Prevent the coalescence of urban areas
- Recreational functions.
- preserve the character of historic towns
- Safeguard the countryside from encroachment
- Improve the degraded urban fringe
- Provide access to the open countryside
- Protect agriculture, forestry, and related uses.
- Enhancement of the urban ecology including air purification, improving microclimates and increased biodiversity.
- Educational function as a green belt can demonstrate the importance of nature

3.2 Evidence on Health Benefits of Urban Green Spaces

The pathways leading to beneficial health effects of green space are diverse and complex. Various models have been formulated to explain the relationship between green space and health. Hartig et al. (2014) suggested four interacting pathways through which green space can affect health and wellbeing: improved air quality, enhanced physical

activity, stress compensation and greater social cohesion. Lachowycz and Jones (2013) proposed physical activity, engagement with nature, relaxation, and social interactions as major pathways to health. Villanueva et al. (2015) argued that urban green spaces mitigate the urban heat island effect providing protection from heat-related health hazards, improve social capital and cohesion, and enhance physical activity. In addition to the pathways outlined above, Kuo (2015) suggests a central role for enhanced immune functioning as a pathway between nature and health, recognizing that there may be multiple pathways, some of which may interact and offer both direct and indirect benefits. Hartig et al. (2014) summarized the existing strong evidence for restorative psychological effects from interaction with green space or natural environments.

Improved Relaxation and Restoration

The evidence of health benefits due to mental restoration and relaxation from having contact with nature and green space is well documented (Hartig et al. 2014). It has been suggested that contacts with nature (e.g. views of green space) can trigger positive effects for persons with high stress levels by shifting them to a more positive emotional state and that stimuli in natural settings help to restore a sense of well-being in persons suffering mental fatigue (Kaplan, 2001).

For example, a study in the United Kingdom used wearable sensors to demonstrate the effects of a short walk in a green space on brain activity that might be associated with enhanced relaxation and restoration (Aspinall et al. 2015). It was also shown that walking in natural environments produces stronger short-term cognitive benefits than walking in the residential urban environment (Gidlow et al. 2016). Cortisol measures have demonstrated that gardening alleviated acute stress faster than reading (van den Berg and Custers 2011). It has also been demonstrated that exposure to green space reduces neural activity in the subgenual prefrontal cortex and alleviates depression symptoms (Bratman et al. 2015).

Improved Functioning of the Immune System

Kuo (2015) suggested a central role for enhanced immune functioning in the pathways between nature and health. Associations between visiting forests and beneficial immune responses, including expression of anti-cancer proteins, have been demonstrated in Japan (Li et al. 2008). This suggests that immune systems benefit from direct exposure to natural environments or through contacts with certain factors in the green space. Living in residential areas with more street trees was shown to be associated with lower asthma prevalence (Lovasi et al. 2008). Studies

have demonstrated that increased biodiversity in the environment around homes is linked with reduced risk of allergy (Ruokolainen et al. 2015; Hanski et al. 2012). Greater exposure to commensal microorganisms, especially in the early life, may lead to more diverse skin and gut microbiomes, and provide protection against allergy and autoimmunity. It has also been suggested that the human microbiome associated with natural environmental may improve mental health (Logan 2015).

Enhanced Physical Activity and Improved Fitness

Physical activity has been shown to improve cardiovascular health, mental health, neurocognitive development, and general well-being and to prevent obesity, cancer, and osteoporosis (Owen et al. 2010). Providing attractive and accessible urban environments may encourage people to spend more time outdoors and facilitate physical activity. The quality of the urban green space and presence of specific amenities are important factors facilitating physical activity in older adults. For urban residents with mental health problems, physical activity in green space may be particularly therapeutic (Roe and Aspinall 2011). Other populations or subgroups may benefit, in a similar way, from green space that makes outdoor activity enjoyable and easy, and encourages less sedentary lifestyles. Hartig et al. (2014) summarized available evidence for an association between green space and physical activity levels in three domains: work, active transport and leisure. Studies have demonstrated that recreational walking, increased physical activity and reduced sedentary time were associated with access to, and use of green space in working age adults, children and senior citizens (James et al. 2015; Sallis et al. 2016).

Improved Social Capital and Cohesion

Social relationships have a well-known protective effect on health and well-being, while social isolation is predictor of morbidity and mortality (Yang et al. 2016). Green space can play an important role in fostering social interactions and promote a sense of community that is essential for social cohesion as well as for human health (Kim and Kaplan 2004) . Public urban green space has been shown to facilitate social networking and promote social inclusion in children and adolescents. The quantity and the quality of greenery have been linked with improved social cohesion at the neighbourhood scale while shortage of green space has been associated with perception of loneliness and lack of social support (de Vries et al. 2013).

Anthropogenic noise buffering and production of natural sounds

Noise pollution is a major and increasing threat to human health, due to continuing urbanization, rising traffic volumes, industrial activities, and a decreasing availability of quiet places in cities. Evidence suggests that a well- designed urban green space can buffer the noise, or the negative perception of noise, emanating from non- natural sources, such as traffic, and provide relief from city noise (González- Oreja et al., 2010). Vegetation has been considered as a means to reduce outdoor noise pollution, mainly in areas with high volumes of traffic. A study in Uttar Pradesh, India showed significant reductions in traffic noise pollution from vegetation belts of 1.5 – 3 m width (Pathak et al., 2008).

4.0 CONCLUSION

The available evidence summarized in this unit suggests that potential causal pathways leading to public health benefits of urban green spaces include psychological relaxation and stress reduction, improved social cohesion and psychological attachment to the home area, immune system benefits and enhanced physical activity. Green space can also provide ecosystem services associated with reduced exposures to noise, air pollution. These health benefits depend on the overall greenness of residential areas and can be provided by adequate urban planning mechanisms.

5.0 SUMMARY

In this unit, we have learnt:

- The relevance of green space in urban planning
- The health benefits of urban green space

6.0 TUTOR-MARKED ASSIGNMENT

1. State the objectives green spaces in urban and city planning.
2. List and explain five health benefits of urban green space.

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UNIT4 GREEN BELT AND AIR POLLUTION CONTROL

CONTENTS

1.0 INTRODUCTION

Human exposure to air pollutants posed severe health problems especially in urban areas where pollution levels are on the increase. Pollution due to traffic constitute up to 90 – 95% of the ambient carbon monoxide levels, 80 – 90% of nitrogen oxides, hydrocarbon and particulate matter in the world, posing a serious threat to human health. Increased pollution from mobile sources is on the increase with per capita increase in vehicle ownership. The consequence of this is the congestion of most urban city roads and a corresponding increase in the burden of air pollutants and their associated effects.

The previous units have summarized evidence that green belt (i.e vegetation) plays an important positive role in atmospheric purification and air pollutants reduction. Generally, urban green vegetation offers the ability to remove significant amounts of air pollutants and consequently improve environmental quality and human health. Trees remove gaseous air pollutants primarily by uptake via leaf stomata, though some gases are removed by the plant surface.

2.0 OBJECTIVES

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

- Define air pollution
- State the principal pollutants from vehicle traffic.
- List and explain three sources of air pollutants.
- Explain the impact of air pollutants on human health

- Discuss the role of green belt in improving urban air quality.

3.0 MAIN CONTENT

3.1 Pollution

Air pollution is defined as the introduction into the atmosphere of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organism, or damage the environment. Pollutants are substances introduced into the environment in an amount sufficient to cause adverse measurable effects on human beings, animals, or materials. Pollutants are referred to as primary pollutants, if they exert the harmful effects in the original form in which they enter the atmosphere e.g. CO, NO_n, HCs, SO_n, particulate matter and so on. On the other hand, secondary pollutants are products of chemical reactions, among primary pollutants are ozone, hydrogen peroxide, peroxyacetylnitate (PAN) and peroxybenzoyl nitrate (PBN). Classification of pollutants can also be according to chemical compositions i.e. organic or inorganic pollutants or according to the state of matter i.e. gaseous or particulate pollutants. Air pollution is basically made up of three components and these are source of pollutants, the transporting medium, which is air and target or receptor which could be man, animal, and structural facility (AbdulRaheem and Adekola, 2011).

3.2 Traffic Air Pollutants

Transportation involves the combustion of fossil fuels to produce energy translated into motion. Pollution is created from incomplete carbon reactions, unburned hydrocarbons or other elements present in the fuel or air during combustion. The principal pollutants from the transport sector responsible for adverse health effects include lead, various types of particulate matter, ozone (formed from atmospheric reactions of oxides of nitrogen and volatile organic compounds), various toxic VOCs, nitrogen dioxide, carbon monoxide, ammonia and sulphur dioxide (Gorham, 2002). The exhaust, the crankcase, the fuel tank and the carburettor are the sources of unburned hydrocarbon (HC). However, the proportion of these various pollutants attributable to the transport sector varies significantly across different cities. Carbon monoxide binds reversibly with haemoglobin and inhibits oxygen uptake and thus, interferes with the ability of the blood to carry oxygen to tissues; the most sensitive of these tissues are in the heart and brain (Henry *et al*., 2006). The health effects of carbon monoxide poisoning ranges from impaired mental alertness and performance, headaches, nausea, fatigue, and dizziness to coma and death. Long term (chronic) exposure to low levels of CO may produce heart disease and damage to the nervous

system. Exposure of pregnant women to CO may cause low birth weight and nervous system damage to the offspring (Henry *et al*., 2006).
Motor vehicle emissions are the primary source of nitrogen dioxide in outdoor air, but power plants and fossil fuel-burning industries also contribute. Nitrogen dioxide can irritate the lung and alter its defense mechanisms, thereby increasing a person's risk for respiratory infections. Its role in the formation of photochemical oxidants and smog has attracted the attention of several scientific researchers in recent years. Sulphur dioxide is an unpleasant gas formed when sulfur is exposed to oxygen at high temperatures during fossil fuel combustion, oil refining, or metal smelting. SO_2 is toxic at high concentrations, but its principal air pollution effects are associated with the formation of acid rain and aerosols (Haley, 2003). Sulfur dioxide combines with atmospheric water, oxygen, and oxidants to create weak acids that fall to the Earth as dry particles, snow, fog, or rain, which is commonly referred to as acid rain. When these acidic substances fall to the Earth, they can harm and acidify lakes and streams. Sulphur dioxide can also constrict air passages, making breathing difficult for those with asthma, and may also alter the immune system and aggravate existing cardiovascular disease (Haley, 2003).

Methane (CH_4), the simplest and most long-lived VOC, is of importance both as a greenhouse gas and as a source of background tropospheric ozone. Major anthropogenic sources of methane include natural gas production and use, coal mining, livestock, and rice paddies. Upon their release, VOCs' fate and dilution are controlled by atmospheric transport, dispersion, and removal mechanisms; hence, they are commonly encountered by people as they go about their daily routine. There is growing evidence that chronic exposure to VOCs has adverse health effects to human. The short-term adverse effects include conjunctive irritation, nose and throat discomfort, headache and sleeplessness, allergic skin reaction, nausea, fatigue and dizziness. Meanwhile, the long-term adverse effects include loss of coordination, leukaemia, anaemia, cancer and damage to liver, kidney and central nervous system (Nazarrof and Weschler, 2004; Wallace, 2001; Kerbachi, 2006).

Particulate matter includes naturally occurring dust and pollen as well as soot and aerosols from combustion activities such as agricultural burning, transportation, manufacturing, and power generation. The most harmful particles are not the large particles, which are mostly removed in the upper airways, but the small particles that may be deposited deep in the lungs.

3.3 Sources of Air Pollutants

The presence of airborne pollutants is due to the anthropogenic sources, industrial activities and the effects of natural activities such as volcanoes eruption. Most of the airborne particulates are emitted from the combustion engines from vehicles contributing at least 70-75% of the total air pollution. This happened due to the increase of the number of registered road vehicles every year which then become a dominant source of urban air pollution.

Biomass in form of firewood, coal, bamboo trunks and dead leaves are commonly used sources of cooking fuel. Of all these the most frequently used is firewood. This fuel woods are usually logged from nearby bushes and forests or are collected as dead branches within the residential vicinities by the women and sometimes children and are used to generate energy for cooking. The combustion of firewood releases gaseous pollutants and particulate matter. The particulate matter generated is in the form of carbon black, sooth and fly ash which are major components of smoke and are most often within the 10μm size range.

The process of bush burning leads to the release of various types of gaseous pollutants and particulate matter. Very often the gas stream is inundated with volatile organics and oxides of carbon (CO_n), sulphur (SO_n) and nitrogen (NO_n) depending on the fuel composition and intensity of the flame. Particulate matter usually within the 10μm size range is also produced in the course of the combustion process.

Refuse disposal is a major environmental problem in most urban areas. The refuse is usually from multiple sources including domestic, municipal, agricultural and industrial sources. One of the environmentally unfriendly methods of managing the waste is by open burning either on nearby lands or open dumps within the residential vicinities. The composition of the refuse, age of the dump and intensity of the flame usually determines the nature of the air pollutants. Often times the air within refuse burning sites is inundated with VOCs, CO_n, SO_n, NO_n, total hydrocarbons (THCs), as well as various classes of toxic and hazardous compounds viz polycyclic aromatic hydrocarbons(PAHs), dioxins, PCBs(Polychloro Biphenyls) and heavy metals such as lead, nickel and mercury. The diesel or petrol-fired electricity generator is also a source of air pollution, and it is contributing to the choking air in cities. Natural gas flaring is responsible for about 46 % of Africa's total gas flared per ton of oil produced. Much of the natural gas extracted in oil wells in the Niger Delta is immediately flared into the environment at a rate that approximates 70 million /m^3 per day. Oil and non oil related industries

including refinery, petrochemical, liquefied natural gas, chemical fertilizer, aluminum smelter, paper, cement, flour, wood, battery and textile industries etc which are major sources of greenhouse gas emissions.

3.4 Impacts of Air Pollution

High concentrations of pollutants have a negative impact on lives, properties and the environment. Studies have shown that airborne pollutants may cause adverse effects on human health such as hypertension, stroke and mortality. Life expectancy could also be reduced in the long-term exposure especially to the elderly and children. Nitrogen oxides and sulfur oxides, for example, are associated with immune system impairment, exacerbation of asthma and chronic respiratory diseases, reduced lung function, and cardiovascular disease. Exposure to carbon monoxide can result in fatigue, headaches, dizziness, loss of consciousness, and even death at very high concentrations. Particulates are especially dangerous because they have been implicated in the development of lung cancer and higher rates of mortality (Schwela, 2000). Lead is similarly dangerous as poisoning causes irreversible neurobehavioral consequences, such as decreased IQ and attention deficits, and death at high levels of poisoning (Schwela, 2000). In addition to these pollutants, vehicle emissions contain volatile organic compounds (VOCs), a class of petroleum combustion by-products which includes many known and probable carcinogens and reproductive toxicants. VOCs are also hazardous because they can react with sunlight to form ozone, which exacerbates asthma and has other adverse respiratory effects (WHO, 2000).

Material deterioration occurs when the following factors; moisture, temperature and sunlight are involved. This mechanism of deterioration has been attributed to air pollution. It also involves five systems, namely abrasion, deposition and removal, direct chemical attack, indirect chemical attack and electrochemical corrosion (Otti, Nwajuaku, and Ejikeme, 2011). Some solid particles of large enough sizes and travelling at high enough speeds can cause deterioration by abrasion. Liquid and solid particles that settle on exposed surfaces cause enough aesthetic deterioration on certain monuments and building. Solubilisation and oxidation/reduction reaction occur directly by chemical attack on some materials; example is the chemical reaction between sulphur dioxide (SO_2) and limestone ($CaCO_3$) in the presence of water to form calcium sulphate ($CaSO_4$) and gypsum ($CaSO_4.2H_2O$) (Otti *et al*., 2011). More so, some pollutants react with some components indirectly, there always would be chemical attack on the material that might lead to destruction, when leather absorbs some

sulphur dioxide (SO_2) which reacts to form sulphuric acid and the leather becomes totally brittle.

The presence of acidified rain water in the environment also increases the corrosion rate of roofing sheets, monuments and other economic structures. In the Niger delta area there is glaring evidence of the impacts of corrosion on several building structures and arts work and these cases have been observed to deteriorate at rather alarming rates (Ana, 2012).

3.5 Role of Urban Green Belt in Pollutant Removal

Urban green belt consists of multiple species of trees and other vegetation which are intentionally planted or naturally grown within the urban areas. It contains a diverse mix of plant species which are arranged in heterogeneous or homogenous patterns. Urban green belt helps in maintaining the oxygen released through photosynthesis and absorbing carbon dioxide through carbon sequestration which helps in improving the air quality of the urban areas. The trees cool down the cities by shading as well as reducing the urban heat island intensity.

Trees are the effective in ameliorating the pollutants concentration in atmosphere. Therefore, the trees planting scheme in a city would be the most effective way in achieving the objective of improving the air quality. Steward *et al*. (2005) measured the rate of pollutants deposition on woodland, grassland and other short vegetation in the West Midlands conurbation for 50 years. They found that woodland captures pollutants three times higher than the grassland as woodland had greater leaf surface area and the trees which were located at the edge of woodland were exposed to the wind and heavy traffic. Nowak *et. al*., 2006 worked on air pollution removal by urban trees and shrubs in the United States. This was a modeling study that used hourly meteorological and pollution concentration data from across the conterminous United States to demonstrate that urban trees remove large amounts of air pollutants that consequently improve urban air quality.

Besides greening purpose, urban belt provides green open spaces such as children playground, recreational sites and sports area that act as an isolation for human to escape from the stress of urban life. Urban belt also consists of plants which are having therapeutic constituents. These services provided by urban green spaces can yield significant economic returns, such as energy and medical costs averted, increased worker productivity, and increased property values.

4.0 CONCLUSION

In conclusion the studies reviewed show the capabilities of urban green belt and surrounding vegetation in filtering the atmospheric environment by reducing the airborne particulates concentration. It further confirms that one of the most efficient and environmentally friendly methods that could be applied to alleviate the pollutant concentration in ambient air is by planting vegetation in urban areas which are closely connected to the busy roads of a city.

5.0 SUMMARY

In this unit, we have learnt:

- Define air pollution
- State the principal pollutants from vehicle traffic.
- List and explain three sources of air pollutants.
- Explain the impact of air pollutants on human health
- Discuss the role of green belt in improving urban air quality.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define air pollution.
2. State the principal pollutants from vehicle traffic.
3. List and explain three sources of air pollutants.
4. Explain the impact of air pollutants on human health.
5. Discuss the role of green belt in improving urban air quality.

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UNIT5 ARID GREEN BELT: THE AFRICAN EXPERIENCE

CONTENTS

1.0 INTRODUCTION

One major environmental problem in the drylands is aridity and it implies a low rainfall for a given period below a threshold. Drylands occupy more than 40% of the world's land surface. They are home to about 1 billion people. Dust storms are a symptom of poor land management and a constant reminder of the interaction between people, the land they use and the climate. When land management is inappropriate as a result of the traditional technologies not been able to cope with burgeoning populations and the shrinking resource base, wind erosion will occur resulting in dust and sand been transported thereby leading to land degradation. Prevention of these problems is essential for sustainable development and poverty alleviation. Programme of tree planting is targeted at reduction in soil erosion, floods, landslides and numerous ecosystem services including biodiversity conservation, carbon sequestration, clean water supply, and recreational space. The arid shelter belt/ green belt project consist of strips of trees to protect valuable farmland against wind erosion and desertification.

2.0 OBJECTIVES

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

- Explain the factors that promote the establishment of arid green belt.
- List the objectives of arid green belt project.
- Explain the structure and implementation of arid green belt in a any African country.

3.0 MAIN CONTENT

3.1 Great Green Wall Initiative

Sahelian Africa faces a persistent problem of variability in rainfall, which is the major driver of vulnerability in the region. Populations in the Sahel are among the poorest and most vulnerable to climatic variability and land degradation. They depend heavily on healthy ecosystems for rainfed agriculture, fisheries, and livestock management to sustain their livelihoods. These constitute the primary sectors of employment in the region and they generate at least 40 percent of the gross domestic product (GDP) in most of the countries. Furthermore, ecosystem services provide much needed livelihood products, such as fuel wood among others. Unfortunately, increasing population pressures on food, fodder, and fuel wood in a vulnerable environment have deteriorating impacts on natural resources, notably vegetation cover. Climate variability along with frequent droughts and poorly managed land and water resources (surface and underground) have caused rivers and lakes to dry up and contribute to increased soil erosion. Since the severe droughts of the 1970s and 1980s, which caused the loss of thousands of lives and forced hundreds of thousands to migrate, much knowledge has been gained by the communities and nations on strategies to cope with and mitigate environmental degradation and climate change. Although climate vulnerability is exacerbating land degradation trends, there is growing evidence across the region of successful sustainable land management innovations that protect fragile soils, improve productivity, and create income opportunities for the vast rural population. The Great Green Wall for the Sahara and Sahel Initiative is one of such arid green belt with the objective to protect the arid areas from sand encroachment and curbing deforestation and erosion by increasing forestland productive capital.

3.2 Examples of Green Belt Project in Africa

The idea of a green belt saw the light of day in the 1950s, long before the United Nations Conference on Combating Desertification (Nairobi, 1977). The best known projects are the **green belt** in Niamey (1965), the **green dam** in Algeria (1971) and the **green belt** in Nouakchott (1975). In the other countries, reforestation and dune fixation activities were often carried out with the assistance of the forestry departments. Considered as infrastructure, these undertakings provide a public environmental service. Their implementation is carried out by the State. The **Green Dam** refers to a large-scale reforestation activity on an arid strip of land reaching a length of up to1500 km. Its main objectives are protecting arid areas from sand encroachment and curbing deforestation and erosion by increasing forestland productive capital. The arid **Green**

belt is a tree plantation ring-fencing of urban areas to protect cities, including outskirts, from sand encroachment and erosion. The green belt is also aimed at protecting specific public infrastructure such as roads. Wind breaks were the earliest recorded achievements in tackling encroaching sand.

Windbreaks

The Moroccan experience started in 1915 with the biological fixation of coastal dunes along the Atlantic Ocean coast to protect cities such as Tangiers, Kenitra and Agadir. Rainfall levels were often favourable (200-700 mm/yr), thus allowing the introduction of fast-growing imported species, such the Eucalyptus, Acacia cyanophylla and Acacia cyclops. Over 34,000 ha were planted in 60 years. The size of the greenbelt varies greatly from one site to another, ranging from 14ha to 12,000 ha. Since1979, Oases and continental cities have also been equipped with smaller greenbelts ranging from 3 to 165 ha. In Tunisia, the aim was to protect the oases and the roads. The project involved 20,000 ha of plantations comprising both local and introduced species. These first projects took the form of peri-urban or rural infrastructure, generally built by the public authorities with no specific production or exploitation purpose.

In Sahelian Africa, the idea of a peri-urban green belt was initiated in the 1960s in response to the problem of land degradation in peri-urban sylvo-pastoral areas, and with a view to meeting the needs for:

i. protection against sand encroachment and for de-polluting the dusty urban environment firewood

These needs are prioritized depending on the specific needs of the concerned urban areas. With time, the goals of the plantations in these two regions shifted from protection of populated areas and public infrastructure to production that could contribute to improving incomes.
Starting from the 1970s, Algeria has been putting in place a green dam along its border with the Sahara. This project, which is still underway, has gone through several phases. Its underlying concept has also witnessed an important evolution. The original concept entailed the reforestation with Aleppo pine planted on an east/west arid strip of essentially pastoral land covering 3 million hectares (1,500 km x 20 km) in the zone located between the 200 and 300 mm isohyets.

In 1965, Niger put in place a greenbelt around the capital, Niamey. It is still visible today. This is the country's biggest achievement in this field. It is composed of the greenbelt per se – a 2,500 ha plantation of local and introduced species – and a 2 ha recreational park.

The urban greenbelt, a protection against encroaching sand

In general, there are two types of models:

- The "large urban area" model (the Niamey greenbelt)
- The "urban areas and developed basins (cultivated lands)" model in Saharan zones, which includes small protective greenbelts (10 -150 ha) covering a total area of less than 1,000 ha.

Mauritania is unarguably the country where the greenbelt experience is the most diversified and extensive in terms of the number and distribution of projects and sites. Three types of greenbelts have been installed all of them had a protective rather than a productive purpose namely the "large urban area" model, the "urban area and cultivated zone" model and the "road" model.

- The "**large urban area**" model concerns the national capital and the regional capitals or main cities. The Nouakchott greenbelt is

located in a Saharan climate. It was planted using a variety of techniques: mechanical stabilization followed by biological fixation (mainly Prosopis juliflora plantations). This played an important role in protecting the city and its outskirts and in providing informal employment. On the other hand, plans for the greenbelt did not take account of pressure caused by urban expansion. Inherent problems of post-investment management have not yet been fully resolved. The Kiffa greenbelt in the Sahelian zone was created through direct reforestation of moving rows of sand dunes without mechanical stabilization or irrigation. This greenbelt sets a good example by its relatively low installation cost.

- **The** "**urban area and cultivated zone**" model (oasis in Saharan and Sahelian zones, rainfed agriculture in Sahelian zone) includes greenbelts of an area ranging from 15 to 335 ha that could provide effective protection and also produce wood to cover maintenance costs, especially in the Sahelian zones where extending the greenbelt area would not be costly.
- The "**road**" model: is applied to sites ranging from 5 to 15 ha, and aimed at ensuring punctual protection.

The Mauritanian experience covered over 100 sites. It showed that, on the one hand, forestry plantations could provide long-term protection without irrigation wherever rainfall levels exceeded 150 mm or in sites benefiting from the existence of groundwater tables; on the other hand, the participation of local communities, which was almost non-existent in the beginning, has improved on the basis of contracts that stipulated conditions and modalities for sharing the direct costs. More than 15 small greenbelts, ranging from one to twenty ha, were installed thanks to local initiatives, supported by incentives in kind such as the supply of tools and products that were not available locally. Last, the Mauritanian experience also showed that protecting the plantations is difficult for objective reasons such as poverty and lack of means, especially at the local level.

Mali's experience with greenbelts only dates back to 1990 when a sand encroachment control programme was started in the Timbuktu and Gao regions.

According to the concept developed by this country, the greenbelt is composed of two parts:

- an "intensive protection" perimeter located next to the urban area where mechanical dune stabilization is followed by biological fixation,

- an "extensive protection" area in the so-called "supply" zones, upstream of the protection area, in order to reduce the pressure of the moving dunes on the area.

The project's implementation approach was original. In order to produce nursery plants, three ways were explored and tested, namely the direct administration to meet 20% of the needs; private producers under contract to meet 30% of the needs; and by the local communities to meet 50% of the needs (300 nursery managers, of which 180 were women. For mechanical stabilisation and tree planting, two methods were tested: pilot sites under State administration to enhance and test the techniques, and extrapolation to prepare for extension to other areas by transferring responsibility to the beneficiary communities.

In Dakar the capital of Senegal, the conceptual originality of greenbelt resides in the fact that it consists of a network of natural forests that are part of a forestry regime consolidated and completed by plantations, perimeters for the stabilization of soils, and green spaces as well as roadside plantations, involving local communities and municipalities. The natural forests component, despite a rather rigid status, lost ground to urban expansion, but this did not jeopardize the effectiveness of the system. As for the second component, the local institutions were not able to ensure the sustainable management of the works in place.

The urban greenbelt: useful in tackling atmospheric pollution

The Ouagadougou greenbelt illustrated three salient elements in the Burkina Faso experience:

- opting for the concept that the greenbelt would be part of urban and peri-urban landscape development;
- opting for community participation;
- opting for irrigation in spite of the prevailing Sudanese climate (rainfall: 700 mm).

On the whole, despite these sound approaches, there are still enormous problems, especially in the outskirts, that prevent the development and consolidation of efforts made, and even jeopardize achievements in the absence of an adequate solution ensuring the sustainable management of what has been accomplished.

In Egypt there are two types of experiences worth mentioning: the Cairo peri-urban greenbelt and the greenbelts aiming to thwart sand encroachment, using treated sewage water and poor quality water from the deep water tables. The Cairo peri-urban greenbelt has two components: 50 meter wide shelterbelts (rows of trees) along the Cairo circular road and suburbs using drip irrigation with water from the purification stations supplied by the sewage system. The objective was to cover a cumulated length of 100 km. Four forest species, – Eucalyptus, Casuarina, Cypress and Acacia, – have been selected. The second component consists in the introduction of green spaces within the urban area. With its two components, the Cairo greenbelt intends to rid the air from sand and dust brought by the wind. Thus, it acts as an atmosphere de-pollution mechanism rather than an intervention to fixate dunes in motion. It has been designed as an investment for the Ministry of Environment with an installation phase, sub-contracted to the Army, and an "unlimited" maintenance phase integrated into the young graduates' employment policy. This makes it an element of urban infrastructure just like the road networks that it is supposed to accompany or protect. Its role will be only protection, not at all (or very little) production. The greenbelt concept here is reduced to its basic meaning or simplest expression. Its form and contents clearly reflect its name, and vice versa.

The countries of East Africa, such as Kenya, seem to favour the fragile ecosystem restoration concept based on the adaptation of prevailing land use methods and the decentralization of responsibility to the local institutions. Two experiences are worth mentioning: those of Kenya and Sudan.

The Kenyan experience with plantations is original for two reasons: first, the concept is based on the principle of environmental conservation through community development by and for the people, optimizing local resources and know-how, and second, the Greenbelt Movement was launched at the initiative of a women's group, Kenya's National Council of Women. Planting trees has had a catalysing effect and has integrated development actions. It has also played a role in conserving biological diversity.

The Sudanese experience is characterized by the involvement of the local institutions and has succeeded in rehabilitating an ecosystem which

was itching toward degradation, and allowed the sustainable use of forestry resources in a natural reserve located in an arid region.
The broad objectives of arid green belt include the following:

i. To enhance environmental sustainability.
ii. To promote integrated natural resource management.
iii. To combat desertification and slow the advance of the Sahara desert.
iv. To conserve biological diversity.
v. To reduce poverty.
vi. To control land degradation
vii. To improve rangeland and the development of the country's animal stock.
viii. To increase food production to overcome food shortages.
ix. To improve the household and rural people.
x. To create wealth and employment.

4.0 CONCLUSION

Arid greenbelt offer protection against sand encroachment and farmland protection, it is very important in the fight against erosion and land protection and crop production improvement (thanks to an improved water balance). With to rural energy demand, it provides firewood with a view to meeting local needs and reducing pressure on nearby natural forests; the development and management of natural forests involves the neighbouring populations and the external actors; fodder and pastoral production is envisaged with a view to increasing family incomes and reducing pressure on nearby rangelands. In the urban areas, the city models for the greenbelt fit in with urban development policies and have the objectives of protecting the cities against sand encroachment and pollution, providing recreational areas for city dwellers and wood production in adequately managed plantations.

5.0 SUMMARY

In this unit, we have learnt:

- Factors that promote the establishment of arid green belt.
- Objectives of arid green belt project.
- Examples of arid green belt in African.

7.0 TUTOR-MARKED ASSIGNMENT

- Explain the factors that promote the establishment of arid green belt.
- List the objectives of arid green belt project.
- Explain the structure and implementation of arid green belt in a any African country.

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MODULE 3

UNIT1 MEANING AND DEFINITION OF SOIL EROSION

CONTENTS

1.0 INTRODUCTION

Soil erosion is a ubiquitous naturally occurring process in which weathered material is removed from the landscape. It encompasses the processes of sediment entrainment and transportation, leading to lowering of the land surface. Ultimately the eroded material is deposited elsewhere.

2.0 OBJECTIVES

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

- Explain the term soil erosion.
- List and explain the types of soil erosion.
- List and explain the factors affecting the rate of soil erosion.
- List the techniques of controlling soil erosion by either wind or water.

3.1 Meaning and Definition of Soil Erosion

Soil loss can occur through surface erosion, gully erosion and soil mass movement. Soil erosion involves the detachment and subsequent removal of soil particles and small aggregates from land surface by water or wind. This type of erosion is caused by the action of raindrop, thin film of flowing water, concentrated overland flows or the action of wind. While less serious in forested environments, surface erosion can be an important source from rangeland and agricultural croplands. Gully erosion is the detachment and movement of individual soil particles or large aggregates of soil in a well defined channel. Type of erosion is a major form of geologic erosion that can be accelerated under poor land management. Soil mass movement refers to erosion in which cohesive masses of soil and rock materials are displaced and moved down gradient by gravity. This movement can be rapid as occurs with landslide or bluff collapse or it can be slow as with soil creep and channel slumps.

All of the above erosion processes can occur singly or in combination. People's activities such as timber harvesting intensive livestock grazing, road construction, or row crop agriculture can accelerate the processes. At times it is difficult to distinguish the basic types of erosion and to determine whether they are natural processes or been accelerated by poor land use practices.

3.2 Types of Soil Erosion

Sheet erosion is defined as the uniform removal of soil in thin layers from sloping land, resulting from sheet and overland flow. Raindrops detach the soil particles and the detached sediment can reduce the infiltration rate by sealing the soil pores. When the rate of rainfall exceeds the rate of infiltration of water into the soil, water starts to flow over the soil of the sloping land. At this point erosion commences and picks up the rain drop-detached particles and carries them along. The eroding and transporting power of sheet flow is a function of the rainfall intensity, infiltration rate and field slope for a given size, shape, density of soil particles and erodibility potential of the soil.

Rill erosion is the detachment and transport of soil by a concentrated flow of water in a minute channel. It is most serious where intense storm occurs on soil with high runoff producing characteristics and high erodible top soil.

Gully erosion produces channels larger than rills. These channels carry water during and after rains. The amount of sediment from the gully depends primarily on the run-off producing characteristics of watershed,

and the drainage areas; soil characteristics, alignment, size and shape of the gully and slope in the channel.

3.3 Factors Controlling Soil Erosion

Erosion by water is known to be directly controlled by a number of factors; climate, vegetation, soil properties and topography. Each factor is itself complex, and the various factors interact with one another.

Climate: The climatic term needs to be appropriately summed over the frequency distribution of storm rainfalls, but it can be seen that this approach provides a rationale for combining the effects of topography, soils and climate into a single integrated erosion forecast. Both low frequency and high frequency components of the climate are important for erosion. Low frequency events determine the seasonal cycle of the soil water balance, which provides the environment for growth of crops or natural vegetation. It may be appropriate to run a vegetation growth model (natural or crop), which then contains the potential to give a dynamic response to changed land use or climate conditions. High frequency rainfall events are clearly crucial for generating overland flow. The simplest effective tool for estimating runoff is the notion of a threshold storm size. Beneath the threshold there is little or no runoff; above it all or a high proportion of the additional rainfall generates overland flow. The runoff threshold and proportion of subsequent runoff are simplifications of cumulative infiltration and runoff curves. Runoff Threshold is estimated from the crown cover, soil organic matter and soil texture/ structure characteristics. The threshold represents the effects of surface storage in random roughness and plough furrows, the dynamic evolution of soil crusting and moisture storage within the upper soil layers.

Vegetation: Vegetation acts on several ways, which may be dominant under different conditions, first by protecting the soil from rain splash impact and crusting, second by intercepting rainfall which is lost to evaporation and third by building up organic matter in the soil which greatly enhances the short-term dynamic storage and release of soil moisture. The combined effect of these processes is to decrease the runoff and soil erodibility. Vegetation also resists erosion by adding to surface roughness which reduces overland flow velocity, and binds the soil together with shallow root mats, particularly in grasses. However, it is recognized that vegetation is strongly influenced by land use, agricultural activity, both in cropland and by grazing, fire management etc.

Soil Properties: The most important soil property is the erodibility. Erodibility is seen as primarily a property of the soil texture, with

highest values for fine sand and silt soils with low clay content. Factors that influenced soil erodibility are its texture, organic matter content, pH, structure, bulk density of plough layer and subsoil, aeration, porosity, parent materials aggregation and various interactions of these variables.

Topography: It is important to correctly allocate topographic and soil classes, since there is a strong correlation between high relief areas and strong rocks/soils. After a period of adjustment through erosion, erodible areas are reduced to lowlands while less erodible areas form highlands. High erosion is partly associated with the anomalies from such equilibrium landscape which are associated with recent tectonics or sea level change. More generally, the erosion of an uplifted highland area produces marginal piedmont areas where dis-equilibrium conditions of high erosion rates tend to persist longest in the landscape.

3.4 Soil Conservation Measures

The basic cause of erosion is usually inadequate soil and land management on farms grazing land and other cleared areas. Tackling the problem in these areas is therefore the key to reducing soil erosion rates and alleviating the impacts. The measures developed to combat soil erosion are known as soil conservation measures.

Techniques for controlling erosion by water

1. Mechanical measures

Bench terraces
Contour bunds
Tie- ridging
Strip cropping

2. Biological measures

Cover cropping
Mulching
Afforestation
Contour cultivation
Minimum and no-till cultivation

Techniques for controlling erosion by wind

1. Reduction of wind velocity
    a. Vegetative measures

Cover cropping

Close growing crops
Sand dune stabilization
b. Cultivation measures
Mulching
Rotation grazing
Crop rotation
Planting crops normal to prevailing winds
Field and strip cropping
Primary and secondary tillage
c. Mechanical measures
Windbreaks
Shelter belts
Dune stabilization by brush matting or stones

2. Reduction of soil erodibility
a. Moisture conservation
Mulching
Tillage
Timing seedbed preparation
Irrigation
Terracing
Contour cultivation
Strip cropping
b. Topsoil conditioning
Correct timing of tillage
Minimum tillage
Crop rotation
Manuring
Chemical stabilizers

4.0 CONCLUSION

Soil erosion is an important form of land degradation and it regularly constrains rural development and exacerbates poverty by undermining the productive capacity of arable land agriculture. Localization of erosion-prone areas and quantitative estimation of soil loss rates with sufficient accuracy are of extreme importance for designing and implementing appropriate erosion control or soil and water conservation practices.

5.0 SUMMARY

In this unit, we have learnt:

- The meaning and definition of soil erosion.
- Types of soil erosion.
- Factors affecting the rate of soil erosion.
- Methods and techniques of soil conservation.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the term soil erosion.
2. List and explain the types of soil erosion.
3. List and explain the factors affecting the rate of soil erosion.
4. List the techniques of controlling soil erosion by either wind or water.

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UNIT2 SURFACE SOIL EROSION

CONTENTS

1.0 INTRODUCTION

Surface soil erosion is a process in the physical sense that work requires the expenditure of energy. The energy is impacted to the surface by forces resulting from impulses produced by the momentum (mass × velocity) of falling raindrop or the momentum of eddies in the turbulent flows of runoff or wind.

3.0 MAIN CONTENT

3.1 Surface erosion by wind

Erosion by both water and wind is a natural feature in dry regions. Wind erosion is an inevitable consequence where rainfall is inadequate to support a protective cover of vegetation. Any land use that further reduces the vegetation cover tends to accelerate wind erosion beyond that which is a natural consequence of the environment. Watersheds that support a natural vegetative cover and receive precipitation in excess of 400mm/year experience little wind erosion. However, when soils are exposed, excessive wind erosion can even occur in regions with more than 800mm/year annual precipitation. Wind erosion tends to diminish with increasing annual precipitation in either case.

The actions of water or wind are often complementary in their roles of removing soil particles in dry regions. For example, a soil stripped of vegetation by the abrasive action of wind-blown sand is rendered vulnerable to erosion by water. Likewise, a barren loess deposit is subject to erosion by wind. The largest soil particles that wind can move to any extent are about 1 mm. Very fine clay and silt particles less than 0.02 mm are lifted into the air and carried away as wind-blown dust. Sand-size particles are carried along in the air layer near the ground by saltation until they reach an obstruction where they can pile up into

drifts and under extreme conditions into dunes. The erosive power of wind increases exponentially with velocity and wind with velocities of less than about 20km/h at 1 m above the ground seldom impact sufficient energy at the soil surface to dislodge and put into motion sand size particles.

Wind erosion can be controlled by planting wind breaks (shelter belts) of trees and shrubs to reduce the velocity of blowing winds. Planting of annual or perennial herbaceous species strip cropping or stubble mulch tillage on agricultural fields helps to protect the soil surface fro wind erosion.

3.2 Surface erosion by water

The dislodgement of soil particles at the soil surface by energy imparted to the surface by falling raindrops is a primary agent of erosion particularly on soils with sparse vegetative cover. The energy released at the surface during a large storm is sufficient to splash more than 200 tones of soil into the air on a single hectare of bare and loose soil. Individual soil particles can be splashed more than 0.5 m in height and 1.5 m sideways. A major impact of the impulse impacted to the soil surface by raindrops is deterioration of the soil structure by the breakdown of soil aggregates. The subsequent splashing of finer soil particles tends to puddle and close the soil surface which reduces infiltration and thereby increase surface runoff. Surface runoff combined with the beating action of raindrops causes rills to be formed in the soil surface. Rill erosion is the form of surface that produces the greatest amount of soil loss worldwide.

As surface runoff becomes concentrated in rills and small channels, the velocity, mass of the suspension, and the intensity of the turbulence in the flow increase down slope. Raindrops striking the water surface add to the turbulence when the depth of runoff is shallow. Considerable energy is released by the turbulent eddies that are random in size, orientation and velocity and provide the impulses in runoff to dislodge and entrain soil particles. The intensity of the turbulence in surface runoff is the product of velocity and depth of runoff which are both affected the slope and the roughness of the surface cover which the water flows. As the kinetic energy increases so does the ability of the flow to dislodge and transport soil particles.

In contrast to rainfall that is distributed more or less uniformly over an area, surface runoff quickly becomes concentrated in rills and channels where its erosive power is magnified as the depth and mass become concentrated over a smaller surface area. Furthermore, as the flow picks up and carries more sediment, the abrasive action of the sediment adds

to the erosive power of the runoff. On steep, unobstructed slopes and with heavy rains, soil loss in this manner can be dramatic. Such losses are also common on drylands where normally sparse vegetative cover has been disturbed by poor land practices.

Surface soil erosion by water can be controlled by vegetation ie trees, shrubs and herbaceous plants break the force of rain drops and hold the soil in place. The roots of these plants plus the activities of earth worms and termites they foster create thousands of pores and channels through which water can infiltrate into and percolate through the soil. But when vegetative cover is removed soil becomes exposed to the erosive power of water. The increase in surface erosion after removal of vegetation can be spectacular.

4.0 CONCLUSION

Erosion problems are basic issues at a global scale. This is possibly due to their limitless imprints, which are frequently hazardous thereby reducing the productive capacity of land resources and the sediment loading to downstream channels.

5.0 SUMMARY

In this unit we have learnt surface erosion by wind and water and their control measures.

6.0 TUTOR-MARKED ASSIGNMENT

1. Discuss the process of surface soil erosion by wind.
2. Explain surface soil erosion by water.
3. Enumerate the control measures applied to curb surface soil erosion.

7.0 REFERENCES/FURTHER READING

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UNIT3 MEASUREMENT OF SURFACE EROSION

CONTENTS

1.0 INTRODUCTION

Surface erosion by water is a serious problem of farmland over large parts of the world. It is particularly acute on gently to steeply sloping land of both humid and semiarid areas. In semiarid conditions, serious rain erosion often occurs because the rain, although low in quantity, comes in very severe storms. In other cases, steep slopes and vulnerable soils can lead to quite serious erosion. Surface erosion from a small area can be measured or approximated by the use of plots, stakes or natural landscape features such as soil pedestals. Surface erosion over larger areas such as a drainage basin can be measured by repeated reservoir surveys of designated transects or through the use of tracers.

2.0 OBJECTIVES

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

- Mention the methods of measuring soil erosion.
- Discuss in details any two methods of measuring soil erosion.

3.0 MAIN CONTENT

3.1 Erosion Plots

The most widely used method of quantifying surface erosion rates is to measure the amount of soil that washes from plots. In installing these plots, collecting trough are sunk along the width of the bottom of the plots and walls of plastic, sheet metals, plywood, or concrete are inserted into the soil surface to form the boundaries of the plot. The collecting trough empties into a tank or other container in which both sediment and runoff are measured. These tanks are sometimes designed

with recording instruments so that the rates of flow can be measured. In other cases the total volume of sediment and water is measured after a rainfall event has occurred. Plots vary in size from micro plots of 1 to 2 m^2 to the standard plot of 6 ft x 72.6 ft (approximately 2 m x 22 m). The techniques used and the objectives of the measurements dictate the size of the plot. Larger plots can provide more realistic estimates of erosion because they better represent the cumulative effect of increasing runoff and velocity down slope.

3.2 Erosion Stakes

The insertion of stakes or pins into the soil can be used to estimate soil losses and sediment deposition that occur along hill slopes. Commonly, a long metal nail with a washer welded to the top of the nail is inserted into the soil and the distance between the head of the nail and the washer is measured. This distance increases as erosion occurs because the soil that supports the washer is washed away. If the washer causes a pedestal to form beneath the washer because of protection from rainfall impact measurements are made from the nail head to the bottom of the pedestal. A benchmark should be established in close proximity to the stakes as a point of reference and stakes should be clearly marked so that original stakes can be accurately relocated on subsequent surveys. Erosion stakes are usually arranged in a grid pattern along hill slopes with repeated measurements of the stakes taken over time in which the changes in soil surface are related to soil loss and deposition. This method is inexpensive compared with the plot method but presents more difficulty in converting observation into actual soil losses in tons per hectare with measurements of bulk density.

3.3 Natural Landscape Features

Using the same principles as the stake method, erosion estimates can sometimes be made from natural landscape features. Pedestals often form beneath clumps of bunch grass, dense shrubs, stones, or other areas protected from rainfall. As erosion removes soil from around the pedestals, the distance between the pedestal top and bottom increases. Repeated measurements of the height of residual soil pedestal provide estimates as described above. The key to applying this method is to relate measurements to a common point of reference or benchmark. Sometimes, soil that has eroded away from the base of trees can be estimated with repeated measurements of a soil surface and a point on exposed tree roots or from a nail driven into the tree trunk.

4.0 CONCLUSION

Methods for measuring soil erosion should be appropriate to the task. The techniques for measuring erosion discussed in this unit are all appropriate and necessary for assessing soil loss.

5.0 SUMMARY

In this unit we have learnt the methods of measuring soil loss from surface erosion.

6.0 TUTOR-MARKED ASSIGNMENT

1. Mention the methods of measuring soil erosion.
2. Discuss in details any two methods of measuring soil erosion.

7.0 REFERENCES/FURTHER READING

Brooks, K.N., Ffolliott, P.F. and Magner, J.A. (2013) Hydrology and the Management of Watersheds, USA: John Wiley and Sons Ltd.

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UNIT 4 PREVENTING AND CONTROLLING OF SURFACE EROSION

CONTENTS

1.0 INTRODUCTION

Avoiding erosion susceptible situations, inappropriate land use practices and maintaining a vegetative cover in the first place is the most economical and effective means to combat soil erosion and to maintain the productivity of land resources.

2.0 OBJECTIVES

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

- Explain the guideline for preventing water and wind erosion.
- State the basic principle of reducing impact of road construction on surface erosion in forest land.
- Enumerate steps of controlling surface erosion on a rangeland.
- Mention 5 common mechanical methods of controlling surface erosion.

3.0 MAIN CONTENT

3.1 Guideline for Preventing Water and Wind Erosion Water Erosion

Avoid land use practice that reduces infiltration capacity and soil permeability.

Encourage grass and herbaceous cover for as long as possible each year.
Locate livestock watering facilities to minimize runoff production to water bodies.

Avoid logging and heavy grazing on steep slopes.
Apply erosion control techniques on agricultural fields and promote infiltration.

Wind Erosion

Avoid uses which will lead to the elimination of shrubs and trees over large areas.

Avoid locating livestock watering facilities on erodible soils.
Protect agricultural fields and heavy use areas with shelterbelts.
Manage animals and plants in your area to maintain a good balance between range plants, woody trees and shrubs.

When planting shrubs and trees on grazing lands, locate and space them to reduce wind velocity.

3.2 Surface Erosion Control in Forest Land

A minimal amount of surface erosion is expected in most undisturbed forest ecosystems with surface erosion rate rarely in excess of 0.04t/ha/year. However, activities that remove vegetative cover such as timber harvesting road and rail construction for the evacuation of timber expose mineral soil and lead to high rates of surface erosion. Maintaining vegetative cover and litter accumulations will help to control erosion by reducing raindrop impact on a soil surface while maintaining high infiltration rates.

Many potential erosion problems can be eliminated in the planning stage before road and rail construction. The following have been identified as the basic principle to follow in reducing impact of roads and road construction on erosion:

- Minimize the area of roads on a watershed by reducing mileage and distance.
- Avoid high erosion hazard area when locating roads.
- Establish and maintain a vegetative cover to protect cutbanks and fill slopes along roads on landings in timber harvesting operations, and in other critical areas of exposed mineral soil.
- Minimize the extent of exposed soil and disturbed, unstable area on a watershed.
- Keep roads away from stream channels to the extent possible.

- Avoid steep gradients which tend to be less stable; they expose more soil due to excessive cut-and-fill requirements, and promote high flow velocities of drainage water.
- Properly size space and maintain culvert to avoid road washouts.
- Provide adequate compaction of fill materials and minimize the amount of side-cast materials.

Timber- harvesting operations that have minimal effect on the compaction and disturbance of surface soil should be favoured. Small cable systems can be used to remove cut trees on sites where tractors would cause excessive soil disturbance on slope greater than 30-35%.

3.3 Surface Erosion Control on Rangelands

The greatest amount of erosion in the world occurs in the dryland regions. These regions are generally too dry for intensive agriculture with livestock grazing often being the only commercial use of the land. However, livestock grazing is controlled and excessive in many countries. The establishment of appropriate range management practice must be a priority under these conditions. Otherwise most other soil conservation practice will fail. Simply controlling livestock density and the grazing practice is often sufficient to restore depleted and eroding rangelands. The key is to maintain a healthy and extensive vegetative cover and not to reduce infiltration capacities of rangelands. If excessively grazed these rangelands are characterized by low plant density, compacted soils, surface runoff and excessive erosion.

Fire is commonly used as a management tool to increase forage production of rangelands. Uncontrolled fires can reach temperatures that are high enough to reduce infiltration capacities. Wildfire can leave large areas of exposed mineral soil that are vulnerable to rainfall impact, surface runoff, and erosion. Controlled burning should not adversely impact the hydraulic properties of soils.

Rangelands that are in poor conditions can require reseeding of herbaceous plants and mechanical treatments to conserve water and help establish vegetative cover.

3.4 Mechanical Methods of Controlling Surface Erosion

Vegetative measures of controlling surface erosion must be accompanied by mechanical measures when land is severely and seriously eroded. However, because of their expense, mechanical methods can be justified only if:

- Surface runoff and sediment from the watershed threaten important downstream development.
- Reclamation is essential to the survival of people in the area.
- The value of the increased production of forage equal or exceeds the cost of the treatment.

Some of the more common mechanical methods of surface erosion control are:

1. Contour furrows- small ditches 20-30 cm deep that follow the contour forming miniature depressions and terraces that hold the water in place until it infiltrates into the soil that reduces surface erosion and promotes plant establishment.
2. Contour trenches- large furrows that usually are required on slopes too steep for contour furrow; they are designed to hold greater amounts of runoff and have potential for focused groundwater recharge depending on soil conditions.
3. Fallow strips- vegetation strips along contour have proven successful on level to gently rolling land to break the slope length until desirable vegetation can become established.
4. Pitting- a technique of digging or gouging shallow depression (20-30 cm wide to 45-60 cm long) into the soil surface to create depression storage for surface runoff and provide soil water for re-vegetation measures that are suited for rangeland rehabilitation, generally on gently sloping lands.
5. Basins- large pits usually about 2m long 1.8m wide and 15 to 20m deep. They store a greater amount of water and can help create pockets of lush vegetation. Basins generally are more costly to construct and are not as widely used as pitting methods.

4.0 CONCLUSION

Intensive land use with associated vegetation cover loss and unwholesome land use practices contributes to accelerated surface erosion which must be tackled at catchment scale to reduce the problems.

5.0 SUMMARY

This unit essential provide information on the methods and techniques of prevention and control of surface erosion.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the guideline for preventing water and wind erosion.
2. State the basic principle of reducing impact of road construction on surface erosion in forest land.
3. Enumerate steps of controlling surface erosion on a rangeland.
4. Mention 5 common mechanical methods of controlling surface erosion.

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UNIT5 GULLY EROSION

CONTENTS

1.0 INTRODUCTION

Gully erosion is defined as erosion process whereby the accumulated surface runoff recur in narrow channels and, over short periods, removes the soil from this narrow area to considerable depths. Gullies are entrenched channels extending into areas with previously undefined or weakly defined channels. Gully erosion may be a significant source of sediment to the stream. Gullies may also form in the stream banks due to uncontrolled flows from the flood plain (valley trenches). The severity of gully development depends on a number of factors including soil type, vegetation, rainfall, concentrated flow, and human disturbances. Gullies can erode hill slopes and fill stream channels with sediment. Unchecked, they erode and deliver sediment through a variety of processes that cause loss in soil productivity, channel entrenchment, and head ward expansion into the landscape.

2.0 OBJECTIVES

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

- Explain the processes involved in gully formation.
- Describe the components of gully profile.
- Enumerate and explain the contributing factors of gully formation.
- Itemize the preventive measures of gully control.
- Outline and explain three physical techniques of gully erosion control.
- Explain the significance of vegetative measures in gully erosion control.

3.0 MAIN CONTENT

3.1 Gully Erosion Processes

Active gullies are recognized by head cuts (primary knickpoints), where there is an abrupt drop in elevation. The channel below the headcut or knickpoint is enlarged by plunging flow and erosion. Secondary knickpoints may be located downstream, showing additional base-level adjustments. Several processes are involved in knickpoint migration including cavitation, plunge development, soil piping, bank failure, and freeze-thaw cycles. Knickpoints travel upstream as gully systems enlarge and expand in response to rainfall, runoff, and changed cover conditions. Restrictive channel materials such as bedrock or tree roots can halt or slow knickpoint migration. As the channel elevation decreases and approaches the ground water level, the length of the period of saturation or flow increases at the headcut and channel banks. The processes responsible for headcut migration vary somewhat with the position on the landscape and land use and cover conditions. Surface flow and plunge action exert pressure to undercut, widen, and collapse the knickpoint. Saturated soil is susceptible to cavitation enlargement and slope failure, winter frost heaving, slope raveling. Storm runoff causes plunge enlargement and material removal. Soil piping in certain soils has also led to gully development. As gullies expand, storm runoff increases, with declines in infiltration, ground water, base flow, and evapotranspiration. The increased drainage density, soil exposure, erosion, and sediment delivery cause adjustments to both the adjacent uplands and downstream bottomlands. In this process of channel entrenchment, ground water tables may be lowered, resulting in declining base flows and conversion of perennial streams to intermittent or ephemeral flow. Lands adjacent to entrenched gullies have reduced moisture available for plant growth, as the water table is lowered. Aggraded channels in downstream valleys have reduced capacity for flow, resulting in more frequent and extensive flooding. When the capacity of the channel cannot efficiently move the sediment load, braided channels develop with multiple divisions and frequent shifts. Gullies not only alter and deplete the physical character and biological capability of the affected landscape, but their downstream effects can also be pronounced.

A **B**

A. Incision and widening of concentrated flow channels (up slope portion), headcutting, knickpoint migration and widening.

B. Active gully headcut (knickpoint) is enlarged by concentrated flow and erosion.

3.2 Sections of Gully Profile

(a) Gully head

- It is the upper part of the gully (in topo-sequence) where the gully starts
- It is the location through which most of the run off enters to the gully
- This part in most of the cases is very much active for gully formation and expansion
- The most commonly accepted measures for this spot are physical structures, such as paving with loss stone, diverting water using cutoff drains and reshaping.

- Nevertheless integrated treatment with biological measures will also help in stabilizing the gully head.
- Some creeping plant species can be used for reinforcing the structures constructed
- (b) Gully offset
- It is a part of gully area which is located away from the gully embankment and extended to the next land use type
- It is a part which has to be considered in the gully treatment scheme to avoid further expansion of the gully
- In most of the cases these areas are characterized by medium soil depth, moderately wet in the rainy season and dry in the dry season, and with moderate slope
- Micro basin construction, trench and sub soiling are recommended for better performances of crops planted in the area
- Thus the plant species recommended for the treatment of this area are those with moderate tolerance to dryness and wetness.
- (c) Gully sidewall
- It is a part of the gully between the gully offset and gully bed
- It is characterized by high slope gradient, shallow soil depth, susceptible to erosion and mass movement, very dry in most of the time due to less water holding capacity.
- Reshaping and hence constructing moisture harvesting structures are the recommended measures to treat gully sidewalls
- As far as farmers/land users are convinced to undertake reshaping, the gully offsets can be converted into potential areas for multiple purposes
- Biological measures can play a pivotal role in rehabilitating this section of the gully
- The species to be selected should have invading characteristics, with light foliage and steam biomass and high tolerance to drought
- (d) Gully bed/floor
- It is a part of the gully on top of which the run off flows
- It is occupied with the flow of runoff throughout the rainy season
- This gully parts can be treated in the dry season with physical measures like arc weir, loose stone, and gabion, brushwood and sandbag check-dams.
- These areas are regarded as very wet in most of the year, with deep alluvial soil
- Thus the biological material recommended for this part of the gully should be tolerant to water logging, with high root biomass and, resistant to soil sedimentation and high flow of water.
- A lot of biological material which can fit to this condition can be found at the local condition in consultation with the farmers.

3.3 Factors Contributing to Gully Formation

Some critical conditions (alone or in combination) could cause rejuvenation of gullies and channel forming processes with rapid erosion and expansion of the drainage network. Land use, soil, climate, rainfall, and hydrology are some of the leading considerations in evaluating gully processes and their control.

Land use practices

Land use practices that alter cover, soil or hydrologic function can act as trigger mechanisms to gully formation and development. Practices that disturb and compact soils contribute to soil detachment and concentration of surface flow. Practices such as farming, road construction, grazing, mining, water transmission (ditches, trenches, terraces, or waterways), urbanization, development, and impermeable surfaces have the potential to alter conditions by changing the balance of rainfall absorption, runoff, or flow capture from adjacent areas. Soil properties altered by years of cultivation show major reductions in subsurface soil percolation and macropore space, resulting in increased surface flow. Early farming and other practices had a severe effect on many landscapes, reducing soil productivity from years of surface erosion. In many instances, the soil surface is gone, exposing subsoils to continued erosion. Disturbed soils loose much of their structure and have increased risk for gullying, especially if left exposed or subjected to concentrated flow for extended periods. Loss of vegetation alters the balance of rainfall, infiltration, evapotranspiration, surface cover, root strength, and runoff. Failure to use preventative practices or heed warning signs of rill entrenchment may allow gullies to form. Although gully formation and enlargement are typically episodic, they are not instantaneous. Careful observation and treatment in the initial phases can slow or halt development.

Soil properties

Certain soils and landforms are especially susceptible to gully formation. Soils with weak cementation, poor consolidation, and low cohesion (alluvium, colluvium, loess, ocean, or lake deposits) have more risk. Oxisols are susceptible to gully formation due to their high degree of physical and chemical weathering. Soils that are altered by physical, chemical or biological activity may develop weaknesses that increase their erodibility. Soils sorted by water or wind often form deposits in layers of uniform-sized materials, losing much of their natural cohesive forces and erosion resistance. Soil chemical imbalances, such as high sodium absorption ratios (SAR) or low dithionite extractable iron, are more prone to be highly erodible. Gullies are more apt to develop in

landforms with comparatively steep, narrow valleys on a unit area basis. Water accumulation on low-permeability soil or hard layers, such as a fragipan or bedrock, can contribute added flow to a gully headcut or stream channel.

Climate

Certain climate, soils, and bedrock types limit the abundance and permanence of plant cover, resulting in extended periods of soil exposure. Arid and semiarid areas or nutrient deficient or depleted soils have increased risk for gully development because the presence of plants can be tentative and fragile. In these circumstances, understanding and maintaining the natural balance can be the key to gully prevention. Native plant cover needs to be protected. If native cover is gone, restoration, replacement or other stabilization measures may be needed to control exposed soil, erosion, and the erosion caused by concentrated flow. The ability to maintain quality plant cover, infiltration, and root support across drainage areas will often prevent severe erosion and gully formation. Even minor gullying can alter soil moisture conditions and contribute to poor plant cover. To restore arid climates, mechanical means may be needed to capture and collect rainfall for plant recovery.

Hydrologic and hydraulic controls

Hydrologic alterations that modify the normal flow patterns can occur naturally or be affected by land use and treatment. Geologic controls, such as faults, may affect channel dimensions, which may confine and focus flow energy within the channel, leading to entrenchment. Roads along streams may also impinge on the natural ability to dissipate energy on a flood plain. Wildfires on erosive soils may reduce cover or develop non-wettable soil layers that contribute to gully development. Excessive traffic and hoof shear from wildlife or cattle can develop trails that concentrate flow, eventually leading to rill and gully formation. Stream capture as a result of erosion from an adjacent area can also generate severe erosion, gully formation, or channel entrenchment. Severe storms can cause erosion and sediment delivery even from relatively small gullied areas.

3.3 Gully Erosion Prevention and Control Techniques

Prevention of Gully Formation

The principle of "*prevention is better than Cure*" is highly relevant for gullies. Preventing the formation of a gully is much easier than controlling it once it has formed. If incipient gullies are not stabilized, they become longer, larger and deeper. Under certain climatic and geological conditions, vertical gully banks can easily become as high as

20-30 meters or more. This type of gully can engulf hillside farming areas, grass lands and even forest lands. In most cases, it is not possible to stabilize those gullies because of the huge landslides which occur on vertical (20-30m) gully banks after heavy rains and alternate freezing and thawing.

Prevention is also more economical than cure because structural measures are considerably more expensive than preventive measures. Even if the resource is available, the technique of its rehabilitation is more difficult and complex. Therefore, in gully control, emphasis should be given to the following practices:

(a) Proper land-management practices:

- Adoption of conservation effective, improved soil, water and crop management practices in a ridge to valley approach for all catchment contributing to the gully.
- Protection of the soil by good canopy during rains,
- Prevention of forest fires and illegal wood cutting in plantations and natural forests,
- Prevention of grass fires,
- Applying control grazing, and re-vegetation of open grazing lands,
- Maintenance of soil fertility through proper inputs, crop rotation and control of land degradation,
- The immediate stabilization of moderate sheet and rill erosion, and incipient gullies in forest, rangeland and cultivated areas.

(b) Retention and infiltration of surface water:

In addition to proper land-management practices, specific slope-treatment measures, such as retention and infiltration ditches, terraces, wattles, bundles and grass sods should be carried out above the gully area, and in the eroded area between the branch gullies, to reduce the rate and amount of surface run-off. These also decrease the cost of structural gully-control measures.

(c) Diversion of surface water above the gully

In many cases, the simplest, cheapest and safest gully control method is to divert runoff before it enters into the gully. This practice is particularly useful in forest land and grasslands. Diversions constructed above the gully area can direct run-off away from gully heads, and discharge it either into natural waterways or vegetated watercourses, or onto rock outcrops and stable areas which are not susceptible to erosion. Surface water must not be diverted over unprotected areas or it will

cause new gullies. The basic aim of diversions is to reduce the surface water entering into the gully through gully heads and along gully edges, and to protect critical planted areas from being washed away.

Cutoff drains and waterways are drainage management structures which are commonly used to divert runoff before reaching gullies, cultivated lands and residences. They are effective measures for soil and water conservation in general and gully rehabilitation in particular. Though the experience of cutoff drain construction seems old enough, particularly in high rainfall areas, there are always problems in keeping the standard and technical specification during designing, layout and construction. As a result, most of the old cutoff drains and waterways are destroyed and gradually changed into gullies. As far as the failures in quality of construction are avoided, cutoff drains can be considered as potential options for gully prevention and control.

Gully Control Techniques

Stabilization of gullies involves the use of appropriate structural (physical) and vegetative measures in the head, floor and sides of the gully. Once gullies have begun to form, however, they must be treated as soon as possible, to minimize further damage and restore stability. There are a multitude of physical and vegetative techniques which can be applied for effective gully treatment. The combination of the two approaches is the best solution for effective gully control and for productive use of the gully area. The construction of gully physical structures will be followed by the establishment of vegetative measures. The natural regeneration which is coming after the gullies are protected and enclosed should also be considered in the overall rehabilitation scheme.

To obtain satisfactory results from physical and vegetative measures, it is vital to understand the nature of the whole gully system/network and properly diagnosing of the different parts in the gully section: the gully bed, gully sidewall and gully offset. Overall, stabilized watershed slopes are the best assurance for the continued functioning of gully control structures. Therefore, attention must always be given to keeping the gully catchment well vegetated. Some of the most common physical and vegetative measures which have been proven for their effectiveness are explained below:

Physical measures

In gully control, temporary physical structural measures such as gully reshaping, brushwood, sandbag, loose stone, gabion and arc-weir check-dams are used to dissipate the energy of runoff and to keep the stability

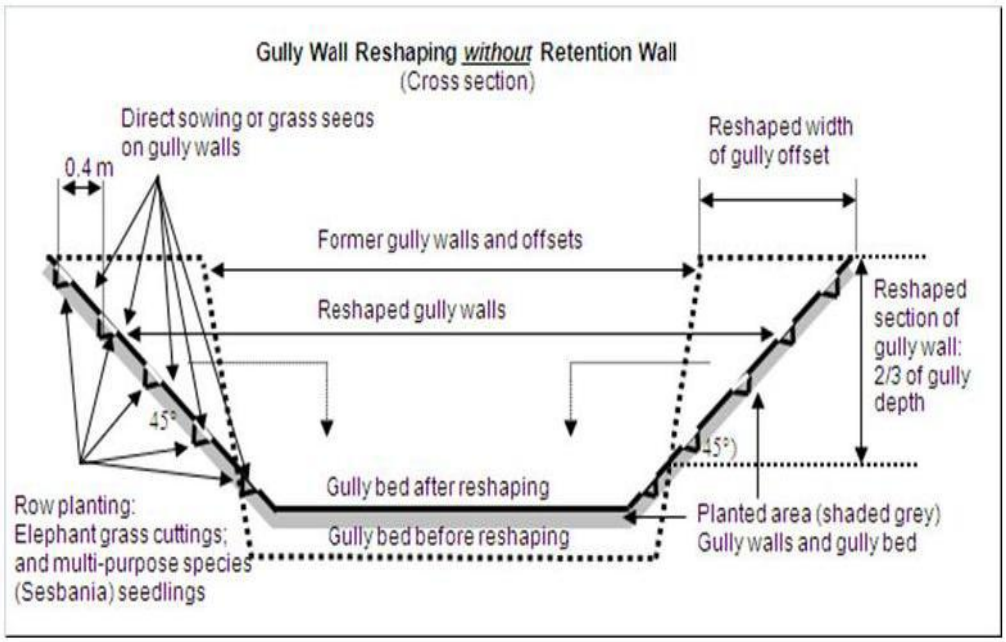
of the gully. Check-dams are constructed across the gully bed to stop channel/bed erosion. By reducing the original gradient of the gully channel, check-dams diminish the velocity of water flow of runoff and the erosive power of runoff. Run-off during peak flow is conveyed safely by check-dams. Temporary check-dams, which have a life-span of three to eight years, collect and hold soil and moisture in the bottom of the gully. To give vegetation an opportunity to establish, runoff control structures may be needed in the gully. The structures can be either temporary or permanent. The choice of the measures and extent of their use will depend on the amount of the runoff and the status of the gully whether young and actively eroding or mature and establishing naturally. Good judgment is required in determining what measures to use and it would be a mistake to use expensive measures where more economical ones would do. Consideration should then be given to ways of stabilizing the gully head, floor and sidewalls. The gully head is often the most difficult to deal with, especially if it is more than about 2 m high because of the erosive power of falling water. Control structures for large gullies require an engineering design and are expensive. If the stabilization of gully head appears too costly or difficult, there are two approaches: One is to divert runoff away from the gully head so that it ceases to erode. The other is to place a check-dam close enough to the gully head so that it will trap sediment, raise the floor level and submerged the head. The use of stepped gabions, stone *rip-rap*, brushwood carpet, sandbag and planting grass sod are alternative measures which can be sued for gully head treatment. For stability of structures and quick healing the gully head should be reshaped and planted with grasses.

Gully head control with sand bags and other vegetative measures.

(a) Gully reshaping and filling

Gully wall reshaping is cutting off steep slopes of active gully flanks into gentle slope (Minimum at 45% slope), up to two-third of the total depth of the gully and constructing small trenches along contours for re-vegetating slanted part of the gully walls and beds. If the gully is wide and has meandering nature with huge accumulation of runoff flowing down, cut off soils and soil materials can be washed away by runoff water and requires constructing of retaining walls, to protect displaced (not yet stabilized) soils and soil materials and newly created sidewalls of the reshaped gully.

Gullies with very little water flow can be stabilized by filling and shaping, that is, if the surface water is diverted, and livestock are kept out. Steep gully heads and gully banks should be shaped to a gentler slope (about a one-to-one slope). Filling of gullies is applicable only for small discontinuous gullies, in their early stages of development. The filled gully area can be planted even be used for cultivation. Rills and incipient branch gullies may be filled in by spade, shovel or plow (on cultivated lands).



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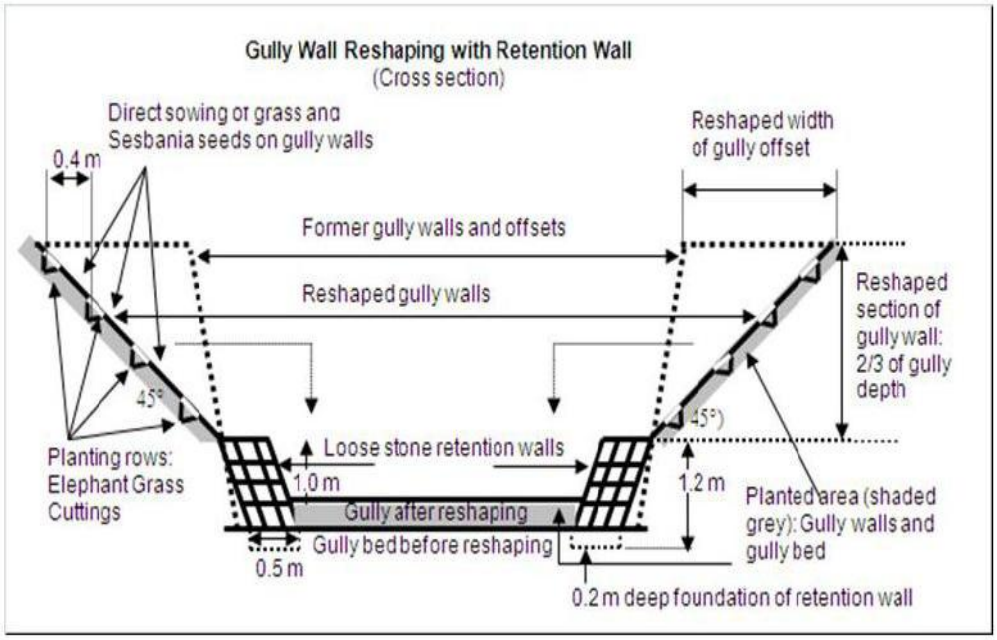


B

A& B: Designs and working procedures of gully reshaping

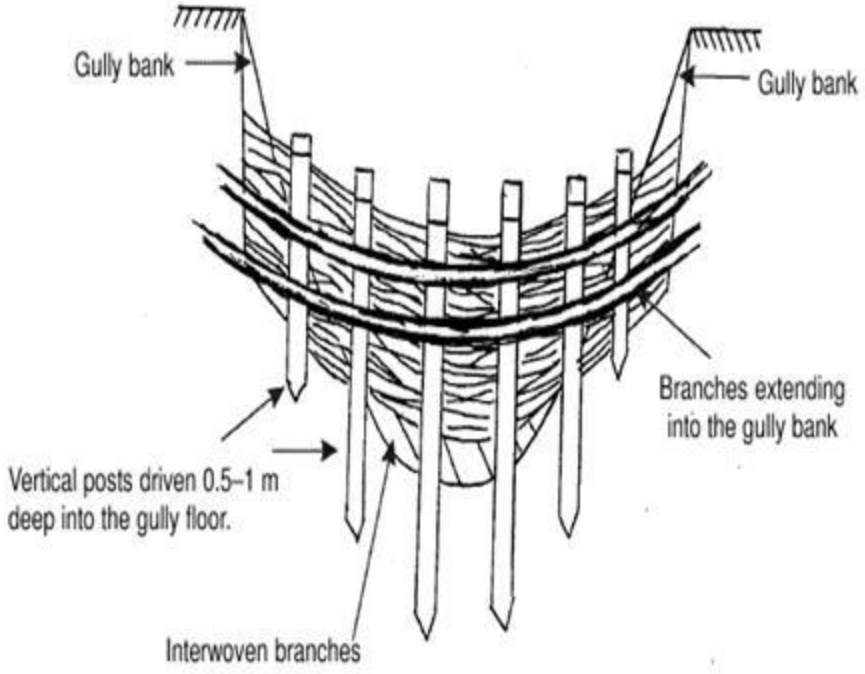
The practicability of shaping a gully depends on its size and the amount of fill needed to restore the gully to its desired shape. Steep gully sides can be reshaped. Topsoil should be stockpiled and re-spread over exposed areas to ensure the rapid establishment of vegetation. Annual grass and crops such teff, oats or barley can be used to provide a quick cover. It may be possible to temporarily divert water from the battered gully while grass is establishing. Filling should only be attempted after the water flow that caused the gully has been controlled or diverted above the gully head. Otherwise fill placed in the gully is likely to be undermined and washed away. The common practice of filling gullies with rubbish, logs, rocks, branches, twigs and other materials does very little to solve the problem. In most cases, it makes the gully worse particularly if the placement and anchorage of those materials is not done properly. Generally, in the filling and shaping process the following need to be considered:

- The soil should be well compacted
- The filling operation should be done before the rains
- To protect it from erosion, close growing crops should be planted or seeded immediately
- The entire work of shaping and filling should be done in one operation

(b) Brushwood check-dams

Brushwood check-dams made of posts and brushes are placed across the gully and the main objective of brushwood check-dams is to hold fine

material carried by flowing water in the gully. Small gully heads, no deeper than one meter, can also be stabilized by brushwood check dams. Brushwood check-dams are temporary structures and should not be used to treat ongoing problems such as concentrated run-off from roads or cultivated fields. They can be employed in connection with land use changes such as reforestation or improved range management until vegetative and slope treatment measures become effective. In areas where the soil in the gully is deep enough, brushwood check-dams can be used if proper construction is assured. The gradient of the gully channel may vary from 5 to 12 percent, but the gully catchment area should not be as such huge which produces high amount of runoff volume. Similarly, in the gullies which are long enough and have high pick runoff rate, the utilization of brush wood check-dams is very limited.



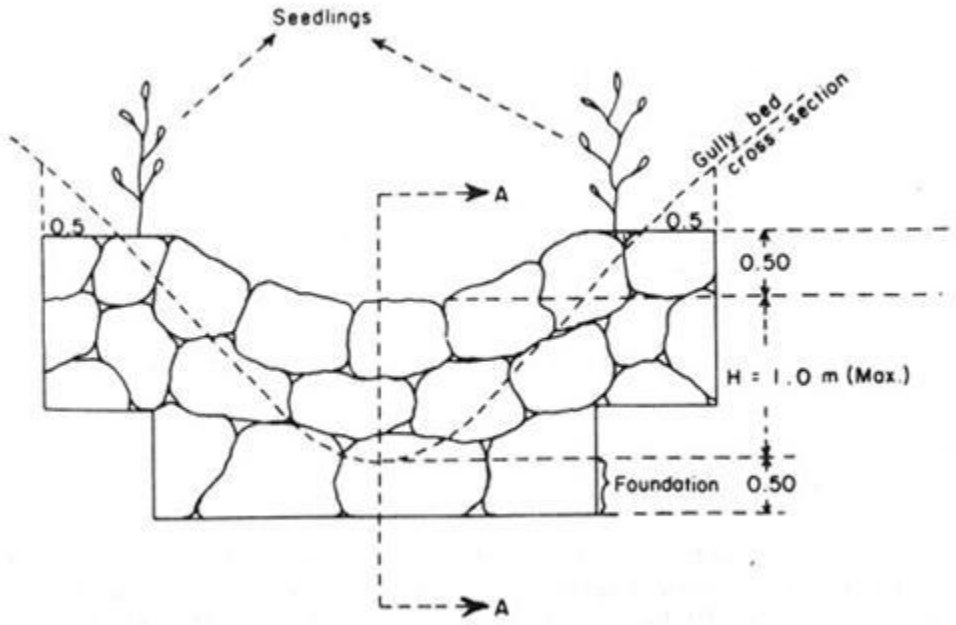
Single row brushwood check-dam, front view

(c) Loose stone check-dam

Loose stone check-dam is a structure made of relatively small rocks and placed across the gully or small stream, which reduces the velocity of runoff and prevents the deepening and widening of the gully. Sediments accumulated behind a check-dam could be planted with crops or trees/shrubs, grasses and thus provide additional income to the farmer. It is commonly used to check gullies on highly eroded grazing and cultivated lands and hillsides. Check-dams could be constructed in a wide range of conditions: (1) small gullies serving large one, (2) as outlets for traditional or newly constructed bunds or terraces unable to accommodate all runoff and, (3) to trap silt before a water pond.

Design and construction specifications of loose stone check-dam:

- The foundation of the dam is dug so that the length of the foundation will be more than the length of the spillway.
- The width of the foundation depends up on the reservoir level height.
- The dam should be properly keyed across its base and up the abutments to the crest elevation.
- An adequate spillway should be provided for safe disposal of water.
- An apron of non erodible material should be provided at the base, to dissipate the energy of water falling through the spillway.
- Proper spacing between the successive dams should be ensured
- The height of the dam should be properly planned
- Stones should be placed such that they interlock easily and form a denser structure. If small stones are to be used they should be placed in the center and the outer surface covered with large stones to strengthen the dams.
- Loose stone check-dams can be strengthened by covering the upstream wall and the crest with bamboo/reed-mat.
- It is very much important to plug the scouring places with jut bag after every run off, until it is fully silted up to the reservoir level.



Front view of a loose stone check-dam

(d) Gabion check-dam

Gabions are rectangular boxes of varying sizes and are mostly made of galvanized steel wire woven into mesh. The boxes are tied together with wire and then field with either stone or soil material and placed as building blocks. Small stones can be used as the wire mesh will prevent them being washed away. If large stones are used, they must be placed

carefully with small stones filling the spaces between them otherwise water may jet through the gabion and undermine the ground beneath. Gabions are filled in situ and as they are very heavy they will not be washed away provided they have been correctly installed. The main advantages of gabions are that they are tough and long lasting provided that the wire has been well galvanized. Furthermore they are somewhat flexible and can be installed where the surface is uneven. They can be used to stabilize gully sides, gully heads, roadside embankments, river banks and even landslips. However they are expensive and should only be used if no other cheaper method will suffice. Installing gabions is no substitute for land misuse and, if the land is denuded, installing gabions will not solve the problem. However, in conjunction with measures to restore vegetative cover they can play a role. Gabion check-dams can be undermined or bypassed round the side due to incorrect installation or unstable soils. Common problems are failure to embed the gabions to a sufficient depth in the floor of the gully and failure to insert to a sufficient distance in to the gully banks. Once in placed and properly anchored, gabion check-dam can resist even strong floods and last for a long time. Gabion check-dams are built usually not higher than 1.5 m spillway height in the first year. After sediments have been deposited behind the structure, it is possible to raise the spillway height by adding additional gabion boxes.

Gabion check-dam under construction

(e) Sandbag check-dam

Sandbag check-dams are made from used jut or polyethylene bags (50 kg) filled with soil. The bags are piled up to a maximum of 3 – 4 layers to form a small check-dam. This cheap technique is particularly useful in areas with insufficient supply of stones for building ordinary check-dams. By erecting sandbag dams large rills or small gullies (finger

gullies) can be controlled, while they are not suitable for the treatment of large gullies.

Sandbag check-dams constructed to treat medium sized gullies

Use of vegetation in gully control

The use of vegetative material in gully control offers an inexpensive and permanent protection. Vegetation will protect the gully floor and banks from scouring. Grasses on the gully floor slows down the velocity of the runoff and causes deposition of silt. It can also be of economic value to the land users. Vegetation can be established in a gully by natural recovery or use of planting materials. A gully will re-vegetate naturally if the water causing erosion is conserved or diverted before it reaches the gully and if livestock are kept away. Costs are minimal but recovery will be slow if the soil is poor. Furthermore, if the gully sides are steep, vegetation may not establish itself. Where establishment of natural vegetation is too slow to cope with the erosion or where a particular species is desired, planting should be done. The establishment of vegetation either naturally or artificially has to contend with a hostile

environment. The type of planting material to be used should be seriously considered based on the specific situation of the gully. Conservationists and farmers should properly assess the soil and moisture conditions in the gully head, gully floor/bed, gully sidewall and gully offset/gully buffer zone. Practically speaking, these different locations of a gully do have different soil and hydrological characteristics which determines the type of species of grass, shrubs/bushes and trees to be planted.

4.0 Conclusion

Gullies can have serious negative impacts. These impacts can range from loss of agricultural production to impacts on water supply and channel conveyance to destruction of downstream habitat. However, there are numerous land management and treatment practices that have proven effective in stopping gully formation.

5.0 SUMMARY

In this unit gully erosion was presented and information on gully processes, gully profile, factors that contribute to gully formation and gully prevention and control techniques were discussed.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the processes involved in gully formation.
2. Describe the components of gully profile.
3. Enumerate and explain the contributing factors of gully formation.
4. Itemize the preventive measures of gully control.
5. Outline and explain three physical techniques of gully erosion control.
6. Explain the significance of vegetative measures in gully erosion control.

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MODULE 4

UNIT 1 DEFINITION, TYPES AND CAUSES OF DROUGHT

CONTENTS

1.0 INTRODUCTION

Drought is the most widespread hydro-meteorological problem of prolonged period of water scarcity affecting natural resources, environment and the peoples' livelihoods. Environmental changes, viz. climate change, land-use changes and natural resource degradation have aggravated drought occurrences and vulnerability, thus disrupting the normal socio-economic settings. Sahelian Africa suffers drought incidences of varying periodicity. Drought is recognized as one of the ecological problems in Nigeria currently plaguing the country. The drought prone frontline states in Nigeria include Adamawa, Borno, Bauchi, Gombe, Jigawa, Kano, Katsina, Kebbi, Sokoto, Yobe and Zamfara. These states occupy an estimated land area of 397,222 Square Kilometre.

Persistent drought, delay in onset of rains, early cessation of the rains and short rainy season including pronounced dry spells have caused low agricultural productivity for a country that is mostly dependent on rain fed agriculture. Inadequate water resources resulting from reduction in quantity of river flow and Lakes have fewer water supplies for use in agriculture, hydropower generation and other uses.

2.0 OBJECTIVES

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

- Define drought from two scholar's perspective.
- Enumerate and explain types of drought.
- Discuss the causes of drought.

3.0 MAIN CONTENT

3.1 Meaning and Definition of Drought

Drought is one of the major weather phenomena that constitute hazards to agriculture both temperate and tropical regions of the world. Drought is a natural hazards and a threat to people's livelihood and socio-economic development. Drought can be defined as an extended period where water availability falls below the statistical requirements for a region. Drought can also be defined as a prolonged absence or marked deficiency of precipitation that results in water shortage for some activity or for some group or a period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance. Drought could also imply a low probability of rainfall for a given period below a relatively low threshold. Drought is not a purely physical phenomenon, but instead is interplay between natural water availability and human demands for water supply. There is no universally accepted definition of drought. It is generally considered to be occurring when rainfall or precipitation is deficient or scanty. Failure of the right quantity of rainfall causes crop failure, drying up ecosystems and shortage of drinking water results in undue hardship to the rural and urban communities. Although droughts are still largely unpredictable, drought disaster is caused by the combination of both a climate hazard (the occurrence of deficits in rainfall and snowfall) and a societal vulnerability (the economic, social, and political characteristics that render livelihoods susceptible in the region influenced by the deficits). The severity of the drought depends upon the degree of moisture deficiency, the duration, and the size of the affected area. Drought tends to occur less frequently than other hazards. However, when it does occur, it generally affects a broad region for seasons or years at a time. This can result in a larger proportion of the population being affected than when other disasters occur. Globally, drought disasters account for less than 10 percent of all disaster occurrences, but they account for nearly 40 percent of all people affected by natural disasters. The impact of drought varies regionally and over time. Disasters triggered by prolonged drought in Africa can affect millions of people and contribute to malnutrition, famine and loss of life, whereas droughts in the United States primarily result in economic losses. Severe

drought often results in extensive desertification and more frequent sand and dust-storms from arid and semiarid regions.

3.2 Types of Drought

Droughts are classified into four interrelated categories: namely meteorological drought, hydrological drought, agricultural drought and socio-economic drought.

Meteorological Drought

It is based on the degree of dryness or rainfall deficit and the length of the dry period. Usually, it is determined by the general lack of moisture in the weather such as lack of precipitation, and the play of other weather conditions such as dry winds, high temperatures and so on. It is expressed in relation to the average conditions of the region over a long period of time. It is usually an indicator of potential water crisis if the condition is prolonged. Meteorological drought can begin and end immediately.

Agricultural Drought

This is when atmospheric moisture is reduced to the extent that soil moisture is affected. It refers to the impacts on agriculture by factors such as rainfall deficits, soil water deficits, reduced ground water, or reservoir levels needed for irrigation. Under this condition, crops, animals and evapotranspiration are affected.

Hydrological Drought

It results from the impact of rainfall deficits on the water supply such as stream flow, reservoirs and dam water levels and ground water table decline. It occurs when there is a deficiency of surface water and ground water supply in a region, often as a result of less precipitation, excessive reliance on surface water for farming, energy and other needs.

Socio-economic Drought

This considers the impact of drought conditions on supply and demand of some economic goods such as fruits, vegetables, grains and meat. It occurs when the supply of some goods and services such as energy, food and drinking water are reduced or threatened by changes in meteorological and hydrological conditions. Sometimes it is even made worse by growing populations and excessive demands of such goods, to the point that it creates stress on the little water available. It takes a very

long time for this kind of drought to get into full gear and a long time to recover from it.

3.3 Causes of Drought

Lack of rainfall (or precipitation)

Drought is the consequence of a natural reduction in the amount of precipitation received over an extended period of time, usually a season or more in length, although other climatic factors (such as high temperatures, high winds, and low relative humidity) are often associated with it in many regions of the world and can significantly aggravate the severity of the event.

Deforestation

Forest trees play a key role in water cycle as they help to reduce evaporation, store water and also contribute to atmospheric moisture in the form of transpiration. Deforestation exposes surface water to more evaporation and reduces the ability of the ground to hold water and make it easier for drought to occur. Cutting down trees reduces water shed potentials.

Changing landuse and agricultural intensification

Agricultural land expansion and intensification of cropping pattern increases the crop water demand. In addition to the practice of slash and burn agriculture that leaves no residue of the previous season's crops on farmland, can reduce water infiltration while increasing evaporation as well as wind. These serve to trigger and exacerbate the effects of drought and direct long-term impacts on land and soil quality, soil structure, organic matter content and ultimately on soil moisture levels.

Global Warming
Changes in the earth's temperature due to increasing green houses gases results in warmer temperatures that increases dryness and bush fire. These conditions tend to speed up drought conditions.

4.0 Conclusion

Saharan Africa is particularly susceptible to climate variability and drought and is increasingly being threatened by desertification processes, degradation of land and water resources and loss of biodiversity. Droughts tend to reduce production to below the already marginal levels, thus threatening subsistence farming. These conditions occur where the local economy is least diversified and where almost

everyone depends either directly or indirectly on agriculture. Frequent exposure to drought causes agricultural production to be out of equilibrium with the seasonal conditions, representing an inability on the part of most smallholders to adjust land use to climate variability. Farmers must either increase agricultural productivity or develop alternative sources of income if their livelihoods are to be sustained.

5.0 SUMMARY

In this unit several perspectives of drought was presented, types of drought and causes of drought were explained.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define drought from two scholar's perspective.
2. Enumerate and explain types of drought.
3. Discuss the causes of drought.

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UNIT 2 DEFINITION AND CAUSES OF DESERTIFICATION

CONTENTS

1.0 INTRODUCTION

Forests provide numerous ecosystem services including biodiversity conservation, carbon sequestration, clean water supply, and recreational space. Rates of exploitation of natural resources has been on the increase over the past few decades resulting from rapid population growth, increasing incidence of poverty, urbanization, rising economic output and consumptive lifestyles. All these contribute to land degradation in all of its forms. Land degradation through desertification is a global problem not only in drylands but also in humid ecosystems so much so that its prevention and mitigation is essential for sustainable development.

2.0 OBJECTIVES

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

- Explain the meaning of land degradation
- Define desertification.
- State the causes of desertification.

3.0 MAIN CONTENT

3.1 Meaning and Definition of Desertification

Land refers not only to soil but terrestrial bio-productive system that comprises soil, vegetation, other biota, and the ecological and hydrological processes that operate within the system.

Land degradation is the reduction or loss of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or

range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as soil erosion caused by wind and/or water; deterioration of the physical, chemical and biological or economic properties of soil; and long-term loss of natural vegetation.

Desertification is a form of land degradation in drylands resulting from various factors including climatic variations and human activities leading to a condition of significantly reduced soil fertility and water holding capacity. Increasing occurrences of water scarcity, whether natural or human-induced, serve to trigger and exacerbate the effects of desertification through direct long-term impacts on land and soil quality, soil structure, organic matter content and ultimately on soil moisture levels.

3.2 Causes of Desertification

The principal cause of desertification is the unsustainable exploitation of land productivity by pastoral, farming, and agro-pastoral land uses.
Degradation of the rangeland through livestock grazing, mechanical removal of vegetation cover also contributes to the process of desertification.

Changing rainfall patterns increase the risk of drought leading to desertification and declining agricultural yields and diminished food security. Already, temperature increases of about 0.2^0 C - 0.3^0C per decade have been observed in the various ecological zones of the country, while drought persistence has characterized the Sudan-Sahel regions, particularly since the late 1960s.

4.0 CONCLUSION

Ensuring sustainable agriculture and range management practices, improved animal husbandry and management of water resources in the desertification prone areas with a view to achieving sustainable livelihoods, poverty reduction and wealth creation through the introduction of modern and affordable production technologies to resource poor farming communities should be encourage.

5.0 SUMMARY

This unit presents the perspective of desertification and some of the causes of desertification

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the meaning of land degradation
2. Define desertification.
3. State the causes of desertification.

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UNIT3 IMPACTS OF DROUGHT AND DESERTIFICATION

CONTENTS

1.0 INTRODUCTION

Drought and Desertification are forms of land degradation in drylands resulting from various factors including climatic variations and human activities which trigger some impacts that affect humans as well as the environment in the form of increasing occurrences of water scarcity with direct long-term impacts on land and soil quality, soil structure, organic matter content and ultimately on soil moisture levels.

2.0 OBJECTIVES

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

- Outline the impacts of drought and desertification
- Discuss in details any five impacts of drought and desertification

3.0 MAIN CONTENT

3.1 Status and Trends of Drought and Desertification

Two thirds of Africa is classified as deserts or drylands. These are concentrated in the Sahelian region, the Horn of Africa and the Kalahari in the south. Africa is especially susceptible to land degradation and bears the greatest impact of drought and desertification. It is estimated that two-thirds of African land is already degraded to some degree and land degradation affects at least 485 million people or sixty-five percent of the entire African population. Desertification especially around the Sahara has been pointed out as one the potent symbols in Africa of the global environment crisis. Climate change is set to increase the area susceptible to drought, land degradation and desertification in the

region. Under a range of climate scenarios, it is projected that there will be an increase of 5-8% of arid and semi Arid lands in Africa. Estimates from individual countries report increasing areas affected by or prone to desertification. It is estimated that 35 percent of the land area (about 83,489 km2 or 49 out of the 138 districts) of Ghana is prone to desertification, with the Upper East Region and the eastern part of the Northern Region facing the greatest hazards. Indeed a recent assessment indicates that the land area prone to desertification in the country has almost doubled during recent times. Desertification is said to be creeping at an estimated 20,000 hectares per year, with the attendant destruction of farmlands and livelihoods in the country. Seventy percent of Ethiopia is reported to be prone to desertification, while in Kenya, around 80 percent of the land surface is threatened by desertification. Estimates of the extent of land degradation within Swaziland suggest that between 49 and 78 % of the land is at risk, depending on the assessment methodology used (Government of Swaziland, 2000). Nigeria is reported to be losing 1,355 square miles (1mile =1.6km) of rangeland and cropland to desertification each year. This affects each of the 10 northern states of Nigeria. It is estimated that more than 30% of the land area of Burundi, Rwanda, Burkina Faso, Lesotho and South Africa is severely or very severely degraded. These rates and extent of land degradation/desertification undermine and pose serious threats to livelihoods of millions of people struggling to edge out of poverty. They also cripple provision of land resources - based ecosystem services that are vital for a number of development sectors.

With regard to drought, the continent has witnessed a high frequency of occurrence and severity of drought. Drought is one of the most important climate-related disasters in Africa. Climate change is set to exacerbate occurrence of climate related disasters including drought. Current climate scenarios predict that the driest regions of the world will become even drier, signaling a risk of persistence of drought in many parts of Africa (arid, semi-arid and dry sub humid areas) which will therefore bear greater and sustained negative impacts.

3.2 Impact of Drought and Desertification

It is common knowledge that land degradation and desertification constitutes major causes of forced human migration and environmental refugees, deadly conflicts over the use of dwindling natural resources, food insecurity and starvation, destruction of critical habitats and loss of biological diversity, socio-economic instability and poverty and climatic variability through reduced carbon sequestration potential. The impacts of drought and desertification are among the most costly events and processes in Africa. The widespread poverty, the fact that a large share of Africa’s economies depend on climate-sensitive sectors mainly rain

fed agriculture, poor infrastructure, heavy disease burdens, high dependence on and unsustainable exploitation of natural resources, and conflicts render the continent especially vulnerable to impacts of drought and desertification. The consequences are mostly borne by the poorest people and the Small Island Developing States (SIDS). In the region, women and children in particular, bear the greatest burden when land resources are degraded and when drought sets in. As result of the frequent droughts and desertification, Africa has continued to witness food insecurity including devastating famines, water scarcity, poor health, economic hardship and social and political unrest. The gravity of drought and desertification impacts in the region is demonstrated by the following examples.

Impact on economic growth and poverty reduction

The majority of the populations in most African countries live on marginal lands in rural areas practicing rain-fed agriculture. Desertification threatens agricultural production on these marginal lands exacerbating poverty and undermining economic development. Growing levels of entrenched poverty, environmental degradation, desertification, and underdevelopment of rural areas characterize most rural areas of the African countries. The impact of drought and climatic variability in both economic and mortality terms is generally larger for relatively simple and predominantly agricultural economies. These types of economies dominate Africa. In 2004, the UNCCD estimated that some six million hectares of productive land was being lost every year since 1990, due to land degradation. This in turn had caused income losses worldwide of US$ 42 billion per year. With two-thirds of arable land expected to be lost in Africa by 2025, land degradation currently leads to the loss of an average of more than 3 percent annually of agriculture GDP in the Sub-Saharan Africa region. In Ethiopia, GDP loss from reduced agricultural productivity is estimated at $130 million per year. In Uganda land degradation in the dry lands threatens to wreck havoc on the country's economy and escalate poverty. This is because these drylands constitute the Uganda cattle corridor, which accounts for over 90 percent of the national cattle herd and livestock production contributes 7.5 percent to the GDP and 17 percent to the agricultural GDP.

Drought and floods account for 80 percent of loss of life and 70 percent of economic losses linked to natural hazards in Sub-Saharan Africa. The drought of 1990/1991 in Zimbabwe resulted in a 45 percent drop in agricultural production but also a 62 percent decline in the value of the stock market, a 9 percent drop in manufacturing output and a GDP drop of 11 percent. Similarly, in Kenya, the drought of 1999-2001 cost the economy some 2.5 billion dollars. As a proportion of the national economy this is a very significant loss and can best be thought of as 2.5

billion dollars of foregone development, for example, hospitals and schools not built.

Desertification in Africa is a major cause and consequence of poverty and resource depletion, which threaten economic growth. In many African countries poverty and desertification are expected to rise during the twenty first century given that most governments are unable to increase expenditure on economic and agricultural production to drive rural and urban economic development and reduce the dependence of the poor on the natural environment, a process that exacerbates desertification and poverty. Increased agriculture and rural economic development expenditure each year contribute to improved food security and to a steady decline in the incidence of rural poverty and the process of desertification.

Impact on food security

The loss of natural resources, environmental degradation and desertification affects food security. The poor households that are affected by drought and desertification do not have adequate resources to deal with food shortages leading to food insecurity and hunger that affects millions of people. If land degradation continues at the current pace, it is projected that more than a half of cultivated agricultural area in Africa could be unusable by the year 2050 and the region may be able to feed just 25 percent of its population by 2025. Agriculture being one of the main economic activities in Africa (which represents around 40 percent of the region's GDP and employs about 60 percent of the active labour force), this would lead to a catastrophe with unprecedented repercussions. In the two northern regions of Ghana severely hit by soil degradation, it is estimated that malnutrition among children increased from 50 percent in 1986 to 70 percent in 1990. The most severe consequence of drought is famine. Food aid to the subcontinent accounts for approximately 50 percent of the yearly budget of the World Food Aid Programme. The consecutive droughts that have occurred in southern Africa since 2001 have led to serious food shortages. The drought of 2002–03 resulted in a food deficit of 3.3 million tonnes, with an estimated 14.4 million people in need of assistance. At the height of the Horn of Africa's drought in 2000, 3.2 million Kenyans were dependent on food aid, and malnutrition reached 40 percent of the population, more than 3 times the normal level.

The worst affected countries included Ethiopia, Zimbabwe, Malawi, Eritrea and Zambia, a group of countries where at least 15 million people would go hungry without aid. The situation in Niger, Djibouti and Sudan also deteriorated rapidly. Many of these countries had their

worst harvests in more than 10 years and were experiencing their third or fourth consecutive severe drought.

The Sahelian drought and famine of 1968 to 1974 is a horrific reminder of the combined effects and impacts of desertification and drought. In the span of six years, hundreds of thousands of people died and millions of animals perished. Images of starving children, dead livestock and desolate land quickly grabbed the world's attention and catapulted desertification centre stage. In Africa as a whole, food consumption exceeded domestic production by 50% in the 1980s and by more than 30% in the 1990s. Although agriculture will remain for many years a major contributor to the economies of most developing countries, in some countries, however, its share of GDP will progressively decline as drought and desertification take their toll with food shortages increasing at the same time.

Impact on water

Both drought and desertification influence water availability, which is projected to be one of the greatest constraints to economic growth in the future. In Africa, climate change is expected to intensify the continent's increasingly critical water situation. Reduced annual average rainfall and its run-off would worsen desertification in southern Africa. This sub-region being one of many water-stressed regions could thus see a further decrease in streams flow and the ability of groundwater to 'recharge'. Furthermore, it is projected that by 2025 Southern Africa will also join most countries in North Africa that can already be classified as having absolute water scarcity today. This means that countries in these regions will not have sufficient water resources to maintain their current level of per capita food production from irrigated agriculture - even at high levels of irrigation efficiency - and also to meet reasonable water needs for domestic, industrial, and environmental purposes. To sustain their needs, water will have to be transferred out of agriculture into other sectors, making these countries or regions increasingly dependent on imported food. By the year 2025, it is thus estimated that nearly 230 million Africans will be facing water scarcity, and 460 million will live in water-stressed countries. Already, 14 African countries are subject to water stress or water scarcity, increasing to 25 countries by 2025, a situation that will further exacerbate desertification, perilous food security and economic underdevelopment.

In the Nile region, most scenarios estimate a decrease in river flow of up to more than 75 percent by the year 2100. This would have significant impacts on agriculture, as a reduction in the annual flow of the Nile above 20 per cent will interrupt normal irrigation.

Such a situation could cause conflict because the current allocation of water, negotiated during periods of higher flow, would become untenable. The situation of women and children who are responsible for fetching water for the households is therefore worsened by drought and desertification. These can add hours of labour to an already fully charged workday.

Impact on biodiversity

Biodiversity existing in dry lands and other habitats underpin ecosystem services that vital for livelihoods of millions of people in Africa. It is the foundation for sustainable development in the region and globally. The dry areas of the world are the origin of a large number of globally important cereals and food legumes, such as barley, wheat, faba beans and lentils. Four hundred million people, two thirds of sub-Sahara African population, rely on forest goods and services for their livelihood. Drought, land degradation and desertification have had serious impact on the richness and diversity of Africa Diversity. These factors remain some of the most serious threats to the management, sustainable use and equitable sharing of benefits of biodiversity. The projected devastating impacts of climate change in the region including exacerbating these factors will escalate biodiversity degradation and loss associated with drought, land degradation and desertification. These factors affect biodiversity directly and indirectly. Onsite impacts include habitat and species degradation and loss, leading to overall loss of economic and biological productivity. For instance on rangelands, overgrazing not only reduces the overall protective soil cover and increases soil erosion, but also leads to a long-term change in the composition of the vegetation. Plant biodiversity will change over time, unpalatable species will dominate, and total biomass production will be reduced. These in turn trigger and contribute to indirect or offsite impacts. Soil erosion will contribute to denudation and pollution of wetlands and water bodies. As biological and economic productivity deteriorates, communities are forced migrate to other areas or engage in other coping activities that too contribute biodiversity degradation.

In the sand dune areas of countries such as Mauritania, Mali, Niger, Nigeria and Senegal major river basins siltation processes accumulate debris and materials that engulf natural vegetation, such as the *Acacia nilotica* riparian forests. Soil erosion contributes to moving the seed capital of the ground, uprooting grassy as well as woody species, and in accumulation areas it smothers valuable species.

In West Africa the movement of people south towards sub-humid to humid tropical areas has resulted into loss of primary forests and woodlands, repeated logging of the secondary vegetation, and depletion

of a number of species. More diffuse degradation of land resources also occurs in the arid and sub-humid parts. These include the extraction of tree resources outside forests for charcoal making (about 150 million tonnes/year from the savannah and woodland areas), and the use of high-value woods. Most affected are the *Meliacaea family* (*Khaya species*), *Pterocarpus erinaceus,* and *Dalbergia melanoxylon.*

There is mounting evidence to show that drought and desertification as exacerbated by climate change will have devastating impacts on habitats and species in the region. For example shifts in rainfall patterns could affect the fynbos and karoo in southern Africa by altering the fire regime critical for their regeneration. Decreasing run off could impact wetland ecosystems such as the Okavango Delta and the Sudd area.

Impact on Energy

The impacts of drought and desertification on the energy sector are felt primarily through losses in hydropower potential for electricity generation and the effects of increased runoff (and consequent siltation) on hydropower generation. The gravity of impacts of electricity generation is further demonstrated by the case of Ghana, where for the first half of 2007 (and it was projected to continue for the year), the water level at the Akosombo dam had fallen below the minimum level of 240 feet. This led to reduction in hydro-electricity generation and hence loads shedding of electricity in the whole country. Energy impacts are also experienced through changes in the growth rates of trees on which a vast majority of the people in the region rely for fuel wood. Due to the limited alternatives available to them and low priority accorded to meet their needs in times of scarcity, the rural areas and the urban poor bear the greatest cost of decrease in energy resources. This undermines efforts to pull these categories of people out of the poverty trap.

Impact on Migration

The effects of desertification extend beyond the affected dryland areas. As the level of vulnerability due to the combined impacts of desertification and socio-economic susceptibility increase, the greater the probability of human migration. Desertification is displacing big population of people and forcing them to leave their homes and lands in search of better livelihoods. Desertification and drought related migration takes many forms the majority occurring as internal migrations, that is, displacements of populations within national boundaries. At greatest risk are those at the low end of the socio-economic spectrum, both in developed and developing regions. In developing regions, the poorest inhabitants are often forced to live on marginal land outside urban areas or coastal zones, potentially prone to

desertification. Migration is often a coping mechanism, with little faith in finding permanent residence.

Availability of natural resources for example prompts pastoralists along the borders of Ethiopia, Kenya and Uganda to migrate away from areas of dwindling resources; thus raising competition over finite resources with incidence of conflict increasing when these individuals move into areas of crop growing communities. It is estimated that 135 million people - the combined populations of France and Germany - are at risk of being displaced by desertification. The problem appears to be most severe in sub-Saharan Africa, the Sahel and the Horn of Africa. Some 60 million are estimated to eventually move from the desertified areas of sub-Saharan Africa towards Northern Africa and Europe by the year 2020.

Already, it is reported that in the past 20 years, nearly half of the total male population in Mali has migrated at least once to neighbouring African countries (96 percent) or to Europe (2.7 percent). In Burkina Faso, desertification can be identified as the cause of 60 percent of the swelling of main urban centres. In Kenya one of the consequences of desertification is a constant flow of rural poor to Nairobi. The population of Nairobi has grown by 800 percent from 350,000 in 1963 to 2,818,000 in 2005. Migration will exert stress on the poor and limited public infrastructure in urban areas and may exacerbate conflicts already witnessed in the region as result of scarcity of grazing land and water.

Against this background of the devastating impact of drought and desertification, which permeates and undermines the very foundations for securing sustainable livelihoods and economic growth, poverty eradication in Africa is inextricably linked to success in combating desertification and mitigating the impacts of drought. For millions on the continent, hopes of getting out of poverty therefore hinge on efforts at national, regional and global levels to prioritize the provision of support and the implementation measures for desertification control and coping with drought.

4.0 CONCLUSION

The cost of managing desertification is huge when the problem is full blown, government policies should be evaluated in such a way as to encourage participatory approach in environmental management.

5.0 SUMMARY

This unit presents some of the impacts of drought and desertification at it affects human and the environment.

6.0 TUTOR-MARKED ASSIGNMENT

1. Outline the impacts of drought and desertification
2. Discuss in details any five impacts of drought and desertification

7.0 REFERENCES/FURTHER READING

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UNIT4 MEASURES TO MITIGATE DROUGHT AND COMBAT DESERTIFICATION

CONTENTS

1.0 INTRODUCTION

Drought and desertification are ecological disasters in the dryland and most governments in the region have been grappling with the problems of accelerated desertification, increasing frequency and severity of the impacts on economic and human activities. Drought and desertification leads to poor crop growth, lower yield and reduction in vegetation cover, and causes depletion of soil moisture, making the soil susceptible to wind erosion. To tackle the grave ecological problems, a series of measures need to be taken in a massive campaign to save the drylands. Several approaches have been adopted to control drought and combat desertification.

2.0 OBJECTIVES

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

- List the approaches to control and combat desertification
- Explain the importance of shelter belt desertification control

3.0 MAIN CONTENT

3.1 Mitigation measures

Better Management Practices

The potential for environmental problems due to agricultural activities is well documented. There are practical ways to ensure that risks to the environment are minimized without sacrificing economic productivity. These pollution-preventing farming methods are known as Better Management Practices (BMPs). The first category emphasizes reduction

in the use of inputs in the interests of pollution prevention. The less a potentially harmful substance is used in agriculture, the less likely it is to affect other parts of the environment. This applies most directly to fertilizers, manure and pesticides. Nutrient management is the practice of applying fertilizers and manure only in the amounts that can be taken up by a crop. Applications in excess of the actual needs have the potential to enter surface and ground water. The use of herbicides and insecticides can be minimized through *"Integrated Pest Management."* This refers to a management strategy that includes an understanding of the target pest and use of a combination of physical, chemical, biological and cultural controls. The second type of BMP is directly concerned with erosion and runoff control. Practices such as strip-cropping, shelterbelts and use of cover crops prevent erosion and reduce the movement of nutrients and pesticides from agricultural land. Residue management through conservation tillage and continuous cropping has proved effective at controlling erosion, but the approach is likely to require higher inputs of fertilizer and herbicides.

The third type involves the planting of barriers and buffers to intercept and contain contaminants that are being carried from agricultural lands. In most cases, these are strips of vegetation that slow the velocity of runoff water enough for sediment to settle out, water to infiltrate into the ground and nutrients to be taken up by plants. Grassed waterways, vegetative strips and field borders are examples of buffers that can be used in annually cropped fields. Where buffer zones surround a stream or lake, they are usually referred to as *riparian buffers*. The vegetation helps capture sediment and nutrients from water and stabilize the banks and shores from erosion. Sound management practices are powerful tools in protecting soil and water. Many of the potential negative impacts of farming can be greatly reduced by use of BMPs.

Zero Tillage

Other solutions include *"Zero Tillage."* Also known as *"Minimum Tillage,"* zero tillage is an operation that places seed and fertilizer into a seedbed with minimum soil disturbance, packs the furrow and retains adequate surface residues to prevent soil erosion. Zero tillage seeding provides considerable benefits by slowing organic matter depletion and allowing for runoff reduction and better water infiltration. A scheme known *as "Crop Residue Management"* has substantially reduced the risk of erosion because it decreases the period during which soils are exposed to erosion by wind or water.

C**onservation Fallow**

In recent years, some new techniques that are collectively known as conservation fallow appear to gain popularity. One such technique is known as *"Chemical Fallow,"* which involves the spraying of herbicides to reduce tillage and retain surface residues to help trap precipitation and reduce evaporation losses.

Strip farming for wind erosion control

Also called *"Strip Cropping"* or *"Contour Cropping,"* Strip Farming is the practice of growing crops between alternate strips of land. The idea is to reduce wind erosion by reducing wind speed on the surface of the soil. Another benefit is the increased soil moisture from precipitation catch.

The most commonly used method is to determine the rotation and divide fields into strips of desired width.

The Permanent Cover Programme

Permanent cover programme is a form of agro-forestry that encourages the conversion of lands from annual crops to perennial forage or forest cover under adequate incentives to encourage the local farmers. After the establishment of forage or tree covers, farmers are allowed to continue to use the land, primarily for cattle grazing or forage production. Benefits of this practice include reduction in soil degradation, water quality improvement and wildlife habitat enhancement. There is no question that ultimately the local farmers benefited the most from implementing the programme as a result of adequate incentives.

Shelterbelt planting

Along with forage cover, forests are recognized as the best line of defense against drifting soils. Growing shelterbelts has long been considered an effective practice to reduce soil erosion. Shelterbelt can be in the form of field shelterbelts, farmstead shelterbelts and forest belts. Shelterbelts consist of rows of trees planted on agricultural land to protect crops and soil, to catch and distribute precipitation, and to improve the microclimate for crops. Reduction of soil erosion by wind is the major reason for planting shelterbelts. Trees and shrubs have been planted where soil is easily blown or where little vegetative cover remains. Recent research shows that field shelterbelts reduce wind speeds for a distance of 20 to 30 times their own height and increase crop yields considerably. Other benefits include enhanced wildlife

habitat and improved scenic landscapes. In addition to their role in reducing soil erosion, protecting farmyard from year-round winds and providing habitat for wildlife, trees and shrubs can also provide valuable products such as fuel wood, lumber, pulp and fruit. Further, shelterbelts prevent wind damage to shrubs, loss of fruit at harvest, reduce evaporation, increase biodiversity, harbor insects, birds, wild flowers, mammals and mushrooms, and provide reduce global warming, shelterbelts is effective in serving as a carbon sink. It Provide direct income to farmers and beautify landscape by providing long-term shelter, because forest belts are comprised of many species with varied life spans.

4.0 CONCLUSION

Drought and desertification management in Nigeria needs to be proactive to reduce costs and impacts on communities and the environment.

5.0 SUMMARY

This unit presents some of the measures used in controlling the drought and the spread of desertification.

6.0 TUTOR-MARKED ASSIGNMENT

1. List the approaches to control and combat desertification
2. Explain the importance of shelter belt desertification control

7.0 REFERENCES/FURTHER READING

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UNIT5 DROUGHT AND DESERTIFICATION MITIGATION PROGRAMMES

CONTENTS

1.0 INTRODUCTION

The challenges of drought and desertification are high in the dryland region of Africa posing problems of food security and it affects the sustainable livelihoods and socio-economic development in the dryland communities. Affected countries, including Nigeria, have been making efforts to reverse the situation by implementing projects and programmes.

2.0 OBJECTIVES

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

- Discuss the phases of national intervention in the control of drought and desertification.
- Enumerate policies relevant to the control of drought and desertification in Nigeria.
- Explain the history and goals of Green Wall for Sahara Initiative

3.0 MAIN CONTENT

3.1 National Efforts to Address the Challenges of Drought and Desertification in Nigeria

The major concern about the possible southward shift of the Sahara desert into Nigeria was expressed in the 1930s. In response, an Anglo-French Commission in 1937 investigated the report in the northern parts of Nigeria, and directed the border emirates to embark on tree planting to stop the encroachment. Thousands of seedlings were raised and distributed at nominal prices. It was not until the 1940s that a small action programme in the form of a tree planting campaign was launched. The bad situation of the affected areas prompted the establishment of shelterbelts in the northern fringes in the 1960s.

The catastrophic Sahelian drought of 1972/73 made the Federal Government of Nigeria to develop various programmes at all levels of governance to promote sustainable land management and enhance environmental sustainability in the context of national development. These efforts can be captured under (i) promoting an enabling policy environment for desertification control; (ii) institutional and capacity building; (iii) political and legal framework; (iv) partnership building and participation in global initiatives; (v) implementation of special initiatives.

Promoting an Enabling Policy Environment

The government has taken cognizance of the multi-sectoral problems of desertification. In this regard, it has developed a number of policies and plans to ensure a truly national response to the significant and multi-facetted impacts of land degradation and desertification on national development. The Nigeria Vision 20:2020 in particular, recognizes that sustainable use of natural resources provides a buffer against poverty and opportunities for self-employment in the informal sector. Conversely, if poorly managed, the environment could easily become hazardous and threatening to rapid socio-economic development and human survival. The goal is the conservation of the environment within the Vision 20:2020 framework, with emphasis on *halting land degradation, combating desertification and mitigating impacts of droughts*. The specific initiatives are to:

i. Prevent further loss of biodiversity and restore already degraded areas and protect ecologically sensitive sites;
ii. Harness and sustain natural resource use;
iii. Reduce the impact of climate change on socio-economic development processes;

iv. Make Nigeria a visible actor in global climate change response;
v. Halt land degradation, combat desertification and mitigate impacts of droughts;
vi. Secure a clean environment through appropriate waste management;
vii. Reduce the occurrence and impact of environmental hazards and disasters;
viii. Raise the level of awareness on the state of the Nigerian environment; and
ix. Improve the overall governance of the environment.

Key policies and plans of direct relevance to desertification control in Nigeria include:

(i) National Policy on the Environment, (ii) National Drought and Desertification Policy, (iii) National Drought Preparedness Plan and (iv) National Action Plan to Combat Desertification (NAP). The NAP identifies long-term integrated strategies that focus simultaneously on improved productivity of land and on the rehabilitation and sustainable management of land and water resources. Other policies and plans of action that are relevant to desertification control and drought mitigation include: (a) Nigeria National Environmental Action Plan (NEAP) and States Environmental Action Plans (SEAPs), (b) Nigeria Climate Change Policy and Response Strategy, (c) National Adaptation Strategy and Plan of Action for Climate Change, (d) National Forestry Action Plan, (e) National Conservation Strategy, (f) National Biodiversity Strategy and Action Plan (NBSAP), (g) National Resources Conservation Action Plan, (h) National Policy on Agricultural Policy (NPA), (i) National Water Resources Master Plan (NWRMA).

Institutional and Capacity Building

In 1977, the Federal Government set up a National Committee on Arid Zone Afforestation Programme (AZAP) with the responsibility of in-depth examination of the problems of desertification and to draw up a suitable programme of afforestation geared towards checking desert encroachment. A programme of shelterbelt planting for the protection of adjoining agricultural lands against desiccating winds in the extreme northern part of the region was embarked upon. However, the committee was dissolved in 1985 and its functions were transferred to Department of Rural Development and River Basin Development Authorities (RBDAs) in the then Federal Ministry of Agriculture, Water Resources and Rural Development. By 1987, the RBDAs were reorganized and their afforestation functions transferred to the Forestry Department of the Federal Ministry of Agriculture.

The establishment of FEPA by Decree 58 of 1988 was probably the most far-reaching initiative undertaken by the Federal Government of Nigeria for the purpose of addressing the multifarious environmental problems (drought and desertification inclusive) and protecting the Nigerian Environment. Government further demonstrated its commitment to environmental issues through Decree 59 of 1989, which increased the powers of FEPA. The decree provided legal backing of the Agency with a broad mandate and specific powers of sanctions in the implementation of the National Environmental Policy. By Law, FEPA was therefore the apex institution for all issues relating to environmental protection. The Federal Environmental Protection Agency also facilitated the establishment of State Environmental Protection Agencies (SEPAs) in the 36 states of the Federation and the Federal Capital Territory (FCT). As earlier stated, Nigeria signed the Desertification Convention on 31 October 1994 and ratified same on 8 July 1997, thereby qualifying the country as a Party to the convention with effect from 6 October 1997.

As part of the implementation strategies of the UNCCD, a National Coordinating Committee to combat desertification control was established in 1993, with Secretariat in the then FEPA. The Committee, which comprised of representatives of line Ministries, Agencies, relevant research Institutes, and Non-governmental Organizations (NGOs), has responsibility for coordinating the implementation of the Convention to Combat Desertification. It must be noted that most states of the Federation have legislation relating to environmental protection, such as edicts on bush burning and deforestation. The creation of the Department of Drought and Desertification Amelioration (DDDA) in the new Federal Ministry of Environment (FMEnv) in 1999 strengthens the existing institutional arrangement for more effective coordination of activities by Government, towards the implementation of the CCD in the country. The move was to ensure a sharper focus to rehabilitation and restoration of desertified and desert-like conditions in the affected areas. The upgrading of Nigerian Metrological Services from a department in the Ministry of Aviation to a semi-autonomous agency, namely the Nigerian Meteorological Agency (NIMET), in 2003 represents yet another major bold step at addressing drought and desertification in the country. There is also a National Council on the Environment, made up of representatives of governments at the Federal and State levels. The Council meets at regular intervals to take stock of the state of the environment in Nigeria.

Legal Frameworks

A number of environmental objectives to protect and improve the environmental resources (air, land and water) of Nigeria have been

enunciated in section 20 of the constitution of the Federal Republic of Nigeria. Many laws and regulatory measures have been put in place to ensure effective environmental management. Notable among these are: (i) Federal Environmental Protection Agency Act – retained as Cap F10LFN 2004, but repealed by the National Environmental Standards and Regulations Enforcement Agency (NESREA) Act 2007, which is being developed into the National Environmental Management Bill; (ii) Environmental Impact Assessment Act – retained as Cap E12 LFN 2004 (which sets out the general principles, procedures and methods of Environmental Impact Assessment in various sectors); (iii) National Park Service Act – retained as Cap N65 LFN 2004 (for conservation and protection of natural resources (wildlife and plants) in national parks; (iv) Endangered Species (Control of International Trade and Traffic) Act- retained as Cap E9 LFN 2004 (conservation of wild life and protection of threatened and endangered species); and (v) National Environmental (Desertification Control and Drought Mitigation) Regulations, 2011.

Building Partnerships and Participation in Global Initiatives

Government has recognized that it cannot alone tackle the hydra-headed problem of desertification without involving others. To this end, it has facilitated the involvement of other actors, including the Private Sector, NGOs, CBOs and Donors. At present, a number of NGOs are actively involved in the implementation of CCD in Nigeria, and some of them participated very actively in the negotiation process. Prominent national and international NGOs that are actively participating in the activities of the Global NGO network on Desertification in Nigeria are the Nigerian Environmental Study/Action Team (NEST), the Nigerian Conservation Foundation (NCF), Forestry Association of Nigeria (FAN), and International Union for Conservation of Nature (IUCN). Other NGOs, which have general concern for the protection of the environment include, Nigerian Field Society, Young Foresters Club, the Fauna Conservation Society, Ecological Society of Nigeria, Horticultural Society of Nigeria, Nigerian Environmental Society, Nigerian Society for Biological Conservation, etc.

At the international level, Nigeria has participated actively at meetings and activities of the UNCCD. As part of its obligations to the UNCCD, Nigeria submitted its National Action Plan to Combat Desertification (NAP) to the Convention's Secretariat in 2000. A revised draft of NAP was completed in 2004. Nigeria is involved in a number of bilateral and multilateral relations, which directly or indirectly relate to desertification control. These include (i) Lake Chad Basin Commission (LCBC); (ii) Nigeria – Niger Joint Commission for Co-operation (NNJCC); (iii) African Ministerial Conference on Environment (AMCEN); (iv)

Permanent Inter-State Committee on Drought Control in the Sahel (CILSS); (v) Economic Community for West African States (ECOWAS); (vi) United States Agency for International Development (USAID); (vii) United Nations Educational, Scientific and Cultural Organization (UNESCO); (viii) Japanese International Cooperation Agency (JICA); (ix) Canadian International Development Agency (CIDA); (x) TerrAfrica; (xi) CAADP. In addition, the country has also enjoyed some form of financial and technical assistance from international agencies and NGOs on matters relating to desertification control. They include The World Bank (WB), African Development Bank (AfDB), United Nations Development Programme (UNDP), IUCN, World Wide Fund for Nature (WWF), and Royal Society for Protection of Birds (RSPB).

Implementation of special programme and project initiatives

In Nigeria, several sectoral and multi-sectoral programmes have been put in place over the years to tackle the twin problem of drought and desertification. These are specifically in water, forestry, agriculture and energy.

In the water sector, the RBDAs (e.g. Sokoto-Rima, Hadejia- Jama'are, Benue River, Niger River and Chad Basin River Basin Development Authorities) are actively involved in the development of water resources, particularly for irrigation, including improvement of community water supplies and provision of watering points in rangelands. The Government, with World Bank assistance, has also implemented a programme tagged “National Fadama Development Project” for the purposes of optimally utilizing the water resources of the wetlands of Nigeria for small-scale irrigation to provide dry season alternative employment avenue for several rural population who are engaged in off-season trade in firewood.

Towards improving the forest resources of Nigeria’s drylands, AZAP was instituted by the Federal Government in 1977. The focus of the programme was to tackle the problems of desertification through the establishment of woodlots, shelterbelts and windbreaks. Over 10 million seedlings were raised annually between 1978 and 1984. About 150 kilometers of shelterbelts, 3,680 hectares of woodlots, 24 boreholes, 70 tree nurseries, and a Forestry Vocational School, were established. The European Economic Community (EEC) also supported similar pilot project in Katsina State, over an area covering about 1.6 million hectares; so also the World Bank in several of the frontline states. In all the programmes, the emphasis is on farmer participation and extension. In the agriculture sector, the Government of Nigeria, assisted by the World Bank, has expended enormous resources to the establishment of

Agricultural Development Programmes (ADPs) in all the 36 states of the Federation and the Federal Capital Territory. The ADPs operate the Training and Visit (T & V) system of unified extension system covering the areas of Crop Production and Protection, Livestock Production and Animal Health, Fisheries, Agro-forestry and Gender related issues in Agriculture. This unified extension system is employed for the dissemination of proven agricultural technologies (aimed at ensuring sustainable development) to the small-scale, resource poor farmers who are responsible for well over 90 percent of the national food production.
As part of the Government's effort to revamp the agriculture sector, ensure food security, diversify the economy and enhance foreign exchange earnings, the Federal Ministry of Agriculture & Rural development recently embarked on a transformation agenda (Agricultural Transformation Agenda - ATA). The vision in the transformation strategy is to achieve a hunger free Nigeria, through an agricultural sector that will drive income growth, accelerate achievement of food and nutritional security, generate employment and transform the country into a leading player in global food markets. The agenda is designed to make the agricultural sector a business project, as against development project, to promote private investment, execute integrated projects via value chain processes, generate employment, and transform Nigeria into a net exporter of agricultural commodities. The transformation agenda targets rural communities particularly women, youth and farmers associations, as well as improvement of rural institutions and infrastructures.

To reduce human pressure on the scarce wood resources of the desertification prone areas of Nigeria, the Energy Commission of Nigeria (ECN) has put in place some programmes for promoting optimal utilization of renewable energy resources with a view to reducing deforestation associated with fuelwood sourcing. In particular, significant efforts are being made to promote solar photovoltaic electrification projects for remote rural areas. All energy-related environmental projects that are being implemented in Nigeria are guided by the National Policy Guidelines on Energy.

There are also many integrated programmes and projects targeted at poverty reduction. Notable among these are the Northeast Arid Zone Development Programme (NEAZDP), the Federal Ministry of Environment/University of Maiduguri (FMEnv/UNIMAID).

Linkage model village project, the Katsina State Agricultural and Community Development Project (KSACDP), the Sokoto Environmental Protection Programme (SEPP), Projects for the Millennium Development Goals (MDGs), and the Integrated Ecosystem Management (IEM).

The NEAZDP, funded by the Federal Government of Nigeria with European Union assistance, commenced in February 1990 with the main objective of motivating and assisting the rural population to improve their standard of living through proper resource use and management. The programme covers an area of about 25,000 km^2 in the extreme northern part of Yobe State. The major components of this programme include water resources development and management (including irrigated agriculture), provision of micro-credit for off season economic activities, cottage industries, livestock fattening, rural banking and popularisation of animal traction for land preparation for agricultural activities.

The FMEnv/UNIMAID Linkage Centre on Drought and Desertification Control initiated a model village project at Sabon-garin Nangere, Yobe State in 1995. Activities carried out at the model village include establishment of community woodlots and roadside tree planting, provision of energy efficient wood stoves, provision of biogas for domestic cooking, provision of Ventilated Improved Pit (VIP) latrines and provision of solar powered water pump for the community boreholes. The model village project, though presently constrained by lack of funds, is no doubt a major success that deserves replication in other parts of the drylands of Nigeria.

The Katsina State Agricultural and Community Development Project (KSACDP) was conceived as the first stage of an IFAD strategy to speed up and intensify rural development in the drylands of Nigeria. Its main strategy is community participation and credit supply to farmers in the fight against land degradation and desertification. Achievements recorded included improvement in farming practices, investments in community and amenity development in off-farm income generating activities for groups of poor and landless households, with emphasis on those headed by women.

The Sokoto Environmental Protection Programme covers an area of about 17,500 km^2 in the northeastern part of Sokoto State. The objective of the programme was to improve the utilization of resources to achieve long-term sustainable growth and environmental protection. The Programme is jointly financed by the Federal Government of Nigeria, Sokoto State Government, and the European Union under the Sixth European Development Fund (Lome III). The programme components include Afforestation, Livestock and Rangeland management, and development of rural infrastructures, Irrigation, Women development and Adult literacy. The programme did record some successes, having led to increased income of many households within the 17,500-km^2-project area.

The implementation of the on-going MDG Projects has focused on the rehabilitation of ten oases and provision of water to communities for domestic usage and farming in the affected areas.

The Integrated Ecosystem Management Project is a transboundary project between Nigeria and Niger, which started in August 2006. The overall goal of this 2-phased 8 year project is to restore and enhance the productive and protective functions of the ecosystems in the transboundary areas between Nigeria and Niger. This is to improve the social and economic well being of the rural communities and households utilizing the region's ecosystem resources to meet their livelihood needs, while preserving its unique landscape and globally significant biodiversity. Its objective is to create conditions for sustainable and integrated management of the natural resources in the Komadugu-Yobe, Tagwai-El Fadama, Gada-Goulbi of Maradi and Maggia-Lamido catchments. In its Phase I, the project was implemented in 7 pilot communities in 6 states and represents a pilot experience of sustainable and integrated ecosystems management whose replicability of actions should serve as knowledge sources in the whole area. The achievements of Phase I will be up-scaled if funding is made available for Phase II implementation.

3.2 Progress and achievements in combating desertification and mitigating impacts of drought in Africa

A review of the progress made in combating desertification and mitigating impacts of drought is within the context of measures set out in Agenda 21 of the United Nations Convention to Combat Desertification and the Johannesburg Plan of Implementation (JPOI) of the World Summit on Sustainable Development (WSSD) in the Countries experiencing serious drought and/or desertification, particularly in Africa.

1. Development and implementation of National Action Programmes to combat desertification (NAPs)

African countries with support from development partners are at different stages in developing and implementing their National Action Programmes to combat desertification (NAPs). NAP is developed through highly participatory processes and it is the overall strategies for specific land and drought-related plans and programs, it also serves as an important tool in guiding the implementation, donor coordination and monitoring of efforts in combating desertification and poverty reduction. The NAP processes have contributed significantly to the strengthening of capacity of various stakeholders to deal with drought and desertification.

2. Establishment and operation of National Desertification Funds (NDFs)

Some countries have set up National Desertification Funds (NDFs) as part of the NAP process. The NDFs serve as local and easily accessible sources of funding for implementation of NAP priorities. A case in point is the Kenya Desertification Community Trust Fund, which was launched in June 2004. The Fund has benefited from a significant contribution by the private sector and has assisted in the implementation of priority activities in the country's NAP.

3. *Development and Implementation of Sub-regional Action Programmes (SRAPs) and the Regional Action Programme (RAP) on drought and desertification.*

Sub-regional Action Programmes (SRAP) and the Regional Action Programme (RAP) on drought and desertification complement the NAPs particularly with respect to trans-boundary resources such as lakes, rivers, forests; and crosscutting issues including information collection and dissemination, capacity building and technology transfer.

Five SRAPs have been put in place. The SRAPS were developed and are being implemented under the auspices of sub-regional institutions namely: the Permanent Inter-State Committee on Drought Control in the Sahel (CILSS) and Economic Community of West African States (ECOWAS) for West Africa and Chad sub-region; the Arab Maghreb Union (AMU) for the AMU sub-region; the Southern African Development Community (SADC) for the Southern Africa sub-region; and the Intergovernmental Authority on Development (IGAD) for the Eastern Africa sub-region. Among the projects being implemented within the IGAD SRAP are: the AfDB funded pilot project on water harvesting in the drylands of the IGAD sub-region, the IGAD Pro-poor livestock policy initiative and fertilizer and inputs program. Under the auspices of the Central African Forest Commission (COMIFAC), the SRAP for the Central Africa region has also been prepared. Under the auspices of the Regional Coordination Unit (RCU) hosted by the AfDB, a RAP has being finalized. The RAP is constituted based on six Thematic Programme Networks (TPNs) namely: TPN1 on Integrated management of international river, lake and hydro-geological basins; TPN2 on promotion of agro-forestry and soil conservation; TPN3 on rational use of rangelands and promotion of fodder crops development; TPN4 on ecological monitoring, natural resources mapping, remote sensing and early warning systems; TPN5 on promotion of new and renewable energy sources and technologies; and TPN6 on promotion of sustainable agricultural farming systems. The RCU plays a critical role

including the exchange of information on combating desertification between regional and global level.

4. Comprehensive Africa Agricultural Development Programme (CAADP)/New Partnership for Africa Development (NEPAD)/

Comprehensive Africa Agricultural Development Programme *(CAADP) has* been developed and endorsed by African heads of state and governments as a framework for the restoration of agricultural growth, food security and rural development in Africa. Pertinent to combating drought and desertification is CAADPs pillar 1: "*Extending the area under sustainable land management and reliable water control Systems."* Under this pillar CAADP aims to among others reverse fertility loss and resource degradation, and ensure broad-based and rapid adoption of sustainable land and forestry management practices in the smallholder as well as commercial sectors.

The NEPAD Environment Initiative (EI) which includes combating desertification as an integral and one of its priority program areas has been developed by UNEP under the guidance and leadership of the African Ministerial Conference on Environment (AMCEN). In 2006 UNEP continued to work closely with African sub-regional organizations including CILSS, IGAD, Sahara and Sahel Observatory (OSS), SADC, UMA, and ECOWAS, to finalize sub-regional action plans for the NEPAD Environment Initiative, many of which have been adopted. With support from Norway, UNEP is providing support to Mozambique, Libya, Ethiopia, Ghana and Cameroon to develop their national action plans for the NEPAD EI on a pilot basis. These pilot projects will provide key lessons for further implementation in other countries in Africa.

5. ***The Green Wall for the Sahara Initiative***

A program initiated by the African Union (AU) and developed by the AU Commission (AUC) in collaboration with ECA, FAO, UNEP, UNCCD, and CEN-SAD was launched in December 2006. African Heads of State and Government in their Summit in January 2007 adopted the Decision on the implementation of the initiative. The programme stretches from Mauritania to Djibouti. It is covers a wide group of countries, including: Algeria, Tunisia, Libya, Egypt, Mauritania, Mali, Niger, Chad, Sudan, Eritrea, Ethiopia, Djibouti, Cameroon, Nigeria, Benin, Burkina Faso, Senegal, The Gambia, and Western Sahara and Cape Verde. The goals of the programme are: to slow the advance of the Sahara Desert, enhance environmental sustainability, control land degradation, promote integrated natural

resources management, conserve biological diversity, contribute to poverty reduction, and create jobs.

3. 3 Progress in developing and strengthening systems for monitoring, early warning and adaptation to drought and desertification

Important in the efforts to manage impacts of drought and to tackle desertification are effective systems for understanding, monitoring and forecasting drought and land degradation as well as mechanisms for identifying and prioritizing appropriate responses, and evaluating the impact of the interventions.

1. Desertification and land degradation monitoring and information systems

At the initiative of the Sahara and Sahel Observatory (OSS), the Long-term Ecological Monitoring and Observatory Network have been established. The network covers 12 affected countries in the sub-region. It gathers environmental data for use of decision makers. This initiative has facilitated observatories in 11 countries to operate and gather high quality information on the evolution of natural resources and the effectiveness of management systems. To respond to the need for up-to-date and comparable land degradation information, the Land Degradation Assessment (LADA) project, a global initiative was implemented by UNEP. LADA project has developed and tested effective assessment tools for land degradation in drylands through pilot projects and studies undertaken in selected countries. In Africa a pilot project was carried out in Senegal, Tunisia and South Africa; and case studies were conducted in Kenya. The LADA project is targeted to produce the global land degradation assessment (GLADA) which will allow Parties to the UNCCD to have an overview of the status of land degradation and to identify the areas where targeted investment may be needed to stop and/or reverse land degradation. At the same time, the identification of bright spots will allow countries to exchange methods for ecosystem management that have proved to be effective.

2. Drought monitoring and early warning systems and programs

Drought monitoring and early warning systems and programs are being developed and made operational. These include the following: Regional Climate Outlook Forums are convened annually by the World Meteorological Organization (WMO) in the Greater Horn of Africa, in South Africa and in West Africa, to elaborate and ensure appropriate dissemination of consensual regional outlooks, bulletins and products

about the next rainy season. These outlooks are directed towards the needs of users from agriculture, health, water management and energy, based upon their input and feedback. Climate for Development in Africa (ClimDev Africa) Programme is being developed under the auspices of Global Climate Observing System (GCOS) in collaboration with ECA.

The purpose of this three-phase programme is to guide the effective integration of climate information and services into development planning for Africa and to ensure the mainstreaming of climate considerations in achievement of the sustainable Development Goals. To support drought monitoring, WMO and UNDP have provided support in the establishment of the IGAD Climate Prediction and Applications Centre (ICPAC) in Nairobi as a specialized institution of the Intergovernmental Authority on Development (IGAD). Another centre is established in Harare, Zimbabwe. These centres are charged with timely monitoring of drought intensity, geographical extent, duration and impact on agricultural production, and issuing early warnings. The African Centre of Meteorological Applications for Development (ACMAD) is also in place and provides similar services. The World Hydrological Cycle Observing System (WHYCOS) contributes towards an easily accessible source of hydrological information that provides the basic building blocks for sustainable development through water resources assessment and planning, ecosystem and water quality monitoring, flood forecasting and drought monitoring and prediction. In this regard, WMO is also providing advisory services to the countries in their efforts to reorganize and strengthen the national hydrological services for Volta, Niger and later Senegal Basins. Few early warning systems have been established and Zambia has an Early Warning System that has assisted the country to intervene and take necessary measures where drought has occurred.

3. Drought risk and disaster management

At national, sub-regional and regional level, strategies and programs to enable countries to manage impacts associated with disasters including drought are being established. More than 30 countries have platforms for disaster risk reduction (DRR) as a way of shifting from disaster response to mainstreaming disaster risk and some of these countries are reported to have succeeded in linking DRR to poverty reduction related strategies. In this connection poverty Reduction Strategy Papers (PRSPs) for countries such as Gabon, Madagascar, Malawi, Mozambique, and Niger have incorporated aspects of natural disaster risk management as part of national poverty reduction strategies. Some countries have embarked on emerging innovative market schemes for managing risks associated with drought. Index-based weather insurance schemes are being piloted in Ethiopia and Malawi, which are expected

to demonstrate the viability of insuring extreme risks, such as drought, and enhance access to finance by farmers. Mozambique's policy strategy also encourages people to adopt risk insurance mechanisms and other preventive or mutual assistance instruments, while Namibia's National Drought Policy and Strategy promotes on-farm risk management.

At the sub-regional level, the Inter-Governmental Authority on Development (IGAD) has developed a sub -regional strategy for disaster reduction. The Economic Community of West African States (ECOWAS) in early 2007 approved a sub-regional Common Policy and mechanisms for DRR. The Southern Africa Development Community (SADC) has revised its sub-regional strategy, factoring in DRR and the Economic Community of Central Africa States (ECCAS) has established a sub-regional centre for DRR in the Republic of the Congo and is developing a sub-regional strategy.

Under the auspices of the AUC and NEPAD, the Africa Regional Strategy for Disaster Risk Reduction and program of action for its implementation (2006-2010) have been developed and adopted. The strategy aims to contribute to sustainable development and poverty eradication by facilitating the integration of disaster risk reduction into relevant strategies and programs. As part of this effort the Africa Working Group on Disaster Risk Reduction has been established to support national governments to advance disaster risk reduction and facilitate the mainstreaming and integration of disaster risk reduction into all phases of development in Africa to help achieve NEPAD's objectives.
In addition, the African Drought Risk and Development Network**,** known in its short name as the Drought Forum have been established with the support of the UNDP Drylands Development Centre and the Bureau for Crisis Prevention and Recovery and the UNISDR. The Drought forum is promoting the development of coordinated strategies for enhanced and effective drought management at national level. It is providing a platform that is assisting practitioners to address issues related to drought risk and its implications for development.

4.0 CONCLUSION

Remedies to the problem of drought and desertification involves awareness, protection of marginal lands, planting of indigenous tree and shrub species, sustainable agricultural practices and also needful is to bridge the gap between the formation of policy and strategies of combating drought and desertification so that government efforts to combating desertification can be productive.

5.0 SUMMARY

In this unit the various programmes at national and regional level towards mitigating the impact of drought and desertification were reviewed and some of successes were highlighted.

6.0 TUTOR-MARKED ASSIGNMENT

1. Discuss the phases of national intervention in the control of drought and desertification.
2. Enumerate policies relevant to the control of drought and desertification in Nigeria.
3. Explain the history and goals of Green Wall for Sahara Initiative.

7.0 REFERENCES/FURTHER READING

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