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NATURAL RESOURCES AND SUSTAINABLE DEVELOPMENT

DEM 102

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DEM 102 NATURAL RESOURCES AND SUSTAINABLE DVELOPMENT CR 4

UNIT-1: NATURAL RESOURCES AND SUSTAINABLE MANAGEMENT

UNIT STRUCTURE

1.1 OBJECTIVES

After going through this unit, you will be able to:

- discuss the various types of natural resources available on our earth and their distribution.
- differentiate between different types of natural resources and create awareness among others about the need for the conservation of natural resources.

1.2 INTRODUCTION

Life on earth depends on various natural resources like soil, water, air, energy from the Sun, etc. The earth's natural resources are finite, which means that these resources are limited by the Earth's capability to renew them, and if we use them continuously, we will eventually exhaust them. Natural resources are both living and non-living resources on land as well as in the ocean. Forests, wild life, and biodiversity in terrestrial or aquatic forms are the living resources. The non-living resources include air, water in the rivers or under the ground, soil and mineral deposits. Freshwater, forests and harvested products are renewable while minerals, oil, gas and coal are non-renewable resources. Thus, natural resources do not share the same characteristics- this is what we need to recognize. Distribution and availability of natural resources on earth are

not uniform spatially or in terms of amount, for example, some of these resources are found in abundance, while others are found in limited quantities and that too in some restricted parts of our land or the ocean. These renewable or non- renewable resources are largely exploited locally, regionally or globally in the name of development of growing nations, for international trade or to meet the daily needs of the poor local people. The current rates of exploitation and pressure on the Earth's natural resources will impose negative influence on earth's environment's ability to renew them in nature.

1.3 EARTH'S NATURAL RESOURCES

Natural resources are the resources that occur naturally within environments that exist relatively undisturbed by mankind, in a natural form that people can use. The earth's natural resources are limited in their abundance, which clearly indicate that if they are used endlessly, we will finally exhaust them. A resource can be defined as 'any natural or artificial substance, energy or organism, which is used by human being for its welfare'. Some resources are renewable while some are non-renewable, based on their ability of renewability or potential natural regeneration. Air, water, soil, minerals, coal, petroleum, animals and plants, etc are the natural resources which surround us and they play the basic role in the development and welfare of livelihood and prosperity of the nation. In fact, earth's natural resources bestowed on us are essential to the survival and development of the human population for civilized living. Therefore we have to understand that the earth's natural resources are finite and have to be used wisely and judiciously. However, it is believed that these resources are being used indiscriminately in the name of various developmental purposes of a nation. Over exploitation and unscientific land-use practices put great pressure on resources and cause resource depletion. These pressures to natural resources are largely imposed by the growing human population, modern agricultural practices and expansion of agricultural land, industrialization and urbanization, etc.

1.4 KEY THEMES - CLASSIFICATION OF NATURAL RESOURCES

Natural resources can be classified in various ways based on their origin as biotic and abiotic; stage of development as potential resources and actual resources; and based on availability- exhaustible and inexhaustible, and on the basis of renewability they can be classified as renewable resources and non- renewable resources.

Biotic natural resources are all those resources obtained from the biosphere which are living in nature. Plants and animals existing in the forests and their products, fish and other marine organisms are important examples of biotic natural resources. Fossil fuels like coal and

petroleum are considered under the biotic resources because they are the product of decomposed and fossilized organic matter of plants and animals over geologic periods of time. Abiotic resources comprise all those non-living components of organic and inorganic substances or mixtures of these. For example, soil, land, water, air, and minerals such as silver, gold, copper, nickel, iron, etc.

Any resources which are under reserve and remain in stock until they are actually mined or used up, i.e. kept for future use are referred to as potential resources. Simply we can say that these are those resources which we are not currently used but are kept for future use. While actual resources are those resources that have been surveyed, their quantity and quality determined, and are in current utilization.

Before discussing the renewable and non-renewable resources, let us comprehend the exhaustible resources and inexhaustible resources. Exhaustible resources are those resources that are available in limited quantities and are going to be exhausted as a result of continuous use, e.g. coal and petroleum. While the resources which cannot be exhausted by human consumption and other uses, are called inexhaustible resources**.** These resources are like solar radiation, wind power, hydel power and tidal power, and substances like sand, clay, air, water in oceans, etc.

A non-renewable resource is a natural resource that can't be remade or re-grown at a scale comparable to its consumption. Fossil fuels are considered as non-renewable resource because they can't be replenished within a short period of time. Nuclear energy is also considered as non-renewable resources because once the Uranium is used for energy production, it is gone. Renewable resources are the resources that can be replenished within a short period of time or are able to regenerate on a human time scale, thus maintaining a flow. Examples of renewable resources are forest (biomass), fisheries, water, solar, wind, geothermal, etc. They are often connected in ecological systems which means involved in circular flows of the ecosystem. For example, soil water and air are important for forest, water is important for fisheries. On the other hand, time required for renewal or replenishment differs from one resource to another depending upon the characteristics of the resources and their degree of involvement in the cycle of ecosystem. For instance, forest is a climax state of vegetation form by different strata. Once degraded it will definitely take longer period of time for restoration and regeneration, for renewal of water and soil it may take a few years; while for agricultural crops it may take short period of time for renewal. However, some of the resources are considered both

renewable and nonrenewable depending upon the ability of renewal which is influenced by natural and anthropogenic pressure, for example, forest.

1.5 CONCEPTS AND TOOLS ASSOCIATED WITH NATURAL RESOURCES

Understanding the utilization of natural resources is inbuilt in human beings since time immemorial. Our ancestors are well conscious about the availability and sustainable harvesting of resources from their surrounding, as they have been living in harmony with the environment. With the progress of civilization and introduction of modern scientific tools and techniques the hidden natural resources in different regions across the globe are explored and harvested or exploited for utilization for various purposes of the human development.

Increased human population and increasing level of industrialization and urbanization of the modern human society increase the demand of consumption of natural resources. Increasing human activities in different spheres are harmful to all types of resources. For the construction or buildup of new road connectivity, mountains are blast off destroying the habitat of diverse flora and fauna. Agricultural land and degraded land are turned into residential or commercial centers. Large scale illegal cutting of trees for lumber leads to disappearance of trees and soil is exposed to physical conditions and during rainfall soil is wash away, leaving unfertile condition, unfit for growth and development of vegetation.

So, if the resource is not properly managed and judiciously used, a serious scarcity will result in a very short period of time which will also upset the entire ecological balance.

1.5.1 EXPLORATION OF NATURAL RESOURCES: CONVENTIONAL METHOD

Conventional methods of exploration of natural resources are exclusively based on the knowledge available with the ancient people without any advanced scientific technologies. So, discovery of minerals or fossil fuels are truly accidental in ancient times. Ancient people used the buried or hidden resources of earth when they dug out land for finding water or for construction of houses. However, such stock and utilization were in a very small scale at the household level and could possibly be located only in their nearby surroundings close to the surface of earth. Now, knowledge and intelligence of the modern people are much advanced and they are now able to trace the hidden resources using advanced technologies of exploration. Likewise, conventional method of exploration of natural resources has been developed based on scientific advancement and thus systematic exploration of resources has

been made by digging or drilling up to the potential depth of the earth from harvesting resources.

1.5.2 EXPLORATION OF NATURAL RESOURCES: ADVANCED TECHNIQUES

Remote sensing techniques are one of the advanced techniques employed in various fields of study and exploration. Using the techniques of remote sensing the characteristics of natural resources available in different parts of the earth which are unevenly distributed in terms of size/area, shape and character can be identified without direct contact with them. Further, one could locate various resources with proper determination of their quantity and quality. Certain wavelengths are used for the identification of different types of natural resources, like, water, soil, vegetation cover, minerals deposits, etc. Aerial photos, satellite pictures, radio waves, thermal or infra-red reflection and magnetic measure cuts also provide information about different types of resources.

1.5.3 UTILIZATION OF NATURAL RESOURCES

As human civilization has progressed, man's dependence on natural resources has grown tremendously. In the past, natural resources were considered as a source to support for human life, but now-a-days, it is largely understood as a basic means of all kinds of comforts of life. Today, we are completely dependent on these resources for various social and developmental activities. Since all the developmental activities utilize natural resources in one form or the other, the efficiency of converting the resources into useful products becomes the key parameter for estimating the waste and pollution generated. The Natural Resources are converted into an effective product/service through an appropriate technology. An effective utilization of natural resources to useful product/service thus requires appropriate technology, effective management, and low waste production.

1.5.4 CONSERVATION OF NATURAL RESOURCES

Rising human population had led to increasing demands on natural resources and hence put pressure on their supply to meet the ever increasing needs/demands of various requirements in their daily life. As the demand on resource is increasing day-by-day, exploitation of resources is also rising, leading to severe depletion of the supply of resources gradually. Furthermore, the use of resources releases wastes as a product as contaminants (toxic materials, excess nutrients and greenhouse gas emissions) which pollute air, soil and water. Thus, there is an urgent need to conserve natural resources. By conservation we understand the proper management of a natural resource which not only means to prevent its exploitation, destruction or degradation but also ensure their judicious use so that they do not get exhausted. Thus, conservation of all types of resources particularly, non-renewable natural

resource is inevitable. The best alternative to conserve them is by using renewable resources like solar energy and wind energy. Management of the human use of natural resources to provide the maximum benefit to current generations while maintaining the capacity to meet the needs of the future generations is called conservation of resources. Overall, conservation is the sum total of activities which can derive benefits from natural resources but at the same time, prevent excessive use, leading to destruction or neglect.

1.6 THE PRINCIPLES OF NATURAL RESOURCE MANAGEMENT

1.6.1 SOIL

The upper portion of the earth surface consisting of disintegrated rocks and decaying organic materials is referred to as soil which is a very important constituent of the lithosphere. It is one of the most important and essential natural resources, which is required for production of food, industrial raw materials as well as for generation of energy resources. Most life on earth depends on soil as a direct or indirect source of food. Plants and animals source their nutrients from the soil and it is home to many different forms of life. Soil comes in a variety of forms and takes many years to develop. However, it can be destroyed very easily. Soil is defined as a covering over most of the earth's land surface. It is made of air, water, particles of rock and minerals, living things and the remains of living things as organic material. It takes thousands of years for soil to form just a few inches and for some parts of the country it has been less than that. On a volume basis a good quality soil is one that is 45% minerals (sand, silt, clay), 25% water, 25% air, and 5% organic material, both live and dead. The mineral and organic components are considered a constant with the percentages of water and air the only variable parameters where the increase in one is balanced by the reduction in the other.

Soil erosion is one form of soil degradation along with soil compaction, little organic matter, loss of soil structure, poor internal drainage, salination, and soil acidity problems. Soil erosion is a naturally occurring process on all land. The agents of soil erosion are water and wind, each contributing a significant amount of soil loss. Naturally, background erosion removes soil at roughly the same rate as soil is formed. But 'accelerated' soil erosion by water or wind leads to loss of soil at a much faster rate than it is formed and it is a major concern of soil degradation. Soil erosion by water is caused by rainfall intensity and runoff, soil erodability, slope gradient and length, and type of vegetation cover. While the rate and magnitude of soil erosion by wind is due to erodability of soil, soil surface roughness, climate and vegetation cover. In general, it is always a result of mankind's reckless actions, such as overgrazing or unsuitable cultivation practices, which leave the land unprotected and

vulnerable. Then, during times of erosive rainfall or windstorms, soil may be detached, transported, and deposited somewhere else possibly traveling a long distance. Thus, it has impacts which are both on-site (at the place where the soil is detached) and off-site (wherever the eroded soil ends up).

Along with the land management practices, tillage and cropping practices directly affect the overall soil erosion problem and solutions on an arable farm. A combination of approaches or more extreme measures might be always better when crop rotations or changing tillage practices are not enough to control erosion on a field. In this case, contour plowing, strip cropping, or terracing may be considered as a useful practice for soil conservation.

1.6.2 WATER

Water is a renewable resource, essential for sustaining all forms of life, food production, economic development, and for general well being. Water is an integral part of life on this planet and it is continuously moving around the earth and constantly changing its form. At room temperature, it is an odorless, tasteless substance that covers more than three-fourths (covering about 70 -75 percent) of the planet Earth's surface. In nature, water exists in liquid, solid, and gaseous states and it is essential for all life on Earth. Water obtained from rain and melting of ice is stored in various surface sources and underground aquifers. Human beings use this water for various purposes. Most of the water on Earth, 97% to be exact, are found in seas and oceans that contain dissolved salts and are therefore unfit to drink. Because of the salt we can not drink sea and ocean water or use it for crops. Only about 3% of the Earth's water is fresh. Two percent of the Earth's water (about 66% of all fresh water) is in solid form, found in ice caps and glaciers. Because it is frozen and so far away, the fresh water in ice caps is not available for use by people or plants. That leaves about 1% of all the Earth's water in a form useable to humans and land animals. This fresh water or drinking water is found as groundwater in underground aquifers, and on the surface in ponds, lakes, and rivers. In fact, a small amount of water is found as vapor in the atmosphere. Thus, that 1% of the world's water supply is a precious commodity necessary for our survival.

The continuous movement of water between the earth and the atmosphere is the hydrological cycle. Water is continually moving around, through and above the Earth as water vapor, liquid water, and ice. In fact, water is continually changing its form. The transport of water and the energy exchanged as it is converted from one state to another are important drivers of our weather and climate system. Water regulates the Earth's temperature. It also regulates the temperature of the human body, carries nutrients and oxygen to cells, cushions joints, protects organs and tissues, and removes waste.

Water is important for many things for people, for drinking, cooking, cleaning, irrigating, making electricity, etc. It is important for conserving for fish, trees and plants.

Fresh, clean water is a limited resource (about 1% of all the Earth's water) and it is a key component in determining the quality of our lives. As all the people on Earth rely on such a small percentage of all the water on Earth, it only makes sense that we must preserve and conserve our water. But the uneven distribution of good quality water has made the problem quite serious. Moreover; the problem of water pollution is becoming a threat to many lives across the globe. Water shortages in many parts of the world result from rising demand of good quality of fresh water, unequal distribution, increased contamination and wastage of fresh water due to the unscientific ways of usage and improper conservation methods. The causes of water contamination are numerous, arising from wide range of various factors -- from various factories and industries effluents discharges, our diverse living life style, agricultural runoff, and local drainage condition to improper use of household chemicals. But, it not always proper to lay the blame only on big factories and industries up stream since a large number of contaminants also arise from improper disposal of our household chemicals like, lawn chemicals, prescription drugs, gasoline, cleaning products, etc. Considering all the factors, water conservation is a big thing to be done by each and every one of us. We all must make changes in our lifestyles that will change to improve the course of our water and its quality. Water conservation needs to be a way of life, not just something we think about once in a while. Since we all enjoy the benefits of having pure, clean water, we must help conserve water so that we may continue to enjoy these benefits. We must not pollute our water because it is the only water we will ever have. Some people do not realize the importance of water, and they are continually polluting it. We must learn to save water now so that it will be available to us in the future. Saving water helps to preserve our environment. Water conservation can be made possible to a certain extent through watershed management, rain harvesting programmes, appropriate land-use practices and careful disposal of industrial, domestic, and agricultural wastes.

1.6.3 VEGETATION/FORESTS

Vegetation means any plants or trees that grow on their own ‘naturally’ without any form of human intervention. Natural vegetation includes both native and introduced species. It also refers to the ground covered by plants of different shape, size and forms. When it evolves according to the environmental conditions of a region it is known as natural vegetation. On the other hand, when we talk about the forest, it is a big area of vegetation which is covered by trees with other associated plants and animals. It is a complex ecosystem of trees that

buffer the earth and support a myriad of life forms. Factors that influence natural vegetation/forest are: topography, latitude or altitude, soil, amount of rainfall, temperature, biotic factors, etc. Some of the important criteria used in the classification of vegetation are: physiognomy, structure, function, component, dynamic (success ional phenomenon) and habitat relations and history. Forests are classified according to their nature and species composition, the type of atmospheric conditions in which they thrive, and their relationship with the surrounding environment in terms of soil, water, air and biotic components.

A number of ecological factors dictate the type of forest in a particular country. In our country the most detailed classification of Indian forests is given by Champion and Seth (1967) in which 16 major types of forests (Table1) have been identified.

Table 1. Major forest types of India

Sl. No.	**Forest Type**	**Area in Sq. Km**	**State-wise occurrence**
1	Tropical Wet Evergreen Forest	51249	Arunachal Pradesh, Assam, Karnataka, Kerala, Manipur, Nagaland, Tamil Nadu, Andaman and Nicobar Islands and Goa
2	Tropical Semi-Evergreen Forest	26424	Assam, Gujarat, Karnataka, Kerala, Maharashtra, Nagaland, Orissa, Tamil Nadu, Andaman and Nicobar Islands and Goa
3	Tropical Moist Deciduous Forest	236794	Andhra Pradesh, Assam, Bihar, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Tripura, Nagaland, Orissa, Tamil Nadu, Uttar Pradesh, West Bengal, Andaman and Nicobar Islands, Goa, and Dadar and Nagar Haveli
4	Littoral Swamp Forest	4046	Andhra Pradesh, Bihar, Gujarat, Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Jammu & Kashmir, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal and Kerala.
5	Tropical Dry Deciduous Forest	186620	Andhra Pradesh, Bihar, Gujarat, Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Jammu & Kashmir, Orissa, Punjab,

			Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal and Kerala
6	Tropical Thorn Forest	16491	Andhra Pradesh, Gujarat, Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh
7	Tropical Dry Evergreen Forest	1404	Andhra Pradesh and Tamil Nadu
8	Sub-Tropical Board-Leaved Hill Forest	2781	Assam, Maharashtra, Meghalaya and West Bengal
9	Sub-Tropical Pine Forest	42377	Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Manipur, Meghalaya, Nagaland, Sikkim and Uttar Pradesh
10	Su-Tropical Dry Evergreen Forest	12538	Himachal Pradesh, Jammu & Kashmir and Mizoram
11	Montane Wet Temperate Forest	23365	Arunachal Pradesh, Karnataka, Manipur, Nagaland, Sikkim and Tamil Nadu
12	Himalayan Moist Temperate Forest	22012	Himachal Pradesh. Jammu & Kashmir and Uttar Pradesh
13	Himalaya Dry Temperate Forest	312	Jammu & Kashmir, and Himachal Pradesh
14	Sub-Alpine Forest	18628	Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Nagaland, Sikkim and Himachal Pradesh
15	Sub-Alpine Forest		Jammu & Kashmir, Uttar Pradesh and Sikkim
16	Dry Alpine Scrub		Jammu & Kashmir

These 16 major types are further grouped into 5 major categories viz. moist tropical, dry tropical, montane sub-tropical, temperate and alpine forests.

1. MOIST TROPICAL FORESTS: These forests are largely found in the areas of quite high temperature and in very wet regions receiving 100-250 cm average annual rainfall more or less evenly distributed throughout the year. The forests are dense, multi-layered with

closed canopy and continuous, allowing little light penetration and have many types of trees, shrubs, lianas, epiphytes and ground vegetation. It is characterized by the greatest diversity of species. Based on the species composition, and environmental characteristics these forests are further classified into 4 types namely, Tropical moist evergreen forests, Tropical moist semi-evergreen forests, Tropical moist deciduous forests and Littoral and swamp forests.

2. DRY TROPICAL FORESTS: These forests are found in the areas where wet season is followed by a relatively long period of dryness during which trees remain leafless showing deciduous characteristic of forests. These forests are dominated by smaller trees and shrubs and have abundance of shrubs or sometimes grasses. The canopy of the trees does not normally exceed 25 m. There are three types of forests under this category i.e. Tropical dry deciduous forests, Tropical thorn forests and Tropical dry evergreen forests**.**

3. MONTANE SUBTROPICAL FORESTS: These types of forests are found in between the areas where climate is cooler than tropical but warmer than temperate areas i.e. on the hills between the altitudes of 1000 m and 2000 m. Plants are adapted to low temperature and high radiation levels. Dominant plants are semi-xerophytic evergreen ones. Sub-tropical broad-leaved hill forests, Sub-tropical dry evergreen forests and Sub-tropical pine forests are the three types of forests of this category.

4. TEMPERATE FORESTS: These forests are found in lower latitudes having quite low temperature along with comparatively high humidity due to sufficient rainfall than the comparable areas of higher latitudes. The forests occur mainly in the Himalayas at altitudes 2000-4000 m. The forests are generally dominated by moderately dense canopy of tall conifers or angiospermic evergreen trees and allow light to penetrate, resulting in well-developed and richly diversified understory vegetation, epiphytic mosses, lichens and ferns and stratification of animals. The category includes three types of forests i.e. Wet temperate forests, Himalayan moist temperate forests and Himalayan dry temperate forests.

5. **ALPINE FORESTS:** Plants growing at the altitude of 2900 to 6000 m are called alpine plants. These forests are found in the regions of the Himalayas having extremely low temperature and humidity. The forests are dominated by perennial and annual herbs and grasses though some trees may also be present in areas of relatively high humidity. Abundant lichen flora is characteristic feature of these forests. This category includes three types of forests namely, Sub-alpine forests, Moist alpine scrub forests and Dry alpine forests.

Today, people depend on the forest for multipurpose uses to fulfill their needs at domestic and national and international levels. Forest products like paper, timber, firewood, medicine, and fodder also serve as the raw material for various forest based industries and rural needs. However, forests are becoming major casualties of civilization and development. Increased human population over the past several decades has led to deforestation, pollution, and industrial usage problems. The demand for firewood and the increasing population is affecting the existing forests. Rapid development and progress saw large forest tracts fragmented by roads, canals, and townships. Keeping in view of the importance of forest in our life and understanding the effects of deforestation, people across the globe have taken up certain measures to conserve forest legally or non-legally based on their traditional beliefs. Certain laws have been made to prevent unnecessary felling of trees and some of the forests have been declared as protected areas in the form of Reserved forests or Wildlife sanctuary.

1.6.4 ENERGY

Energy is an inevitable resource for existence. . It has an important position in our day-to-day life. Its consumption is linked to the comfort and convenience of our lives but not really to the standard of living. It is an indispensable component in economic as well as technological development. Coal, petroleum, natural gas, solar energy and electricity from wind, etc. are some of the sources of energy. It is estimated that 86% of the world's commercial energy comes from the burning of the fossil fuel i.e. petroleum, natural gas, and coal, with about 40% coming from petroleum. Contrary to this, in some poorer countries biomass supplies more than 90% of their energy requirements for heating and cooking, which on the other hand is also a serious threat to forest destruction. Some of the renewable resources like solar, wind, geothermal and hydroelectricity make up to about 9% of the commercial consumption. Nuclear power provides about 7% of commercial energy worldwide. Energy in various sources is used in industry, transportation, commercial and for residential needs. Utilization of any of the energy resources has some impact on the environment. The environmental damage caused by mining, shipping, processing, and using fossil fuels may necessitate reduction in the use of energy resources. Coal combustion is the major source of acid precipitation and accumulation of CO_2 in the atmosphere which has the potential to trap heat radiated from the surface of the earth and let the earth's temperature rise to a devastating level like global warming. Several accidents have convinced many people of the risk of nuclear power. Thus concern about of accidents or terrorist attacks in nuclear power plant is a great fear in order to avoid the release of hazardous radioactive materials into the environment. Another worry is the disposal of the radioactive wastes of the nuclear fuel cycle. And it is difficult to know how

long it will be safe after safety disposal. With the increased concern about the dangers and costs associated with conventional energy (fossil fuels and nuclear energy) sustainable energy sources of non-conventional sources should be reexamined as a part of sustainable future source of energy for the humankind.

There are two main categories of energy sources: Conventional Sources of Energy, which are easily available and have been in use for a long time, since ancient times.

Another one is Non-Conventional Sources of Energy, that are other than the usual, or that are different from those in common practices. Various types of energy resource are presented in table 2.

Table2. Various types of energy sources

Sources of Energy		
Conventional Energy		**Non-Conventional Energy**
Conventional Nonrenewable Energy (Mostly fossil fuels found under the Ground) Examples: Coal, Oil, Natural gas etc.	**Conventional Renewable Energy** (Mostly non-fossil fuels seen above the Ground) Examples: Firewood, Cattle Dung, Farm Vegetable Wastes, Wood charcoal, etc	Solar Energy Hydel Energy Wind Energy Nuclear Energy Hydrogen Energy Geothermal Energy Biogas Tidal Energy Bio-fuel

1.6.5 MINERAL

As one of the most important resources, minerals have a decisive influence on the economic development of a country. They are seen in solid, liquid and gaseous forms. Minerals exist everywhere in small amounts but to find them concentrated in economically recoverable levels is a challenging task. Minerals can be classified into metallic and non-metallic minerals and are not evenly distributed across the globe. Most economic minerals are metal ores, minerals with usually high concentrations of metals. Non-metallic resources include graphite, feldspar, quartz crystals, diamonds and other crystals which also include sand, gravel, salts, limestone and soils. Indian is rich in mineral resources. The main natural metallic minerals of India are Iron ore, manganese, pyrite, nickel, gold, silver, copper, lead, bauxite, etc. Sand stone, nitrate, potash, dolomite, mica, gypsum, coal and petroleum are the non- metallic minerals found in India. Fossil fuels such as coal, petroleum and natural gas are the product of fossilized remains of dead plants and animals that have been exposed to the heat and pressure

deep within the earth's crust. Iron ore is depicted as the backbone of human civilization and it acts as the major raw material for the iron and steel industry for the national development. On the other hand, major portion of the energy in India (67% of the energy requirement) is generated from coal. Coal comes in a variety of forms with varying chemical composition, harness, and energy content. Anthracite is the highest quality coal having hard and black in colour with 80% carbon content.

1.7 CONCLUSION

Natural resources should not be diminished and they should be preserved, so that future generation can have lifestyle at least as healthy and happy as ours or perhaps better. Sustainable future depends on how we use and conserve our resources and our environment. Sustainable land management can be defined as the use of land resources, including soil, water, animals and plants for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of the resources and the maintenance of their environmental functions. Development of very efficient energy conservation measure is the wise tool to conserve natural resources. In fact, the earth's natural resources are limited with uneven distribution across the globe in terms of quantity and quality. Therefore, management of natural resources is very important. Conservation is the sum totals of activities, which can derive benefits from natural resources but can, at the same time, prevent excessive use leading to destruction or degradation. Natural resource management refers to the management of natural resources with a particular focus on how management affects the quality of life for both present and future generations. It mainly focuses on systematic and scientific understanding of resources in relation to the ecology and the life-supporting capacity of the resources. In this regard, the government should implement certain policies through which responsibilities of conservation and management may be given to all the individuals so that our economy and welfare of livelihood become healthier and future generations can avail of the benefits from the earth's natural resources. Lastly, we all know conservation offers many benefits to all human beings and our environment and it entirely lies in out hand. So, let us use less of the natural resources. This is the best way to avoid shortage and to get relief from various health problems and environmental related pollutions.

1.8 SUGGESTED READINGS

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3. Rai, G. D. 1997. *Non-conventional Energy Sources*. Khanna Publishers, New Delhi.

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1.9 PROBABLE QUESTIONS

Q1. What are natural resources?

Q2. How do people use natural resources?

Q3. Could we survive without natural resources?

Q4. Which resource do you think is the most important? Why?

Q5. Define conservation.

Q6. Why should we conserve the natural resources?

Q7. What do you understand by renewable and non-renewable resources?

Q8. Coal is a non-renewable source of energy whereas wood charcoal is renewable. Why?

Q9. What are the methods used for resource exploration?

DEM 102 NATURAL RESOURCES AND SUSTAINABLE DVELOPMENT CR 4

UNIT-2: SUSTAINABLE DEVELOPMENT

UNIT STRUCTURE

2.1OBJECTIVES

Securing economic development, social equity and justice and environmental protection is the goal of sustainable development. After going through this unit, you will be able to:

- illustrate a clear picture of the concept in a holistic manner.
- build a strong knowledge base on evolution, principles, and strategies for achieving the goals of sustainable development.
- provide information on some resistances and alternatives of the concept.

2.2 INTRODUCTION

The evolution of the concept and its main principles

The concept of sustainable development emerged as an important theme in 1987. The Brundtland Commission on Environment and Development in its report Our Common Future called for application of sustainability as a criterion for all development initiatives. **"In order for development to be sustainable, it must meet the needs of the present generation**

without compromising the ability of the future generations to meet their own needs" said the commission.

This definition is highly generalized and hence has been subjected to a variety of interpretations. Broadly speaking, developed countries lay emphasis on economic and technological aspects. How to integrate environmental costs into economic decision-making while protecting and enhancing their industrial competitiveness and employment opportunities? The general feeling is that the current development/growth processes can continue provided the technological innovations are rapid and appropriate enough to reduce environmental side effects. In contrast, the perspectives of developing countries are understandably different. In their view, poverty is the greatest polluter of environment and hence, they must accelerate economic growth to meet the basic needs of the people. And, if the industrialized rich countries are really serious about the environment, they should realise that it is they who have created the present environment crisis, not the poor countries, and hence they should assist the latter with finance and latest environment friendly technological knowhow to promote economic growth.

Interestingly, both sides have a firm faith in economics and all that goes with it, such as industrialization, urbanisation and environmental deterioration. Both pin their hopes on science and technology to solve the emerging problems. It is simply the question of access to resources, particularly finances and technology. One wants to maintain the status quo, i.e., its economic and technological superiority and competitiveness; the other wants to change the existing world order to make it more egalitarian. The means for achieving the goals are the same.

The United Nations 2005 World Summit Outcome Document refers to the "interdependent and mutually reinforcing pillars" of sustainable development as economic development, social development, and environmental protection. Based on the triple bottom line, numerous sustainability standards and certification systems have been established in recent years, in particular in the food industry.

A useful articulation of the values and principles of sustainability can be found in the Earth Charter. It offers an integrated vision and definition of strong sustainability. The document, an ethical framework for a sustainable world, was developed over several years after the Rio Earth Summit in 1992 and launched officially in 2000. The Charter derives its legitimacy from the participatory process in which it was drafted, which included contributions from hundreds of organizations and thousands of individuals, and from its use since 2000 by

thousands of organizations and individuals that have been using the Earth Charter as an educational instrument and a policy tool.

[Source: R.P. Misra. Sustainable development: The ecological perspective In: Book on Sustainable Development: Issues and case studies (1994).]

2.3 DEFINING SUSTAINABILITY

In view of these divergent approaches, it is almost impossible to define sustainable development more sustainably done by the Brundtland Report. Each country and each region assigns different weights to different approaches to achieve a sustainable future. Each definition is interest-oriented and genuine efforts to look at the issue from the point of view of human survival and development have remained confined to a limited number of scholars and thinkers.

Sustainable development cannot be a static concept and hence, cannot be defined once for all. It is a dynamic process and will be applied by different countries in tune with their own cultural, political and economic perspectives. But unless there is a broad agreement on goals, directions and means, the concepts will prove sterile and the business of development will continue as usual with more tensions among the national states and regions and localities within the nation state.

An attempt is, therefore, being made here to offer a broad outline of what constitutes sustainable development or how sustainable development differs from development. In general, (i) it cannot be achieved in the short run; (ii) it is based on equity and justice; (iii) its approach is balanced and integrative; (iv) it has common goals but different routes; (v) it accepts nature not only for as a resource for development but also earthly womb for survival and development of humankind; and (vi) it is participatory in nature. Sustainable development has to be a long term process and one may say a continuing process. The economic, political, technological and social structure and super structure built during the last few centuries the world over, particularly in industrialized countries of the world, cannot be dismantled in a day. No structure is, however, permanent. Elemental and partial changes do take place as a part renewable process. This renewable process can be accelerated within the tolerable birth pangs and death agonies that mark any such change. The renewable process must aim to achieve the characteristics of sustainable development listed above.

Equity and justice are the sin qua non of sustainable development. It is four dimensions: (1) Equity among nations-rich nations, poor nations, developing nations;

(2) Equity within countries-between regions, social classes, genders, sectors of activities;

(3) Equity between generations;

(4) Equity between economics and ecology and science and spirituality.

The first two equities, although obvious, yet need some explanation. Let it not be construed to mean that pollution, for example, should be equally distributed. Equity is not equality; nor does it have any negative connotations. Equity promotes variety, not disparity. It is positive in the sense that it does call for a fair distribution of harmful things. Moreover, it is directly linked with ability and capacity to bear the burden. This means that rich countries, rich regions, rich groups and the favoured sex will have to take greater responsibility for sustainability.

Equity between generations invariably raises contentious issues like: Why should the present generation bother about the future? How we can be sure that future generation would not be better off in terms of scientific knowledge and technological knowhow to resolve their problems? Presuming that the dependence of the future generations on the nature will not be less than our own, humanity demands that we should not defer costs of present development to our children. Is there any doubt that the future generations too would need fertile soil, scenic beauty, clean air, potable water, virgin forests, energy and wildlife?

Lastly we must try to bring about equity between our economic and ecological interests. The last few centauries have seen economic goals being pursued is unmindful of what is going to happen to the Earth which sustains life. We are witnessing and experiencing the consequences of this approach. Similarly, science and bounded rationality have guided our thoughts and actions. Today, its social and environmental consequences are obvious to us. Economics and science have great potentials for human welfare. In fact, they have taken humanity to a point of achievement beyond imagination. But, their side effects on man and environment are proving unbearable. What we need now is the integration of economics and ecology, and science and spirituality to cure the developmental disease inflicting humanity and also to carry man safely to the new heights of glory.

Stop and read

In the context of sustainability, the term equity has to do with fairness - whether all people have similar rights and opportunities, basic needs to maintain an acceptable quality of life. **Equity,** in this context, refers to the idea that all people throughout a community, whether a village, town, city, country or the entire world, have these same basic needs that must be taken into consideration. This concept is often referred to as intra-generational equity, meaning equity among the present population.

Equity is not just relevant to all people alive today. Inter-generational equity is concerned with fairness between current and future generations. This means striking a reasonable balance between satisfying our needs now and setting aside enough to provide for needs of our children and grandchildren in the future.

[Source: R.P. Misra. Sustainable development: The ecological perspective In: Book on Sustainable Development: Issues and case studies (1997).]

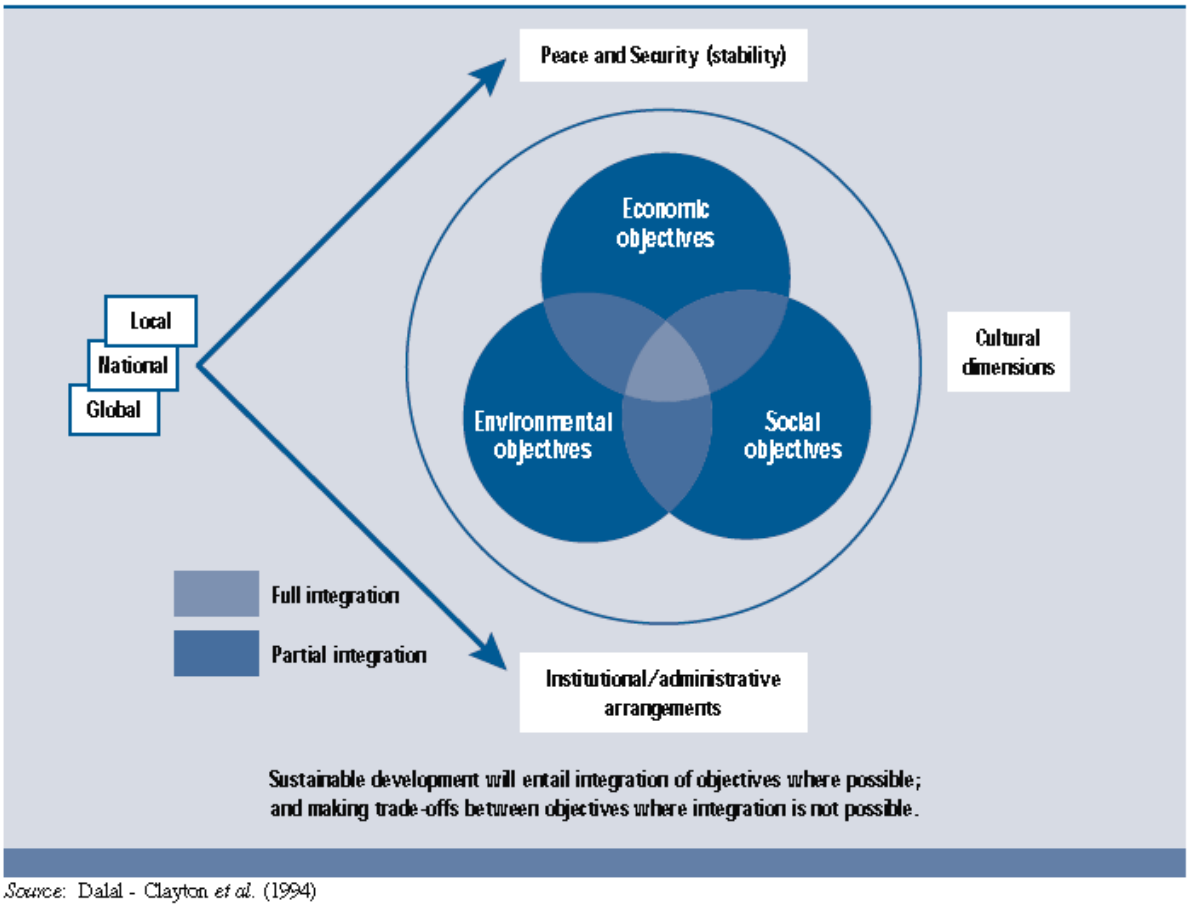
2.3.1 INTEGRATING AND MAKING TRADE-OFFS BETWEEN ECONOMIC, SOCIAL AND ENVIRONMENTAL OBJECTIVES

Sustainable development is not just about the environment. It entails balancing the economic, social and environmental objectives of society — the three dimensions of sustainable development — integrating them wherever possible, through mutually supportive policies and practices, and making trade-offs where it is not possible (Figure 1). This includes, in particular, taking into account the impact of present decisions on the options of future generations. The pursuit of sustainable development thus requires policy changes in many sectors and ensuring coherence between them. However, sustainable development has often been interpreted narrowly as an environmental issue without implications for more than a small group of society. In many countries, the responsibility for sustainable development issues has been given to environmental ministries and departments — often amongst the weakest and least influential in government. This has hindered the necessary process of cross-sectoral policy integration.

2.3.2 DEVELOPING APPROACHES WHICH REFLECT EACH COUNTRY'S UNIQUE CIRCUMSTANCES

The relative priority given to the three dimensions of sustainable development varies in individual countries, societies, cultures and situations, and over time. Thus, while sustainable development is a universal challenge, practical responses can only be defined nationally and locally. Approaches to sustainable development reflect the diversity of the social, economic and environmental challenges faced by developing countries. This is why there are many interpretations of sustainable development, deriving from different values and interests in different societies. For example, in Thailand, sustainable development is defined as holistic development which involves six dimensions: economic, social, environment, politics, technology and knowledge, and mental and spiritual balance. In Bolivia, there is a particular emphasis on political dimensions (e.g. good governance and participation) and on the cultural and spiritual identity of diverse indigenous peoples.

Figure 1: The Dimensions of Sustainable Development



Source: Dalal - Clayton *et al.* (1994)

Source: The DAC Guidelines by OECD (2001).

2.4 GOALS OF SUSTAINABLE DEVELOPMENT

All regions have a common goal, i.e., realization of the self. They follow different paths to arrive at this common point. If all of them had employed right means, world would have been happier today.

Sustainable development too has a fixed set of goals. Approaches and means to achieve them can differ. These goals are: (1) Basic needs of all human beings, food, clothing, shelter, education, health, security, and self esteem must be met adequately. Priority must go to these needs. Level of these needs will be determined by natural and technological resources available and global socio-economic context;

(2) Development processes should be so articulated that ecological balance and environmental purity is least disturbed, if at all;

(3) All nations and people must join hands to support each other and work with each other to create a world in which the above two goals are optimized. Each country should find ways and means to promote this interdependence.

Sustainable development demands a change in our attitude towards nature. Nature is not just a material resource for human consumption. Man is also a part of nature. What will happen if a baby in the mother's womb gets the power to break open the womb and come out prior the time of maturity. Both the mother and the baby will be in trouble. The idea is not to go back to the past, but to create a new future of the present as it is. The past can help in shaping the new future.

And finally, sustainable development is not the business of the government and private companies alone. It is a process which has to be initiated at each level of human endeavour and life. It involves individuals, families, communities, corporate bodies, nations and global society. It has to be a movement, because it involves paradigmatic change which is difficult to bring about unless great many people get involved. Democratisation of decision-making and decentralisation of power and authority is therefore, a must.

[Source: R.P. Misra. Sustainable development: The ecological perspective In: Book on Sustainable Development: Issues and case studies (1997)]

2.5 COMPONENTS OF SUSTAINABLE DEVELOPMENT

- ***Environmental sustainability***

Environmental sustainability is the process of making sure that the current processes of interaction with the environment are pursued with the idea of keeping the environment as pristine as naturally possible, based on ideal-seeking behavior.

An "unsustainable situation" occurs when natural capital (the sum total of nature's resources) is used up faster than it can be replenished. Sustainability requires that human activity only uses nature's resources at a rate at which they can be replenished naturally. Inherently the concept of sustainable development is intertwined with the concept of carrying capacity. Theoretically, the long-term result of environmental degradation is the inability to sustain human life. Such degradation on a global scale could imply extinction for humanity.

Consumption of renewable resources	State of environment	Sustainability
More than nature's ability to replenish	Environmental degradation	Not sustainable
Equal to nature's ability to replenish	Environmental equilibrium	Steady state economy
Less than nature's ability to replenish	Environmental renewal	Environmentally sustainable

Source: The DAC Guidelines by OECD (2001).

- **Sustainable agriculture**

Sustainable agriculture is a balanced management system of renewable resources including soil, wildlife, forests, crops, fish, livestock, plant genetic resources and ecosystems without degradation for providing food, livelihood for current and future generations, maintaining or improving productivity and ecosystem services of these resources. Sustainable agriculture system has to be economically viable both in the short and long term perspectives. Natural resources not only provide food, fibre, fuel and fodder but also perform ecosystem services such as detoxification of noxious chemicals within the soil, purification of water, favourable weather and regulation of hydrological processes within watersheds. Sustainable agriculture has to prevent land degradation and soil erosion. It has to replenish nutrients and control weeds, pests and diseases through biological and cultural methods.

Sustainable agriculture is also known as ecofarming or organic farming or natural farming or permaculture. It is known as ecofarming as ecological balance is given importance. It is also called organic farming as organic matter is the main source for nutrient management. But some scientists consider that it is a misconception to think that sustainable agriculture is farming without chemical inputs. It is considered by some as integrated, low input and highly productive farming system.

Difference between Modern and Sustainable Agriculture

Sustainable agriculture substantially differs from modern day chemical based agriculture. The differences are summarised in the following table. The main differences between the two are that in modern agriculture, synthetic fertilisers containing N P K are used to enrich the soil and chemical pesticides are used to control pests whereas in sustainable agriculture farm yard manure, compost, green manure and bio-fertilisers are used. Sustainable agriculture also involves agro forestry and multi-level cultivation and integrated animal husbandry. Crop production and animal husbandry have to be employed as an integral system for sustainable agriculture to succeed.

Differences between sustainable and modern agriculture

Particulars	Sustainable agriculture	Modern agriculture
Plant nutrients	Farmyard manure, compost, green manures, biofertilizer and crop rotations are used	Chemical fertilisers are used
Pest control	Culture methods, crop rotation and biological	Toxic chemicals are used.

	methods are used.	
Inputs	Highly diversity, renewable and biodegradable inputs are used	High productivity and low chemicals are used.
Ecology	Stable ecology	Fragile ecology
Use of resources	The rate of extraction from forests,fisheries, underground water resources and other renewable resources do not exceed the rate of regeneration	The rate of extraction exceeds the rate of regeneration. Felling of trees,deforestation, overgrazing and pollution of water bodies takes place.
Quality of food materials	Food materials are safe	Food materials contain toxic residues.

Problems of Modern Agriculture: The Earth's climate has been considered till recently as a remarkably stable, self-correcting machine, taking care of all human misadventures and assaults on fragile biosphere. But, it is clear that nature cannot be taken for granted. Modern technology of both industry and agriculture as well as other developmental activities of modern society are highly exploitative in nature, enhancing pollution and causing enormous damage to the environment. Emission of smoke and gases from industry and automobiles etc., is increasing carbon dioxide content of the atmosphere. Effluents of the industry and mining are contaminating water bodies and are degrading the land. High dose of nitrogenous fertilisers are polluting water bodies with high levels of nitrates. Pesticide residues in the soil contaminate water bodies. The developmental activities including agricultural hasten the degradation of land, loss of arable land, desertification and reduction of genetic diversity. Halting pollution of air and water is a great challenge which is intimately connected with the health of the population and ecosystem. Inland water bodies and coastal areas have so far been treated as dumping grounds for wastes thus affecting aquatic and marine life.

[Source: T.Y. Reddy and G.H.S. Reddi (1995). Principles of Agronomy, Kalyani Pub.]

Elements of sustainable agriculture

- **Agroforestry**: According to the World Agroforestry Centre, Agroforestry is a collective name for land use systems and practices in which woody perennials are deliberately integrated with crops and/or animals on the same land management unit. The integration can be either in a spatial mixture or in a temporal sequence. There are

normally both ecological and economic interactions between woody and non-woody components in agroforestry.

- **Mixed Farming**: Many farmers in tropical & temperate countries survive by managing a mix of different crops or animals. The best known form of mixing occurs probably where crop residues are used to feed the animals and the excreta from animals are used as nutrients for the crop. Other forms of mixing takes place where graving under fruit trees keeps the grass short or where manure from pigs is used to feed the fish. Mixed farming exists in many forms depending on external and internal factors. External factors are: Weather Patterns, Market Prices, Political Stability and Technological Development. Internal factors relate to Local Soil Characteristics, Composition of family and Farmer's Ingenuity. Mixed Farming provides farmers with a) an opportunity to diversify risk from single-crop production; (b) to use labour more efficiently; (c) to have a source of cash for purchasing farm inputs; (d) to add value to crop or crop by-product; (e) combining crops and livestock.

- **Multiple Cropping**: The process of growing two or more crops on the same piece of land in one calendar year is called Multiple Cropping. It can be rightly called a form of polyculture. It can be – (a) Intercropping (growing two more crops simultaneously on the same piece of land with a definite row pattern); (b) Relay Cropping (refer to planting of the succeeding crop before harvesting the preceding crop).

- **Crop Rotation**: The process of growing two or more dissimilar or unrelated crops in the same piece of land in different seasons is known as Crop Rotation. This process could be adopted as it comes with a series of benefits like – (a) avoid the build up of pests that often occurs when one species is continuously cropped; (b) the traditional element of crop rotation is the replenishment of nitrogen through the use of green manure in sequence with cereals and other crops; (c) Crop rotation can also improve soil structure and fertility by alternating deep-rooted and shallow-rooted plants.

[Source: Wikipedia and T.Y. Reddy and G.H.S. Reddi (1995). Principles of Agronomy, Kalyani Pub.]

- **Economic sustainability**

The concept of economic sustainability differs from the other perspectives in that lower priority is given to ecosystem functions and resource depletion. A useful three-level

perspective on sustainability is given by economists Pearce & Warford (1993) and adapted by O'Riordan (1995).

a. Weak sustainability: overall stock of capital assets (natural, human and man-made) remains constant; sustainability seeks the substitution of one form of capital for another.

b. Moderate sustainability: constant stock cannot be maintained because of constraints imposed by assimilative capacity; the critical natural capital has to be protected from irreversible decline or catastrophe.

c. Strong sustainability: guards the primacy of ecosystem functioning in the most cost effective and natural way; nature is protected for a balance of utilitarian, precautionary and ethical reasons. Indicators used: value of existence, aversion to uncertainty, tolerance to depletion and environmental wellbeing. A premium is placed on peace of mind in knowing that one lives in a sustainable world.

These economic perspectives of sustainability have gained primacy by virtue of institutions that promote them and the importance ascribed to economic considerations in investment decisions. The prevailing trends of actions towards sustainability have included, for example, "polluter –pays" principles, where those who cause the pollution bear the costs of rectifying the damage. On a larger scale, international environmental accords now adopt the cause of compensatory balancing payments for greenhouse gas emissions and "carbon taxes".

Monetary valuation of environmental goods and services towards a goal of sustainability thus assists the making of choices. The wisdom and rationality of these choices depend on the way the valuations are carried out, and there is much cause for scepticism over the underlying assumptions used by environmental economists and the actual values so derived (Bartelmus 1994).

[Sources:

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2.6 STRATEGIES FOR PROMOTING SUSTAINABLE DEVELOPMENT

To meet the challenges of sustainable development outlined in the previous section, strategic planning practices need to become more effective, efficient, credible and

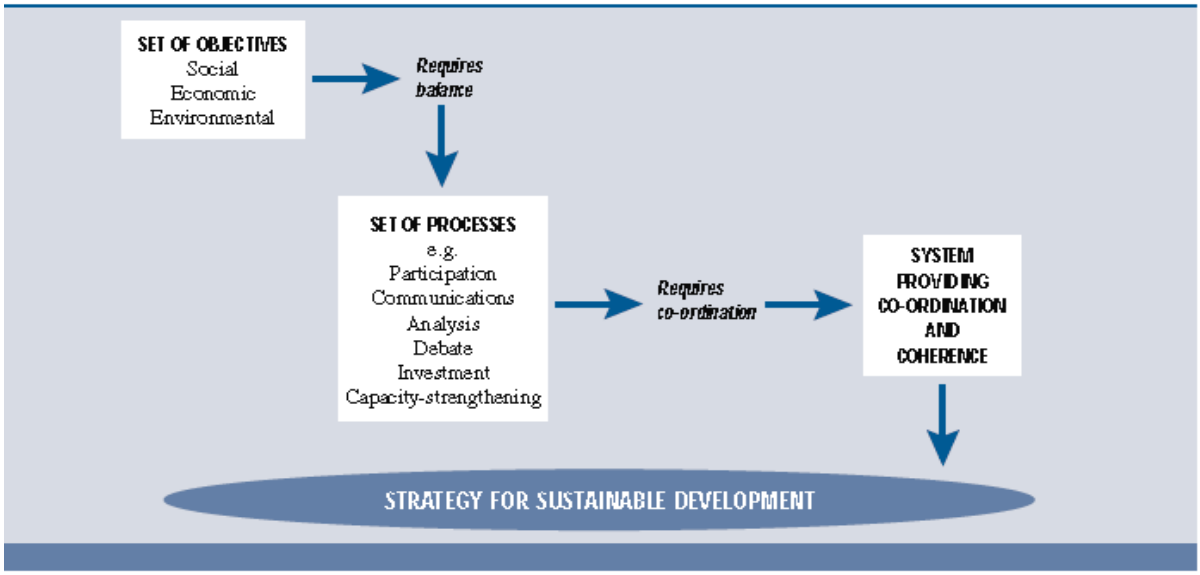
lasting. A standardised or blueprint approach is to be avoided, being at best irrelevant and at worst counter-productive. Instead, there is a need to restructure existing processes, institutional arrangements and procedures according to individual countries' own needs, priorities and resources. Therefore, a strategy for sustainable development should comprise:

A co-ordinated set of participatory and continuously improving processes of analysis, debate, capacity-strengthening, planning and investment, which seeks the integration of the short and long term economic, social and environmental objectives of society – through mutually supportive approaches wherever possible –and manages trade-offs where this is not possible.

Sustainable development strategies require systematic approaches (illustrated in figure 2) and iterative processes of learning by doing. They do not have discrete beginnings or ends. They will rarely imply initiating completely new or stand-alone strategic planning projects.

A variety of established strategic planning processes can be used as starting point for a strategy for sustainable development. Their label does not matter. What is important is adhering to basic strategic planning principles and having in place, a co-ordinated set of mechanisms and processes to ensure their implementation. A key objective is to improve convergence between existing strategies, avoid duplication, confusion and straining developing country capacity and resources.

Figure 2: Rationale for a systematic approach to strategies for sustainable development



2.6.1 PRINCIPLES FOR STRATEGIES FOR SUSTAINABLE DEVELOPMENT

These are principles towards which strategies should aspire. They are all important and no order of priority is implied. They do not represent a checklist of criteria to be met but encompass a set of desirable processes and outcomes which also allow for local differences.

- **People-centred**

An effective strategy requires a people-centred approach, ensuring long-term beneficial impacts on disadvantaged and marginalized groups, such as the poor.

- **Consensus on long-term vision**

Strategic planning frameworks are more likely to be successful when they are based on a long-term vision with a clear timeframe upon which stakeholders agree. At the same time, they need to include ways of dealing with short- and medium-term necessities and change. A long-term vision needs to have the commitment of all political parties so that an incoming government will not view a particular strategy as representing only the views or policies of its predecessor.

- **Comprehensive and integrated**

Strategies should seek to integrate, where possible, economic, social and environmental objectives. But where integration cannot be achieved, trade-offs need to be negotiated. The entitlements and possible needs of future generations must be factored into this process.

- **Targeted with clear budgetary priorities**

A sustainable development strategy must be fully integrated in existing budget processes to ensure that plans have the financial resources to achieve their objectives, and do not represent mere "wish lists". Conversely, the formulation of budgets must be informed by a clear identification of priorities. Capacity constraints and time limitations will have an impact on the extent to which the intended outcomes are achieved. Targets need to be challenging – but realistic in relation to these constraints.

- **Based on comprehensive and reliable analysis**

Identification of priorities must be based on a comprehensive analysis of the present situation. Forecast trends and risks, and the links between local, national and global challenges. External pressures on a country – such as those resulting from globalisation, or the impacts of global climate change – need to be factored in this analysis. Such analysis requires credible and reliable information on changing environmental, social and economic conditions, pressures and responses, and their correlations with strategy objectives and indicators. Local capacities for analysis and existing information should be fully used, and different perceptions amongst stakeholders should be reflected.

- **Incorporate monitoring, learning and continuous improvement**

Monitoring and evaluation need to be based on clear indicators and built into strategies to steer processes, track progress, distil and capture lessons, and signal when a change of direction is necessary.

- **Country-led and nationally-owned**

Past strategies have often resulted from external pressure and development agency requirements. It is essential that countries take the lead and initiative in developing their own strategies if they are to be enduring.

- **High-level government commitment and influential lead institutions**

Such commitment – on a long-term basis – is essential if policy and institutional changes are to occur, financial resources are to be committed and for there to be clear responsibility for implementation.

- **Building on existing processes and strategies**

A strategy for sustainable development should not be thought of as a new planning process but instead built on what already exists in the country, thus enabling convergence, complementarity and coherence between different planning frameworks and policies. This requires good management to ensure co-ordination of mechanisms and processes, and to identify and resolve potential conflicts. The latter may require an independent and neutral third party to act as a facilitator. The roles, responsibilities and relationships between the different key participants in strategy processes must be clarified early on.

- **Effective participation**

Broad participation helps to open up debates on new ideas and sources of information; expose issues that need to be addressed; enable problems, needs and preferences to be expressed; identify the capabilities required to address them; and develop a consensus on the need for action that leads to better implementation. Central government must be involved (providing leadership, shaping incentive structures and allocating financial resources), but multi-stakeholder processes are also required. These should involve decentralised authorities, the private sector and civil society, as well as marginalised groups. This requires good communication and information mechanisms with a premium placed on transparency and accountability.

- **Link at national and local levels**

Strategies should be two-way iterative processes within and between national and decentralised levels. The main strategic principles and directions should be set at the central level (here, economic, fiscal and trade policy, legislative changes, international affairs and external relations, etc., are key responsibilities). But detailed planning, implementation and monitoring would be undertaken at a decentralised level, with appropriate transfer of resources and authority.

- **Develop and build on existing capacity**

At the outset of a strategy process, it is important to assess the political, institutional, human, scientific and financial capacity of potential state, market and civil society participants. Where

needed, provision should be made to develop the necessary capacity as part of the strategy process. A strategy should optimise local skills and capacity both within and outside government.

Figure 3: Mechanisms contributing to a sustainable development strategy

Explanation

This figure visualises suggested basic elements of a system for developing and implementing a strategy for sustainable development. The system should encourage and facilitate the building of consensus in the society about a vision, goals and objectives for sustainable development (the centre circle). It should provide a coordinated set of information and institutional mechanisms to deliver these (the satellite boxes). In establishing such a system, there is a need to look for precedents, recent trends and improvements in mechanisms beyond branded and packaged approaches that might provide examples on how to make progress.

2.6.2. ILLUSTRATIVE STEPS FOR DEVELOPING, CO-OPERATING AND CONTINUOUSLY IMPROVING STRATEGY MECHANISMS

The following steps apply particularly to strategy development tasks, i.e. those needed to establish the mechanisms by identifying elements that work, improving/building on them,

and/or initiating new elements if necessary. But the same or similar tasks are then iterated during strategy co-ordination and continuous improvement:

1. Take stock of, and analyse, *current strategies:*
    - Catalogue the range of existing strategies.
    - Analyse the issues covered, vision, goals, responsibilities and outcomes to date.
2. Establish a *mandate* for the strategy (handed down or generated). The more this represents domestic public demand with high level support, rather than external, the better (e.g. a mandate from prime minister or president is better than from international bodies).
3. Identify the *stakeholders* of an integrated sustainable development strategy, and outline their (potential) responsibilities, rights and relations.
4. Establish *a secretariat* (or strengthen an existing one) acceptable to these stakeholders, with powers and resources to co-ordinate the steps outlined in this box and the strategy mechanisms.
5. Establish the *rules* governing the strategy process:
    - Debate how all decisions will be made and agreed.
    - Co-ordinate means for negotiation of trade-offs and conflict management.
6. Establish the *mechanisms* to be used in the strategy:
    - Identify mechanisms used by existing strategies (see Figure 3).
    - Review achievements of these mechanisms in terms of synergies, conflicts and gaps, and their outcomes.
    - Identify what is required to improve synergies and plug gaps.
7. Establish *regular debate and analysis* across sectors and between levels:
    - Regular periodic thematic, national, decentralised and local stakeholder fora (round tables, hearings, workshops, etc) to reach and improve consensus on basic vision, goals, principles, system components, pilot activities, targets and responsibilities, and to review progress.
    - Communication and information systems to ensure regular flows of information concerning sustainable development between stakeholders and between fora. This will include development of key information products such as 'state of environment and development' reports, policy briefs and news releases.
    - Analysis of the sustainability of the outcomes of policy, legal, institutional and financial changes.
8. Establish a *schedule of implementation* of the strategy process – determine activities, responsibilities, capabilities and resources needed, and their timing.
9. Establish continuous *monitoring and accountability* mechanisms, notably:

- Development and review of sustainability indicators and the collection and analysis of baseline information on the environmental, social and economic issues.
- Participatory development and review of standards/codes of practice that can be used in regulations, incentives and voluntary mechanisms.
- Encouraging innovative processes to promote the culture of action-learning.
- Identifying possible roles for independent monitoring or "watchdogs".

10. Prepare a budget for the strategy process, secure financial resources, and allocate them to agreed uses in a timely and accountable manner.

11. Establish what are *residual trade-offs* at any stage and operate rules for negotiating them and managing conflict.

2.7RESISTANCE TO SUSTAINABLE DEVELOPMENT

Development progress over the past thirty years has been unprecedented. Life expectancy in developing countries has risen by more than 20 years; infant mortality rates have been halved and primary school enrolment rates have doubled. Food production and consumption have increased around 20% faster than population growth. The pace of improvements in income levels, as well as in health and education, has exceeded that of the industrialised countries. Notwithstanding this remarkable progress, there remain many complex and urgent challenges for sustainable development. These challenges faced by local, national and global institutional system, are summarized as below:

- ***Extreme poverty*** still ravages the lives of one out of every five persons in the developing world. The social ills associated with poverty, including diseases, family breakdown, crime, and the use of narcotic drugs, are on the rise in many countries.
- ***Political instability***, sometimes leading to violent conflict, hinders socio-economic progress in many countries and regions. Growing inequality of income both within and between countries as well as the marginalisation of ethnic and other minorities contribute to this instability.
- ***Environmental deterioration*** continues to increase. Natural resource depletion (soil erosion; loss of forests, habitats, biodiversity and depletion of fish stocks); and pollution are clearly evident in most countries, placing growing strain on the quality of water, soil and air. Current patterns of production and consumption and global climate change all raise questions about the continued capacity of the Earth's natural resource base to feed and sustain a growing and increasingly urbanised population. Recent studies have revealed that the Earth's ecosystems and renewable natural resources

declined by over 30% over the last 30 years while demands on them have increased by 50%. Developing countries, and notably the least developed, are expected to be the most vulnerable to the impacts of global climate change, although their current contribution to the problem is small.

- ***Population growth*** is expected to exacerbate these pressures, although it is people's consumption levels that matter more than their mere numbers. Over 95% of the estimated increase of 2 billion people over the next twenty years will live in the developing world.
- ***HIV-AIDS and malaria*** are particularly serious diseases which erode the productive capacity and social fabric of nations. In the worst affected countries, HIV has already had a profound impact on existing rates of infant, child and maternal mortality. Nearly 500 million people suffer from acute malaria a year, of whom 1 million will die.
- ***Marginalisation.*** Many countries are struggling under the combined weight of slow economic growth, a heavy external debt burden, corruption, violent conflict, and food insecurity. They also suffer from actions taken in the North such as trade protectionism and pollution causing global warming. As a result, they are increasingly marginalised from the global economy.

2.7.1 SOME ALTERNATIVE APPROACHES

- **Sustainable de-growth**

It is the transition to a smaller economy with less production and consumption. The concept of sustainable de-growth has been attracting interest. There is a little agreement on international targets on greenhouse gas emissions and other targets, such as UN Millennium Development goals, look increasingly unachievable. Alternative policy approaches are therefore being considered.

Currently sustainable development approach is the favoured approach, which aims to address environmental concerns whilst promoting economic growth. Sustainable de-growth has at its core a downscaling of economy and it is believed that economic growth, even if disguised as sustainable development, will lead to social and ecological collapse. **It proposes that decreasing the size of resource flows is the only way to ensure resources are not depleted and this must be coupled with strengthened social and ecological values.**

The origins of sustainable de-growth are complex because it is both a Marxist-influenced intellectual concept developed in France and a grass-roots movement developed in Northern countries. The latter is based in ecological economics and proposes a decrease in consumption in countries that exceed their allowable ecological footprint.

Although the concept of sustainable de-growth appears to be a theoretical alternative to sustainable development and one that might bring faster and more impressive results, its practical application needs careful consideration. De-growth cannot be simply 'switched on' and societies will find it very difficult to undergo the change. Adequate preparation and conditions are needed if it is to successfully lead to the changes it proposes.

Firstly, alongside the EU's agreement to decrease CO_2 levels, there should be targets for reducing environmental impact indicators, such as energy consumption, natural resources, and land use. Accompanying this there should be research and analysis to understand the required conditions for reaching these objectives. For example, research into the profiles of societies, in terms of their levels of consumption and industrialization.

Secondly, inherent to sustainable de-growth is a reduction in GDP. This is likely to cause an increase in unemployment unless initiatives are in place to reduce the amount of working time by individuals, delink income from employment or develop formulas for a basic income. An existing partial example of this is the case of European agri-environment measures which provide farmers with incentives linked to sustainable use of land instead of production. In general, the relations between de-growth, income, and employment need careful discussion.

However, GDP is not the only economic indicator and the concept of growth itself must be further defined and developed so that the meaning of 'de-growth' is clearer and more consistently understood. Currently it has different definitions depending on whether it is used by academics or grass roots organizations. There may also need to be more coherence in general between its proponents, for example, between conservationists, trade unions, agro-ecologists and peasant movements.

Sustainable de-growth has an obvious disadvantage in that it confronts current powers in society. No important economic players, such as government leaders or private sector executives, would have an interest in considering a no-growth policy. Advantages in downsizing and improving the ethical aims of society need to be promoted in this respect.

[Source: Martínez-Alier, J., Pascual, U., Vivien, F-D. & Zaccai, E. (2010) Sustainable de-growth: Mapping the context, criticisms and future prospects of an emergent paradigm. Ecological Economics. 69:1741-1747.]

- **Precision agriculture**

Precision farming or precision agriculture is a farming management concept based on observing and responding intra-field variations. It can be denoted as an alternative or complementary approach to sustainable agriculture. It relies on new technologies like satellite imagery, information technology and geospatial tools. It is also aided by the farmers' ability to locate their precise position in a field using satellite positioning system like GPS.

Precision agriculture aims to optimize field level management by matching farming practices more closely to crop needs (e.g. fertilizer inputs), by minimizing environmental risks (e.g. leaching of nitrogen) and by boosting competitiveness through more efficient practices (e.g. improved management of fertilizer usage and other inputs).

Precision agriculture management practices can significantly reduce the amount of nutrients and other crop inputs used while enhancing yield. Farmers thus obtain a return on their investment by saving on cultivation costs. However, large scale benefit of targeting inputs in terms of spatial, temporal and quantitative aspects, concerns environmental impacts. The application of the right amount of inputs in the right place and at the right time benefits crops, soils and groundwater, and the entire crop cycle. Consequently, precision agriculture has become the cornerstone of sustainable agriculture, since it respects corps, soils and farmers. Sustainable agriculture seeks to assure a continued supply of food within the ecological, economic and social limits required to sustain production in the long term.

[Source: Wikipedia.]

2.8 SUMMARY

Sustainable development is the contemporary approach of development which considers economic development within the framework of environmental protection, resource conservation and international understanding. However, the concept has to be appreciated through numerous decision making processes for building up the strategies both at micro and macro levels. Hence, this particular section covers the evolution and genesis of the concept, its definitions and goals along with the different components of sustainability approach. The strategies for promoting the concept of sustainable development have also been critically analyzed in this section. The unit also covers potential resistances that are creating substantial obstacles in achieving the goals of sustainable development. At the same time, few alternative approaches like “Sustainable De-growth” and “precision agriculture” have been elaborated at the end.

2.9 RECOMMENDED READINGS

1. ***Our Common Future*** by the World Commission on Environment and Development (Brundtland Commission).
2. ***People and Environment*** by S. Morse & M. Stocking (ed.). UCL Press Ltd., London.
3. ***Sustainable Development: critical issues*** by OECD.
4. ***Sustainable agriculture*** by Lichtfouse, Nvarrete and others (ed.). Springer Online Publ.

2.10 PROBABLE QUESTIONS

1. Define sustainable development. State the reasons behind the genesis of the concept.

3 How does Sustainable Development differ from Development?

4 What do you understand by equity? What are the dimensions of equity?

5 The relative priority given to the three dimensions of sustainable development varies from place to place and over time. Justify the statement with your answer.

6 What are the basic goals of sustainable development?

7 Sustainable development demands changes in our attitude towards the nature. Do you agree to this statement? If so, then why?

8 How does sustainable agriculture differ from modern agriculture? What are the different elements of sustainable agriculture?

9 What are the rationales for strategy development for promoting sustainability?

10 State in brief the challenges and resistances to sustainability.

11 Write short notes on:

a. Sustainable de-growth
b. Precision farming
c. Environmental sustainability
d. Strong sustainability
e. Crop rotation
f. Agroforestry

DEM 102 NATURAL RESOURCES AND SUSTAINABLE DVELOPMENT CR 4

UNIT-3: FOREST MANAGEMENT

UNIT STRUCTURE

3.1. OBJECTIVES

After going through this unit, you will be able to:

- discusss the different types of forest and their resources in India.
- Acquire a basic idea about the principles of forest management and their sustainability and harvesting.
- discuss the services provided by forest in different ways.

3.2 INTRODUCTION

Forest is one among the crucial components of natural system and largely interfered by and vulnerable to rapid degradation due to geographic characteristics and, natural and anthropogenic pressure. It is one of the world's most abundant resources that provide a wide

range of bioresources for the rural people such as fodder, firewood, small timber and many other products for daily use and survival. The role of the forest in moderating local climate, enhancing local rainfall and water holding capacity of soil, protecting soils by maintaining soil fertility and preventing erosion, maintaining biodiversity of nature, conserving and regulating water cycle and generating many more roles towards the biogeochemical cycles of the environment is also well understood in addition to the supply of forest products. Furthermore, forests have aesthetic and tourist values and serve as gene pool of important species of plants and animals. It is very evident that our ancestors have realized the benefits gained from forest as resources in different forms like food, shelter, fuel, medicine, raw materials, even the associated spiritual beliefs and values since pre-historic times. In fact, we human beings always try to compel forest natural system to produce more products and services as per our needs. Likewise, forests have largely been influenced by human beings for thousand of years by various uses and over exploitation of forest resources for direct or indirect benefits. Acknowledging all these important roles played by the forest and the threats faced by the forest, forest should have been protected and managed in an ecologically sound and economically sustainable manner. It is we human beings only who can effectively conserve and protect the forest keeping in mind the extremely diverse ground conditions in terms of ecology, economic, social and cultural perspectives of the locality.

3.3 FOREST TYPES AND RESOURCE OF INDIA

3.3.1 FOREST TYPES

The word 'forest' comes from the Latin word 'foris,' which means outdoors or away from human habitation. Forest refers to natural vegetation.. It may be defined as a complex ecosystem or assemblage of ecosystems dominated by trees and other woody vegetation. Although trees are the dominant biotic elements of a forest, it is also associated with different species of shrubs, herbs, climbers, mosses, algae, fungi, insects, mammals, birds, reptiles, amphibians, and large number of microorganisms living on the plants and animals and in the soil. These biotic elements interact and operate with abiotic elements like air, water, soil and minerals in one or the other ways. In fact, local environmental factors prevailing in the region determine which individual species can survive and which different species can live there together. Distinct associations of different species are largely established in transition zones or ecozones within the periphery of the region. Interaction between biotic and abiotic components of the forest forms a recognizable structure of different vertical layers. Each layer of the forest, from the soil surface to the treetops, is formed by one or more dominate plant species. Forest may be classified into different types based on geography, climate, dominant species, floristic

composition, or gross appearance. Forests are also classified according to nature, the type of climate in which they thrive and their relationship with the surrounding environment. Classification may be made on the basis of the leaf longevity of the dominant trees as evergreen, deciduous, needle-leaved trees, board-leaved trees or mixed. There is no universally accepted or set principle to classify forests.

India is characterized by a great diversity in its physical features, climatic conditions, natural vegetation, minerals resources, human habitation, socio-cultural and linguistic groups, etc. India being a sub-continent has varied climatic elements (temperature, humidity, rainfall, and wind etc.) which have greater influence on vegetation and human activities. Evidently, India has a diverse range of forests: from the rainforest to the alpine pastures, from the deserts to the evergreen forests in the northeast. Primarily, there are 6 major forest types in India, namely, Moist tropical forest, Dry tropical forest, Montane sub tropical forest, Montane temperate forest, sub-alpine forest and apline forest. These are further subdivided into 16 major types of forests by Champion and Seth (1968) as given in table 1. While classifying these forests into different types, the main factors taken into consideration include climatic climaxes depending on soil type, fertility, topography, and elevation.

Table 1. Forest/Vegetation Types of India following Champion and Seth, 1968.

Sl. No.	**Vegetation Type**	**General composition**	*** Area in Sq. Km**	**%**
1	Tropical wet evergreen forests	Dense Tall forests, entirely evergreen or nearly so	51,249	8.0
2	Tropical semi evergreen forests	Dominants include deciduous species but evergreens predominant	26,424	4.1
3	Tropical Moist deciduous forest	Dominants mainly deciduous but sub-dominants and lower story largely evergreen top canopy even and dense but 25m high	236,794	37.0
4	Tropical dry deciduous forest	Entirely deciduous or nearly so top canopy uneven rarely over 25 m high	186,620	28.6
5	Tropical thorny/ scrub forests	Deciduous with low thorny trees and xerophytes predominant top canopy more or less broken, less than 10 m high	16,491	2.6
6	Tropical dry evergreen forest	Hard leaved evergreen trees predominates with some deciduous emergent often dense but usually under 20 m high	1,404	0.2
7	Littoral and swampy forest	Mainly evergreens of varying density and height but always associated predominantly with wetness	4,046	0.6
8	Subtropical	Broad-leaved largely evergreen high	2,781	0.4

	broad-leaved hill forests	forests		
9	Subtropical pine forests	Pine associated predominates	42,377	6.6
10	Subtropical dry evergreen forests	Low xerophytic forest and scrubs	12,538	2.5
11	Montane wet temperate forests	Evergreen without coniferous species	23,365	3.6
12	Himalayan wet/ moist temperate forests	Evergreen forests mainly scleriphyllous oak and coniferous species	22,012	3.4
13	Himalayan dry temperate forests	Coniferous forests with sparse xerophytic undergrowth	312	-
14	Sub-alpine forests	Stunted deciduous or evergreen forests, usually close formation with or without confers		
15	Moist alpine	Low but often dense scrub of evergreen species	18,628	2.9
16	Dry alpine	Xerophytic scrub in open formation mostly of deciduous in nature		

Further, forests of India are also broadly classified into 5 classes based on forest cover. They are: i) Dense forest; forest with tree cover of canopy density of 40% and above, ii) Open forest; forest with tree cover between 10% to 40%, iii) Mangrove; those salt tolerated forest ecosystem found mainly in tropical and sub-tropical inter-tidal regions, iv) Scrub; area with poor tree growth mainly of small or stunted trees having canopy density less than 10%, and v) Non-forest; any area not included in any of the above classes. Change in any category may be a result of improvement somewhere and degradation elsewhere.

Distribution of Indian forests is widely uneven. Moist, deciduous and wet evergreen forests are found in Eastern zone of India. The western zone forms the thorny and dry deciduous forests. Northern and Central zones consist mainly of dry and moist deciduous forests. Southern zone of India holds characteristics of both Western and Central zones, comprising mainly of thorn dry and eastern highlands moist deciduous forests.

3.3.2. FOREST OF RESOURCE

Forest is one of the invaluable renewable natural resources benefiting human beings in several ways since time immemorial. The forest cover of the country has been estimated to be 637,293 sq.km, which is 19.39% of the geographic area of the country (SFR, 1999). The dense forest, open forest and mangrove constitute 11.48%, 7.76% and 0.15% of geographic area respectively. Moreover, plantation of trees constitutes a very important part of the forest resources. A lot of wood produced in the country now comes from tree plantations established

within or outside forest reserves. A large number of species can be planted due to the varied agro-climatic conditions of our country. *Eucalyptus globulus*, *E. grandis, E. tereticornis, Tectona grandis, Acacia auriculiformis, A. catechu, A. mearnsii, A. nilotica* and *A. tortalis* are the main species planted under larger area compared to other species. Among the coniferous plants, *Cedrus deodara*, *Pinus roxburghii* and *Pinu kesiya* are mainly planted in major areas. *Pinus patula* and *P. carribaea* are also found to be planted in a limited area.

As we all know that forest is a valuable natural resource. Basically, it not only provides basic requirements of the people but also contributes to the economic development of our country by providing goods and services to the people and industry. They are also intimately linked to our culture and civilization. For indigenous people inhabiting in forested areas forest is the source of all their food (tuber, roots, leaves, fruits, meat from birds and other animals) and basic requirements (fuel, fodder, building materials and clothing). Taking account of the major forest product, wood is a major forest produce and it is extensively used for various purposes, as raw materials for various forest based industries, construction of houses, agricultural implements, bridges, railway sleepers, etc., for fence posts and other local uses such as for fuel, etc. Forest also provides fodder for the cattle, sheep, goats and camels. In addition to these, a large number of non-wood forests products are also available from forests, commonly known as minor forest products (MFP), not because these are of minor significance but since they are harvested in smaller quantities. Such a variety of resources are gums, resins, rubber, tan and dyes, fibres and flosses, medicines, katha, insecticides, camphor, essential oils (e.g. rosha grasses, khas and sandal woods), cooking oils, spices, insecticides, grasses and bamboos, edible products (fruit, flowers, seeds, tubers etc), lac and other products. All these resources of forests is the productive functions of the forests.

Protective and amelioration functions of the forests have a great significance to mankind and wildlife. Forests are important resource habitats for a variety of wildlife containing a biological diversity as yet not fully uncovered. Forests act as sink of CO_2 and maintain O_2 balance in the atmosphere, productivity of soil by adding large quantity of organic matter and recycling of nutrients, increases precipitation by about 5 to 10% due to their microclimatic effects. Forest canopy reduces the violence of rain and check splash erosion and check flood and intercept about 13-36% of the total rainfall which increases infiltration and water holding capacity of the soil, lower surface runoff and ultimately check soil erosion. Forests of trees provide shelter belt and wind break effect which is beneficial to agricultural crops, particularly in arid and semi-arid areas. They reduce wind velocity, wind erosion, shifting of sand dune and halts desertification in arid areas. They also play an important role in reducing atmospheric pollution by collecting the suspended particulate matter and by absorbing carbon dioxide. Lastly, forests have aesthetic and tourist values and serve as gene reserves of important species. Forest provides scientific benefits as experimental filed and laboratory for

teaching to students and researchers by providing sites for ecological studies and also fulfill our cultural and spiritual needs. As a part of their developmental functions, forests also help in improving socio-economic conditions through collection, processing and marketing of various forests products.

3.4 PRINCIPLES AND PRACTICE OF FOREST MANAGEMENT PLANNING

The basic principles of forest management are forests are essential to economic development and the maintenance of all life forms so need to be managed sustainability and maintaining closeness to nature. Closeness to nature indicates natural processes that are pursued in forestry. Through this management, the natural cycle of the forest ecosystem is slightly manipulated for betterment without affecting the social sustainability and monetary benefits. The goal of the forest management is to achieve sustainable forest resources development and maintaining the capacity of a forest ecosystem to regenerate naturally. Agenda 21 of the 1992 Earth Summit also clearly stated the preamble and principles of forest management. The Principles of Forest Management assert the right of nations to profit from their own forest resources, but recommend that this should occur within a framework of forest protection, management and conservation. The principles are not legally binding but provide recommendations on sustainable practices.

The Forest Principles**,** developed at the *Earth Summit* - the United Nations Conference on Environment and Development (UNCED, held in Brazil in 1992) - have defined forest management as "*Forest resources and forest lands should be sustainably managed to meet the social, economic, cultural and spiritual human needs of present and future generations. These needs are for forest products and services, such as wood and -wood products, water, food, fodder, medicine, fuel, shelter, employment, recreation, habitats for wildlife, landscape diversity, carbon sinks and reservoirs, and for other forest products. Appropriate measures should be taken to protect forests against harmful effects of pollution, including air-borne pollution, fires, pests and diseases in order to maintain their full multiple values.* (Source: UNCED, 1992. *Earth Summit - Rio Declaration & Forest Principles*).

These principles of forest management include a number of points.

- All nations should take part in "the greening of the world" through planting and conserving forests.
- Forests should be managed in order to meet the social, economic, ecological, cultural and spiritual needs of present and future generations.

- Unique examples of forest should be protected, for example ancient forests and forests with cultural, historical, spiritual and religious importance.
- Pollutants that harm forests should be controlled.
- Forestry plans should consider the non-economic values of forests and the environmental consequences of their management. Forest degradation should be avoided.

Above all the keys principles and practice of forest management planning are conservation of biodiversity (variety and variability of all life forms on earth); maintaining a healthy forest ecosystem condition and productivity; extending forest ecosystem, contribution from local regional to global ecological cycles; conservation of soil, fertility and water resources; and improving socio-economic condition of the communities and public in the society by providing multiple benefits through sustainable development.

A forest management plan requires a thorough understanding of the forest ecology to provide managerial intervention over time, to formalize administrative arrangements and to provide a basis for monitoring forest activities. Sustainable forest management should have effective monitoring and implementation of an approved management plan and should consider the conservation of forest ecosystems as a whole as well as in the context of present or future forest resource (e.g. wood). A forest management plan has the purpose not only of setting out approved management objectives and specified action but, equally importantly, of communicating these to the people who are concerned with the implementation of a plan in a forest or group of forests to which it applies. Effective forest management relies on the use of good quality information on forest types, wood volumes and growth, on a range of other environmental matters, on local community and wider social relationships and on economic issues. On the other hand, inadequate funding and human resources for the preparation, implementation and monitoring of forest management plans, and lack of mechanisms to ensure the participation and involvement of all stakeholders in forest planning and development interfere with the successful forest management plan.

3.5 IMPLEMENTATION AND MONITORING OF SUSTAINABLE FOREST MANAGEMENT (SFM)

Sustainable forest management (SFM) is not a new concept. However, its popularity has increased in the last few decades because of public concern about the remarkable issues related to the utilization and sharing of forest resource between the local people and the government, and decrease in forest resources. The implementation of SFM is generally achieved by using criteria and indicators, and several countries have established their own

policies for implementation and long term monitoring. Criteria are categories of conditions or processes whereby sustainable forest management can be assessed, whereas quantitative indicators are chosen to provide measurable features of the criteria and can be monitored periodically to detect trends (Brand, 1997; Wijewardana, 2008) and qualitative indicators are developed to describe the overall policies, institutions and instruments regarding SFM (Forest Europe, 2011).

Although there is no universally accepted definition of SFM, the following conceptsare widely accepted: "*the process of managing permanent forest land to achieve one or more clearly specified objectives of management with regard to the production of a continuous flow of desired forest products and services without undue reduction of its inherent values and future productivity and without undue undesirable effects on the physical and social environment*" (proposed by International Tropical Timber Organization: ITTO, 1992).

The General Assembly of the United Nations adopted in December 2007 the most widely, inter-governmentally agreed definition of *Sustainable Forest Management* (SFM): *Sustainable forest management as a dynamic and evolving concept aims to maintain and enhance the economic, social and environmental value of all types of forests, for the benefit of present and future generations. It is characterized by seven elements, including: (i) extent of forest resources; (ii) forest biological diversity; (iii) forest health and vitality; (iv) productive functions of forest resources; (v) protective functions of forest resources; (vi) socio-economic functions of forests; and (vii) legal, policy and institutional framework* (Source: UN 2008, Resolution 62/98).

In our country, the roots of Indian forest policies have clearly reflected that the local people are separated from the forest by explaining the main causes of forest degradation through deforestation. This is, in fact, not true to argue because local people who rely on forest resources for their livelihood for food, economic subsistence of individuals, families and community knew better how to manage and control the forest resources over time. We can say that they are the fundamental managers of the communal forest resources. Because, these people have long term monitoring experience of the forest in terms of natural regeneration, growth and production and harvesting of resources. There are many well-documented examples of how local communities and small farmers have been sustainably managing forest resources and farm trees, based on traditional knowledge accumulated over long periods of time (Barrow, 1986). Indigenous societies are highly adapted to their area, and have developed a database of time-proven methods for harvesting and regenerating their resource base. The potential of forests to contribute to poverty alleviation justifies special emphasis on local community efforts and on the major role they play in improving the welfare of local

people; particularly the rural poor (King, et al, 1990). The situation becomes stricter after independence with imposing restriction to access forests and forest products while trying to meet the demand for the forest based raw material in the industries, and rapid expansion of the agricultural areas for higher agricultural production. These local people inhabiting in and around the forest areas where their livelihood largely depend on forest resources are quite vulnerable to forest policies of India. Even the state governments also fail to establish a proper and effective forest resource management policy that is balanced and that takes into account the needs of the traditional user and the government for the economic development. Besides, such policies often undermine the rights of indigenous people to use and extract forest resources. Such failure leads to the collapse in legal/institutional norms that were formulated in protecting and managing forest resources for local use. Thus, recognition of the fundamental importance of the principle of sustainability is essential in the preparation and subsequent implementation of prescriptions in a forest management plan, irrespective of the objectives of management. Many of the forests located in the tropics and subtropics are still not managed in accordance with the Forest Principles adopted at the United Nations Conference on Environment and Development (UNCED, 1992). Where forest management plans exist, they are frequently limited to ensuring sustained production of wood, without due concern for non-wood products and services or social and environmental values. In addition, many countries lack appropriate forest legislation, regulation and incentives to promote sustainable forest management practices.

Sustainable forest management means the environmentally appropriate, socially beneficial, and economically viable management of forests for present and future generations. Its task is to ensure that forest products and ecological services meet the present-day needs while at the same time secure their continued availability and contribution to long-term future development. It implies various degrees of intentional human involvement, ranging from safeguarding and maintaining the forest ecosystem and its functions, to favouring specific socially or economically valuable species or groups of species for the improved production of goods and services. But, undue emphasis on industrial wood production and ignoring of minor forest values and uses become the fundamental weakness of SFM. Another problem is lack of knowledge and skill of the ecological and social processes governing resource sustainability towards the implementation and monitoring of SFM. Recent statements on sustainable forest management go well beyond concern with the mere maintenance of timber volumes and site productivity; they focus on the sustainability of forests as ecosystems (Poore, et al, 1989; ITTO, 1991, 1992). Central to the successful implementation of research

findings of sustainable forest management is their efficient transfer from the researcher to the manager (Farrell et al, 2000).

3.6AN INTRODUCTION TO KEY CONCEPTS, ISSUES AND PROTOCOLS

It is estimated that approximately 60 million indigenous people are almost wholly dependent on forests. 350 million people depend on forests to a high degree for subsistence and income, and about 1.2 billion people rely on agroforestry farming systems (World Bank 2004). These people lack the basic necessities to maintain a decent standard of living: sufficient and nutritious food, adequate shelter, access to health services, energy sources, safe drinking-water, education and a healthy environment. A number of key issues are needed to be considered in determining an acceptable forest management activity. These may include: forest system and jurisdiction, forest land, climate change and forest sector and conflicts.

3.6.1 FOREST SYSTEM AND JURISDICTION

The legal and customary rights of indigenous peoples to own, use and manage their lands, territories, and resources shall be recognized and respected. Forest management operations shall maintain or enhance the long-term social and economic well being of forest workers and local communities. Its operations shall encourage the efficient use of the forest's multiple products and services to ensure economic viability and a wide range of environmental and social benefits.

On the basis of ownership of the forest system forests have been classified in three groups i.e. i) Government forests which include *reserved forest, protected forest and village forests*. *Reserved forests* is an area of land duly notified under the provisions of section 20, chapter II of India Forest Act, 1927 or the State Forest Acts having full degree of protection. All activities like hunting, grazing, etc are prohibited unless specific orders are issued otherwise which also reveal complete protection. Depending on the potential, value and threats, reserved forests are often upgraded to the status of wildlife sanctuaries, which in turn may be upgraded to the status of national parks, with each category receiving a higher degree of protection and government funding. *Protected forest* is an area or land where all activities are permitted unless prohibited and framed under the provision of section 29, Chapter IV of Indian Forest Act, 1927. In protected forests the Government may issue notifications declaring certain trees to be reserved, or suspend private rights for a period of time or prohibit quarrying, removal of any forest produce, or breaking of land, etc. Protected forests are of two kinds - *demarcated*

protected forests and *undemarcated protected forests*, based on whether the limits of the forest have been specified by a formal notification. After Indian independence, the Government of India retained the status of the existing reserved and protected forests, as well as incorporating new reserved and protected forests. A large number of forests which came under the jurisdiction of the Government of India during the political integration of India were initially granted such protection. While, *Village forest* is constituted under section 28, Chapter III of the Indian Forest Act, 1927, the Government may assign to any village community the rights over a land which may not be a part of a reserved forest for use of the community.

ii) Private forest. Forest own by the individual or group of individuals as a private property. Government and other agencies have no legal right to interfere unless there is a profound demand for the development of the state with due compensation to the owner provided the owner consents.

iii) Forest owned by corporation, panchayats, societies and other bodies.

3.6.2 FOREST LAND

Forest land may vary and be differentiated in terms of services as they make available to the surrounding --economically or ecologically. Likewise, forest land may be categorized as economically or ecologically viable land to be considered for forest management. On the other hand, forest land can be outline based on canopy density as Very Dense Forest (VDF) having > 70 percent crown density range**,** Moderately Dense Forest (MDF) within crown density range of 40-70 percent, Open Forest (OF) within crown density range of 10-40 percent and Scrub <10 percent crown density range which comes under non-forest cover.

3.6.3 CLIMATE CHANGE AND FOREST SECTOR

Forests play a significant role in climate change and global carbon cycle largely by affecting the amount of CO_2 in the atmosphere. When forests grow, carbon is removed from the atmosphere and stored in biomass and soil. Because forests can absorb and store carbon over an extended period of time, they are considered "carbon sinks". This carbon remains stored in the forest ecosystem, but can be released into the atmosphere when forests are burnt and fell down. Changes in forest sector, especially afforestation and deforestation bring major understanding on carbon absorbing, storing, and releasing which is accountable for the climate changes. The impact of climate change on the forests is expected to take place in location as well as in the extent of the different types of forests. Forest sector holds a great space for carbon sequestration through increases in forests and trees and forest carbon stock enhancement through management practices. To increase carbon sequestration by the forest,

afforestation and forest restoration are highly needed in order to increase tree cover. These practices may be carried out through agroforestry, urban forestry and tree planting in rural landscapes. Modified forestry management practices may enhancement forest carbon stocks (in both, biomass and soils) and sequestration capacity. Here we can identify four major roles of forests in climate change. Firstly, they contribute about 1/6 of global carbon emissions when deforested, overexploited or degraded; secondly they react sensitively towards the changing climate conditions; third when managed sustainably there is a continuous supply of fuel wood; and finally, they have the potential to absorb about 1/10 of global carbon emissions projected for the first half of this century into their biomass, soils and products and store them for infinity.

3.6.4 FOREST PLANTATION

Diminishing forest land and resources and increasing demand for the forest raw materials encourage the plantation of trees in degraded and wasteland areas involving proper techniques for soil working, species selection, maintenance, protection and harvesting. Forest plantations are mainly developed to supply raw material for industry and for other uses, such as fuel wood. These also provide additional non-wood forest products (minor forest products) and benefits, from the trees planted or from other elements of the ecosystem that they help to create. They contribute to the wellbeing and benefits of environment, social, and economic condition. Forest plantations are used in combating desertification, absorbing carbon to offset carbon emissions, protecting soil and water, rehabilitating lands exhausted from other land uses, providing rural employment, and, if planned effectively, diversifying the rural landscape and maintaining biodiversity. The prospective for tree plantations are to meet the demand for wood and fiber for industrial uses to a larger extends and maintains the ecological and social economic balance.

3.6.5 CONFLICTS

Many poor forest communities inhabit forested areas and governments have historically neglected these regions and their people due to poor connectivity and assessment. Governments have failed to recognize local people's claims to rights over forests and frequent exploitation of such property rights consequently lead to limited allegiance to governments and they look to other groups to perform traditional government functions. Variety of forest resources like, timber, medicinal plants, wildlife, fiber and floss, spices, minerals and fossil fuel deposits, etc attract large groups of outsiders to harvest and exploit. These groups of people always wait for any chance to create conflict with the local people or with each other

to overcome confidence of local people and then with the mere compensation engage the local people for harvesting and supplying of resources from the forest. Timber is one of the forest resources that can be received as a source of good income and often leads to violent conflict among the government, local people and contractors.

Forest related conflicts can be observed at different levels and with varying dimensions and intensities. The conflict lies among the local forest users, different government agencies in- and outside the forest administration, civil society, and the private sector. Illegal activities and poor governance in forest management are two factors which can encourage forest conflicts. Illegal activities in the forest largely mean the illegal felling of timber, collective illegal activities of local people for food and fuel, encroachment and conversion of forest land for agriculture usage, poaching, etc. Illegal felling of timber reveals many such activities without official permissions like timber theft, falsification of documents, financial crimes or usage of the violence against the local people. Basically the local people harvest forest resources for fulfilling their basic needs which may not be considered as the illegal activities. Lastly, the lack of law enforcement encourages illegal activities in the forests.

3.6.6 PROTOCOLS

The Kyoto Protocol came into force on 16 February 2005, though it was initially adopted on 11 December 1997 in Kyoto, Japan, to make assessment on the emission of green house gases for fighting global warming. The protocol and the UNFCCC oblige all member countries to regularly assess and report national greenhouse gas emissions, including emission and removal of carbon reflected as stock changes in forests. To that end, IPCC has created guidelines, methods and default values for all parameters needed to assess carbon stocks and their changes in forests (IPCC, 2003). The Kyoto protocol and numerous offset systems recognize the potential of existing forest acting as a useful tool of CO_2 sequestration from the atmosphere and reducing its effect on global warming.

3.7 AN OVERVIEW OF THE GLOBAL FOREST ESTATE

The primary source for global information on forest resources to date is the United Nations Food and Agricultural Organization's (FAO) Forest Resource Assessment (FRA). These data, supplied by the contributing member countries, are the current reference for global forest change from 2000 to 2005. FAO has a mandate to carry out periodic assessment of the world forest resources. The first assessment was in 1942 and the latest is in 2005. FAO defines forest as "land spanning more than 0.5 ha. With trees higher than 5 m and a canopy cover of

more than 10%, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or urban land use. Definition has been stable since 2000 and is now globally accepted. A more recent source of information on forest change is the United Nations Framework Convention on Climate Change (UNFCCC), which tracks national reports on greenhouse gas emissions, including those associated with forest land use and land use change. These national inventories focus on the use of managed lands as a proxy for estimating direct human-induced emissions and removal related to land use. The area changed within forest land use areas is required to estimate emissions and removals, and this information is not available in the FAO and FRA reports.

3.7.1 FOREST STOCKS: Total forest area across the globe as of 2005 is estimated at 3 952 million hectares or 30 percent of the total land area. This corresponds to an average of 0.62 ha per capita. However, the area of forest is unevenly distributed. The total net change in forest area in the period 2000–2005 is estimated at 7.3 million hectares per year or equivalent to a loss of 200 km2 of forest per day.

3.7.2 GROWING STOCK (VOLUME OF LIVING TREES): In 2005 the total global growing stock of forests was estimated at 434 billion m^3, which corresponds to an average of 110 m^3 per hectare. The countries with the most growing stock per hectare were found in central Europe and some tropical areas. Total growing stock shows a slight overall downward tendency – mainly owing to a decrease in forest area. However, some regions also show significant trends in growing stock per hectare, for example, Europe shows an increase and Southeast Asia a decrease.

3.7.3 CARBON STOCK – IN BIOMASS, IN DEAD ORGANIC MATTER AND IN SOIL: It is estimated that the world's forests store 283 gigatonnes (Gt) of carbon in their biomass alone and 638 Gt of carbon in the ecosystem as a whole (to a soil depth of 30 cm). Thus forests contain more carbon than the entire atmosphere. Roughly half of the total carbon is found in forest biomass and dead wood combined and half in soils and litter combined.

3.8 SUSTAINABLE FOREST MANAGEMENT FROM ITS FOUNDATION IN ECOLOGICAL PRINCIPLES

The concept of sustainability began to increase in importance at the end of the 1980s and at the beginning of the 1990s with the Brundtland report (1987) and the Conference on Environment and Development held in Rio de Janeiro, Brazil, in 1992 (Earth Summit), respectively. Nevertheless, the need to preserve natural resources for use by future

generations had long been recognized. Three instruments should be recognized in encouraging rural community participation in sustainable forest management: the ecological tolerance of nature must not be weakened; in other words, the environment may only be altered to the extent that nature is able to recover its former condition after the change. The social and cultural values of forests may not be weakened, either. Thirdly, forestry must be financially profitable to all partners involved.

Sustainable forest management was recognized by parties to the Convention of Biological Diversity (Decision VII/11 of COP7) to be a concrete means of applying the Ecosystem Approach to forest ecosystems. The two concepts, sustainable forest management and the ecosystem approach, aim at promoting conservation and management practices which are environmentally, socially and economically sustainable, and which generate and maintain benefits for both present and future generations.

Basic of ecological principles in sustainable forest management reveals that there should be a clear recognition and respect for the rights of indigenous peoples who live in or have a traditional dependence on forests. Collaboration among the local people and institutions are required to promote particularly those who are involved in the various aspects of forest management, in order to more effectively support the needs of rural communities and to minimize or avoid conflicts in forest management. Taking care of the enhancement of the well-being of forest workers and local communities are elementary tools for successful management.

3.9 MARKETS FOR FOREST PRODUCTS

Although forests have traditionally been managed by society, and government agencies it is expected that the current growth in the world population and the high economic growth of developing countries will lead to greater use of forest resources. For utilization of forest resources there should be a transaction through the market which may be local, regional, national or international, if it not harvest only for household purposes.

For the major forest product timber is relatively undifferentiated commodity where market and business are well developed in different levels of domestic and international market sectors. In some of the states timber is supplied through commercial depots and then this goes to the saw mills, and other wood based industries. But, now-a days the supply of timber is becoming a constrained due to massive consumption of wood for fuel and other rural needs, the degradation of natural forests, and restrictions on timber harvesting in order to conserve remaining forests for environmental services.

Fuelwood is another important source of Indian energy sector particularly in rural areas. An estimated 59 percent of rural households obtain their wood from home-grown sources or free collection; only 21 percent pay for all of their wood (Kholin and Ostwald 2001). Markets of fuelwood are generally of two forms. One is a semi-commercial market through forest department channels, in which forest department plantation or other larger-scale supplies are sold to large commercial customer. In the second and more common approach, individuals (usually women) from communities engage in small-scale fuelwood trading with other households or middlemen for low returns.

On the other hand, recognizing the local market for non-timber forest product is indeed required to understand the potential resources available in the locality which in fact does not come to the picture at boarder scale. Because, an emphasis on global markets for non-timber forest products (NTFPs) often overshadows attention to the local trade in many traditionally important products. Many hundreds of millions of people across the developing world trade in a diverse range of non-timber forest products (NTFPs) everyday, which are marketed primarily in local and regional domestic markets (Scherr et al. 2004). Such product includes wild edible leaves, flower, fruits, barks, for medicine, food or socio-religious purpose, gum, resins, honey, oils and alcoholic beverages, fiber and flosses, etc. NTFPs provide low cost building materials, income, fuel, food supplements and traditional medicines. Non-wood forest products help local people survive in the case of famines, emergencies, in periods between crop harvests, and in some cases is the only source of income for landless or unemployed people. Local NTFP markets encompass different types of small to medium size markets in the villages and peripheries of cities, village markets, special day week market of a locality, markets within neighbouring villages and local towns, roadside, junction selling points, and markets in the nearest large urban centres and cities. Consumers of locally marketed forest products are largely local people, poor urban residents or 'outsiders' such as tourists passing through an area. However, local markets tend to be relatively poorly acknowledged, under-appreciated and often neglected and considered as low profile markets compared with the timber products of the forest. Recognition and support of the all kinds of trade of forest related products are essential even at the local trade in NTFPs.

3.10 ENVIRONMENTAL SERVICES : LOCAL TO GLOBAL FOREST

Natural landscapes such as forests, grasslands, mangroves and wetlands as well as managed ecosystems provide a range of 'services' to sustain human welfare. Forests are very important, because, forests provide habitat for millions of species biodiversity on Earth. Approximately, one half of the world's forest carbon is found in boreal forests and over one

third in tropical forests (Mathews, et al, 2000). It provides ecosystem goods and services including nutrient cycling, climate regulation, and raw materials (Costanza, et al,1997). In terms of economic values, forests form the basis of a variety of industries including timber, processed wood and paper, rubber, and fruits. The production and manufacturing of industrial wood products contributed US $ 400 billion to the global economy, approximately 2 percent of the global GDP (Solberg, et al. 1996). Indigenous and non-indigenous people inhabit forests and depend on them for their livelihood and thus preserve the cultural integrity and values of these people. These people have strong cultural and spiritual attachments to the forests and understand how to conserve and use forest resources. Therefore, destruction of forests and their allocation to another area destabilizes the competence of these people to survive economically, culturally and spiritually. The appreciation of forest environmental services at local, regional and global scales will lead to better governance and sustainable use of ecosystem services. Thus environmental services provided by the forest may be discussed in three ways i.e ecological services, economic services and socio-cultural services. Forests provide consumption goods, regulate local and global climate, buffer weather events, regulate the hydrological cycle by intercepting rainfall and regulating its flow. Forests protect watersheds and their vegetation, water flows and soil quality, limit erosion and provide protection of soil against the direct impact of rainfall. They are the key component of biodiversity both in themselves and as a habitat for other species, seed dispersal, natural pest control, and provide a vast store of genetic information.

3.11 CONCLUSION

It is important to have forests in one's country, because they are useful in the life of man. Forest ecosystem delivers a wide array of products and services to the society. They supply all kinds of basic needs and raw materials for various developmental activities carried out at different levels in terms of wood (timber) and non-timber forest products. About one-third area of the land mass should ideally be under forest cover to keep ecological balance. Ancient people survived on forest resources for their food mainly by hunting and by gathering wild plants, and finding means for clothing and housing. At present many people (indigenous, tribal people) live in the forest and are a natural part of it. Development and civilization bring people to be settled in cities, but a large number of people still depend on forest for various products. Comparing to the ancient times, toady's people are mostly depend on forests especially for their economic, environmental and recreational needs. Therefore, management of forest for sustainable development and production is the primary role to be carried out in any region.

There are many potential approaches to the management of forests. Management systems are directed toward enhancing production of a mix of desired products or services from a forest ecosystem. Management objectives chiefly focus on production of timber or pulp, but also include wildlife habitat, watershed protection and erosion control, fuel wood, non timber forest products and forest grazing for livestock. Restricting human activities and keeping the forest area free from excessive human use are the most basic aspects of any forest management. More active forest management systems generally follow a plan of harvesting,

planting, protection and maintenance activities which are drawn up for the area of forest in question. Through these practices sustainable forestry can be achieved by correctly managing forest resources through replanting, conservation and protection from fire, disease and pollution. Commercial forests should not be made up only of one tree species - there should be a variety of trees and a layer of smaller plants (an 'understorey') to provide refuge for wildlife.

Forest management should respect all relevant laws of the country in which they occur, and international treaties and agreements to which the country is a signatory, and comply with all FSC Principles and Criteria. The National Forest policy 1952 stated that one third of the geographical area of the country should be under forest. Forest (Conservation) Act, 1980 was enacted with a view to checking indiscriminate de-reservation and diversion of forest land for non-forest purposes. This act was amended in 1988 to incorporate stricter penal provisions against violators. The basic objectives of the National Forest Policy of 1988 include conserving the national flora and fauna, meeting the needs of rural and tribal populations, and encouraging efficient utilization of all forest produce. The policy states that NWFPs which provide sustenance to local communities should be protected and improved. It provides for research into the conservation and management of forest resources and for increasing productivity through the application of modern scientific and technological methods. Considerable effort is needed for the successful forest management for sustainable development and ecological balance.

3.12 RECOMMENDED READING

1. Jerram, M. R. K. 2006. A Text Book on Forest Management: In Agriculture, Horticulture and Forestry. Asiatic Publishing House.
2. Negi, S. S. 2006. A Text Book of Forestry & Wildlife Management (Vol.1) International Book Distributing Co.
3. Lawrence, D.K., Norman Johnson, Pete Bettinger and Theodore Howard. 2001. Forest management To Sustain Ecological, Economic, and Social Values. .

3.13 PROBABLE QUESTIONS

Q1. Define forest. Explain the forest type of India.
Q2. What is forest management?
Q3. Can climate change be mitigated through forest management?
Q4. How can forests affect climate change?
Q5. What products are extracted from forests?
Q6. What are the economic and social benefits of forests?
Q7. What is sustainable forest management?
Q8. Do forests provide any environmental services? If so, explain.

DEM 102 NATURAL RESOURCES AND SUSTAINABLE DVELOPMENT CR 4

UNIT-4: WILDLIFE SUSTAINABLE MANAGEMENT

UNIT STRUCTURE

4.1 OBJECTIVES

After going through this unit, you will be able to:

- provide an introduction to wildlife conservation by exploring different topics.
- discuss the relationship between wildlife and their varied habitats.

4.2 INTRODUCTION

The concern for wildlife is, however, the concern for man itself. Human race can survive only by living in harmony with nature and explore it for optimum use.Wildlife is the organisms that live freely in the natural environment. In short, life existing in the wild is wildlife. Wildlife includes all non-domesticated plants, animals and other organisms. Domesticating wild plant and animal species for human benefit has occurred many times all over the planet, and has a major impact on the environment, both positive and negative. These wildlife species and numerous others provide us with beauty, recreation, economic opportunities, and maintain our quality of life by regulating and modifying how our ecosystems function. Wildlife need a place to live that we called as ‘habitat’ which is not just trees, shrubs, grass, or crops but a complex mixture of plant communities, water, soil types, weather, animals, and

other environmental features that provide the cover and food as they required. Wildlife habitats are directed by both natural occurrences and disturbances and cultural changes. It may vary in size from "macrohabitats" containing hundreds of acres of trees or crops to "microhabitats" such as the bank of a stream or a single boulder occupying only a few square feet. However, habitat requirements for wildlife change during the seasons. The food of wildlife consume during the winter season may not be the same as they have in the summer. There are four basic habitat requirements of wildlife such as food, water, usable space (the area required to accommodate necessary movements of an animal – for example: breeding range, brood range, fall feeding area), and cover (shelter or protection from predators, severe weather, etc.). All wildlife needs shelter to protect themselves from predators and, especially during winter, from severe weather. In general, all creatures need an extent of area to roam, and many species establish territories to defend from others of their kind, especially during the breeding season. This type of habitat requirement is called living space or simply, space. The exact needs and the arrangement of space and other set of specific requirements differ according to species. Here in this unit we will be largely focusing on wild animals as wildlife and their resources, values, management and societal values will be discuss.

4.3 WILDLIFE RESOURCES AND SOCIAL AND ECOLOGICAL VALUES

In India, wildlife resources are so rich and diverse, that a few places on the globe can be compared with it. Our country wildlife resources spread from rain forest of northeastern region to arid zone and fragile mountains of mighty Himalayas. The unique biogeographic position of the Indian subcontinent adds significance in the context of wildlife and its resource. In fact the location of Indian subcontinent at the confluence of Ethiopian, Palaearctic and Indo-Malayan realms bestow a number of interesting components from each of these realms as well as several peculiarly indigenous genera of faunas. Thus, the wildlife of India comprises the originality of our country's indigenous species as well as the species which migrated from elsewhere, which illustrate the mixture of Indian, Malayan, African and European elements.

4.3.1 WILDLIFE AS A RESOURCE:

Wildlife resource is a product of land and water, and anyone who owns land or is charged with its responsibility is a manager, or manipulator, of habitat. The resource of wildlife is determined based on the need and requirements of the people using the wildlife resources. Wildlife products are often major items of consumption or display and have high medicinal and spiritual values in many human cultures (Scoones et al., 1992).

Meat: Wild meat or animals flesh is the source of protein for the tribal or local people inhabitant in forest areas. They get such resources through hunting and killing birds and animals of their choice and availability. Dependence on meat protein by these people heavily depends on the wild meat, which they get regular supply from diverse wild animals. The diversified natural animal communities act as the major source of animal flesh/meat compared to the products rise forms the domestic animals for the purpose of meat. Wild meat serves the major source of protein particularly in hilly and countryside with vast areas of forest cover. But, speedy human population and decrease in forest coverage due to encroachment and other activities lead to decline of wildlife population that indicate alarming bell for the need of conservation of wildlife resource. Galo tribe of Arunachal Pradesh consumes some of the edible insects to serve a source of additional nutrients, particularly fats and proteins. Such insects are immensely important for this tribe (Kato and Gopi, 2009). Meat of wildlife provides significant calories to rural communities, as well as essential protein and fats (for a comprehensive review of the importance and role of wildlife in nutrition (Hladik et al. 1989, 1996 and Froment et al. 1996).

Animal's parts: Use of wildlife artifacts are integral parts of cultural heritage of large number of tribes, and are closely linked to social status, or believed to provide special or "magic" forces. Many parts and products of wild animals such as ivory, bone, teeth, skin, horns, antlers, hooves, fur, feathers, tails, musk, hide, bile, beak, etc. are used for various purposes such as for clothing, decoration, traditions used, household products, perfumes and many more. The use of ivory for jewellery items and embellishment items is very prominently recognized, feathers of peacock for decorative items and other items associated with the religion practice, horn of Rhinoceros for various purposes such as for medicine and others. Killing of wild animals for such parts is tremendously increasing with the increasing demands in local demands utilized for the gallantry, pride and recognition of higher status in the society of certain tribal peoples and the wildlife trade. In fact, increasing demands of these animals' parts and products are the roots causes of wildlife trade across the country.

Tourism: Country with rich diversity of flora and fauna has a great potential for wildlife tourism, where certain animals play a key role in attraction of tourism across the globe. Viewing or otherwise interacting with free-ranging animals in their own natural habitat is the main activities of the wildlife tourism. This business sector of wildlife is an important part of the tourism industries in many countries including India. It also provides a good platform for long term monitoring and general research relevant to conservation of wildlife and their

resources. Strengthening the protection and conservation of wildlife through protected areas like National Parks and Wildlife sanctuary helps wild animals to survive freely in their home range.

Gene Pool: Variety and variability's of wildlife present in the natural habitat serve as the natural gene pool of wildlife. Through proper investigation of a particular species we can determined how richness the gene pool of a particular species is. Larger the gene pool the more the extensive genetic diversity, which is associated with robust populations while, low genetic diversity have lower gene pool with low potential to increased biological fitness and have high chance of extinction. Wildlife serves as a gene pool and gene banks for development of breeding improved varieties of animals. Thus, the importance of preserving the existing genetic diversity of the wildlife and relatives of these species has been recognized. We need to maintain the genetic pool of wild animals such as gene banks in general and particularly to a very rich fauna of wildlife. Protection of wildlife is very important to maintain the ecological balance in the nature and also to preserve the gene pool. Since wild life contains different gene pools that may be considered as Nature's property; and its existence is important to keep running the natural processes, protection and preservation of wildlife is essential in the human interest.

Research and scientific: Wildlife and their habitat gives immense platform for the research and scientific development for the better conservation practice and finding drugs for the treatment of human health problems. Knowledge gained from research on wildlife provides many spin-offs that are of direct value to humans. Certain modern applied biology critically depends on the wildlife and their behaviour under their natural settings at definite environmental profile. Large numbers of research workers are engaged all over the world in conducting scientific studies on the wild animals to achieve different scientific aims and objectives. When any drugs of any diseases are invented, the research of its positive and negative effects is first carried on wild animals before administering on human body. Primates and large mammals are some of the wild animals that have utmost scientific interest for this concern due to certain similar characteristics and these species make it possible for us to understand and control human social and physical behavior.

Medicine: Wildlife provides some important components of traditional medicine. The medicinal value of animal parts is largely based on superstition and associated local beliefs of a particular tribe. Ethnozoology has direct relationship with animals/wild animals to mankind.

Medicinal uses pertaining to animals or animals products and their uses in traditional therapy by different tribes are well known in India. Tribal people inhabiting remote areas and from mainstream that lack of proper education and health care are very much unaware of modern physical treatments. So, they largely rely on natural resources that could meet their every bit of requirements for food and medicine. Large numbers of wild animals are used for the treatment of various common and uncommon health related problems or ailments. The knowledge that they have for harvesting and utilization of such wildlife resources as medicine is remain in oral tradition which pass on from one generation to another. Though, there is considerable report of variation in the hypothetical therapeutic value of different parts, organs and secretions of wild animals, such claims require thorough scientific study.

4.3.2 SOCIAL AND ECOLOGICAL VALUES

The values of wildlife for society are wide-ranging and diverse. It plays an important role in addressing many social demands. The use of wildlife has important livelihood aspects and serves multiple roles. Important social and cultural values are linked to foods and medicines derived from wild resources. Therefore while hunting provides meat and income it also remains an important social and cultural tradition for many peoples (both in developed and in developing countries). In many cultures to be a hunter is essential in gaining respect, achieving manhood or winning a bride. As a result, people hunt, even when they have alternative sources of nutrition or income (Young, 1970, Posewtz 1994, Bennet & Robinson 2000). These links between hunting, wildlife, religion, mythology, and sociology of forest-dwelling peoples have to be considered in conjunction with sound conservation and management plans (Bradley 2002).

Cultural value: In various cultures of the humankind, wildlife has occupied a special place of worship and preservation. This is because of having been forest-dwellers in the past, people have a deep evolutionary attachment to the nature, so nature worship is very inevitable. Wildlife is considered as a strong recognition for the popular culture and tradition of any country. The connection with the forest has given rise to gratitude and worship, which is very well revealed in social customs and rituals, art, literature and music as well. Historical monuments, caves, rocks and iron pillars had evidence for close association of wildlife and human's cultural and social association and it also shows an integral testimony when it is been reflected through age-old craving and paintings. Rich culture of India has certain traditional measures for protection of wildlife, e.g. Chanakya's game laws in *Arthashastra* in third century BC, religious value of trees, holy books containing edicts for conservation,

Ashoka pillar edict giving names of wildlife species to be afforded protection, Kalidas' *Abhyranya* pleading for wildlife protection etc.

Ethical value: The entire living being including human beings on the earth has the same right for their survival in their natural surrounding i.e. nature. Nature belongs to every one and it is not the custodian of a particular thing. Truly it is not reasonable to underestimate a plant against an animal, or animals as for human being. On the basis of certain qualities and characteristic features, human-beings claim themselves as superior to other. Ethically, we human beings should understand that we have no right on our planet to kill or destroy the other living creatures of the nature including wildlife. As human beings, we should realize that plants and animals also have a right to live on this earth and thus required proper ecological security for them. We should appreciate that any species of wildlife is a unique creation of nature and cannot be manufactured by man. A species once lost from the nature cannot be retrieved. It is very much unethical to be responsible for the destruction of a species. Thus the challenge for environmental ethics is to find a solid rational justification for why nature should be protected from human actions.

Aesthetic value: Wildlife has a great aesthetic value. Everyone loves to appreciate the beauty of wilderness and valued the tranquility of forest. India has got a varied and colorful natural heritage of wildlife consisting of simple and beautiful, some majestic and powerful, and magnificent and bountiful. This rich magnificence of wildlife heritages illustrate that our country has a great potential and opportunity of great aesthetic values of wildlife and also compels us to preserve the wonderful form of wildlife in nature. Interest and efforts for preservation and conservation of wildlife are coming from various ways since there are huge number of people who are in search of some moments of pleasure and mental piece of mind out of their busy routine of modern lifestyle in wilderness full of natural beauty. Worldwide, it is this aesthetic value that becomes more important and provides economic justification.

Commercial or economic value: Wildlife being a renewable resources act as a potential source of useful products of global economic interest. Wildlife is the source of food, medicine, and other wildlife products that are a source of tremendous economical gain. Wildlife resources constitute an important source of food for those people living in hills and forests. The medication used in the treatment of various ailments owes its origin to wild plants and animals rather than synthesized commercial chemical products. Products of global trade includes, musk, ivory, rhinoceros horn, fur of monkey, rabbit, bear, tiger, leopard, etc, wool,

skin, hoof, meat, bone, fats, bile salts, bone charcoal, bone glues, trophies, perfumes, cosmetics, medicines etc. Trade in wild life and its products are very profitable. Unchecked trade in wildlife products has considerably annihilated the rare wild animals. On the other hand, such trade also provides a way to meet the demands of scientific or educational institutions for research purpose. However, any trade of wildlife for the commercial and economic benefits should not be beyond its optimum-level and natural-balance should not be interfered.

Game value: Game value is a form of recreational value to those who hunt or fish for sport. This practice is the inherent of our kings and emperors who were famous for hunting and creating reserves for the purpose. But these practices in due course of time turn into a merciless and unscientific mass killing of certain majestic wild animals. In this regard, many businessmen earn considerable amount of money by providing needs of hunting like firearms or fishing tackle, camping equipment, recreational vehicles, or by providing accommodation, food or drink, thus earning revenue. At the same time government is also raising fund by providing licenses for fire arms, gun, etc. But all this game value is lessened after the amendment of Wild Life (Protection) Act 1972, amendment in1991.

Ecological value: The variety of life in itself has an enormous ecological value. Preservation of wildlife has its own meaning towards the understanding of its ecological significance. Terrestrial and aquatic plants and animals are closely linked to each other in terms of their habitat and food chain. The species diversity and types of ecosystems influences the productivity and services provided by the ecosystems. If any species is disturbed it results in disturbance to another and ultimately causes imbalance of the whole ecosystem. This ecological value is the intangible value that we cannot asses directly through any monetary value or direct benefits. It is very well recognized that existence of any species of our ecosystem is essential for the stability of environment. When the diversity of species in a given ecosystem evolves as a consequence of extinction or introduction of species, the capacity of the ecosystem to absorb pollution, maintain the fertility of soils and microclimates, purify water and provide other ecological services changes as well (World Resources Institute,1994). Wildlife has an obvious direct effect on the physiognomy of habitats. They also play an important role in seed dispersal and pollinisation of certain plants. While some of the wild animals and birds are used as indicators to determine the health of the environment.

4.4 BIOLOGICAL AND ECOLOGICAL PRINCIPLES GOVERNING WILDLIFE POPULATIONS AND THEIR HABITATS

Wildlife form important links in the transfer of food and energy in their natural habitat. Habitat size determines diversity and distribution of species, maintaining viable population and receiving sufficient amount of food requirements. All the components of nature i.e. biotic and abiotic components are responsible for successful regeneration of a particular species and maintaining the diversity of species with mutual interaction with the prevailing physical factors. These complex interactions of biotic and abiotic components of the ecosystem lead to verify whether the system is in balanced state or in imbalanced condition. Hence, protection of wildlife is very important to maintain the ecological balance in the nature and also to preserve the gene pool.

Biological and ecological principles governing wildlife populations and their habitats can be able discuss in different principles.

Principle 1: Large intact patches of native vegetation should be maintained by preventing fragmentation.

Wildlife population in natural habitats of a particular areas or landscape need to be inventoried or mapped thoroughly which should generate any fragmented or currently not fragmented patches. Larger patches of habitat should be protected in preference to smaller ones because habitat patch exerts a strong influence on wildlife population size. Possible effort should be given to minimize developmental activities within the areas in order to avoid fragmentation. Large intact patches of native vegetation are valuable for wildlife because such patches support large, persistent populations and provide habitat for a greater diversity of species compared to fragmented small patches. Moreover species diversity tends to increase asymptotically with increased patch area.

Principle 2: Priority for species protection should be formulated for the protection of habitats. Identification and ranking of species with reference to the priority demand for protection and conservation that constrain the distribution and abundance of those species. Variety of species, threats to persistence, economic and aesthetic value of the wildlife are some of the system for prioritization which can be used in combination with an understanding of local values to select a set of species that will receive particular attention in conservation efforts.

Principle 3: Protection of rare habitat elements for wildlife safeguard.

Inventory of wildlife habitats and vegetation within the area of interest is the basis of this principle. This is important because habitat types are distributed unevenly across an area where some are rare and some are having very common features. Such inventories act as a tool to identify certain unique patches such as wetlands, riparian zones, cliffs, or old growth

forest that are uncommon or are necessary to support rare or threatened species. Therefore, protection of such unique habitat elements from human intervention will definitely help to protect rare species of wildlife.

Principle 4: Connections among wildlife habitats should be maintain by identifying and protecting corridors for their movement.

Wildlife corridors need protection. Corridors are areas of the landscape that are more likely to be used for wildlife movement among habitat patches than other areas. We can determine and map the routes that are used by wildlife to move among habits by simply following then or observing movements with radio-telemetry or other techniques. Identification of corridors demands further investigation to understand the need of protection from blocking due to developmental activities like road/rail connectivity or illegal trespassing, etc. Because, blocking corridors reduce the area of habitat available to species; increase the likelihood of population extinction by reducing immigration; and exacerbate genetic problems that result from inbreeding.

Principle 5: Understanding the significance of ecological processes.

Protection of habitat will sustain the value of habitat and nature will cope up the sustainability is in fact true but there are certain ecological processes which need to be monitored and analyzed for the protection of wildlife. Several ecological processes such as grazing, fires, floods, drought, windstorms, etc have certain impact on habitat as well as population of wildlife. So it is necessary to understand how far these processes are responsible for disturbance and influences for maintaining wildlife within the landscape. Local communities should consult with private and public land managers and ecologists to identify which ecological processes are most important to the community's priority wildlife species, and to assure that those processes are sustained.

Principle 6: Protection of rare species by protecting their local habitat.

Across the regional or local area certain pockets of habitat for rare or sensitive species need to be identified. Such patches of habitats should preserve through local conservational plan involving the local people, especially if these patches of habitats contains a large proportion of the total habitat in the region. This principle reflects the concept of global thinking while acting locally by the local people and it contributes to the regional persistence of rare species by protecting some of their habitat locally.

Principle 7: Regulation of recreational use of wildlife by the public with the habitat needs of wildlife.

Balance the opportunity for recreational use of protected habitat on public land to minimize impacts on sensitive species. Indirectly it demands the protected areas remain restricted for high intensity of recreational purpose. It has been stated that frequent human recreational activity can disturb wildlife populations and their habitat in such a way that they will fail to thrive in profoundly disturbed areas. It is necessary to develop a wise mechanism in comprehensive conservation plan so that there would be limited recreational human activities that are appropriate for wildlife protection and some more protected areas may be open for recreation use with certain limitation.

4.5 THE VALUES AND ECOLOGICAL FUNCTION OF WILDLIFE – SPECIES, POPULATIONS, COMMUNITIES AND ECOSYSTEMS

The values and ecological function of wildlife has been discussed above in section 4.3 (Wildlife resources and social and ecological values). Now in order to understand the levels of community structure we need to study what does species, populations, communities and ecosystems mean and what are their functional roles. Biodiversity at genetic, species, population, community and ecosystem levels contributes to maintaining the ecological functions and services.

Species: Species is a group of organisms or individuals that are morphologically, physiologically, or biochemically distinct and that can potentially interbreed among themselves and do not breed with individuals of other groups and produce fertile offspring. Larger the number of species diversity of a particular area the higher the multiple source of accessible ecological services and complex successional role. All species are closely linked with each other in one or different ways of the biophysical processes along with the prevailing physical condition. And each species has a definite functional role in the ecosystem. Like some of the species provide *provisioning services*, i.e. food, water, minerals, drugs and energy while some of the species serves as *regulating services* by pollination, pest and disease control, purifying water and air, decomposing waste and detoxifying toxic substances etc. Similarly several wildlife species has given *cultural and supporting services* in addition to the provisioning and regulating services. With due acknowledgement of the services and functional role as the species provide to us we need to protect and conserve each and every species where they exist because loss of species will affect the total ecosystem function.

Population: An assemblage of individuals of a particular species occupying a definite habitat, in which the individuals interact, interbreed and exchange genetic information, is referred to as population. From wildlife point of view, it may be defined as 'Productivity added to the number of original individuals is the Population". Wildlife population depends on the interaction of two forces namely, breeding-potential which means the capacity to produce offspring irrespective of their survival to maturity and environmental-resistance; any resistance (disease, starvation, enemies, unfavorable weather conditions, accidents and non-breeding) that does not allow expansion of species. Population is affected by three dynamic rate functions viz, birth rate (natality), growth rate and death rate (mortality). In general population growth or expansion exhibit rapid increase in the young stage leading to gradual increase in adult and finally declines towards the age-old stage giving stable state. Population management is a major concern for the wildlife management with the increase of wildlife exploitation for different purpose. It becomes a challenging task for the management to maintain a viable population size of a species in a particular habitat satisfying all the basic requirement and protection from human intervention.

Community: Community is larger unit than the population constituting several characteristics that are not found in the species and population. Community is described as group of populations or group of species (similar or dissimilar) living together with mutual tolerance and beneficial interaction and interacting with each other in an area under more or less similar natural environmental conditions. A community or biotic community consists of the populations of plants and animals living together in a given place. It is association of organisms living naturally in the same area of habitat and whose members share a degree of interdependence. The species or population within a community influence each other and with their physical environment to form an ecosystem where they determines their distribution, abundance and evolution. Assessment of wildlife communities is a complicated job where one has to monitor thoroughly for a longer period of time. It requires considerable effort, certain tools and technique to understand the interaction of different populations and to establish the mutual tolerance and beneficial interaction among the populations in a particular habitat.

Ecosystem: An ecosystem is generally defined as a community of organisms living in a particular environment and the physical and chemical factors with which they interact and involves exchange of energy and materials. An ecosystem is an open system (functional unit) resulted from the interactions of abiotic (soil, water, light, inorganic nutrients and weather),

biotic (plants, animals, and microorganisms usually categorized as either producers or consumers), and cultural (anthropogenic) components. The boundaries of an ecosystem are not set in any ideal way, although sometimes it has seemed understandable, as with the shoreline of a small pond ecosystem. Usually the boundaries of an ecosystem are chosen for rationally on practical grounds having to do with the goals of the particular study otherwise all types of ecosystem irrespective of their shape and size, whether terrestrial or aquatic are closely linked with their structural and functional attributes. Studying wildlife ecosystem should try to analyzed the major abiotic and biotic factors that determined the health and regeneration potential of the wildlife population. It needs to understand the effects of wild fire, rainfall, wind storm, drought, etc to the survival of wildlife. At the same time, observation on biotic process such as role of predators, role of keystone species, anthropogenic disturbance will help to sustain the conservation practice of wildlife at ecosystem level. Biotic (anthropogenic) disturbances had direct (hunting, encroachment) and indirect (transfer of disease to wildlife) effects in ecosystem. Biotic processes can modify abiotic effects because cattle grazing have altered the extent of burning. Conventionally, linkages were understood to be unidirectional; that is, the biotic realm is built on a foundation of predetermined abiotic processes. These observations on the both linkage between biotic and abiotic, for example grazing and fire, processes have increased our understanding of ecosystem processes for wildlife. Such understanding is required because we all depend directly or indirectly on the products and services of ecosystems, including crops, livestock, fish, wood, clean water, oxygen, and wildlife.

4.6 MANAGEMENT OF WILDLIFE POPULATIONS AND THEIR HABITATS FOR SOCIETAL GOALS

"Wildlife Management" is the science and art of monitoring the numbers of animals in various wildlife populations, and then making adjustments to the populations and their habitats in order to keep the populations at healthy levels over a long time. It is based on understanding how animals, their environment and people interact. Some of the tools used by wildlife managers include habitat protection and improvement, harvest regulations (hunting seasons and bag limits) and wildlife protection (harvest restrictions, refuge areas, etc.). There are some differences in different definition of wildlife management but the three common ideas that are present in every definition, includes; efforts directed toward wild animal populations, relationship of habitat to those wild animal populations, and manipulations of habitats or populations that are done to meet some specified human goal.

The goal of wildlife management is to increase populations but can also decrease or sustain them and allow the wise use of wildlife resources, while ensuring that wildlife populations do

not become threatened, endangered or extinct. It also includes providing the best possible habitat for a particular featured wildlife species. It is necessary to comprehend the quality of the available habitat and the animals that depend on that habitat to survive. Improving habitat for a particular kind of wildlife means understanding what the animal needs to live. It also means knowing how changing habitat may increase or decrease one kind of wildlife.

The concern for wildlife is, however, the concern for man itself. All forms of life i.e. human, animal and plant are closely interrelated that any disturbance in one form of life carries to imbalance in the other's form of life. Societal goals in wildlife management include conservation, preservation, consumption, and non-consumptive objectives. However, it varies widely as a function of a multitude of factors. This variation in goals is related to the variation among societies in the goals of each individual. In general, biological survival for food clothing and water is the most basic goal and spiritual tranquility the most advanced goal. In between it sees the health, safety and security of individuals.

Wildlife management is the legal responsibility of the state government through concerned state departments and several federal agencies. Wildlife management in our country is carried out by applying certain ecological and biological principles for maintaining and increasing our wildlife. A sound knowledge of ecological and biological fundamentals is an essential pre-requisite for wildlife management. And understanding of species biology and application of ecological principles are crucial to successful wildlife management. These days, wildlife management is not a concern for a few related subjects but it has become an integrated science using multidisciplinary subjects of different background.

4.7 CURRENT WILDLIFE MANAGEMENT ISSUES AND CONSERVATION PLANS IN INDIA

Wildlife conservation aims to halt the loss in the earth's biodiversity by taking into consideration ecological principles such as carrying capacity, disturbance and succession and environmental conditions such as physical geography, pedology and hydrology with the aim of balancing the needs of wildlife with the needs of people. Wildlife conservation means to make use of wildlife through sustainable harvesting, hunting, trapping and fishing while making certain populations of wildlife remain healthy around for the future generation to enjoy and study and also to recognize the importance of wildlife and wilderness lands to humans. Important issue is that every hunter should be a wildlife conservationist, someone who makes use of individual animals, but who also cares deeply about the welfare of wildlife

populations. Conservation and protection of wildlife is being done in two ways i.e. '*ex-situ'* and '*in-situ'*. *Ex-situ* conservation is the conservation outside the original habitat of organisms whereas *In-situ* conservation means conservation in the original natural habitat or surrounding. The protection and conservation of wildlife in National Parks, Sanctuaries, Nature Reserves, Cultural landscapes, Biosphere Reserves is called '*in-situ'* protection and conservation. While conservation and protection efforts specified in Zoological parks, botanical gardens, culture collections, genetic resource centres etc. is called as ex-situ conservation.

Wildlife management plan: To achieve the aims and objectives of the wildlife management, a wildlife management plan is logical to prepare. There are three basic components associated with the plan i.e. wildlife population, wildlife habitat and people. Information regarding the same may be obtained through inventory, census and revenue procurement. Specific genetic and ecological feature and their significant role in the wildlife function and attribute are needed to be recognized before establishing a proper managements plan for a particular wildlife species or a group pf species. Wildlife habitat management plans can be prepared in a variety of ways depending on available resources. Management plan can involve increasing, decreasing, or maintaining current numbers and density of different species of wildlife. For developing management plan one should comprehend about the resource inventory that is wildlife food and habitat needs, movement patterns and restrictions and site specific habitat improvement recommendations. One should be confident to recommend habitat management measures that will make the required improvements to the existing habitat; and record keeping and evaluation of management efforts and their impacts on wildlife habitat. Identification of the species to be managed and understanding their current limiting factors in terms of required habitat components, supply of food and other disturbance that threat the population is need to be articulated for consistent management plan. A carefully developed plan provides a rational approach for using a variety of habitat improvement practices.

4.8 SUMMING UP

Man's activities for development may have profound influence on the life on earth. The value of wildlife and their resources has been well conscious by our ancestors to meet all their basic needs in early days. Otherwise also now-a-days wildlife and their habitat plays very important role for the limited aesthetic and touristic aspects. In earliest times harnessing of natural resources by human race for the survival was in harmony with nature and utilization was within optimum limit. But in due course of time, with increasing population and demand of resources a tragedy has arisen for nature where wildlife and their habitat are extensively threatened. Maintaining important habitats are essential to the preservation of species and

characterizing habitats and understanding wildlife requirements is necessary for making decisions that could affect species or habitats and for evaluating potential impacts of proposed activities. However, most habitats are not stable, and they change over time naturally. Such changes are readily recovered or restored within the constructive period of time. But the changes induced by the human intervention are a great concern for the conservation and management programme of wildlife. Spatial and temporal massive exploitation of wildlife resources and hunting of wild animals in different ways had major impact on species composition, habitat, population dynamics and overall tier survival. Control of hunting and illegal exploitation or unsustainable exploitation of resources of wildlife resources has been a tough experience in front of the conservationist. Mitigation of hunting is another big intricate situation since there is no universal solution to solve the problem of unsustainable hunting.

Protection of wildlife for the longer term benefits may be achieved through safeguarding gene banks or for scientific investigations or for purely aesthetic reasons. However, overall protection and management actions may include a monitoring and feedback mechanism, a process to ensure that management is achieving its goal of ensuring sustainability of harvest, and sustainable livelihoods of local communities. Continuous learning to evaluate wildlife habitat may provide an excellent way to increase understanding of wildlife ecology and management practices. Thus, a usable and flexible proper management plans is crucial to develop which incorporates the habitat management activities to increase cover or shelter type, to maximize wildlife health and diversity with the sustainable use of wildlife resources for the benefit and development of nation.

4.9 RECOMMENDED READINGS

1. S. K. Singh. 2005. A text book of Wildlife Management. International Book Distributing Co. Lucknow, India. P.p. 519.
2. B. B. Hosetti. 2008. Concepts in Wildlife Management. Daya Publishing House, New Delhi. pp. 433.
3. R. Gopal. 1993. Fundamentals of Wildlife Management. Justice Home, Allahabad. Pp. 668.
4. Raymond F. Dasmann. 1982. Wildlife Biology. Wiley Eastern Limited. Nataraj Publishers, Dehradun. Pp. 212.

4.10 PROBABLE QUESTIONS

Q1. Define the following:

Species, Populations, communities, ecosystems, wildlife and conservation

Q2. What is wildlife conservation? Why is wildlife conservation so important?

Q3. What does wildlife habitat mean?

Q4. Why do we need to look after nature?

Q5. What are the basic requirements of habitat?

Q6. What is wildlife resource? Describe the social and ecological values of wildlife resources.

Q7. Explain the biological and ecological principles governing wildlife populations and their habitats.

Q8. Write a brief note on ecological function of wildlife.

Q9. What is wildlife management?

Q10. Discuss the current wildlife management issues.

DEM 102 NATURAL RESOURCES AND SUSTAINABLE DVELOPMENT CR 4

UNIT-5: LAND MANAGEMENT

UNIT STRUCTURE

5.1 OBJECTIVES

After going through this unit, you will be able to:

- Discuss land degradation-a major global issue of the present century
- discuss the ways to combat land degradation
- get an idea about the prevailing land management systems of India
- develop an understanding of the sustainable land management system.
- develop an integrated approach to land management.

5.2 INTRODUCTION

Land is a finite natural resource and one of the single most important ingredients for any development in the world. It comprises soil, minerals, water and living creatures. In an ecosystem, these components of land are always present in an organized way which helps to provide a variety of services essential for productive capacity of the environment in an ecosystem. Land is our most important natural wealth as we get the primary needs of living like food, clothing and shelter from the land itself. The most easily categorized varieties of land from the utility point of view are - land fit for use, land with potential for use and land

which appears useless at least in the foreseeable future. Land suffers from varying degrees and types of degradation. According to the latest estimate it appears that most of our land is degraded, is undergoing degradation or is at the risk of getting degraded. Both developed and developing countries are facing this problem. Degraded land can be defined as a land that is decreasing in quality and productivity as a result of disturbances either by nature or human activities through a series of degradation processes which interacted physically, chemically and biologically (Lal, 1995). Agricultural cultivation is generally abandoned in such land. Abandonment usually comes only after the soil has been eroded and its fertility is so depleted that further attempt at cultivation is hopeless. The thermodynamics of soil system suggests that it is easier to degrade soil than to restore it, and degradation occurs at a far more rapid rate than reclamation (Patiram, 2001).On the global basis, the land degradation is caused primarily by overgrazing, agricultural activities, deforestation and industrialization. This leads to soil erosion, salinization, nutrient depletion and desertification problem. The rate of degradation has increased dramatically with the growth in human populations and technology. Among the different categories, lands under cultivation face the biggest problem followed by grazing land and pastures, forests, barren lands and uncultivable lands in decreasing order. The effects of land degradation are not restricted to the soil alone, but have a number of off-site implications. Soil erosion, for example, is often associated with increased incidence of flooding, siltation of rivers, lakes and reservoirs and deposition of mineral in low-lying areas. These problems may be compounded in areas where infiltration capacity is reduced due to compaction, hard setting or indurations of soils. The extent of land degradation is influenced by a number of factors, many of which are interrelated, namely, soil characteristics, relief, climate, land use and socio-economic and political controls so, in the present context land management is an important topic of discussion. Land management can be defined as the process of managing the use and development of land resources. The approaches adopted to manage land can be categorized under two different head e.g., 1) Sustainable land management approach and 2) Integrated land management approach. The land management, whether at a global, regional or local scale, is clearly a complex issue and can be considered as one of the most challenging environmental problems. The problem requires a holistic, multidisciplinary approach involving the collaborative and co-coordinated efforts from all spheres of the society.

5.3 MANAGEMENT OF DEGRADED LAND

5.3.1 MANAGEMENT OF ERODED LAND

Of various factors of land degradation, soil erosion and sand/silt deposition are important factors responsible for land degradation. Soil erosion may take place due to various factors e.g., climate, topography, soil characteristics, wind ,etc. Soil erosion, either by wind or water, can cause substantial declines in productivity and soil quality due to loss of the topsoil. Erosion can also adversely affect water and air quality due to off-farm transport and deposition. Excess rainfall and flooding directly or indirectly elevate the degree of soil degradation. Soil erosion and subsequent deposition have significant impact on soil health as new soil profiles are created which may have completely different physical and chemical characteristics than the pre-flood soils. Affected land should be retested and nutrient management plan should be based on these results. Soil structure and its stability are important in determining the productive potential of a soil as they govern the soil water

relationship and many important processes including aeration, infiltration, permeability, runoff, leaching losses of plant nutrient, etc. In this respect soil organic matter plays an important role in vegetation recovery in flood degraded wasteland which is poorly structured, low in fertility and susceptible to erosion.

Vigorous vegetation ground cover is strongly recommended where heavy soil erosion occurs due to run-off water. Splash erosion can be controlled by mulching, or by leaving the residues of harvested crops on the soil surface. Rill and gully erosion can be controlled by terracing or by placing other barriers parallel to the slope such as contour strips planted with different species of grass. Contour ploughing and minimum tillage are also effective against soil erosion. Water management in flood degraded lands forms an integral part of crop production system where heavy silt deposition occurs during post flood period. The low water holding characteristics of such waste land can be improved by irrigation. The time, rate and the frequency of irrigation also determine the effectiveness and efficiency of water use by plants in flood degraded lands. Biological reclamation is another option for improving function and productivity of degraded ecosystem (Hidayati, 2002). It includes all processes that help reverse these degraded lands and return the land to a stable and more productive condition dominated by vegetation.

5.3.2 RESTORATION OF ORGANIC MATTER IN ERODED LAND

a) Green leaf manuring: Organic matter can be generated by raising fast growing leguminous trees that provide abundant foliage. This approach to generating foliage can be termed as a self-sustaining farming system wherein the green foliage generated in a part of the farm can be used to meet the nutrient requirement of the other crops.

b) Ley farming: Ley farming involves rotation of legume forages with cereals. Inclusion of legumes in cropping system improves soil fertility. In order to make lay farming practically feasible, different segment of the degraded wasteland can be devoted to raise legumes in rotation. Thus forage needs of animal are met and soil fertility is also maintained.

c) Processing organic materials for nutrient enrichment: Through vermicomposting or its inoculation with microorganisms and the quality of organic matters can be enriched as it concentrates the nutrients in the end product. Vermicomposting acts as a slow release source of N for plants as it decomposes. Moreover, it is an excellent source of trace elements. Generally the biochemical activities of the established microbes and the worm

exudates have stimulatory effects on plant growth. Regular application of vermicompost to the flood degraded land may improve the chemical, physical and biological properties of the soil.

d) Biofertilizer: Biofertilizers (BF) are microbial inoculates, which enhance crop production through augmenting the nutrient supply to the crop. There are a number of microbial inoculates with possible practical applications in flood degraded lands. The N-fixing organisms relevant to rain-fed agriculture are ; *Rhizobium* which fixes nitrogen in a number of pulse crops, groundnut, soybean and N-fixing trees; Azotobacter and Azospirillum which are non symbiotic and associative symbiotic organisms respectively. They are useful in promoting plant growth through N-fixation and recreation of hormones in the root zone.Phosphate solubilizing microorganisms is heterotrophic and known to have the ability to solubilize the inorganic phosphorus in to soluble forms by releasing a variety of organic acids. A group of rhizobacteria that exerts a beneficial effect on plant growth is referred to as plant growth promoting rhizobacteria (PGPR) and believed to improve plant growth by colonizing the root system and supporting the rhizosphere microorganisms.

e) Agroforestry: Agro forestry farming system is a sustainable land management system where trees and crops can be grown simultaneously which increases yield. Agroforestry land use system may play a significant role in soil and water conservation in flood degraded wastelands.

5.4 MANAGEMENT OF POLLUTED LAND

Soil gets polluted in a number of ways. The major kind of soil pollutions and their management are described bellow:

a) Acidification: Acidification has a number of natural and anthropogenic causes. The main natural causes are natural weathering and organic decay processes which results in the formation of both acid and base forming chemicals. The base forming cations (Ca^{2+}, Mg^{2+}, etc.) are released from rocks and minerals as they break down. As these acids disassociate, they become direct source of hydrogen ions. In recent times, these long-term natural changes have been increasingly augmented by changes stemming from human activities; rapid increases in human populations, along with widespread industrialization have significant impact on soil pH. For instance; i) use of chemical fertilizer –which have stimulated remarkable increases in global food supplies, have

also brought about significant changes in soil pH. The widely used ammonium-based fertilizer, such as $(NH_4)_2SO_4$ and $(NH_4)_2HPO_4$, are oxidized in the soil by microbes to produce strong inorganic acids which in turn provides H^+ ions that result in lower pH values. Acid rain is a significant worldwide source of nitric and sulfuric acids. Nitrogen and sulfur containing gases are emitted into the atmosphere from the combustion of coal, gasoline and other fossil fuels, as well as from the burning of forests and crop residues. These gases react with water and other substances in the atmosphere to form HNO_3 and H_2SO_4 that are then return to the earth in the rainwater .This precipitation is called acid rain. Acid rain is particularly worrisome in humid forested areas near urbanized and industrialized sites that provide the S and N containing pollutants have also brought about significant changes in soil pH. During plant growth nutrient base cations are obtained through root systems in exchange for H^+ ions, thus leading to increased soil acidity. Nitrification is an oxidative process of organic decomposition whereby NH_4^+(ammonium) ions are converted to NO_3^- (nitrate) ions by nitrifying bacteria with H^+ as a byproduct. The main anthropogenic causes of acidification include certain land use practices, such as needle-leaf aforestation-which produce very acidic litter. Because of their high canopy surface area, needle-leaf trees are able to scavenge acid pollutants from the atmosphere. Soils vary dramatically in their ability to buffer activity, a characteristic known as the buffering or acid neutralizing capacity.

There are a number of approaches to the management of land having acidification problem. They include i) Liming ; ii) Sensible forestry management, and iii) Reduction of acid emission in to the atmosphere. Liming materials most commonly used include ground limestone, chalk and basic slag. The main active constituent being $CaCO_3$ (calcium carbonate) other minor components includes quicklime (CaO), Slaked lime $Ca(OH)_2$ and $MgCO_3$. Lime requirement of a soil varies depending on its buffering capacity and is usually expressed as the amount of $CaCO_3$ (t ha^{-1}) required to raise the pH of the top 15cm of the soil to the desired value. The maintenance of satisfactory soil fertility levels in humid regions depends considerably on the judicious use of lime to balance the losses of calcium and magnesium from the soil. Liming not only maintains the levels of exchangeable calcium and magnesium but also provides a chemical and physical environment that encourages the growth of most common plants. Soil acidification can also be reduced by improving the nitrogen management in crops. This can be obtained by,-

i) Sowing productive perennial pastures and avoiding overgrazing

ii) By using less acidifying nitrogenous fertilizers

b) Stalinization and sodification: This type of soil dominate arid and semi arid regions of the world, where more than half of the world arable lands are found. In these areas salt accumulate naturally because there is insufficient rainfall to flush them from the upper soil layers. Another important source is fossil deposits of salts laid down during geological time in the bottom of now extinct lakes or oceans or in underground saline water pools. Irrigation also induced soil salinity if the irrigated water contains appreciable amount of salt. In cities where deicing salts are used in abundance during winter months-can result in salinity level sufficiently high. The reclamation of saline sodic soil requires two major actions- i) The removal of excess soluble salt by leaching from the upper level of the soil profile. and ii) The removal of excess exchangeable sodium ions first from the exchange complex by replacing the Na^{+} ion with either Ca^{+2} or H^{+} ions and then from the soil solution by leaching the replaced Na^{+} ion from the soil. Once such soils have been reclaimed, prudent management steps must be taken to be certain that the soil remain productive. For example, the number and timing of irrigation episodes help to determine the balance of salts entering and leaving the soil. Likewise the maintenance of good internal drainage is essential for the removal of excess salts.

c) Agrochemical pollution: In recent decades, the use of inorganic fertilizers has increased dramatically at the expense of more traditional organic nutrient treatments. Agrochemical includes all the chemicals like pesticide, fungicide neaticide, weedicide, insecticide, etc. which are commonly used to protect the crop from pest and diseases These inorganic fertilizers are used in preference to organic treatments because the nutrients are in a more readily available form and are released rapidly after applications. Once the land is polluted with agrochemicals, it is very difficult to manage that land. Therefore, emphasis should be given so that the there is least exposure of land towards agrochemicals which includes,-i) The adoption of proper legislation such as “keeping watch on agrochemicals”-a strategy for management of agrochemicals and National action planning tools for its implementation by which we can reduce the use of chemicals in the soil ii) Some of the heavy metal polluted soil can be reclaimed by using the technique of phytoremadiation. In terms of management and remediation of the environmental problems associated with pesticide use, attempts have been made to model the behaviour of pesticides in soils under different

management regimes, with a view to reducing the risk of ground and surface water contamination. In addition, the use of granular slow-release pesticides is being explored, together with ultra-low volume application techniques. By adopting alternative, non-chemical strategies of pest, disease and weed control, the problem of land degradation can be eliminated. These include direct approaches, biological and cultural methods and habitat removal. Direct approaches are aimed at clearly identified animals and plants and specific practices include hunting and hand-weeding. Biological methods involve the use of predatory species, preferably with a wide environmental tolerance range, to control the specific target organism.

d) 5.4 Land Management System in India

The negative effect of land degradation has a great impact on India's environment and economy. Land management is the process of managing the use and development (in both urban and rural settings) of land resources. Land resources are used for a variety of purposes which may include organic agriculture, reforestation, water resource management and eco-tourism projects. Unfortunately in India, land management system is in the state of gross mismanagement. The country's extensive agricultural as well as non-agricultural land management system has collapsed. Of the country's total 142 million hectare cultivated land, 57 million hectare, 40 per cent of the total, is irrigated and the remaining 85 million hectare is rain fed. Of the total geographical area of 329 million hectare, about 146 m ha is classified as degraded, although varying estimates have been provided by different agencies. As generally agreed, the resources have been degrading fast, costing 11 to 26 per cent of the GDP during the 1980s and 1990s. Land distribution is highly skewed, more than 80 per cent of the farmers are small, marginal and sub-marginal and together own about 40 per cent of the total cultivated land, and increasing proportions of the holdings are becoming uneconomical. The soil health has been deteriorating, especially widespread micro-nutrient deficiencies (hidden hunger) and fast depleting carbon content, resulting in low and decelerated TFP growth rates.

In India, we have 264 million hectares of land fit for vegetation, but of this 142 million hectares of land is cultivated and managed by private land owners. The balance 122 million hectares is uncultivated public lands, comprising 67 million hectares under the forest department and 55 million hectares under various other public authorities, which include state revenue department, panchayats and other local bodies. These publicly held lands are the most valuable source for forest products like timber, pulp, fuel wood, and fodders etc., which are the life line to the rural as well as urban population. Additionally, these are the lands which are maintaining ecological balance throughout the country. But the pathetic state of

affairs in land management and utter confusion due to the outdated laws and regulations are doing much harm to our national wealth. Even after centuries, the laws governing the various aspects of land holding and use have not changed or modified to cope with present day needs. The outdated laws and corrupt officials are the biggest hurdle in the way of land development. The state forest department, which owns well over 67 million hectares of land, is totally incapable of managing the forest lands.

5.4.1 MANAGEMENT PROBLEMS

- Common property land resources*:* Common property land resources that are under collective management are often subject to degradation due to lack of clearly defined ownership rights. In India approximately 77 million hectares are common property land resources.
- Integrated approach to planning and management: Agenda 21 envisages an integrated approach to planning and management of land resources to ensure its greatest sustainable use with due consideration for social, economic and environmental issues. This integrated approach aims to :
  - -Review and develop policies to support the best possible use of land and sustainable management of land resources.
  - -Improve and strengthen planning, management and evaluation systems and institutions for land and land resources not later than 2000.
- Land use change: Land use change through industrialization, expansion of agricultural land, urban growth and development of transportation networks will accelerate the process of land degradation. Recognizing this problem, it is suggested to promote appropriate environmentally-sound physical planning and land use practices that contribute to conservation and sustainable use of natural resources.
- Combating land degradation and deforestation: There is need to combat land degradation and desertification and adopt preventive measures in vulnerable areas and rehabilitation of moderate to severely affected areas. This would involve introduction of :
  - Improved land use policies
  - Appropriate environmentally sound and economically feasible technologies
  - Improved land, water and crop management measures
  - Participatory management of natural resources

- Stakeholder participation and awareness creation: It is imperative to ensure active stakeholder-land users, government, executing agencies, NGO's participation in planning and implementing land development programmes and creating awareness about the implications of land degradation and desertification. The role of local communities and their initiatives should be recognized.
- Strengthening knowledge base and developing information and monitoring systems*:* There is need for an integrated information system on land resources for systematic observation of the dynamics of land degradation, desertification and drought processes. There is also need for strengthening of the systematic observation networks to monitor desertification and land degradation and to develop national information systems.
- Legislation, policies, programmes and other initiatives*:* The constitution of India enables the Central Governments and states to enact laws for the preservation and conservation of natural resources. Article 39 (b) and (c) of the Directive Principle of State Policy lays down as the duty of the State and the Centre to develop natural resources for common good. There is a constitutional provision for the involvement and participation of the people at local level for participatory planning and decision making. The eleventh schedule (Article 243-G) of the constitution pertaining to land improvement, implementation of land reforms, land consolidation and watershed development and management under powers, authority and responsibilities of panchayats (rural local bodies).

Besides the above constitutional provisions, there are many policies and programmes in India that promote sustainable development and management of land resources. For combating desertification, the programme is aimed at helping the member parties strengthen their existing infrastructure for tackling desertification and identifying gaps in knowledge and existing data. Six thematic networks have been identified for regional cooperation. These are:

- Desertification monitoring and assessment
- Agro-forestry management and soil conservation in arid, semi-arid and dry sub humid areas
- Range and pasture management in arid areas with particular emphasis on controlling shifting sand dunes
- Water resources management for agriculture in arid, semi-arid and dry sub humid areas

- Drought preparedness and mitigation in the context of climate change
- Strengthening planning capacities for drought management and controlling desertification.

5.4.2 SUSTAINABLE LAND MANAGEMENT

One out of every three people on earth is in some way affected by land degradation. The latest estimates indicate that nearly 2 billion ha of land worldwide – an area twice the size of China – are already seriously degraded, some irreversibly. This includes large areas of cropland, grassland, woodland and forest areas whose degradation reduces productivity, disrupts vital ecosystem functions, negatively affects biodiversity and water resources, and increases vulnerability to climate change.

Sustainable land management (SLM) is crucial to minimizing land degradation, rehabilitating degraded areas and ensuring the optimal use of land resources for the benefit of present and future generations. SLM is based on four common principles:

• Land-user-driven and participatory approaches;
• integrated use of natural resources at ecosystem and farming systems levels;
• Multilevel and multistakeholder involvement; and
• Targeted policy and institutional support, including development of incentive mechanisms for SLM adoption and income generation at the local level.

Its application requires collaboration and partnership at all levels – land users, technical experts and policy-makers – to ensure that the causes of the degradation and corrective measures are properly identified, and that the policy and regulatory environment enable the adoption of the most appropriate management measures. SLM is considered an imperative for sustainable development and plays a key role in harmonizing the complementary, yet historically conflicting goals of production and environment. Thus one of the most important aspects of SLM is this critical merger of agriculture and environment through twin objectives: **i)** maintaining long term productivity of the ecosystem functions (land, water, biodiversity) and **ii)** increasing productivity (quality, quantity and diversity) of goods and services, and particularly safe and healthy food.

5.4.3 SUSTAINABLE LAND MANAGEMENT UNDER CLIMATE CHANGE

The relationship between land degradation and sustainable land management and climate change are complex and multidirectional. They can be described as-

i) Climate change effects on land management and land degradation

ii) Climate change may offer new opportunities for sustainable land management by enhancing rainfall and growing periods.

iii) Land degradation increases vulnerability of people to climate variability and change by reducing average agricultural productivity and incomes

iv) Sustainable land management can reduce vulnerability to climate change and increase people's ability to adapt and in many cases can contribute to climate change mitigation through improved carbon sequestration and reduced green house gas emission.

5.5 INTEGRATED APPROACH TO THE PLANNING AND MANAGEMENT OF LAND

5.5.1 MANAGEMENT-RELATED ACTIVITIES

A) Developing supportive policies and policy instruments to support the best possible land use and sustainable management of land resources. Particular attention should be given to the role of agricultural land. To do this, they should:

- Develop integrated goal-setting and policy formulation at the national, regional and local levels that takes into account environmental, social, demographic and economic issues;
- Develop policies that encourage sustainable land use and management of land resources and take the land resource base, demographic issues and the interests of the local population into account;
- Review the regulatory framework, including laws, regulations and enforcement procedures, in order to identify improvements needed to support sustainable land use and management of land resources and restrict the transfer of productive arable land to other uses;
- Apply economic instruments and develop institutional mechanisms and incentives to encourage the best possible land use and sustainable management of land resources;
- Encourage the principle of delegating policy-making to the lowest level of public authority consistent with effective action and a locally driven approach.

B) Strengthening planning and management systems to review and, if appropriate, revise planning and management systems to facilitate an integrated approach. To do this, they should:

- Adopt planning and management systems that facilitate the integration of environmental components such as air, water, land and other natural resources, using landscape ecological planning (LANDEP) or other approaches that focus on, for example, an ecosystem or a watershed;
- Adopt strategic frameworks that allow the integration of both developmental and environmental goals; examples of these frameworks include sustainable livelihood systems, rural development, the World Conservation Strategy/Caring for the Earth, primary environmental care (PEC) and others;
- Establish a general framework for land-use and physical planning within which specialized and more detailed sectoral plans (e.g., for protected areas, agriculture, forests, human settlements, rural development) can be developed; establish inter-sectoral consultative bodies to streamline project planning and implementation;
- Strengthen management systems for land and natural resources by including appropriate traditional and indigenous methods; examples of these practices include pastoralism, Hema reserves (traditional Islamic land reserves) and terraced agriculture;
- Examine and, if necessary, establish innovative and flexible approaches to programme funding;
- Compile detailed land capability inventories to guide sustainable land resources allocation, management and use at the national and local levels.

C) Promoting application of appropriate tools for planning and management to promote the improvement, further development and widespread application of planning and management tools that facilitate an integrated and sustainable approach to land and resources.

To do this, they should:

- Adopt improved systems for the interpretation and integrated analysis of data on land use and land resources;
- Systematically apply techniques and procedures for assessing the environmental, social and economic impacts, risks, costs and benefits of specific actions;
- Analyze and test methods to include land and ecosystem functions and land resources values in national accounts.

(D) Raising awareness to alert and educate people on the importance of integrated land and land resources management and the role that individuals and social groups can play in it. This should be accompanied by provision of the means to adopt improved practices for land use and sustainable management.

(E) Promoting public participation to establish innovative procedures, programmes, projects and services that facilitate and encourage the active participation of those affected in the decision-making and implementation process, especially of groups that have, hitherto, often been excluded, such as women, youth, indigenous people and their communities and other local communities.

5.5.2 DATA AND INFORMATION

To strengthen information systems: The Governments at the appropriate level, in collaboration with national institutions and the private sector and with the support of regional and international organizations, should strengthen the information systems necessary for making decisions and evaluating future changes on land use and management. The needs of both men and women should be taken into account. To do this, they should:

- Strengthen information, systematic observation and assessment systems for environmental, economic and social data related to land resources at the global, regional, national and local levels and for land capability and land-use and management patterns;
- Strengthen coordination between existing sectoral data systems on land and land resources and strengthen national capacity to gather and assess data;
- Provide the appropriate technical information necessary for informed decision-making on land use and management in an accessible form to all sectors of the population, especially to local communities and women;
- Support low-cost, community-managed systems for the collection of comparable information on the status and processes of change of land resources, including soils, forest cover, wildlife, climate and other elements.

5.5.3 INTERNATIONAL AND REGIONAL COORDINATION AND COOPERATION

To establish regional machinery: The Governments at the appropriate level, with the support of regional and international organizations, should strengthen regional cooperation and exchange of information on land resources. To do this, they should:

- Study and design regional policies to support programmes for land-use and physical planning;
- Promote the development of land-use and physical plans in the countries of the region;

- Design information systems and promote training;
- Exchange, through networks and other appropriate means, information on experiences with the process and results of integrated and participatory planning and management of land resources at the national and local levels.

5.5.4 MEANS OF IMPLEMENTATION

(A) Scientific and technological means

For enhancing scientific understanding of the land resources system, Governments at the appropriate level, in collaboration with the national and international scientific community and with the support of appropriate national and international organizations, should promote and support research, tailored to local environments, on the land resources system and the implications for sustainable development and management practices. Priority should be given, as appropriate, to:

- Assessment of land potential capability and ecosystem functions;
- Ecosystemic interactions and interactions between land resources and social, economic and environmental systems;
- Developing indicators of sustainability for land resources, taking into account environmental, economic, social, demographic, cultural and political factors.

(B)Testing research findings through pilot projects

Governments at the appropriate level, in collaboration with the national and international scientific community and with the support of the relevant international organizations, should research and test, through pilot projects, the applicability of improved approaches to the integrated planning and management of land resources, including technical, social and institutional factors.

5.5.5 HUMAN RESOURCE DEVELOPMENT

(A) Enhancing education and training

This should be done by providing incentives for local initiatives and by enhancing local management capacity, particularly of women, through:

- Emphasizing interdisciplinary and integrative approaches in the curricula of schools and technical, vocational and university training;

- Training all relevant sectors concerned to deal with land resources in an integrated and sustainable manner;
- Training communities, relevant extension services, community-based groups and non-governmental organizations on land management techniques and approaches applied successfully elsewhere.
- Capacity-building

(B) Strengthening technological capacity

To promote focused and concerted efforts for education and training and the transfer of techniques and technologies that support the various aspects of the sustainable planning and management process at the national, state/provincial and local levels.

(C) Strengthening institutions

Governments at the appropriate level, with the support of appropriate international organizations, should:

- Review and, where appropriate, revise the mandates of institutions that deal with land and natural resources to include explicitly the interdisciplinary integration of environmental, social and economic issues;
- Strengthen coordinating mechanisms between institutions that deal with land-use and resources management to facilitate integration of sectoral concerns and strategies;
- Strengthen local decision-making capacity and improve coordination with higher levels.

PROBABLE QUESTIONS

1. How is land degraded? Describe how flood can degrade the land.
2. Write a note on the management of flood degraded land.
3. Write the different means of land pollution. Describe the possible mechanism to reclaim the polluted land.
4. Write a note on sustainable land management.
5. Describe briefly the integrated approach to land management.

SUGGESTED READINGS

1. *The Nature and Properties of Soils*. Nyle C. Brady and Ray R. Weil. Prentice Hall. 12th edition.
2. *Environmental Science*. S.C. Santra. New Central Book Agency(P)Ltd
3. *Essentials of Ecology and Environmental Science*. S.V.S. Rana. PHI learning Private Limited. Fourth edition
4. *Environmental Studies-From crisis to cure*. R. Rajagopalan. Oxford University Press.
5. *Science and Technology for Regional Development: Case for North –East India*. S.K.Dolui and C Mahanta (Eds). Tezpur University, IIT Guwahati and C-MMACS,Bangalore.

DEM 102 NATURAL RESOURCES AND SUSTAINABLE

DVELOPMENT CR 4

UNIT-6: WATER MANAGEMENT

UNIT STRUCTURE

6.0 OBJECTIVES

After going through this unit, you will be able to:

discuss the importance of water

Discuss the social, political and environmental Dimensions of Water Use

Illustrate the water and agricultural landscape in context of India

List the guideline for sustainable water resource management

6.1 INTRODUCTION

Among the nine planets in our solar system, only the Earth has three states of water on its surface that offers a suitable environment for life to begin. India is a water-stressed country, yet our rivers and dams endure a daily onslaught of pollution from various sources. Protecting it, not just for ourselves but all the creatures we share our planet with is vital to ensure the continuation of life. We take water for granted, yet this most precious resource is under threat. The bond that life on earth has with water is inescapable – without water, life can simply not exist. Humans have a special connection with water – we are 65% water, we drink it, we use it for sport and recreation and it is part of our rituals. Most religions consider water as a

purifier, yet we consider it so lightly. Over 1 billion people worldwide have no access to clean water within a 15-minute walk of their homes.

The phenomenal human population growth has intensified pressure on each and every natural resource to produce adequate food and raw materials to meet the proportional demand (Smil, 1999). With the advent of Green Revolution technologies, India has increased the consumption of fertilizer from 0.3 million metric tons in 1961 to 18.7 million metric tons in 2000, which resulted in a 170% increase in cereal production during the same period where as the increase in population nearly doubled (FAO, 1996). During the next three decades, world population will increase by another 2 billion demanding a higher production of food. The food security can be achieved only through improvements in crop yields, which would require a 30% increase in fertilizer use. This increased fertilizer requirement has to be balanced against the environmental and human health concerns stemming from intensive fertilizer applications, particularly in fast developing and industrialized countries.

The World Health Organization (WHO) has repeatedly insisted that the single major factor adversely influencing the general health and life expectancy of a population in many developing countries is lack of ready access to clean drinking water (Nash and McCall, 1995). In recent years, in many parts of India especially in the arid- and semi-arid regions, due to the vagaries of monsoon and scarcity of surface water, dependence on groundwater has increased tremendously. In the view of international perspective of '<1700m^3/person/yr' as water stressed and '<1000m^3/person/yr' as water scarce, India is water stressed today and is likely to be water scarce by 2050 (Gupta and Deshpande, 2004). It is projected that by 2020, the number of people living in water-scarce countries will increase from about 131 million to more than 800 million (Gardner-Outlaw and Engelman 1997). India supports more than 16% of the world's population with only 4% of the world's fresh water resources (Singh 2003; Kumar et al., 2008). The total area cultivated in India using groundwater has increased from 6.5 million hectare in 1951 to 35.38 million hectare in 1993 (GWREC 1997). The study of fertilizer consumption data at the state level shows that consumption of plant nutrient per unit gross area is highest in Punjab at 158.9 kg/ha and lowest in Assam 14.6 kg/ha (Census of India, Punjab 2004). However, uncontrolled extraction without commensurate recharge and heavy leaching of pollutants from pesticides and fertilizers to the aquifers has resulted in pollution of groundwater (Rajmohan and Elango, 2005).

It is thus clearly evident that water is directly related to food and majority use for irrigation water. Second vital use is for drinking purpose for which in general colour and taste of the

water are the two basic criteria for a consumer to decide the suitability of given water for drinking without considering other lethal chemical contaminations like arsenic, nitrate, fluoride and other heavy metal. It is therefore becomes essential to know the environmental and social and political dimensions of water resource management. Water is our most precious natural resource. More than ever we need to work together to use it wisely. While the world's growing population is consuming more freshwater, climate change is making less water available in many regions as glaciers recede, rainfall becomes less predictable, and floods and droughts become more extreme. Managing water carefully and balancing the varied needs for it is vital.

6.2 WATER: A PRECIOUS NATURAL RESOURCE

Water is an indispensable natural resource on this earth on which all life depends. About 97% of the earth's surface is covered by water and most of the animals and plants have 60-65% water in their body. Water is characterized by certain unique features which make it a marvelous resource:

- It exists as a liquid over a wide range of temperature i.e. from 0 to 100 C.
- It has the highest specific heat, due to which it warms up and cools down very slowly without causing shocks of temperature jerks to the aquatic life.
- It has high latent heat of vaporization. Hence, it takes huge amount energy for getting vaporized. That's why it produces a cooling effect as it evaporates.
- It is in an excellent solvent for several nutrients. Thus, it can serve as a very good carrier of nutrients, including oxygen, which is essential for life. But it can also easily dissolve various pollutants and become a carrier of pathogenic microorganisms.
- Due to high surface tension and cohesion it can only easily rise through great heights through the trunk even in the tallest of the trees like Sequoia.
- It has anomalous expansion behaviour i.e. as it freezes; it expands instead of contracting and thus becomes lighter. It is because of this property that even in extreme cold, the lakes freeze only on the surface. Being lighter the ice keeps floating, whereas the bottom waters remain at a higher temperature and therefore, can sustain aquatic organisms even in extreme cold.

The water we use keeps on cycling endlessly through the environment, which we call as Hydrological Cycle. We have enormous resources of water on earth amounting to 1404 million km^3. The water from various moist surfaces evaporates and falls again on the earth in the form of rain or snow and passes through living organisms and ultimately returns to

oceans. Every year about 1.4 inch thick layer of water evaporates from the oceans more than 90% of which returns to the oceans through the hydrological cycle. Solar energy drives the water cycle by evaporating it from various bodies, which subsequently return through rainfall or snow. Plants also play a very vital role by absorbing the groundwater from the soil and releasing it into the atmosphere by the process of transpiration. Global distribution of water resources is quite uneven depending upon several geographic factors. Tropical rain forest areas receive maximum rainfall while the major world deserts occur in zones of dry, descending air (20-40 N and S) and receive very little rainfall.

Due to its unique properties water is of multiple uses for all living organisms. Water is absolutely essential for life. Most of the life processes take place in water in water contained in the body. Uptake of nutrients, their distribution in the body, regulation of temperature, and removal of wastes are all mediated through water. Water use by humans is of two types:

1. Water withdrawal : taking water from groundwater or surface water resource and
2. Water consumption: the water which is taken up but not returned for reuse.

Although water is very abundant on this earth, yet it is very precious. Out of the total water reserves of the world, about 97% is salty water (marine) and only 3% is fresh water. Even this small fraction of fresh water is not available to us as most of it is locked up in polar ice caps and just 0.003% is readily available to us in the form of groundwater and surface water. Overuse of groundwater for drinking, irrigation and domestic purposes has resulted in rapid depletion of groundwater in various regions leading to lowering of water table and drying of wells. Pollution of many of the groundwater aquifers has made of these wells unfit for consumption. Rivers and streams have long been used for discharging the wastes. Most of the civilizations have grown and flourished on the banks of rivers, but unfortunately, growth in turn has been responsible for pollution of the rivers.

Groundwater: About 9.86% of the total fresh water resources is in the form of groundwater and it is about 35-50 times that of surface water supplies

Effects of groundwater usage: 1.Subsidence 2.Lowering of water table 3.Water logging

Surface water: The water coming through precipitation (rainfall, snow) when does not percolate down into the ground or does not return to the atmosphere as evaporation or transpiration loss, assumes the form of streams, lakes, ponds, wetlands or artificial reservoirs known as surface water. The surface water is largely used for irrigation, industrial use, public water supply, navigation etc.

6.3 SOCIAL, POLITICAL AND ENVIRONMENTAL DIMENSIONS OF WATER USE

The uncertainty related to the physical availability of water is a central dimension. This uncertainty can be further highlighted if we look at it from the perspective of our confidence in water abundance some 50 years earlier. In spite of the vast availability of water on the planet, whose surface area is primarily covered by water, human beings vitally depend on fresh water found in the polar ice caps, groundwater, and surface water. To a small but incredibly important extent, we have at our disposal water transported from oceans to land via precipitation of rain and snow, which then drains into channels formed by slopes and river banks, penetrating the soil, where once again the water evaporates and heads towards the sea. In the beginning of the 20th century, these same running rivers appeared abundant and it seemed wasteful that they flowed without being exploited; however, now these waters have been collected artificially, often in an effort to transplant water from regions of abundance to regions with deficiencies. At some sites, environmentalists try to restore the free flow of water to rivers by dismantling dams. The exploitation of underground water compliments the use of surface water. Paradoxically, this exploitation occurring today results in current and future insufficiencies, and places doubt on the conservation of aquatic resources.

For centuries, civilizations treated water as a common good for the benefit of all human welfare. According to Garrett Hardin's "Tragedy of the Commons," however, "freedom in a commons brings ruin to all." Hardin's theory holds that competition drives individuals to maximize utility of common goods, such as water, yet holds no one individually accountable for maintaining the commons or distributing the resource equitably. As a solution to the tragedy of the commons, some scholars have proposed commoditization and privatization, since the owner would have a vested interest in maintaining the quality of their property or resources. In the face of increasing scarcity, the value of water is ever rising. Indeed, the competitive nature of global trade has resulted in a mounting economic value for water. Some scholars advocate privatization of water and water delivery systems not only because of the potential for better management of the resource, but also because imposing a higher cost on water could encourage conservation. According to Karen Bakker, privatization and commoditization of water services are a form of "market environmentalism" in which economic and environmental needs are met through market mechanisms. Furthermore, Bakker asserts that water pricing is necessary to "maximize the efficiency of water use" because "price signals, encourage customers to conserve where water is scarce. Opponents to privatization and commoditization of water argue that economic profitability supersedes environmental or human needs when resources like water are treated as market goods.

In the face of increasing scarcity due to climate change, population growth, industrialization, inefficient agricultural practices, misdistribution, degradation, and commoditization of water sources, it is certainly a factor that can compound already tense interstate relationships, exacerbate conflicts, and cause mass migrations of environmental refugees. Thus, the water crisis clearly poses a significant threat to international security, albeit requiring scholars and policymakers to re-examine how they define "security" and "war." In Western countries, there is an economic war on water, as governments increasingly surrender authority over water to transnational corporations and international trade agreements. In the East, attempts at diplomatic water negotiations have often been utter failures or extremely asymmetrical in favouring regional hegemony to the detriment of the weaker states, human populations and the environment.

6.3.1 WATER SECURITY: SUSTAINABILITY AS A USEFUL DISCURSIVE HYDRO-POLITICAL CONCEPT

The concept of sustainability is very relevant to any analysis of water policy. But it can lead to a very sterile analysis if its analytical scope is restricted to the water environment. An operational notion of sustainability is captured in the larger context of the sustainability of society, the economy as well as the maintenance of the environmental services provided by water in the environment. The concept of sustainability is very rich indeed if this threefold context is adopted. It is especially rich if discursive hydro-politics are seen to be integral to the achievement of an ever-changing definition of sustainability.

Figure 1 shows the three dimensions of water sustainability –social, economic and environmental – and the central mediating role of discursive hydro-politics. Sustainability is a discursive outcome of the contending articulated concerns of society, those involved in the economy and those anxious about the status of the environment. There is no market and no perfect regulatory system that brings about an optimum outcome. The outcome is second best in economic terms, less than satisfactory in social terms as well as inadequate in pleasing those who want to reconstruct pristine environments.

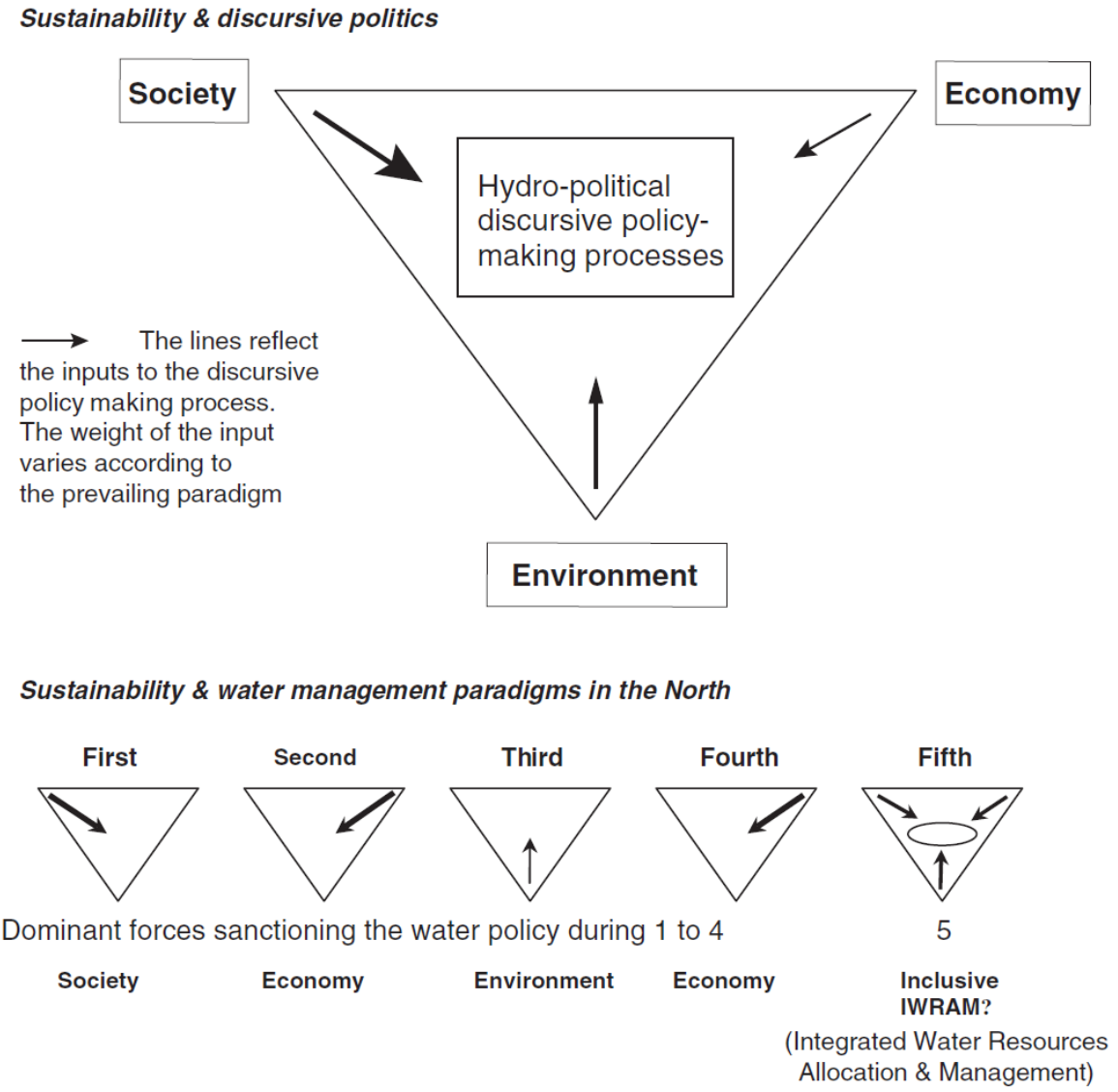


Fig 1: The Concept of Sustainability and the Water Sector; Water Management as a Political Process and Determining Perceptions of the Diverse Values of Water (Source: J.A.Allan,2005)

Political processes are also the only processes that can comprehensively, albeit imperfectly, respond to the driving forces of demography, technology and especially reflect the changing ideas in currency such as the innovations advocated by social movements. The diagram also shows how the level of emphasis given to social, economic and environmental principles in hydro-political processes changes through time. The diagram indicates how the emphasis in the water policy discourse is responsive to different actors – namely to the concerns of civil society, hierarchy (government), to civil movement (NGOs) and to entrepreneurs (the private sector). Identifying the actors involved in discursive hydro-politics is another useful service, which social scientists can contribute.

6.3.2 WATER AND DEVELOPMENT

Water is essential for human activity – for drinking and sanitation, agriculture, hydropower, fisheries, industry, etc. (UNICEF/WHO, 2005). It is also crucial for ecosystem services, which support life on the planet (MA, 2005). Key issues in the water sector include: meeting growing water needs for development and poverty alleviation, mobilizing funds to meet rising costs, maintaining financial viability, improving governance, ensuring diverse, affordable and reliable water services, protecting the environment, and balancing competing uses (World Bank, 2005). Safe drinking water is unavailable to 900 million people, while over 2 billion lack adequate sanitation (World Bank, 2005). Over US$11 billion per year is needed to meet the drinking water and sanitation targets of the Millennium Development Goals (UNICEF/WHO, 2004). In 2001, two million people died from infectious diarrhoea – two thirds were children under five, and most deaths were preventable (UNICEF/WHO, 2005). Poor people living in the slums often pay five to ten times more per litre of water than wealthy people living in the same city (UNDP, 2006). As incomes rise, urban-industrial water demand increases, often leading to competition with rural-agricultural users. Water scarcity exacerbates other development problems among the 3 billion people who survive on less than US$2 per day and almost a billion who are malnourished – many of them children. Two billion do not have access to electricity, while billions are also sick, exposed to environmental degradation (air, land and water), lack shelter and are vulnerable to disasters (IPCC, 2008; UNDP, 2009; Alcamo et al., 2007)

6.3.3 BIG DAMS: BENEFITS AND PROBLEMS

Benefits

River valley projects with big dams have usually been considered to play a key role in the development process due to their multiple uses. India has the distinction of having the largest number of river valley projects. These dams are often regarded as a symbol of national development. There are hopes all over from every corner of the region where such dam is planned to be constructed. Such projects result providing much employment of opportunities, rise in the standard of living and improvement in quality of life. Such projects have tremendous potential for economic uplift and growth. It can check floods and famines, generate electricity and reduce water and power shortage, provide irrigation water to lower areas, provide drinking water in remote areas and bring about overall development of the region.

Environmental problems: The environmental impacts of big dams are also too many due to which very often big dams become an issue of controversy. The impacts can be at the upstream as well as downstream levels.

Upstream problems

- Displacement of tribal people
- Loss of forests, flora and fauna
- Changes in fisheries and the spawning grounds
- Siltation and sedimentation of reservoirs
- Loss of non-forest land
- Stagnation and water logging near reservoir
- Breeding of vectors and spread of vector-borne diseases
- Reservoir induced seismicity (RIS) causing earthquakes
- Growth of aquatic weeds
- Microclimatic changes

Downstream impacts

- Water logging and salinity due to over irrigation
- Micro-climatic changes
- Reduced water flow and silt deposition in the river
- Flash floods
- Salt water intrusion at river mouth
- Loss of land fertility along the river since the sediments carrying nutrients get deposited in the reservoir
- Outbreak of vector-borne diseases like malaria. Thus dams are built to serve the society with multiple uses, but it has several serious side-effects. That it why now there is a shift towards construction of small dams or mini-hydel projects.

The extreme variability in rainfall, long dry seasons and recurrent droughts, floods, and dry spells pose a key challenge to food production. The sole dependence of farming on rainfall has been a major cause of low food productivity, food shortages, undernourishment and famine. The world's hotspots for hunger and poverty are concentrated in the arid, semiarid and dry subhumid regions of the world which depend solely on rainfall for crop production.

Irrigated agriculture has been a major solution used in addressing water challenge affecting food production in areas of unreliable rainfall patterns. Irrigation has historically had a large positive impact on poverty reduction and livelihoods, in both urban and rural areas, producing relatively cheap food and providing employment opportunities for the landless poor (Hussain, 2005). Through increased productivity, irrigation produces secondary benefits for the economy at all levels, including increased productivity of rural labour, promotion of local agro-enterprises, and stimulation of the agricultural sector as a whole (Faurès et al., 2007).

6.3.4 TRANSBOUNDARY WATER CONFLICTS: POLICY AND PITFALLS

A country's economy is largely dependent upon its rivers. The problems arising out of water resources are floods and droughts. Apart from these there are conflicts over water. Indispensability of water and its unequal distribution have often led to inter-state or international disputes. Issues related to sharing of river water have been largely affecting our

farmers and also shaking our governments. Some major water conflicts are: a) Water conflict in the Middle East- countries involving Sudan, Egypt, Turkey- it also affects countries who are water starved viz. Saudi Arabia, Kuwait, Syria, Israel and Jordan. b) The Indus Water treaty is disputed between India and Pakistan, c) The Cauvery water dispute- involves two major southern states of India viz. Tamilnadu, Karnataka. Similarly the Satluj-Yamuna link canal. Dispute also involves two Northern states viz. Punjab and Haryana. Affected states also include UP, Rajasthan as well as Delhi. In traditional water management, innovative arrangements ensure equitable distribution of water, which are democratically implemented. The 'gram sabhas" approve these plans publicly. While water disputes between states and nations often create battle like situations, our traditional water managers in villages prove to be quite effective.

Much of the planet's water, above or below ground, is shared. Forty per cent of the world's people live in one of 263 basins that are shared by two or more countries. Concern over the possibility of violent disputes features regularly in discussions about sharing limited water resources. But while the potential exists for water to act as a catalyst for conflict between States and communities, precedent suggests that the opposite is actually what happens. Cooperation, not conflict, is the most common response by people facing competing demands.

Under the theme "Shared Waters, Shared Opportunities", World Water Day 2011 highlighted how transboundary water resources can act as a unifying force. Worldwide, there are at least 300 international water agreements, often among parties that are otherwise at odds. These agreements demonstrate the potential of shared water resources to foster trust and promote peace. Political will, a flexible policy framework, strong institutions and an inclusive approach will help us build on this foundation for the benefit of all.

6.4WATER AND AGRICULTURAL LANDSCAPE IN THE CONTEXT OF INDIA

A research conducted on a number of small-scale irrigation systems across India by Sarkar (2009) identified six problems affecting small-scale irrigation: (1) the problem of balancing social benefits, national economic strategies and perceived producer benefits; (2) the problem of control (over decision-making, marketing and water use,etc); (3) the problem of hierarchy and technical requirements; (4) the problem of planning production units and process; (5) the problem of water use and adaptation to farmer experiences; and finally (6) the problem of planning for change.

Other studies (Singh, 1992; Shah, 1993; Shah, 1998; Singh, 2002) have identified the following problems: the high costs of investment and negative rates of return; technical flaws in infrastructural design, seepage, sedimentation, cracks in dams and silting up of reservoirs; high input costs, especially cost of fertilizer; pests and diseases especially for onions and tomatoes; high interest rates on loans; management failures; political difficulties; and finally marketing problems. Awulachew et al. (2005) observed that where these types of failures occurred, they have generated lack of maintenance, broken down scheme machinery due to lack of spare parts, and lack of access to input and output markets.

Shah et al. (2002), studying smallholder irrigation systems, identified the following challenges: mismanagement, high cost of working capital, poor linkages to credit, input and output markets, institutional vacuum, land tenure issues, improper management transfers, damaged soils, expensive and ineffective mechanization, poor farmer capacity and lack of farmer entrepreneurship development. The commonalities between the challenges observed by the various authors are identified in Table 1.1.

Table 1.1: Common challenges affecting irrigation development.

Challenges	**Authors**		
	Barnett (1984)	**Awulachew et al. (2005)**	**Shah et al. (2002)**
High Irrigation development cost	New schemes involve huge investment	high costs of investment, high input cost	High cost of working capital
Lack of access to credit	Governments cut down on operation cost by removing credits for farmers	High interest rates on loans	Poor linkages to credit, input and output
Unreliable Markets and lack of access	Artificial market pricing by management of public schemes	Marketing problems	Poor linkages to market
Ineffective Institutions	the problem of control, balancing social, national and producer benefit; hierarchy and technical requirements; adaptation to farmer experiences	negative rates of returns; management failures; political difficulties	Improper management transfers; land tenure issues; institutional vacuum
Choice of technology and maintenance of infrastructure	Problems with adequate and reliable water supply	technical flaws in infrastructural design, cracks, siltation and seepage in reservoirs; lack of maintenance and	Expensive and ineffective mechanization;

		spare parts of machinery	
Low Productivity	problems with production units and processes	Pests and diseases, high fertilizer cost	Damaged soils, poor farmer capacity
New Age Problems			
Climate change	Erratic and unpredictable rainfall	Proper drainage and frequent flooding due to high intensity of rainfall	Human altered hydrological cycle

6.4.1 HIGH IRRIGATION DEVELOPMENT COST

Due to the high costs of Large-scale Irrigation projects, in the anxiety of planners to meet project targets for the national economic benefit, the government sets up its own administration structures for managing the schemes. The administrative structures are mostly authoritarian and they compel the direct producers to comply with enforced artificial pricing of commodities (Barnett, 1984). This has resulted in challenges where social, economic and producer benefits cannot be balanced and eventually result in low productivity due to lack of farmer interest.

6.4.2 LACK OF ACCESS TO CREDIT

Starting in the early 1980s countries across the development spectrum had to adopt a series of policy measures aimed at coping with the severe international economic crisis. An increasing number of countries had to go through economic adjustment processes, either because the drying up of capital inflows left no other option, or because this type of adjustment was made a precondition by the private banks and the multilateral agencies before new money would be released (Edwards and van Wijnbergen, 1992). As a result countries like India introduced the Kisan Credit Card and Loan Waiving Strategies.

Though the reforms were meant to create incentives to agricultural producers, to the majority of smallholder farmers the negative impact of the removal of input subsidies outweighed the benefits from the market reforms. Before the reforms fertilizer subsidies were in the range of 40 to 80%. However, after the reforms prices of most agricultural chemicals used in cereal production increased in excess of 40% between 1986 and 1992 and the price of fertilizer in particular doubled in India in last decade (FAO, 2002). The reforms have not only changed the input price regimes but also the credit environment. That is, credit for the purchase of farm inputs for small holder farmers has been drastically affected by the reforms. Before the reform in India, State Bank of India (SBI) used to provide credit to the agricultural sector with preferential conditions. In addition to the SBI, commercial banks were also obliged to lend

not less than 25 percent of their loanable funds to the agriculture sector at reduced interest rates. These policies were gradually abolished; subsequently the interest rates charged for agricultural credit have been raised to the levels comparable to rates of non-agriculture. Loans to small-scale farmers have virtually evaporated after the liberalization of interest rates. Further, there is no evidence to show that declining institutional credit to agriculture is being replaced by informal credit.

In cases of credit constraints and a risky environment, farmers may use off-farm income to invest in agriculture and thus increase the households' farm productivity (Evans and Ngau, 1991; Reardon et al., 1994; Schrieder and Knerr, 2000). Even in cases where some credit markets exist off-farm income may serve as collateral (Hoffman and Heidhues, 1993). Under such circumstances, agricultural communities are forced to resort to activities that secure a more stable income stream. These include rural-urban migration or local non-agricultural employment (Yilma et al., 2004).

6.4.3 MARKETING AND ACCESS TO MARKETS

Poor access to markets for both inputs and outputs creates problems for agricultural production on a market-oriented basis, whereby lack of markets for certain crops after harvest leads to huge losses (Awulachew et al., 2005). Apart from crop diseases and occasional water shortages, it is the unreliability of markets that limits the benefits obtainable from irrigated agriculture. Marketing of irrigated vegetables is therefore suffering from a number of flaws (Laube et al., 2008). Factories could process perishable vegetable crops such as tomatoes which would help to save losses and stabilise the market. A typical example of market failure of vegetable production was experienced in the 1999/2000 in India, when the market price of onion rose invariably. It further prompted farmers to cultivate onions in higher quantities which resulted in massive production of onion in the next season. Unfortunately, the failure of the buyers and storage facilities resulted in massive losses to the farmers.

Marketing of irrigated products at local, regional and global markets have numerous challenges which affect the irrigation industry. For example, local farmers face a high degree of regional competition from other countries of the sub-region. Addressing these marketing challenges is the key to sustainable and further upscaling of irrigation development in India.

6.4.4 INEFFECTIVE INSTITUTIONS

Irrigation institutions have to be effective to promote and manage irrigation to be productive, efficient and sustainable. Effective institutions are required from the farm level, catchment level to the national level. These institutions are responsible for ensuring irrigation productivity and efficiency, planning of irrigation development, managing of impacts due to irrigation development, formulating and implementing policy directives and funding towards sustainable irrigation development.

The historical bias toward infrastructure investment to the neglect of ensuring effective institutions is one cause of poor irrigation performance (Faurès et al., 2007). Effective institutional arrangements have failed due to insufficient resources, lack of political support, lack of proper involvement of water users, resistance of public agencies and water users and lack of capacity building.

Ineffective institutions have resulted in limited access to water and land for irrigation development (Lahiff, 1999). Insecure tenure is a disincentive to farmers who wish to make long-term investments on their land. For example, in Rhodesia, under the Control of Irrigable Area Regulations of 1970, every plot-holder was issued three permits, which had to be renewed every year (Manzungu et al., 1999). Under such conditions irrigators can be replaced in certain circumstances. As a result farmers were not willing to invest in long-term infrastructure on their land-holdings.

Within the past 15-20 years there have been some institutional reforms in many countries with a focus on withdrawing government from management. Management responsibilities have therefore been transferred from centralised bureaucratic management to lower levels (FAO, 1997; Johnson et al., 2004). However as Faurès et al. (2007) put it, effective institutional arrangements for irrigation still remain a challenge.

Institutional reforms backed by strong political commitment towards productive and sustainable irrigation development are needed (Merrey et al., 2007). Sustainable institutional reforms have the following characteristics: they give legal recognition to farmers and farmer groups, clearly recognize sustainable water rights and water service, specify management functions, provide compatible infrastructure with water service, create effective accountability and incentives for management, have viable arrangements for conflict resolution, mobilize

adequate resources for irrigation and ensure that farmer investments are proportional to benefits that exceed costs (Samad and Merrey, 2005; Merrey, 1997).

6.4.5 CHOICE OF TECHNOLOGY AND MAINTENANCE OF INFRASTRUCTURE

Experience in many parts of the World has shown that with adequate community involvement in planning, design and management, small scale irrigation schemes can be more viable and sustainable than conventional large-scale schemes (Merrey et al., 2002). Limited or lack of community consultation precludes the inclusion of indigenous knowledge or local know-how in scheme planning and construction.

Also the non-acceptance of irrigation schemes by farmers has resulted in the cultivation of only small parts of the potential area. This is largely a function of the top-down implementation process often followed. It also suggests some of the interventions have not been appropriate, given the circumstances of the recipient populations. A classical example is the Meki-Ziway Scheme in Oromia, Ethiopia, which failed largely because farmers could not get spare parts for the imported pumps, could not carry out maintenance, and could not afford the electricity fees to run the pumps. It is now generally agreed that irrigation technology should be commensurate with the capacity of the users (Awulachew et al., 2005). The design should not only fit the capacity of the users, but also many other conditions, such as climate, soils, crops to be cultivated, but also the manner in which the irrigation infrastructure is going to be managed – collectively, individually, as a plantation, as a company or by a public agency. The most difficult is to know and anticipate the capacity of the users to manage a future infrastructure. One of the biggest constraining factors is that there are few experts who can fine-tune all these elements in a design that will prove to work in practice.

The reason for poor maintenance as listed by Sijbrandij and van der Zaag (1993) are: (1) the cost of irrigation scheme maintenance is mostly a significant component of the annual budget of irrigation schemes which sometimes are restricted; (2) neglect of duty by maintenance sections of irrigation management organisations; (3) lack of accountability of maintenance department to the water users; (4) lack of channels for expressing water users' opinion on canal maintenance problems; (5) the informal participation of farmers in maintenance which is sometimes hampered by inhibiting social issues between farmers; and finally (6) apathy from water users due to the perception that they are not responsible over the facility. Lessons need to be drawn from these challenges to create functional maintenance culture and strategies among management and water users to sustain irrigation projects.

6.4.6 CLIMATE CHANGE AND WATER

Climate change will have severe adverse impacts via the hydrological cycle, especially on the vulnerable poor (IPCC, 2007). More droughts and floods are already causing social instability, food insecurity and long term health problems (especially in growing mega-city slums). Sea-level rise and worsening storms could affect hundreds of millions by 2050. The two human responses to climate change are adaptation and mitigation. Making development more sustainable by mainstreaming adaptation and mitigation measures into a sustainable development strategy is considered the most effective solution (Munasinghe, 2002; IPCC, 2007; IARU, 2009). Adaptation refers to adjustments in human and natural systems that reduce vulnerability to climate stresses, moderate damage and enhance benefits – such as building higher sea walls, or strengthening water systems against droughts. Mitigation covers activities that reduce GHG emissions, which will worsen future climate change – such as reducing energy use, halting deforestation, or absorbing atmospheric CO2 by growing biomass. Water and development are interlinked with both adaptation and mitigation. For example, more sustainable water management will make adaptation and mitigation more effective, by enhancing agriculture and forestry. Conversely, many adaptation and mitigation policies can help make water use and overall development more sustainable. Effective longer-term response measures include strengthening water system resilience, building the adaptive capacity of vulnerable socioeconomic and ecological systems and managing disaster risks. More data and analytical capability is crucial.

Climate change is a major risk multiplier, systematically worsening all other problems. The latest scientific evidence indicates that global warming is unequivocal and almost certainly caused by increased greenhouse gas (GHG) emissions from post-industrial human activities (IPCC, 2007; IARU, 2009). Global warming is already worsening water-related problems. Climate change will likely to intensify in the foreseeable future, with severe consequences for the inhabitants of planet Earth. The IPCC (2007) comprehensively describes past and present trends. For over 10,000 years, atmospheric carbon dioxide concentrations were stable at 275 parts per million by volume (ppmv). However, following the industrial revolution, these concentrations rose rapidly, now exceeding 385 ppmv. During the past 100 years, this excess CO_2, together with other minor GHG, like methane and nitrous oxide, have acted as a blanket to trap excess solar radiation and warm the planet's surface an average of 0.75 ºC, through a process called climate forcing. There is other convincing evidence of accelerating climate change – including a systematic rise in the mean sea level (17 cm during the past century), melting of ice in polar areas and glaciers, increased damage caused by extreme weather

events, less precipitation in dry areas and more in wet areas, and significant changes in ecosystems and animal behaviour. If emissions are not curbed, by 2100, CO2 concentrations will be about twice the pre-industrial level (i.e. 550 ppmv). Even if GHG emissions were sharply cut, temperatures would still rise by at least 1.5 ºC by 2100. Increasing scientific evidence suggests that 2 ºC (corresponding to 400–450 ppmv) is the "dangerous" risk threshold, which implies that global emissions of greenhouse gases need to peak by 2020 at the latest. The post IPCC-AR4 data emerging during the past three years indicate that the situation is indeed worsening (IARU, 2009). By 2100, the average global temperature will increase by over 3 ºC above current levels, and the mean sea level will rise at least half a metre. Extremes of temperature and precipitation will worsen, and the melting of ice will accelerate. Weather events will also become more extreme – especially tropical cyclones and heat waves. Groups most vulnerable to climate change impacts are the poor, elderly and children, including those living in rich countries (IPCC, 2007). The most affected regions will be the Arctic, sub-Saharan Africa, small islands, and Asian mega deltas. High risks will be associated with low-lying coastal areas, water resources in dry tropics and subtropics, agriculture in low-latitude regions, key ecosystems (like coral reefs) and human health in poor areas. Such impacts make many of the Millennium Development Goals (MDGs) even more difficult to achieve (MDG, 2009).

6.5 GUIDELINE FOR SUSTAINABLE WATER RESOURCE MANAGEMENT

Looking at the challenges discussed above and comparing with suggestions proposed in the literature, the following factors are identified as vital for sustainable irrigational Water Management: secure access to land and water, appropriate technologies, predictable and stable input/output markets, favourable policies and effective institutions, reliable farmer support environment. A suitable relationship between these five factors is a chain of shackles, the chain being as strong as the weakest shackle (adopted from Penning De Vries et al., 2005 and Vishnudas et al., 2007) (see Figure 2).

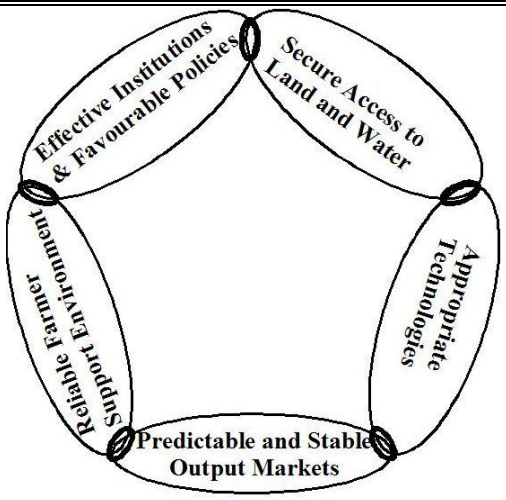


Figure 2: Chain of Success Factors for sustainable Irrigation Development (Source: modified from Vishnudas et al., 2007).

6.5.1 SECURE ACCESS TO LAND AND WATER

Land and water are basic necessities for the development of sustainable water cycle. The challenge usually associated with accessing land is the prevailing land tenure system which determines how land is accessed by individuals and organisations. The acquisition of land for irrigation is done in consideration with accessing potential *water* sources for irrigation. The sources of water which can be harvested for irrigation include groundwater and surface water. Institutional arrangements that allow and protect water access would obviously help to promote irrigation development.

6.5.2 APPROPRIATE TECHNOLOGY

Sustainable water management involves *technology* for the abstraction, transportation, distribution and application of water. Infrastructural and technological development forms the most expensive aspect which needs *investment* from both government and private initiatives. There is the need to invest in new schemes or systems and in new types of technologies as well as existing ones to improve productivity. The nature of investment should promote innovative and appropriate technologies which empower users to better control agricultural production as well as fit into the local context (socio-economy, geography, soils, crops and sources of water). Different technologies enable and/or constrain certain types of organisation of irrigators (centralised/de-centralised which coalesce with different modalities of investment: individual, collective, corporate or government). New technologies may unlock some entrepreneurial investment so far unexploited.

Rainwater harvesting – An alternative technique to water management

Rainwater harvesting locally is collection and storing rainfall through different technologies, for future use to meet the demands of human consumption or human activities. The art of rainwater harvesting has been practised since the first human settlements. It has been a key entry point in local water management ever since, buffering supplies of rainfall to service the human demand of freshwater. As it involves the alteration of natural landscape water flows, it requires water managers to carefully consider the tradeoffs; however, it can create multiple benefits, offering synergies between different demands and users at a specific location (Malesu *et al*., 2005: Agarwal *et al*., 2005). To many water managers, rainwater harvesting is a technique to collect drinking water from rooftops, or to collect irrigation water in rural water tanks. However, rainwater harvesting has much wider perspectives, in particular if it is considered in relation to its role in supporting ecosystem goods and services. Future pressures from climate change, growing population, rapid land use changes and already degraded water resources quality, may intensify water shortages in specific communities and exacerbate existing environmental and economic concerns. As the pressure mounts on our water resources, globally and locally, we need to manage resources more efficiently in order to meet multiple demands and purposes.

(A detailed section on rainwater harvesting has been provided under Urban Water Management Course)

6.5.3 EFFECTIVE INSTITUTIONS AND FAVOURABLE POLICIES

In order to ensure sustainability, there is the need for institutions to effectively take care of the public interests through leading, ruling and managing of the resources.

Effective water management institutions have the following characteristics: (1) has a defined boundary (e.g. hydrological); (2) provides incentives for stakeholders to invest and participate in the profitability of the system; (3) has adequate infrastructure to deliver services in terms of rules and allocations; (4) has the capacity to adapt to changing circumstances; (5) employs cost recovery mechanisms and is equipped with legal instruments for implementing and enforcing policies and laws; (6) has decentralised, integrated and transparent functions; and finally (7) involves stakeholder participation by creating a platform that represents all interest groups at all levels (Perry, 1995; Savenije, 2000; Merrey et al., 2007).

Water policies can enable and facilitate irrigation development. Governments have implemented several policies which have had dire consequences on water related development instead of improving them in India. These include the removal of subsidies for farming through the structural adjustment program, removal of credit facilities for farmers

and improper management transfers. Policies that target the creation of conditions that stimulate the entrepreneurship abilities of stake holders and make them innovative can positively influence the development of sustainable water cycle. Also policies that improve credit accessibility of farmers and/or reduce the capital cost of the producer will contribute positively to irrigation development.

6.6 SUMMARY

Over-exploitation of surface and ground water, and worsening pollution caused by households, industry and agriculture are generating tensions and conflicts between user groups or upstream and downstream users which must be resolved. Droughts and floods are becoming more and more frequent. Agriculture uses more than two thirds of water reserves in order to feed the world, but it often fails to make efficient use of water. The demand for water will continue to rise, and the situation will continue to worsen. Several international conferences have already looked at ways of resolving these problems. A general consensus has emerged on the principles of water management, which are now widely accepted.

The concept of sustainability water supply networks also involves aspects technologically and economically feasible, especially when the system already exists and needs to expand the coverage to the new or other urban areas, adapt to the new needs of people served and to change the requirements concerning public health and environmental policies. For instance, it happens that in an unsustainable system an insufficient maintenance of the water networks, especially in the major pipe lines in the urban areas, can gets seriously deteriorated and will require rehabilitation or renewal.

Also, the householders and the wastewater treatment plants can come up with actions in order to make the water supply network more efficient and sustainable. For example, major improvements in eco-efficiency are gained through a more systematic separation of rainfall and wastewater and also through the use of innovative technologies such as membrane technology for wastewater treatment for recycling water.

Moreover, the municipality in charge of the urban area can develop a "Municipal Water Reuse System" which is a current approach to manage the rainwater. It applies a water reuse scheme for treated wastewater on a municipal scale to provide non-potable water for industry, household and municipal uses. This technology consists in implementing the urine fraction of sanitary wastewater and separating and collecting it for recycling the nutrients(Craddock Consulting Engineerings,2007). The feces and gray water fraction is collected together with organic wastes from the households using the gravity sewer system continuously flushed with

non-potable water. The water is treated anaerobically and the bio-gas is used for energy production.

As part of the sustainable development, sustainable water supply system is an integrated system including water intake, water utilization, wastewater discharge and treatment and water environmental protection. It requires reducing freshwater and groundwater in all sectors of consumption. Nowadays, developing sustainable water supply systems is a tendency because it serves people's long-term benefits (Qiang,2008). There are several ways to re-use and recycle the water, in order to achieve the sustainability for a long-term period, such us:

- Gray water re-use and treatment: Gray water is wastewater coming from baths, showers, sinks and washbasins: If this water is treated it could be used as a source of water for other uses besides drinking. Depending on the type of gray water and its level of treatment, it could be re-used for landscapes, irrigation and toilet flushing. According to an investigation about the impact of domestic grey water reuse on public health which was carried out by the New South Wales Health Centre in Australia in the year 2000, grey water contains less nitrogen and fecal pathogenic organisms than sewage, and the organic content of grey water decomposes more rapidly.
- Ecological treatment system: This is a system that has low energy consumption. There are many applications for ecological treatment systems in gray water re-use, such us reed beds, soil treatment systems and plant filters. This process is ideal for gray water re-use, because of easier maintenance and higher removal rates of organic matter, ammonia, nitrogen and phosphorus.

Other possible approaches to scoping models for water supply network that are applicable to any urban area could incorporate the following:

- Sustainable Urban Drainage System.
- Borehole extraction.
- Inter-cluster groundwater flow.
- Canal/river extraction.
- Aquifer storage
- A more user-friendly indoor water use.

In terms of what advanced economies have suggested, the "Dublin Statement on Water and Sustainable Development", mentioned above, is a good example of the new trend to overcome these new problems. This statement has come up with some principles that are of great significance in the urban water supply networks. These are as follows:

1. Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.

2. Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels.

3. Women play a central part in the provision, management and safeguarding of water. Institutional arrangements should reflect the role of women in water provision and protection

4. Water has an economic value in all its competing uses and should be recognized as an economic good (International Conference on Water and the Environment, 1992).

From these statements, developed in 1992, several policies have been created to give importance to water and to put the urban water system management towards the sustainable development. The Water Framework Directive by the European Commission is a good example of what it has been created from former policies.

Overall, water is in a state of insecurity throughout the world. Global warming, pollution, over consumption, and commoditization pose serious threats to the sustainability of Earth's water resources. Water scarcity, climate change and sustainable development are interlinked problems that pose serious risks to humanity. Short-sighted and piecemeal policies have not proved effective so far. There is an urgent need for reconceptualization of international security that encompasses water sustainability as a vital component to maintaining global security.

PROBABLE QUESTIONS

1. Why has fresh water become an issue in international trade negotiations and disputes now a days?

2. Define Globalization, privatization and Commoditization.

3. "Water is Both a Social Good and an Economic Good", Comment.

4. What is sustainable water pricing?

5. How can rainwater harvesting create synergies for upgradation of rain-fed agriculture and enhancement of productive landscapes?

6. Discuss the usefulness of managing water resources in a landscape?

Assignment

1.Why can water management be considered as a matter of high political relevance?

2. How are agriculture and rural development inter-related?3. What is the meaning of sustainable agriculture practices?

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DEM 102 NATURAL RESOURCES AND SUSTAINABLE DVELOPMENT CR 4

UNIT-7: AGRICULTURAL MANAGEMENT

UNIT STRUCTURE

7.1 OBJECTIVES

The technology of crop production is a rapidly developing subject. In recent years, there has been such rapid progress in the research efforts in this branch that it has become difficult to keep pace with the subject. After going through this unit, you will be able to:

- Get a comprehensive idea of agricultural management.
- Gain knowledge of different aspects of agricultural practices.
- Develop the concepts of modern approaches to pest and fertilizer management in the context of environmental sustainability.

7.2 INTRODUCTION

Agriculture may be defined as an activity of man primarily aimed at production of food, fibre and oils by optimum use of terrestrial resources (*Agronomic terminology,* ICAR). The term 'agriculture' is derived from the Latin words '*ager*' or '*agri*' meaning soil and '*cultura*' meaning cultivation (Reddy and Reddi, 1995). Since the beginning of agriculture man has

chosen and grown plants for food, fibre, edible oils, essential oils and related substances such as beverages, narcotics, dyes, gums, drugs, latex products and so on. It has been estimated that in his relatively short history, man has used over 3000 species of vascular plants and that 150 of these have entered the world of commerce. It will be relevant to mention here that there are nearly 20000 known seed plants and about 10000 of them are needed by man in one form or another. However, only about a thousand plant species are of economic importance and only 15 species of plants and 9 species of animals provide almost all the food for the world's population (Chatterjee, 1997).

7.2.1 HISTORY OF AGRICULTURE

The earliest man *Homo erectus* emerged around one and half a million years ago and by about a million years ago he spread throughout world-- tropics and later to temperate zones. *Homo sapiens*, the direct ancestor of modern man lived 250 thousand years ago. *Homo sapiens sapiens*, the modern man, appeared in Africa about 35 thousand years ago. He is distinguished from all other extinct species of genus *Homo*, by large brain, small teeth and chin and capacity for making and using tools. He hunted a variety of animals and cooked their meat on fire, used stone-tipped arrows and later he domesticated the dog which greatly helped him in hunting. Apart from the meat of animals, he gathered a variety of seeds, leaves and fruits from the jungle. Between the period of 7500 BC to 6500 BC, man gradually shifted from hunting and gathering to agriculture. A short account of few important milestones in the history of agriculture is presented below in table 1.

Table 1: Important milestones in the history of agriculture

Period	Events
Earlier than 10000 BC	Hunting, gathering
7500 BC	Cultivation of crops (wheat and barley)
6000 BC	Domestication of cattle and pigs
4400 BC	Cultivation of maize
3500 BC	Cultivation of potato
3400 BC	Wheel was invented
3000 BC	Bronze was used to make tools
2900 BC	Plough was invented. Irrigated farming started

2700 BC	Silk moth domesticated in China
2300 BC	Cultivation chickpea (gram), sarson and cotton
2200 BC	Cultivation of rice
1500 BC	Cultivation of sugarcane. Irrigation from well.
1400 BC	Use of iron
16 century AD	Introduction of several crops into India by Portuguese. They are potato, sweet potato, tomato, chillies, pumpkin, papaya, pineapple, guava, guava, tobacco, groundnut, American cotton, rubber.

Source: Reddy and Reddi, 1995

Hence, an effort has been made in this unit to elaborate some of the important aspects of agricultural management in the context of recent trends in scientific developments and rapidly changing environment. A brief account on pest and disease management, fertilizers and soil fertility management, crop diversification and interactions of agricultural practices and climate change phenomenon have been discussed under various sections of the unit.

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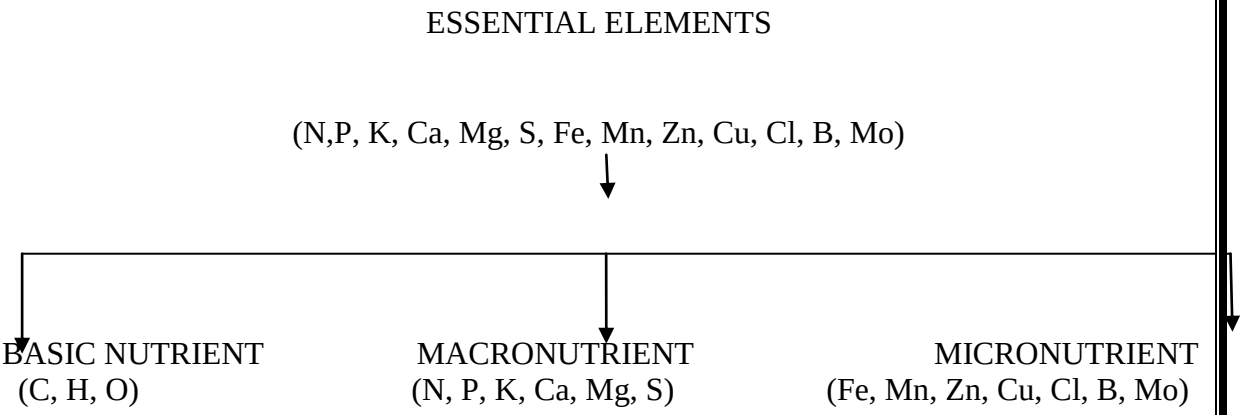
7.3 FERTILIZER AND NUTRIENT MANAGEMENT

7.3.1 DEFINITION: Fertilizers are organic or inorganic synthetic chemical compounds or refined or unrefined natural deposits which, when supplied to soil or to foliage, supply certain essential elements, particularly the primary nutrient elements, for nutrition and growth of plants.

Plants absorb more than 90 elements from soil, water, and air. Of these elements 16 are **ESSENTIAL** for growth of most plants. These are carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), Sulphur (S), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), chlorine (Cl), boron (B) and molybdenum (Mo). Hence they are called as essential elements. Plants absorb C, H and O mostly from air and water in the forms of CO_2, carbon dioxide and water, H_2O. The other 13 essential

elements (N,P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, Cl, B, Mo) are absorbed from soil. Six of them – N, P, K, Ca, Mg and S are needed in **relatively large amounts**. Hence, they are called as **macronutrients.** The other 7 essential elements are Fe, Mn, Zn, Cu, Cl, B, Mo are needed in **relatively small amounts**. They are called **as micronutrients**. The micronutrients are, sometimes, referred to as minor elements or trace elements, because only very small amounts are needed by plants. Of these 7 micro nurtrients, Mo is needed in smallest amount and hence, it is called **as ultra-micronutrient** or **nanonutrient**. Of the 6 macronutrients, N, P and K have been given primary importance to be supplied to plants through fertilizers. Hence, they are termed as primary nutrient elements or fertilizer nutrient elements or primary fertilizer nutrients. The other 3 macronutrients- Ca, Mg and S have been given secondary importance to be supplied through fertilizers; hence, they are termed secondary nutrient elements.



7.3.2 CRITERIA OF ESSENTIALITY

Plant analysis using modern techniques reveals that plant body contains about 30 elements and in some cases as many as 60 elements. The presence of several elements in plants does not mean that all these are essential elements for plants. Arnon and Stout (1939) proposed criteria of essentiality which was refined by Arnon (1954). **An element is considered as essential, when plants cannot complete vegetative or reproductive stage of life cycle due to its deficiency; when deficiency can be corrected or prevented only by supplying these elements; and when the element is directly involved in the metabolism of the plant.**

The criteria are considered too rigid from practical point of view. According to these criteria, sodium is considered non-essential. However, sodium is known to increase yield of several crops such as sugar beets, turnips and celery. Therefore, farmers consider sodium as an essential element. Nicholas (1961) proposed the term **"functional nutrient"** for **any mineral element that functions in plant metabolism whether or not its action is specific.** With these criteria, sodium, cobalt, vanadium and silicon are also considered as functional nutrients in addition to 16 elements.

7.3.3 FUNCTIONS IN THE PLANT

Based on the functions, nutrients are grouped into four:

(1) Elements that provide basic structure to the plant- C, H, and O.
(2) Elements useful in energy storage, transfer, and bonding- N, S and P. These are accessory structural elements which are more active and vital for living.
(3) Elements necessary for charge balance- K, Ca and Mg. These elements act as regulators and carriers.
(4) Elements involved in enzyme activation and electron transport- Fe, Mn, Zn, Cu, B, Mo and Cl. These elements are catalysers and activators.

7.3.4 FORMS OF NUTRIENT ELEMENTS ABSORBED BY PLANTS

ELEMENTS	FORMS
Carbon	CO_2
Hydrogen	H_2O, H^+
Oxygen	CO_2, O_2, H_2O
Nitrogen	NH_4^+, NO_3^-, $CO(NH_2)_2$ and slightly NO_2^-
Phosphorus	$H_2PO_4^-$, HPO_4^{2-} etc.
Potassium	K^+
Calcium	Ca^{2+}
Magnesium	Mg^{2+}
Sulphur	SO_4^{2-}, SO_2 and slightly S
Iron	Fe^{2+}, Fe^{3+}
Manganese	Mn^{2+}
Zinc	Zn^{2+}
Copper	Cu^{2+}
Chlorine	Cl^-
Boron	H_3BO_3-, slightly HBO_3-, BO_3-, $B_4O_7^{2-}$ (borate iron do not contribute to plants need)
Molybdenum	MoO_4^{2-}

7.3.5 MANURES & FERTILIZERS

Inorganic fertilizers are classified mainly into three different types.

1. Straight – Commercial fertilizers containing only one primary nutrient, e.g. Urea.
2. Complex- Fertilizers containing two or more primary nutrients, e.g. Ammonium Phosphate.
3. Mixed – Two or more straight fertilizers blended together physically.

Low analysis: Contain less than 25% of primary nutrients, e.g., SSP-16% P_2O_5, Sodium nitrate- 16%.
High analysis: Contain more than 25% of plant nutrients. e.g. Urea-46% N.

Characteristics of some important Nitrogenous fertilizer

Fertilizer	Chemical form	Nitrogen%(approx)

Sodium nitrate	$NaNO_3$	16%
Ammonium sulphate	$(NH_4)_2SO_4$	21%
Ammonium nitrate	NH_4NO_3	33%
CAN(Calcium Ammon. Nitrate)	$CaCO_3.NH_4NO_3$	25-26%
Urea	$CO(NH_4)_2$	46%
Ammonium sulphate nitrate	$(NH_4)_2SO_4.NH_4NO_3$	26%

1. **Phosphatic fertilizers**

   a) Single super phosphate: total superphosphate- 16% P_2O_5, 6-10.8% P

   b) Triple super phosphate: 40-48% P_2O_5

   c) Ammonium phosphate- Ammoniated superphosphate is produced by treating single super phosphate with ammonia. 19-22% P, 44-52% P_2O_5.

2. **Potassium fertilizer**:

   a) Potassium chloride: chemical formula KCl, composition- K_2O (48-60%), K (40-50%). It is commonly known as Muraite of Potash (MOP).

   b) Potassium sulphate: chemical formula K_2SO_4, composition- K_2O (48-50%), K (40-42%).

Methods of fertilizer application

1. Broadcasting – Evenly spreading of dry solid fertilizers over the field before or after sowing of crops. Broadcasting may be done in following ways:

   a. Basal application – Spreading of fertilizers before sowing or planting and mixing them by cultivating the soil.

   b. Top-dressing – Spreading of fertilizers in standing crops without considering the crop rows but when the crop rows are taken into account the material is dropped on the ground surface near the crop rows then it is called *side dressing*.

2. Placement- This refers to applying fertilizers into the soil where the crop roots can take them easily. Placement can be done in the following ways:

   a. Plough sole placement – When the fertilizers are applied in furrows at plough sole levels.

b. Deep placement – The method is adopted in dryland condition where the fertilizers are placed deeper than plough sole level.

3. Fertigation – The required quantity of fertilizer material is dissolved in irrigation water and can be dripped in the channel of irrigation water.

Manures: Manures are plant and animal wastes that are used as sources of plant nutrients. It is of two types.

a) Bulky organic manure.

b) Concentrated organic manure.

a) Bulky organic manure: Contain small percentage of nutrients and they are applied in large amount. e.g. farm yard manure, compost, vermicompost .

Vermicompost: Vermicomposting is a comparatively new method of composting that involves stabilization of organic solid wastes through earthworm consumption that converts the waste into earthworm casting.

Green manure: Green un-decomposed plant materials used as manure is called green manure,e.g., sunhemp (*Crotolaria juncea*), dhaincha (*Sesbania aculeate*)

b) Concentrated organic manure: Have higher nutrient content than bulky organic manure, e.g., oil cakes, blood meal, fish manures etc.

Biofertilizer: Biofertilizers (BF) are microbial inoculators, which enhance crop production through augmenting the nutrient supply to the crop. There are number of microbial inoculants with possible practical applications in flood degraded lands.

The N-fixing organisms relevant to rain-fed agricultural area are: Rhizobium which fixes N in a number of pulse crops, groundnut, soybeans, and N-fixing trees; Azotobacter and Azospirillium which are non-symbiotic organisms respectively. They are useful in promoting plant growth through N-fixation and secretion of hormones in the root zone.

Two more important free living nitrogen fixing organisms are blue green algae (BGA) and Azolla. Most important species of BGA with respect to N-fixing efficiency are *anabaena* and *nostoc. Azolla* is a free floating fresh water fern. *Azolla pinnata* is the most common species occurring in our country. It fixes nitrogen due to anabaena sp. Of BGA present in the lobes of Azolla leaves. Unlike BGA, it thrives well at low temperature. Small quantity of innoculum of BGA and Azolla from laboratories and they can be multiplied in the farmers field for subsequent application.

Phosphate solubilising micro-organisms are heterotrophic and known to have the ability to solubilize inorganic phosphorus from insoluble source. This group covers some bacteria (e.g; *Bacillus megaterium*, *B. circulans*, *B. subtilis*, *Pseudomonus stratita* and *P. rathonis*); fungi (eg; *Aspergillus awamori*, *Penicillium digitum* and *Trichoderma sp*.), Actinomycetes (eg. *Streptonyles sp*.), etc.

7.3.5 INTEGRATED NUTRIENT MANAGEMENT

Integrated Nutrient Management refers to the maintenance of soil fertility and of plant nutrient supply at an optimum level for sustaining the desired productivity through optimization of the benefits from all possible sources of organic, inorganic and biological components in an integrated manner.

Inorganic Fertilizers

+

Organic Manures

+

Green manures

+

Biofertilizers

Concepts

1. Regulated nutrient supply for optimum crop growth and higher productivity.

2. Improvement and maintenance of soil fertility.
3. Zero adverse impact on agro – ecosystem quality by balanced fertilization of organic manures, inorganic fertilizers and bio- inoculants.

Determinants

1. Nutrient requirement of cropping system as a whole.
2. Soil fertility status and special management needs to overcome soil problems, if any.
3. Local availability of nutrients resources (organic, inorganic and biological sources)
4. Economic conditions of farmers and profitability of proposed INM option.
5. Social acceptability
6. Ecological considerations
7. Impact on the environment

Advantages

1. Enhances the availability of applied as well as native soil nutrients
2. Synchronizes the nutrient demand of the crop with nutrient supply from native and applied sources.
3. Provides balanced nutrition to crops and minimizes the antagonistic effects resulting from hidden deficiencies and nutrient imbalance.
4. Improves and sustains the physical, chemical and biological functioning of soil.
5. Minimizes the deterioration of soil, water and ecosystem by promoting carbon sequestration, reducing nutrient losses to ground and surface water bodies and to atmosphere

Components

Principle: Mobilizing unavailable nutrients and using appropriate crop varieties, cultural practices and cropping system.

Mineral Fertilizer : Coated urea, direct use of locally available rock PO_4 in acid soils, Single Super Phosphate (SSP), MOP and micronutrient fertilizers.

Organic Sources : By products of farming and allied industries. FYM, vermicompost, crop waste, residues, sewage, sludge, industrial waste.

Biological Sources : Microbial inoculants substitute 15 - 40 Kg N/ha.

[Sources
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7.4. PEST AND DISEASE MANAGEMENT

The word 'pest' come from a Latin word, '*pestis*', meaning plague. Insects and disease producing organisms are normally recognized as pests. A pest may be defined as an organism whose existence conflicts with man's welfare and whose population often increases to such a level as to be unacceptable from considerations of economy. The organisms may be insects, nematodes, and disease producing pathogens including fungi, bacteria, viruses, weeds, rodents, birds and other animals

Agriculture upsets the balance of nature by planting large areas of unmixed crops and storing large quantities of products after harvest. These bulk quantities of food invite certain kinds of insects to proliferate excessively and become pests. A few pests and diseases of important crops of India as well as of Assam are given in the table below.

Insect pests		
Common name	Scientific name	Associated crops
Yellow Stem borer	*Scirpophaga incertulas*	Rice
Brown Plant Hopper (BPH)	*Nilaparvata lugens*	Rice
	Nephotettix sp.	Rice
Green Leaf Hopper (GLH)	*Orseolia oryzae*	Rice
Gall midge	*Cnaphalocrosis medinalis*	Rice
Leaf folder	*Sogatella furcifera*	Rice
White backed plant hopper	*Cloethrips oryzae*	Rice
	Nymphula depunctalis	Rice
Thrips	*Spodoptera mauritia*	Rice
Caseworm	*Dicladispa armigera*	Rice
Swarming caterpillar	*Ripersia oryzae*	Rice
Hispa	*Mythimna separate*	Rice
Mealy bug	*Odontotermes obesus*	Wheat, Barley and Oats
Earhead cutting	*Microtermes obesi*	Wheat, Barley and Oats

caterpillar	*Macrosiphum granasium*	Wheat, Barley and Oats
Termites	*Mythimna unipuncta*	Wheat, Barley and Oats
	Same as Rice	Maize
Aphid	*Same as wheat*	Maize
Army worm	*Amsacta moorei*	Maize
Maize stem borer	*Scirpophaga novella*	Sugarcane
Termites	*Chilo infuscatellus*	Sugarcane
Red hairy caterpillar	*Chilo tumidicostalis*	Sugarcane
Top shoot borer	*Pyrilla perpusilla*	Sugarcane
Early shoot borer	*Saccharicoccus sacchari*	Sugarcane
Sugarcane stem borer	*Aleurolobus barodensis*	Sugarcane
Sugarcane leaf hopper	*Emmalocera depressella*	Sugarcane
Sugarcane mealy bug	*Apion corchori*	Jute
Sugarcane white fly	*Anomis sabulifera*	Jute
Sugarcane root borer	*Diacrisia oblique*	Jute
Jute stem weevil	*Nupserha bicolour*	Jute
Jute semilooper	*Earias vitella*	Cotton
Jute hairy caterpillar	*Pectinophora gossypiella*	Cotton
Stem girdler	*Sylepta derogate*	Cotton
Spotted bollworm	*Pthorimaea operculella*	Potato
Pink bollworm	*Agrotis ipsilon*	Potato
Cotton leafroller	*Myzus persicae*	Potato
Potato tubermoth	*Epilachna vigintiooctopunctata*	Potato
Cutworm	*Xylotrupes Gideon*	Potato
Aphid	*Athalia lugens proxima*	Rapeseed & Mustard
Epilachna beetle	*Lipaphis erysimi*	Rapeseed & Mustard
White grub	*Empoasca binota*	Rapeseed & Mustard
Mustard saw fly	*Crocidolomia binotalis*	Rapeseed & Mustard
Mustard aphid		
Jassids		

Leaf webber		
Diseases		
Blast	*Pyricularia oryzae (fungi)*	Rice
Brown spot	*Cochlibolus miyabeanus (fungi)*	Rice
Sheath blight	*Rhizoctonia solani (fungi)*	Rice
False smut	*Ustilagonoidea virens (fungi)*	Rice
Foot rot or Bakanae	*Gibberella fuzikuroi/Fusarium Moniliforme (fungi)*	Rice
Bacterial Leaf Blight	*Xanthomonas oryzae (bacteria)*	Rice
Tungro	*Viral disease*	Rice
Ufra disease	*Ditylenchus angustus (nematode)*	Rice
Pythium root rot	*Pythium aphinidermatum (fungi)*	Wheat
Loose smut	*Ustilago tritici (fungi)*	Wheat
Sclerotial disease	*Pellicularia/Sclerotium rolfsii*	Wheat
Stem rust	*Puccinia graminis (fungi)*	Wheat
Yellow rust	*P. striformis (fungi)*	Wheat
Brown rust	*P. recondite (fungi)*	Wheat
Earcockle	*Anguina tritici (Nematode)*	Wheat
Molya disease	*Heterodera avenae (Nematode)*	Wheat
Red rot of sugarcane	*Colletotrichum falcatum (fungi)*	Sugarcane
Wilt	*Cephalosporium sacchari (fungi)*	Sugarcane
Brown leaf spot	*Cercospora longipes (fungi)*	Sugarcane
Yellow leaf spot	*Cercospora kopkei (fungi)*	Sugarcane
Early blight	*Alternaria solani(fungi)*	Potato
Late blight	*Phytopthera infestans(fungi)*	Potato
Scab	*Streptomyces scabies(fungi)*	Potato
Wart	*Synchitrium endobiotichum(fun.)*	Potato
Black scarf	*Rhizoctonia solani(fungi)*	Potato
Charcoal rot		Potato
Black leg or soft rot		Potato

Alternaria blight	*Macrophomina phaseoli(fungi)*	Rapeseed & Mustard
Downy mildew	*Erwinia carotovora (bacteria)*	Rapeseed & Mustard
	Alternaria brassicae (fungus)	
	Peronospora brassicae (fungus)	

Table 2: Dominant pests & diseases of major crops of India

7.4.1. PEST MANAGEMENT

Pest management refers to the regulation or control of species defined as pests, usually because they are supposed to be detrimental to agricultural crops and their predominance results in substantial reduction in crop production. First of all, we will discuss the prevailing options or methodologies of pest management. Apart from the traditional ways, there are also a few new concepts. Hence, in a nutshell, the various options of pest management are given as below:

a. **Cultural methods**

It includes crop production practices that make crop environment less susceptible to pests. Crop rotation[1], fallowing[2], Trap crop[3], cover crop[4], manipulation of planting and harvesting dates, manipulation of plant and row spacing, and destruction of old crop debris, tillage[5] and growing resistant varieties are the most common examples of cultural methods that are frequently used to manage the pests. Cultural control measures are selected based on knowledge of pest biology and development.

[1]**Crop rotation**- Growing of different crops on a piece of land in a pre-planned succession.

[2]**Fallowing**- It is the practice of allowing crop land to lie idle during a growing season.

[3]**Trap crop**- Growing a crop alongside another crop (main crop) to trap a particular pest that causes economic damage to the main crop but not to the other one, e.g., Bhindi in Cotton.

[4]**Cover crop**- Crops which are grown primarily to cover the soil, e.g., groundnut, cowpea.

[5]**Tillage**- It refers to the use of implements for mechanical manipulation to prepare seed-beds conducive for field crop production.

b. Physical or mechanical methods

These methods have been evolved based on the knowledge of pest behaviour. Some widely adopted methods are as follows:

Hand picking – Effective against caterpillars

Shaking & beating – Effective against caterpillars, semiloopers

Banding (digging circular drains) – Against mealy bug

Wire-gauge screening – Effective against fruit fly

Trench digging – Effective against swarming caterpillar

Flooding & draining – Effective against Rice case worm

Cooling – Effective against stored grain pests

Heating – Effective against stored grain pests

c. Biological methods

These include augmentation and conservation of natural enemies of pests such as insect predators, parasitoids, parasitic nematodes, fungi. Conservation of different bio-control agents viz. spider, damsel flies, dragonflies are needed to be conserved for controlling different insect pests of important crop plants. Usually, these organisms are natural feeders of small insects, and thus capable of reducing pest population significantly. Sometimes, Augmentative release i.e. release of some microorganisms in the existing agroecosystem is done to control certain specific pests. A few examples of bio-control are given below:

Lady bird beetle- feed upon aphids

Bracon sp.(a parasitoid wasp) – feed upon sugarcane stem borer

Augmentative release of *Trichogramma japonicum* or *T. chilonis (egg parasitic insects)* can successfully control rice stem borer and leaf folder respectively.

Spraying of *Beauveria bassiana*, a soil-born fungus acts as a parasite to white grub and other soil -born pathogens.

Release of various strains of *Bacillus thuringiensis*, a bacterium, can successfully feed upon various caterpillars.

d. Chemical methods

This includes application of agrochemical such as insecticides, fungicides, herbicides, rodenticides etc. These are the simplest ways to reduce pest attack on agricultural crops, and results are visible within a short period of time. Hence, examples of some effective chemical control measures for important crop species are presented here:

Crop: Rice

Insect pests

Stem borer – Cabofuran and/or Quinalphos @ 1 kg a.i (active ingredient)/ha.

Brown Plant Hopper – Quinalphos/Chlorpriphos/Monocrotophos/Carbaryl @ 0.5 kg a.i/ha or imidacloprid @ 25 kg a.i /ha (Hectare) or apply ethofenprox @ 75 g a.i /ha.

Green leaf hopper - Quinalphos/Chlorpriphos/Monocrotophos/Carbaryl @ 0.5 kg a.i/ha or imidacloprid @ 25 kg a.i /ha or apply carbofuran @ 0.75 kg a.i /ha.

Gall midge – Carbofuran @ 1 kg a.i./ha.

Diseases

Blast- Carbendazim/ediphenphos (fungicide) @ 0.1% spray.

Brown spot – apply mancozeb @ 0.25 % or carbendazim @ 0.1% spray during early morning or late afternoon and avoid spraying during flowering period.

Bacterial Leaf Blight – Reduce Nitrogen dose and apply nitrogenous fertilizers in small doses in splits. If the disease incidence is observed during panicle initiation stage (the stage begins when primordial of panicles are differentiated and becomes visible), the topdressing of nitrogenous fertilizers should be avoided.

Crop: Wheat

Insect pests

Termites – Treat the seeds with Chlorpyriphos @ 4 ml/kg of seeds.

Aphid – Dimethoate or oxydemeton methyl @ 200-250 g a.i. per ha

Army worm – Quinalphos @ 400 g a.i. /ha.

Diseases

Rust – In India there are several resistant varieties of wheat, but in case of severe incidence foliar spray of propicanazole (0.1%) is effective.

Loose smut – Seed treatment with systemic fungicides like carbrndazim @ 2.5 g/kg of seed.

Molya disease – Application of 1.5 kg a.i/ha of carbofuran 3 G (granule) at the time of seed sowing.

Crop: Rapeseed & Mustard

Insect pests

Sawfly – Malathion 50 EC (Emulsified Concentrate) spray @ 0.05% i.e 500 ml/ ha or Quinalphos/Endosulphan @ 625 ml/ha spray.

Aphid - Quinalphos/Endosulphan @ 625 ml/ha spray or phosphamidon spray 150-250 ml/ha.

Diseases

Alternaria blight & downy mildew – Mancozeb @ 1.5-2 kg a.i/ha.

Demerits of chemical control

However, prolong and indiscriminate application of these agrochemicals causes soil and water pollution and thus environmental degradation takes place. Apart for that, the pathogens or the causal organisms develop resistance against the pesticides. It has been observed that pests whose populations were initially suppressed by pesticide application rebounded in excessive levels within a short period of time and some unimportant non-target species developed into serious pests after long term application of pesticides in order to control other targeted species.

7.4.2. INTEGRATED PEST MANAGEMENT (IPM)

It is an ecology based strategy that relies primarily on natural factors such as predators, parasites, cultural practices, mechanical practices and resistant varieties. Chemicals are used, but only as a last resort. The primary goal is to optimize pest control economically as well as

ecologically and environmentally. Therefore, IPM may be defined as a pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as posible and maintains the pest population at levels below those causing economic injury.

FAO (Food and Agricultural Organization) opines that ***IPM means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM emphasizes the growth of healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms***.

There is a specific population density of each pests or pathogens per unit area of land which causes significant reduction in crop yield. Therefore, it is mandatory to find out the level of pest population that is economically detrimental. That particular pest population density is termed as **Economic Injury Level (EIL)**, which may also be defined as **the lowest pest population density that will cause economic damage**. After establishing the EIL, the tusk of an IPM practitioner to standardize the pest population at which control measures are to be applied. This level of pest density is termed as **Economic Threshold Level (ETL)**, which may be defined as **the pest population at which control measures should be started. Usually it is just below the EIL. ETL is also termed as Action Threshold, i.e. where the action starts.**

Hence, establishment of ETL is the foremost need for IPM. It is, however, not a fixed level but a dynamic concept which may vary markedly with time and space and thus needs revision. Economic threshold (ET) is set on the basis of collection of year wise and season wise data in a prescribed format over the years and analysis of the same. ETL varies from pest to pest and sometimes from season to season and it has to be established for all the crops independently.

[Source
P. B. Chatterjee (1997). *Plant Protection Techniques*, Bharati Bhawan (P&D).]

7.5 CROP DIVERSIFICATION

Crop diversification provides a greater choice in various crops production in a specified area expanding production related activities besides minimising risk. In India, crop diversification is normally picturised as a shift from traditionally grown less remunerative crops to more remunerative crops. The governmental policies and thrust on some crops over a given period

leads to the occurrence of the crop shift (diversification), for example creation of the Technology Mission on Oilseeds (TMO) to give thrust on oilseeds production as a national need for the country's requirement for less dependency on imports. Besides Market infrastructure development and certain other price related supports also induce crop shift. Additionally low volume high-value crops like spices including higher profitability and the resilience/stability in production also boost crop diversification, for example sugar cane replacing rice and wheat. Crop diversification and the numerous crops cultivation are practiced in rain-fed lands to lessen the risk factor of crop failures due to drought or little rainfall. Nowadays, the areas with distinct soil problems are also using crop substitution and shift techniques .The growing of rice in high water table areas replacing oilseeds, pulses and cotton; promotion of soybean in place of sorghum in vertisols (medium and deep black soils) etc. are some of the examples.

7.5.1. CROP DIVERSIFICATION IN THE INDIAN PERSPECTIVE

With the onset of modern agricultural technology, especially during the period of the Green Revolution in the late sixties and early seventies, there was a continuous spurt in diversified agriculture in terms of crops, primarily on economic considerations. The crop pattern changes, however, are the outcome of the in

teractive effect of many factors which can be broadly categorized into the following five groups:

a) Resource related factors covering irrigation, rainfall and soil fertility.

b) Technology related factors covering not only seed, fertilizer, and water technologies but also those related to marketing, storage and processing.

c) Household related factors covering food and fodder self-sufficiency requirement as well as investment capacity.

d) Price related factors covering output and input prices as well as trade policies and other economic policies that affect these prices either directly or indirectly.

e) Institutional and infrastructure related factors covering farm size and tenancy arrangements, research, extension and marketing systems and government regulatory policies.

7.5.2. TEMPORAL CHANGES IN THE AREA SHARE OF CROPS

The temporal behaviour of crop pattern changes at the all India level can be seen from Table 3 and Table 4 that show, respectively, the area share of main crop groups and major crops for the four periods. Both the tables provide evidence for a substantial area shift from cereals to non-cereals. Although cereals gained a marginal increase in area share in the first decade of the Green Revolution, their area and share declined gradually thereafter. Between 1966/67 and 1996/97, 3.35 percent of the gross cultivated area (GCA) - representing approximately about 5.7 million hectares (m/ha) - has shifted from cereal crops to non-cereal crops. In area terms, the shift from food grains to non-food grains involves an approximate area of about 8.36 m/ha. While cereals and pulses have lost area, the major gainers of this area shift are the non-food grain crops especially oilseeds. The area share of oilseeds as a group that has gone up by 4.08 percent accounts for about 83 percent of the 8.36 m/ha involved in the area shift between 1966/67 and 1996/97. Considering the share of individual crops within cereals, the share of cereals as a group has gone down, the area share of rice has increased continuously over all the four periods. Wheat, although having a declining area share until 1986/87, also gained in its share when the entire period is considered. Within oilseeds, the crops showing steady improvement in their area share are: rapeseed and mustard, soybean and sunflower. Since the Gross Cropped Area (GCA) is constantly increasing over time, partly through an expansion of net sown areas as in the initial stages of the Green Revolution and partly through increasing intensity of cropping mainly by irrigation expansion, the declining area share can coincide with an increase in absolute increase in the area under crops.

7.5.3. SUCCESS STORY IN CROP DIVERSIFICATION

It is clear that most of the area shifts that occurred during the three decades between 1966/67 and 1996/97 are from coarse cereals to oilseeds. Three notable aspects of this area shift towards oilseeds can be noted. First, most of these area shifts have occurred particularly during the decade ending 1996/97. A protective trade environment, favourable price policy and the connecting of the Technology Mission on Oilseeds (TMO) during this period have all enhanced the comparative advantage of oilseeds. As can be seen from Table 3, the area share of oilseeds that increased just by a percentage each during the two decades before 1986/87 has risen suddenly by 43 percent during the decade ending 1996/97. Second, the area shift during this period comes mainly from barley and pulses other than pigeon pea. Since most of those crops losing their area share are usually grown under rain fed conditions where oilseeds can also be grown, the area shift can be said to involve mostly rain fed areas, although comparative advantage and crop rotation considerations often favour oilseeds even in groundwater irrigated areas. Thirdly, as can be seen from Table 4, there is also a significant

area shift within oilseed crops. For instance, while the area shares of rapeseed and mustard, sunflower and soybean are increasing steadily, those of sesame, linseed and nigerseed are declining gradually. Thus, the area shift has favoured only a sub-sector within the oilseed sector partly because of constant changes in the comparative advantage of different oilseeds and partly because of the impact of changing consumers' preferences on the relative demand for oilseeds.

Table 3. All India: Temporal Change (percent) in the Area Share of Main Crops and Crop Groups, 1966/67 to 1996/97

No.	Crops	TE 1966/67	TE 1976/77	TE 1986/87	TE 1996/97
1	***Rice***	23.90	24.13	24.75	25.29
2	***Wheat***	11.99	10.01	9.62	15.03
3	***Coarse Cereals***	26.49	29.20	28.09	18.70
4	***All Cereals***	62.38	63.34	62.47	59.03
5	***Gram & Pigeon Pea***	7.26	6.48	6.25	6.30
6	***Other Pulses***	8.06	7.99	7.85	7.45
7	***All Pulses***	15.32	14.46	14.10	13.75
8	***All Foodgrains***	77.70	77.80	76.56	72.78
9	***Sunflower & Soybean***	0.54	0.79	0.91	0.77
10	***All oilseeds***	11.27	11.24	12.07	15.35
11	***Fibres***	6.28	5.25	5.18	5.72
12	***Spices***	0.64	0.83	1.02	1.12

Source: Hazra, 2000

Table 4. All India: Temporal Change (percent) in the Area Share of Major Crops, 1966/67 to 1996/97

Sl. No.	Crops	TE 1966/67	TE 1976/77	TE 1986/87	TE 1996/97
1	***Rice***	23.90	24.13	24.75	25.29
2	***Wheat***	11.99	10.01	9.62	15.03
3	***Sorghum***	1.82	1.65	0.77	6.75
4	***Pearl Millet***	8.03	7.00	6.52	5.81
5	***Maize***	3.23	3.73	3.51	3.60
6	***Finger Millets***	1.70	1.58	1.44	1.05
7	***Small Millets***	3.06	2.88	1.87	1.01
8	***Barley***	8.66	12.37	13.97	0.49
9	***Gram***	5.55	4.86	4.35	4.27
10	***Pigeon Pea***	1.71	1.62	1.90	2.04
11	***Blackgram***	0.00	1.33	1.85	0.62
12	***Greengram***	0.00	1.50	1.78	0.60
13	***Horsegram***	0.00	1.26	1.09	0.21
14	***Peas & Beans***	0.00	0.43	0.29	0.14

15	***Lentil***	0.00	0.57	0.63	0.22
16	***Lathyrus***	0.00	0.98	0.71	0.19
17	***Mothbeans***	0.00	1.21	0.86	0.12
18	***Other Pulses***	8.06	7.99	7.85	7.45
19	***Groundnut***	4.99	4.44	4.27	4.55
20	***Castor***	0.28	0.30	0.38	0.45
21	***Sesamum***	1.74	1.39	1.30	1.15
22	***Rape & Mustard***	1.97	2.11	2.34	3.82
23	***Linseed***	1.17	1.27	0.80	0.52
24	***Safflower***	0.21	0.42	0.55	0.43
25	***Nigerseed***	0.33	0.38	0.36	0.34
26	***Sunflower***	0.00	0.19	0.52	1.20
27	***Soybean***	0.00	0.06	0.82	1.83
28	***Coconut***	0.59	0.68	0.73	1.07
29	***Cotton***	5.39	4.54	4.38	5.11
30	***Jute***	0.54	0.41	0.56	0.46
31	***Mesta***	0.23	0.21	0.18	0.11
32	***Sunnhemp***	0.12	0.09	0.06	0.04
33	***Pepper***	0.07	0.07	0.07	0.11
34	***Chillies***	0.46	0.46	0.51	0.52
35	***Ginger***	0.02	0.02	0.03	0.04
36	***Turmeric***	0.04	0.05	0.06	0.08
37	***Coriander***	0.00	0.16	0.23	0.25
38	***Cardamom***	0.04	0.06	0.07	0.06
39	***Garlic***	0.00	0.02	0.04	0.06
40	***Banana***	0.14	0.14	0.18	0.25
41	***Potato***	0.31	0.38	0.51	0.68

Source : Hazra 2000

7.5.4. Constraints in Crop Diversification

The major problems and constraints in crop diversification are primarily due to the following reasons with varied degrees of influence:

i. Over 117 m/ha (63 percent) of the cropped area in the country is completely dependent on rainfall.

ii. Sub-optimal and over-use of resources like land and water resources, causing a negative impact on the environment and sustainability of agriculture.

iii. Inadequate supply of seeds and plants of improved cultivars.

iv. Fragmentation of land holding less favouring modernization and mechanization of agriculture.

v. Poor basic infrastructure like rural roads, power, transport, communications etc.

vi. Inadequate post-harvest technologies and inadequate infrastructure for post-harvest handling of perishable horticultural produce.

vii. Very weak agro-based industry.

viii. Weak research - extension - farmer linkages.

ix. Inadequately trained human resources together with persistent and large scale illiteracy amongst farmers.

x. Host of diseases and pests affecting most crop plants.

xi. Poor database for horticultural crops.

xii. Decreased investments in the agricultural sector over the years.

7.6 AGRICULTURAL MANAGEMENT AND CLIMATE CHANGE

Agriculture plays a pivotal role in food and livelihood security for a large section of people in India. It is a high-risk profession, since natural factors like temperature, precipitation, hail and thunder storms, and pest epidemics influence crop production and thereby the economic fate of the farmer and Indian agriculture may be described as a gamble in the monsoon and presently becoming a gamble in temperature. For example, an increase in mean temperature of March-April will reduce the duration of wheat crop in Punjab by one week and thereby the yield by about 400 kg per hectare (Swaminathan, 2010).

It is apprehended that climate risks will increase in future and in association with global climate change, the problems of agricultural management would be further compounded. IPCC has projected that global mean annual surface air temperature increase by the end of this century is likely to be in the range of 1.8 to 4 ^{0}C (Aggarwal, 2010). Several recent studies indicate a probability of 10-40 per cent loss in crop production by 2080-2100 AD in India due to increase in temperature, rainfall variability, and decrease in irrigation water supply (Aggarwal, 2010).

Precise weather forecasting is becoming a difficult task due to various factors associated with global climate change and an effective insurance system for saving our farmers from crop loss due to climatic abnormalities, is also lacking in our country. Therefore, producing enough food in future to cope with increasing demand, by keeping our environment protected and against the background of reducing resources in changing climate scenario, is a herculean task.

7.6.1. ADAPTATION STRATEGIES

Our country is bestowed with a considerable amount of traditional wisdom for adapting climatic risks in the agricultural sector that is extremely valuable under the prevailing perspectives on climate change. We have already adapted our agriculture to climatic stresses by resorting to mixed cropping, changing varieties and planting times, by diversifying sources of income for farmers, and maintaining buffer stocks of food for managing periods of scarcity. Some of the key elements of adaptation frameworks as suggested by Dr. P K Aggarwal of International Water Management Institute, New Delhi, are given in following paragraphs:

1. Assisting farmers in coping with current climatic risks such as improving collection and dissemination of weather related information, establishing a regional early warning system of climatic risks, promoting insurance for climatic risk management, facilitating establishment of community partnership in food, forage and seed banks.
2. Intensifying food production systems by promoting new genotypes that are tolerant to multiple stresses like drought, flood, heat, salinity and pest and thereby bridging yield gaps in crops. Enhancement of livestock fishery productivity is also necessary.
3. Improving land and water management by implementing strategies for water conservation and use efficiency, managing coastal ecosystems, increasing the dissemination of resource conserving technologies and exploiting the irrigation and nutrient supply potential of treated wastewaters.
4. Enabling policies and regional cooperation by integrating adaptation perspectives in current policy considerations, providing incentives for resource conservation, establishing regional food security programmes, securing finances and technologies for adaptation and raising capacity in regional climate change assessment.
5. Strengthening research for enhancing adaptive capacity by assessing regional impacts on crops, livestock, fisheries, pests, and microbes, evolving adverse climate tolerant genotypes and evaluating the biophysical and economic potential of various adaptation strategies.

To increase the coping capacity of farmers to meet the challenges of global warming and climate change in addition to common natural calamities specific strategies are needed to be developed. Prof. M. S. Swaminathan, Chairman, M S Swaminathan Research Foundation, has

put down some strategies for climate resilience. The salient features of his suggestions are as follows:

Establishment of Capacity building Centres & Climate Risk Management Centres

The Indian Council of Agricultural Research has divided the country into 13 major and 127 micro level agroclimatic zones. So, in each 127 agro-ecosystems, a research and capacity building centre with a meteorological station and a weather information bureau, for enabling farm families to meet the challenges arising from abnormal monsoon behaviour is needed to be established.

Similarly, in each of the agroclimatic zones, a Climate Risk Management Centre should also be developed. All such centres should have a Village Resource Centre with satellite connection in collaboration with the Indian Space Research Organization (ISRO).

The research and capacity building centres should promote the establishment of seed, grain and water banks in the area. Seed reserves are important for crop security, while grain reserves are important for food security. Hence, the seed bank should consist of locally adapted strains which can do well under late sown and unfavourable conditions.

Development of Village Knowledge Centres

It emphasized the need for a network of village knowledge with internet and satellite connectivity to provide early warning of impending cyclones, tsunami and other natural hazards.

Promotion of sea water faming

Since 97 % of the global water is sea water, this invaluable resource should be utilized for starting agri-aqua farming all along the shore line. Such farms will have a combination of halophytes like mangroves, salicornia, atriplex, as well as plants like casuarinas, cashewnut and coconut. Shrimps, prawns and other aquatic sources of food can be cultured in ponds containing sea water.

Climate Risk Managers

A cadre of Climate Risk Managers, at least one man and one woman in each block, should be developed. At the same time, steps should be taken to extend insurance facilities to communities which ought to be insulated from disaster.

National Bio-security System

Pest and disease outbreaks can cause serious harm to crops and farm families. The H5N1 strain of avian influenza is an example of the loss caused to the poultry farmers. Therefore, a well planned National Bio-security System should be developed as per recommendation of the National Commission on Farmers (NCF).

[Source: Hindu Survey of Agriculture, 2010.]

7.7 SUMMARY

Scientific agriculture plays an important role in the process of economic enrichment of the country. If development is to occur, agriculture must be able to produce surplus food and exportable commercial crops on cost effective basis. At the same time, agriculture practices must sustain the degrading environment and conserve the resource base. Under these perspectives, different aspects of agricultural management have been discussed in this section. The unit covers characteristics and uses of fertilizers and manures, pest and disease management and also provides valuable information on Integrated Nutrient Management (INM) and Integrated Pest Management (IPM) under the light of sustainable development. A few contemporary topics like crop diversification and climate change interactions and their impact on agricultural production have also been duly emphasized in this section.

7.8 SUGGESTED READINGS

Principles of agronomy. Dr. T.Y. Reddy and Prof. G. H. Sankara Reddi, Kalyani Pub., New Delhi.
Modern Techniques of raising field crops. Chiddha Singh, Prem Singh & Rajbir Singh. Oxford & IBH Co. Pvt. Ltd., N. Delhi.
Plant protection Techniques. P.B. Chatterjee. Bharati Bhawan (P&D).

7.9 PROBABLE QUESTIONS

1. What do you understand by criteria of essentiality? Why Mo (molybdenum) is termed as nano-nutirent? Differentiate between basic, macro and micro nutrients.

2. Define fertilizer. What is a low analysis fertilizer? Give characteristics of some important nitrogenous fertilizers. Describe a few methods of fertilizer application.

3. Differentiate between manures & fertilizers. What is bio-fertilizer? Do you think manures and bio-fertilizers play an important role in establishing INM?

4. What is a pest? What do you understand by biological control? Describe with suitable examples. "IPM is the need of the day". Justify your answer.

5. What is the importance of crop diversification? Describe some constraints of crop diversification from the Indian perspective.

6. Suggest some adaptive measures for sustaining agricultural production against the changing climate.

*** Short-notes, MCQs, matching & "true-false" type of questions may come from sections 7.1, 7.2 and 7.3.**

DEM 102 NATURAL RESOURCES AND SUSTAINABLE DVELOPMENT CR 4

UNIT-8: NATURAL RESOURCE MANAGEMENT IN NORTHEAST INDIA

UNIT STRUCTRE

8.1 OBJECTIVES

After going through this unit, you will be able to:

- acquire knowledge of the natural resources available on the earth and understand the concepts of renewability and non-renewability of resources.
- get an idea about different natural (e.g., natural vegetation and forest resources, biodiversity and food resources, water, soil & mineral resources) and managed resources (agriculture & allied resources) and to realize their ecosystem services.
- analyze the causes of depletion of natural resources
- discuss the methods that can be adopted for natural resource management

8.2 INTRODUCTION

The word resource means “a source of supply or support generally held in reserve”. A natural resource is the stock that can be drawn from nature, i.e. air, water, minerals, land vegetation, animals, solar energy and raw materials, for supporting life. For man, resources are those materials which are needed for survival and prosperity. A natural resource may exist as a

separate entity such as fresh water, and air, as well as a living organism such as a fish, or it may exist in an alternate form which must be processed to obtain the resource such as metal ores, oil, and most forms of energy. Soil, water and vegetation are three basic natural resources. The nature of resources varies from society to society, depending upon culture, level of development and nature of work of that particular society. On the basis of their abundance and availability, the natural resources can be classified as Renewable and non-renewable resources. Resources that have the inherent capacity to reappear, or replenish themselves by quick recycling, reproduction and replacement within a reasonable time and maintain themselves, are called renewable resources, e.g. soil, water and living organisms. Resources that lack the ability for recycling and replacement are called non renewable resources, e.g. fossil fuels like coal, petroleum and minerals. Renewable resources can become non renewable if used too rapidly by improper management. So, resource management is an important topic to be discussed. Our resource problem is fundamentally a people problem, too many people chasing after a limited supply of resources. It is impossible to maintain an ever-growing population on a constant average standard of living as population continues to grow and resources are finite.Over-exploitation of natural resources by growing population resulted in various severe problems. Destruction of vegetation has resulted in land degradation, denudation, soil erosion, landslides, floods, drought and unbalanced ecosystems. A balanced ecosystem is an urgent need. To obtain this everybody should have knowledge on natural resource management. The strength of nations- i.e. social, economic and political-is chiefly determined by the resources they conquered and their capacity to utilize and conserve these resources. The developing countries have a large fraction of the world's raw materials. Their resources have been subjected to constant exploitation through the market mechanism of the developed countries. The over-utilization of the natural resources by the developed nations got reflected in the adverse shift of the ecological balance of the world.

8.3 CLASSIFICATION OF NATURAL RESOURCES

There are various methods of categorizing natural resources, these include source of origin, stage of human use, and by their renewability, and these classifications are described below. On the basis of origin, resources may be divided into:

A) Biotic – Biotic resources are obtained from the biosphere (living and organic material), such as forests, animals, birds, and fish and the materials that can be obtained from them. Fossil fuels such as coal and petroleum are also included in this category because they are formed from decayed organic matter.

B) Abiotic – Abiotic resources are those that come from non-living, non-organic material. Examples of abiotic resources include land, fresh water, air and heavy metals including ores such as gold, iron, copper, silver etc.

Considering their stage of development, natural resources may be referred to in the following ways:

A) Potential Resources – Potential resources are those that exist in a region and may be used in the future. For example, petroleum may exist in many parts of India, having sedimentary rocks but until the time it is actually drilled out and put into use, it remains a potential resource.

B) Actual Resources – Actual resources are those that have been surveyed, their quantity and quality determined and are being used in present times. The development of an actual resource, such as wood processing depends upon the technology available and the cost involved.

C) Reserve Resources – The part of an actual resource which can be developed profitably in the future is called a reserve resource.

D) Stock Resources – Stock resources are those that have been surveyed but cannot be used by organisms due to lack of technology. For example: hydrogen.

Renewability is a very popular topic and many natural resources can be categorized as either renewable or non-renewable:

Renewable resources are ones that can be replenished naturally. Some of these resources, like sunlight, air, wind, etc., are continuously available and their quantity is not noticeably affected by human consumption. Though many renewable resources do not have such a rapid recovery rate, these resources are susceptible to depletion by over-use. Resources from a human use perspective are classified as renewable only so long as the rate of replenishment/recovery exceeds that of the rate of consumption.

Non-renewable resources are resources that form extremely slowly and those that do not naturally form in the environment. Minerals are the most common resource included in this category. By the human use perspective resources are non-renewable when their rate of consumption exceeds the rate of replenishment/recovery. A good example of this is fossil fuels which are in this category because their rate of formation is extremely slow (potentially millions of years), which means they are considered non-renewable from a human use

perspective. Some resources actually naturally deplete in amount without human interference, the most notable of these are the radio-active elements such as uranium, which naturally decay into heavy metals. Of these, the metallic minerals can be re-used by recycling them. But coal and petroleum cannot be recycled.

8.4 NATURAL VEGETATION AND FOREST RESOURCE

Forests are the one of the world's most abundant resources. Forest plays a vital role in regulating climate, controlling water runoff, providing shelter and food for wildlife, and purifying the air. They produce valuable materials such as wood and paper pulp on which we all depend. Furthermore, forests also have scenic, cultural and historic values that deserve to be protected. Forests can be broadly classified into six different types on the basis of temperature and rainfall regime of the concern region viz. i) cool coniferous forest, ii) temperate mixed forest, iii) warm temperate moist forest, iv) tropical moist evergreen forest, v) tropical moist deciduous forest and vi) dry forest. The richest and most diverse terrestrial ecosystems on the earth are the tropical forests. These forests are thought to contain more than two third of all plant biomass and at least one half of all plant, animal and microbial species of the world. The loss of forest cover is directly associated with the growth of population and their pressure on the forest ecosystem. Deforestation is the complete clearing of the tree formations and their replacement by using land for other purposes. There are several factors that cause deforestation:

8.4.1 DEFORESTATION AND ITS IMPACT

Deforestation may be attributed to the following factors:

1. Diversion of forest land to non forestry purposes(agricultural expansion, river valley projects, roads, industry and urbanization, transmission lines and other miscellaneous activities)
2. Population growth
3. Fuel wood
4. Shifting cultivation
5. Demand of timber/ use of wood
6. Overgrazing
7. Fires
8. Resin tapping
9. Encroachment

10. Acid rains

Major consequences of deforestation: Apart from causing imbalance in the ecosystem, deforestation has adverse effects on atmosphere, hydrosphere and lithosphere in the following ways

- It threatens the existence of many wild life species due to destruction of their natural habitat.
- Biodiversity is lost and along with that genetic diversity is also eroded.
- Hydrological cycle gets affected, thereby influencing rainfall
- Problems of soil erosion and loss of soil fertility increases.
- In hilly areas, it often leads to landslides.
- Because of deforestation $-CO_2$ in the atmosphere increases which leads to global warming because forest acts as a sink to CO_2.

8.5 BIODIVERSITY AND FOOD RESOURCE

Biodiversity can be defined as species richness (plants, animals and microorganisms) occurring as an interacting system in a given habitat. It is the total sum of genes, species and ecosystems. Genetic diversity is the basic source of biodiversity. It is the total genetic information contained in the genes of individual of plants, animals and microorganisms. Thus, biodiversity may be described in terms of genes, species and ecosystem, corresponding to three fundamental levels of biological organization.

Species diversity implies the variability of population with respect to the reproductive distinctiveness of each of the individuals.

Ecosystem diversity relates to the variety of habitats, biotic communities and ecological processes in the biosphere as well as the diversity within ecosystems.

About 80,000 edible plant species have been reported from wild plants. About 90% of present day food crops have been domesticated from wild tropical plants. Even now our agricultural scientists make use of the existing wild species plants which are closely related to our crop plants for developing new hardy strains. Wild relatives usually possess better tolerance and hardiness. A wide range of species provides many thousands of food products, such as, fruits, vegetables, nuts, meat, and food additives in the form of food colourings, flavourings and preservatives through agriculture and from the harvest of natural populations. Biodiversity,

food and nutrition intersect on a number of key issues. Biodiversity contributes directly to food security, nutrition and well-being by providing a variety of plant and animal foods from domesticated and wild sources. Biodiversity can also serve as a safety-net to vulnerable households during times of crisis, present income opportunities to the rural poor, and sustain productive agricultural ecosystems. The productivity of these food grains sometimes suffers due to flood or drought conditions causing shortage of food. This shortage of food, national or global, gives rise to food problems. These problems are often associated with hunger, starvation and famine.

Biodiversity not only provides direct benefits like food, medicine, and energy; it also affords us a "life support system." Biodiversity is required for the recycling of essential elements, such as carbon, oxygen, and nitrogen. It is also responsible for mitigating pollution, protecting watersheds, and combating soil erosion. Because biodiversity acts as a buffer against excessive variations in weather and climate, it protects us from catastrophic events beyond human control.

The major causes of loss of biodiversity are:

- Habitat destruction (burning or felling of old-growth forests)
- Overexploitation (over hunting of elephants and rhinos)
- Pollution (industrial emissions that cause acid rain)
- Global climate change (the greenhouse effect and destruction of the ozone layer)
- Invasion by introduced species (displacement of native songbirds in the U.S. by European starlings)

These direct threats are often driven by underlying social conditions, including increased per-capita consumption, poverty, rapid population growth, and unsound economic and social policies.

8.6 WATER RESOURCES

Water is the most vital resources for life. Human beings, animals and plant can not survive without water; in fact, the human body is mostly water. We can go without food for up to 30 days, but we cannot go without water even for a few days. Water is used for agricultural, industrial, household, and environmental activities. So our topmost biological necessity- food is mainly obtained from agricultural products. Food, directly eaten by humans including grains, vegetables, fruits, meat and fish, is the consumptive value of biodiversity. The

world's food security may be threatened due to shortage of irrigation water. All of these human uses require fresh water. Water resources are divisible into two distinct categories: the surface-water resources & the ground-water resources. Surface water is water in a river, lake or fresh water wetland. Surface water is naturally replenished by precipitation and naturally lost through discharge to the oceans, evaporation, evapotranspiration and sub-surface seepage. Ground water consists of 9.86% of fresh water. It is filtered through aquifer. Each of these categories is a part of the earth's water circulatory system, called the hydrologic cycle, & is ultimately derived from precipitation, which is rainfall plus snow. They are interdependent & frequently the loss of one is the gain of the other. Hydrologic cycle helps us to get a regular annual supply of fresh water. In most cases there is no substitute for water and as a resource, water is largely irreplaceable.

8.6.1 FACTORS AFFECTING WATER RESOURCES

The water resources of a region, conceived as a dynamic phase of the hydrologic cycle, are influenced by the following four major groups of factors:

(A)Climatic factors

i) Rainfall: its intensity, duration & distribution.
ii) Snow
iii) Evapo-transpiration

(B) Physiographic factors

i) Basic characteristics. Climatic factors

ii) Geometric factors: drainage area, shape, slope & stream density.

iii) Physical factors: land use, surface infiltration conditions, soil types etc.

iv)Channel characteristics : carrying capacity & storage capacity.

(C) Geological factors

i) Lithologic including composition, texture, sequence of rock types & the thickness of rock formations.
ii) Structural, including chief faults & folds that interrupt the uniformity of occurrence of rock types or sequence of rock types also beds, joints, fissures, cracks, etc.

iii) Hydrologic characteristics of the aquifers permeability, porosity, transmissivity, storability,etc.

(D) Anthropogenic factor

i) Extraction of ground water at rates higher than its recharging allowing the incursion of saline water in aquifers and subsidence of ground. Pollution with persistent toxic chemicals.

ii) Inefficient technology for water use.

iii) Change of water runoff and infiltration patterns by deforestation and soil erosion.

8.6.2 POSSIBLE SOLUTIONS TO WATER CRISIS

The following is a list of possible solutions to the water crisis

(A) Reduced demand

i) Educate people to reduce less water.

ii) Install water saving devices (e.g. self closing taps, dual flush toilets, spray taps in sinksets, drip irrigation in agriculture, etc.)

iii) Reduce industrial consumption through recycling, reuse and new water-efficient technologies.

(B) Rain Water Harvesting

(i)Implement rain water harvesting both in urban and rural areas.

(ii) Retain water on land as long as possible through check dams and contour bunds.

(iii) Collect water from dew and fog using large nets

(C) Adopt fairer policies

(i) Price water properly

(ii)Give communities control over local water sources

8.7 AGRICULTURE AND ALLIED RESOURCES

Agricultural land, a farm or a ranch, is a man managed ecosystem which is scientifically manipulated to achieve maximum sustained productivity. In primitive agriculture, a piece of land was kept under cultivation for some years depending upon the fertility of the land. But with the population explosion, the situation changed. Since the agricultural land is limited, modern agro techniques are now practiced to increase productivity. Therefore, agriculture has evolved beyond crop culture to become an environmental technology with its prime focus on the management of land, water air, pest control, fertilizer application, use of high yielding seeds, crop management and so on. The basic resources for agriculture are sunlight, soil and water. Soil is a very important resource as it takes a long time to form. One centimeter of top soil takes 50 years to form. In recent years there have been marked increases in crop productivity due to genetic manipulation, use of fertilizers, pest control methods as well as mechanization and sound ecological methods. Two to three crops have now become possible on the same land due to good irrigation and short duration growth plants (genetic manipulation).Efforts are now being made all over the world to increase production by using biotechnological methods, putting a lot of auxiliary energy into agricultural fields. However the crop yield varies from region to region depending upon the climatic factors, technology inputs and management strategies used. Agricultural lands need to be conserved from degradation and efficient management practice needs to be followed.

8.7.1 SUSTAINABLE AGRICULTURAL PRODUCTION

Intensive cultivation of land without conservation of soil fertility and structure would lead ultimately to the springing up of deserts. Irrigation without proper drainage would result in development of saline and alkaline soils. The indiscriminate use of pesticides, fungicides and herbicides could cause adverse changes in biological balance as well as lead to an increase in the incidence of cancer and other diseases, through the toxic residues present in the grain and other edible parts. Unscientific tapping of underground water would lead to the rapid exhaustion of water resources. The rapid replacement of numerous locally adapted varieties with one or two high yielding strains in large contiguous areas would result in the spread of serious diseases capable of wiping out entire crops. Therefore, the initiation of exploitative agriculture without a proper understanding of the various consequences may only lead us into an era of agricultural disaster in the long run. To obtain an era of agricultural prosperity the following conditions are essential:

i) Organic agriculture: Cultivation without any use of chemical inputs like mineral fertilizers and chemical pesticides

ii) Green agriculture: Cultivation with the help of integrated pest management, integrated nutrient supply and integrated natural resource management systems.

iii) Ecoagriculture: Based on conservation of soil, water and biodiversity and the application of traditional knowledge.

iv) EM agriculture: System of agriculture based on substantial use of microorganisms, particularly fungi.

v) One –straw revolution: System of natural farming without ploughing, chemical fertilizers, weeding and chemical pesticides and herbicides.

Livestock, one of the important renewable resources as they provide milk, eggs, meat, skin and other products. Livestock is also used for rural transport and agriculture. To get a sustained yield, their proper breeding, health care and management and diet are essential. Recent advances in biology have helped produce better livestock and their management.

8.7.2 MANAGEMENT OF FISH RESOURCES

Fisheries are the major sources of world's food supply and are particularly important as a source of protein. It may provide 10-13% of the world's protein. About two million people, mostly in developing countries, depend on fish as their main source of food. Fifty five percent of this fish comes from the ocean, 33% from aquaculture and 12% from inland fresh water fishing in rivers, lakes, reservoirs and ponds. Aquaculture is the artificial production of fish in ponds and under water cages. World's fish harvest is also used as animal feed, fishmeal and to obtain fish oils. A massive increase in global fishing began with the rapid induction of new technology which leads to the increased harvest rate compared with the fish population growth. For each species of fish, there is a maximum sustainable yield (MSY). This is the amount that can be harvested annually, leaving enough breeding stock for the population to renew itself. We have exceeded the MSY in the case of many important species. The tragedy is that the massive harvesting of fish is not driven by nutritional needs, but by the demand for luxury foods or livestock feed. Apart from overexploitation, fisheries are threatened by pollution of water bodies, climate change and destruction of mangroves and coral reefs. Though aquaculture gives high yields in small volumes of water and does not use much fuel, it has some disadvantages also. It needs large inputs of land, requires special feeds and

antibiotics, produces toxic effluents and contaminates water sources. The fish are vulnerable to diseases and the tanks become so contaminated that they have to be abandoned after five years or so. Therefore it is very much important to manage the fisheries. In this regard experts have given some recommendations as follows:

i) Adopt an ecosystem based approach by considering the food needs of the key fish species.

ii) Eliminate any fishing gear that destroys the ocean floor or catches non-target species.

iii) Establish marine reserves as no-fishing zones to help population recover.

iv) Employ traditional aquaculture integrated with agriculture (for example, raising fish in paddy fields at appropriate seasons).

8.8 MINERAL RESOURCES

A mineral is any substance that is naturally present in the Earth's crust. In addition to crustal layers, minerals are also deposited as polymetallic nodules at the oceanic beds. Most of the elements in ocean have weathered from crustal rocks and transported to the ocean by rivers. Other elements are transported through wind and glaciers. The Earth's geological processes have formed these minerals over millions or billions of years and hence they are non-renewable. Mineral resources are broadly defined as elements, chemical compounds, minerals or rocks that are concentrated in a form that can be extracted to obtain a usable commodity. The geographical distribution of minerals is unequal. India is rich in coal, manganese, iron, chromites and mica. It is deficient in the gold, silver, nickel etc. A few elements, viz. oxygen, silicon, aluminum, iron, calcium, sodium, potassium and titanium account for over 99 per cent by weight. Remaining elements are found in trace concentrations.

Minerals form a very important part of the nation's economy. With the advancement of civilization and advent of industrial revolution the use of such minerals is increasing. The main uses of minerals are:

- For development of industrial plants and machinery
- For generating energy e.g. coal, lignite, uranium
- For construction, housing, settlements.
- For defense equipment-weapons.
- For communication equipments like telephone wires, cables, electronic devices.
- In medical system particularly in ayurvedic system.

- Formation of alloys for various purposes.
- Agriculture
- Jewellery, e.g. gold. silver, platinum, diamond

Mining of minerals for utilization of these purposes may lead to the depletion of these minerals. Moreover, increasing level of soil pollution, marine pollution and water pollution may also lead to the depletion of mineral resources to some extent.

8.9 DEPLETION OF NATURAL RESOURCES

In recent years, the depletion of natural resources has become a major focus of governments and other organizations. The depletion of natural resources is considered to be a sustainable development issue. Degradation and erosion of natural resources, namely, land, water, forest, biodiversity (plant, animal and microbial genetic resources), livestock and fisheries along with air and sunlight – those parts of the natural world that are used to produce food and other valued goods and services and which are essential for our survival and prosperity, are one of the root causes of the diminished growth of a nation.

The natural resources and ecological foundations essential for sustained advances in the agricultural productivity are rapidly shrinking and declining under anthropogenic and socio-economic pressures, climate change, monsoonal disturbances, increasing frequencies of floods and droughts, sea level rise and glacial melting. The ecosystem's capacity to support the human and livestock population has exceeded in many parts of the country. Overuse of marginal lands, imbalances of fertilization and deteriorating soil health, extensive diversion of agricultural land to nonagricultural uses (such as the fast multiplying Special Economic Zones and expansion of current fallows), misuse of irrigation water depleting aquifers and irrigation potential and causing salinization of fertile lands and water logging continue.

8.9.1 CAUSES OF RESOURCE DEPLETION

- Over-consumption/irrational use
- Non-equitable distribution of resources
- Overpopulation
- Slash and burn agricultural practices which is now occurring in many developing countries

- Erosion
- Irrigation
- Mining for oil and minerals
- Depletion of aquifers
- Deforestation
- Pollution and contamination of resources

Due to depletion of resources, imbalance in nature takes place which results in shortage of materials. This shortage of materials triggers the struggle for existence which ends with war and violence among the people. Because of all these effects there is slackening of economic growth.

8.10 MANAGEMENT OF NATURAL RESOURCES

Natural resource management refers to the management of natural resources such as land, water, soil, plants and animals, with a particular focus on how management affects the quality of life for both present and future generations . It deals with managing the cow feed the way in which people and natural landscapes interact. It brings together land use planning, water management, biodiversity conservation and the future sustainability of industries like agriculture, mining, tourism, fisheries and forestry. It recognizes that people and their livelihoods rely on the health and productivity of our landscapes, and their actions as stewards of the land play a critical role in maintaining this health and productivity. Natural resource management is also in agreement with the concept of sustainable development, a scientific principle that forms a basis for sustainable global land management and environmental governance to conserve and preserve natural resources. It specifically focuses on a scientific and technical understanding of resources and ecology and the life-supporting capacity of those resources. Environmental management is also similar to natural resource management.

8.10.1 MANAGEMENT APPROACHES

Natural resource management issues are inherently complex as they involve the ecological cycles, hydrological cycles, climate, animals, plants and geography etc. All these are dynamic and inter-related. A change in one of them may have far reaching and/or long term impacts which may even be irreversible. In addition to the natural systems, natural resource management also has to manage various stakeholders and their interests, policies, politics, geographical boundaries, economic implications and the list goes on. It is very difficult to satisfy all aspects at the same time. This results in conflicting situations.

After the United Nations Conference for the Environment and Development (UNCED) held in Rio de Janeiro in 1992, most nations subscribed to new principles for the integrated management of land, water, and forests. Although program names vary from nation to nation, but all express similar aims.

The various approaches applied to natural resource management include:

- Bottom-Up (regional or community based NRM)
- Adaptive management
- Integrated natural resource management approach (INRM)

(A) Regional or Community Based NRM

The community based NRM approach combines conservation objectives with the generation of economic benefits for rural communities. The three key assumptions are: locals are better placed to conserve natural resources, people will conserve a resource only if benefits exceed the costs of conservation, and people will conserve a resource that is linked directly to their quality of life. When a local people's quality of life is enhanced, their efforts and commitment to ensure the future well-being of the resource are also enhanced. Regional and community based natural resource management is also based on the principle of subsidiarity.

Unless clearly defined, decentralized NRM can result an ambiguous socio-legal environment with local communities racing to exploit natural resources while they can.

A problem of community based NRM is the difficulty of reconciling and harmonizing the objectives of socioeconomic development, biodiversity protection and sustainable resource utilization. Understanding power relations is crucial to the success of community based NRM. Locals may be reluctant to challenge government recommendations for fear of losing promised benefits.

Community based NRM is based particularly on advocacy by nongovernmental organizations working with local groups and communities, on the one hand, and national and transnational organizations, on the other, to build and extend new versions of environmental and social advocacy that link social justice and environmental management agendas with both direct and indirect benefits observed including a share of revenues, employment, diversification of livelihoods and increased pride and identity.

(B) Adaptive Management

This approach includes recognition that adaption occurs through a process of 'plan-do-review-act'. It also recognizes seven key components that should be considered for quality natural resource management practice:

- Determination of scale
- Collection and use of knowledge
- Information management
- Monitoring and evaluation
- Risk management
- Community engagement
- Opportunities for collaboration.

(C) Integrated natural resource management (INRM)

A process of managing natural resources in a systematic way, which includes multiple aspects of natural resource use (biophysical, socio-political, and economic) meet production goals of producers and other direct users (e.g., food security, profitability, risk aversion) as well as goals of the wider community (e.g., poverty alleviation, welfare of future generations, environmental conservation). It focuses on sustainability and at the same time tries to incorporate all possible stakeholders from the planning level itself, reducing possible future conflicts. The conceptual basis of INRM has evolved in recent years through the convergence of research in diverse areas such as sustainable land use, participatory planning, integrated watershed management, and adaptive management. INRM is being used extensively and been successful in regional and community based natural management.

8.10.2 FRAMEWORKS AND MODELING

For various frameworks and developments of computer models to assist natural resource management, GIS plays an important role. Geographic Information Systems (GIS) is a computer system capable of computing, storing, analyzing and displaying geographically referenced information. It can be taken as a powerful analytical tool that can help us for natural resource management. Prior to setting development action, information on resource is vital. Knowledge on the spatial dimensions could help to prioritize development actions. Major application of GIS in natural resource management is--

i) Resource assessment

ii) Change detection

iii) Suitability analysis

iv) Scenario study

v) Impact assessment, etc.

8.11 NATURAL RESOURCE MANAGEMENT IN NORTH-EAST INDIA

The Northeastern states of India share 98 per cent of their boundaries with Myanmar, Bangladesh, Nepal, Bhutan and China. The Northeastern Region can be physiographically divided into the eastern Himalayas, the northeastern hills, and the Brahmaputra and Barak valley plains. The hills and highlands of North-east India are covered in lush vegetation and inhabited by indigenous tribal peoples. The region has been identified as one of the biodiversity hot spot regions in the world. The Northeastern Region is socially, culturally, and politically very complex and contains great environmental and natural resource diversity. The immense biodiversity of the Northeastern Region has made it a priority area for investment by the leading conservation agencies of the world. For example, the World Wide Fund for Nature (WWF) has identified the entire eastern Himalaya as a priority Global 2000 Eco region; and Conservation International has subsumed its eastern Himalaya "hotspot" into a wider Indo-Burma hotspot, which now includes all the eight states of the Northeast. The region is one of the endemic bird areas defined by Birdlife International, harbors a World Conservation Union (IUCN) center of endemism, and is an important sub-center for the origin of cultivated crops. The region's lowland and montane moist to wet tropical evergreen forests are considered to be the northern most limits of true tropical rainforests in the world. Northeastern India probably supports the highest bird diversity in the East, with about 836 of the 1,200 bird species known from the Indian subcontinent.

Subsistence agriculture is the dominant employment provider in the region engaging about 80 per cent of its population. While settled cultivation is practiced in the plains, shifting cultivation, locally known as *jhum*, is the predominant agricultural practice for most communities in the hilly regions. In moderation and if practiced correctly, *jhum* is a sustainable system, but it has increasingly not only failed to meet yearly food requirements, but also has put pressure on the fragile ecosystem. The region has been largely closed to the outside world for the past fifty years, but in recent decade's deforestation and watershed deterioration has progressed rapidly due to land clearing by migrants and local people and heavy timber demand from Bangladesh and urban centers in India. Illegal logging and forest clearing is made easier where tenure rights to forests are weak or unclear. Widespread environmental degradation in the north-eastern region of India is aggravating poverty and food security, forcing rural people to exploit dwindling resources to meet subsistence requirements.

The natural wealth of the Northeastern Region is well acknowledged. However, in the available documentation and literature, there are few suggestions on what to do in order to develop them to the benefit of the region's citizens. In Northeast India, there is an urgent need for actions that promote the conservation and sustainable use of the region's endangered forests and watersheds. Appropriate water and forest development and management could provide benefits in the form of hydropower, agriculture, inland water transport, biodiversity conservation, reduced flood damage and erosion, longer dam-reservoir life, forestry, and ecotourism. These benefits, which would accumulate at both regional and local levels, would in turn directly and indirectly increase income and enhance economic growth and poverty reduction. The efforts of the Government of India to establish a network of protected areas in northeast India to conserve biodiversity have had limited impact due to a failure to involve indigenous communities and local government. This top-down approach to the designation of national parks and wildlife sanctuaries has fallen far short of its goals, despite the high biodiversity value of the region. The Supreme Court's requirement for autonomous district councils and forest departments to prepare working plans for all forests in the region has made some progress. A major constraint to these initiatives has been a failure to interface effectively with local communities that are engaged in forest protection and management. Over the past century, however, the role of communities in resource stewardship has been under pressure due to the following reasons:

(a) Changing social structure and growing an inequality which leads to reduced effectiveness of traditional institutions responsible for managing resources.

(b) The nationalization of forests and the establishment of government forest agencies and laws.

(c) The development of silviculture as a dominant forest management system.

(d) The growth of international timber markets and the increasing entry of the private sector in rural resource use practices.

If these hurdles can be removed, it will be very much easier to manage the natural resources available in north east India.

8.12 PROBABLE QUESTIONS

1.Give a detailed account of natural resources with their respective ecosystem services.

2.Differenciate the renewable resources from non-renewable ones.

3.What do you understand by deforestation? Enumerate and discuss the factors responsible for deforestation.

4.How can the natural resource can managed? Write a note on various approaches to natural resource management. Mention how GIS can help in this regard.

5.Write a note on sustainable agriculture.

6.Briefly describe the factors causing the depletion of natural resources.

SUGGESTED READINGS

1. *Essentials of Ecology and Environmental Science*. S.V.S. Rana. PHI Learning private limited.(Fourth edition)
2. *Environmental Science.* S.C. Santra .New Central Book Agency (P) Ltd.
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4. *Environmental management* .N.K. Uberoi. Excel Books, New Delhi.
5. http://www.communityforestryinternational.org/pdfs/Indigenous_Forest_Stewards_of_NE_India.pdf