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EVS 502

Land, Water and Bioresources

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Department of Forestry and Environmental Science
School of Earth and Environmental Science

Uttarakhand Open University
Haldwani, Nainital (U.K.)

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Unit 1: The Land Resources: Characteristics Pattern and Importance

Unit Structure

1.0 Learning Objectives

After studying this unit you will be able to explain:

- What is Land?
- What is the utilization and classification of land?
- What are land resources?
- What are the types of Land resources?
- What is the significance of land resources?
- What is the demand and supply of land resources?

- How can we conserve the land resources?

1.1 Introduction

In this unit, we shall study different types of land and its resources. As we are all dependent on natural resources, land is one of the most important resources. In this unit we discussed about the land resources, its characteristic pattern and importance. All resources have declined badly due to various man made activities. We have also discussed about the solution of these problems too in this chapter. Land is the most important asset which supports natural vegetation, wildlife, human activities, and transport and communication systems.

The land is simply “the solid part of earth surface”. The earth may be classified broadly into aquatic (water) and non-aquatic (terrestrial) areas. Land is a naturally occurring limited resource and it provides the base for survival of living world. It holds everything that constitutes terrestrial ecosystems. The Increasing demand of land resources in modern times due to the rise in human population and modern life style has resulted in degradation of land quality and quantity, decline in crop production, and competition for land. Land is an area of terrestrial surface of the earth, all the attributes of the biosphere immediately above or below this surface including those of the near-surface.

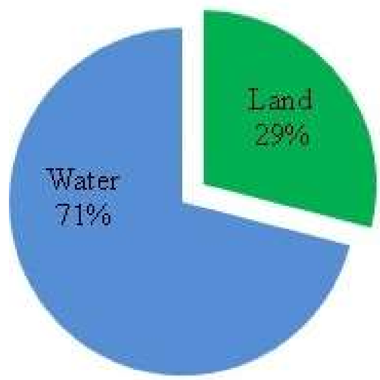

Fig 1: The percentage of water and land area on the globe

The Food and Agriculture Organization (FAO) estimated the worlds land area as of 1994 to be 144.8 million sq km (or about 29% of the surface of the globe) (Fig. 1), of which forest and woodland area accounted for 30%.Thousands of years ago, before large scale human disturbances of the world began, forest and woodlands probably covered nearly 6.0 billion hectares. Since then, about 16% of that area has been converted to croplands, pasture, settlements or unproductive wastelands.

Natural resources are the component of the environment (i.e. atmosphere, hydrosphere and lithosphere), which can be drawn upon for supporting life. In other words, these resources are goods and services supplied by our environment. These include energy, mineral, land, food, forest, water, atmosphere, plants and animals, and other life support provisions.

The vast and diverse India is having most important resources. About 43 percent of the land area, which is plain, provides opportunity for cultivation. The mountainous areas, accounting for about 30 percent of the surface area of the country, are storehouse of natural resources; these are also important for their scenic beauty and ecological services. The plateau area has rich reserve of mineral resources besides forest and arable lands. The mountains and plateau also have fertile river valley offering favorable location for human habitation.

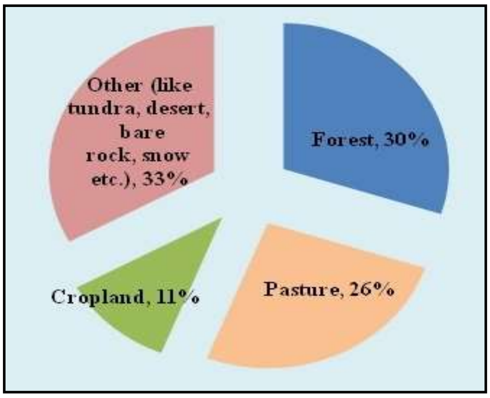

Fig 2: World land utilization pattern

The heavy burden of the population and increasing demand of the same have created lot of burden on land resources, as in 1951 per capita availability of land was 0.89 hectare, but it has been sharply declined with time, the per capita availability of land was only 0.37 ha. In the availability of land area, there is about 60% declination. So this is clearly shown that the growing population is inversely proportion to the availability of land. As the population will be rise the land availability will decrease and vice versa.

1.2 Definition of Land Resources

The resources available from land are known as land resources, thus, the agricultural land which contains natural fertilizer for growth of the products sown, the underground water, the various minerals like coal, bauxite, gold and other raw materials. Land resource refers to the land available for exploitation, like non-agricultural lands for buildings, developing townships etc.

Land resources (natural resources) (economically referred to as land or raw materials) occur naturally within environment that exists relatively undisturbed by mankind, in a natural form.

FAO/UNEP (1997) defined land and land resources as "an area of the Earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface, including those of the near-surface climate, the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, and swamps), the near-surface sedimentary layers and associated groundwater and geo-hydrological reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity (terracing, water storage or drainage structures, roads, buildings, etc.)".

According to the FAO and UNEP (1999), the basic functions of land in supporting human and other terrestrial ecosystems can be summarized as follows:

- A store of financial growth for individuals, groups, or a community
- Support the production of food, fiber, fuel, or other biotic materials for human use
- Provide biological habitats for plants, animals, and microorganisms
- Working as a determinant in global energy balance and the global hydrological cycle, regulation of the storage and flow of surface water and groundwater
- Fulfill the need of minerals and raw material for human being
- Working as a filter for pollutant remover, modifier or as a buffer
- Provide physical space for industries, recreation and other developmental activities
- Storage and protection of evidence from the historical or prehistorically record (fossils, evidence of past climate, archeological remains, etc.)
- Provide an area for movement of animals, plants, and people from one area to another.

Based on the vital role of land understanding and using, it becomes the crucial responsibility of land users, authorities, scientists, and planners. From all appearances, people had used land resource naturally for their purposes to exist. Therefore, land use is a product of interaction between the biophysical and human driving forces (Weng, 2010). The ways of using land resources have been changed from traditional to modern methods throughout different periods of time. In actual development, an emerging issue is how to use land resources to meet the needs of present and future generations. Moreover, land use is characterized by the arrangements, activities, and through the people to produce, change, or maintain a certain land-cover type (FAO, 2005). Land use defined in this way establishes a direct linkage between land cover and the people's actions in their environment. Thus, it can be defined as the human use of land that involves both the manner of including biophysical attributes of land and purposes for use of land (Weng, 2010).

1.3 Land Utilization and Classification

One of the most significant features of land use in India is the major area suitable for agriculture and has already been brought under cultivation. Land utilization statistics are available for about 93% of the total geographic area of 3287.3 lakh hectare. Classification of land basically depends on whether an area is grazed, cultivated or forested. The land area in India is classified into following categories

- Net sown area
- Forest
- Current fallow
- Other Fallows land
- Cultivable wasteland
- Miscellaneous tree crops and groves
- Permanent pasture and grazing land
- Land under non-agricultural use
- Barren and uncultivable land

Net Sown area: Net sown area refers to the net area utilized for growing crops and maintaining orchard. The net sown area has increased considerably in recent years due to reclamation of barren and uncultivable land.

Forests: The group of trees in majority is known as forest. On the land where the majority of trees on a particular land known as forest land.

Current fallow: This class comprises cropped areas, which are kept crop-free during the current year only. For example, if any cropped area is not cropped again in the same year, it may be treated as current fallow.

Other fallow land: other fallow land include the temporarily cultivated for 1-5 years. Such fallow land resulted from inadequate water supply, silting of river and canals and found in Tamilnadu, Bihar, Meghalaya, Mizoram, Andhra Pradesh, Karnatka, Delhi and Rajasthan state of India.

Cultivable wasteland: This type of land either fallow or covered with shrubs or jungles which are not of any use. Lands once cultivated but not cultivated for five years in succession are also included under this category. In India, the state of Uttar Pradesh, Haryana, Punjab and several other states have Reh, Bhur, Usar, and Khola area, cultivated in past but abandoned now due to certain soil nutrient deficiencies.

Miscellaneous tree crops and groves: This class has included all cultivable land which is not included under the area sown but it put to some agriculture use. Such lands occupy 1.21% of the reported area of the country. At the state level, the proportion of land under miscellaneous tree crops and groves is high in Tripura.

Permanent pasture and grazing land: This category includes all grazing lands-meadows, village commons etc. about 4% of the reporting area comprises such lands.

Land under non-agricultural use: This class includes all lands covered by buildings roads and railways or land under water that is rivers and canals and other lands put to uses other than for agriculture.

Barren and uncultivable land: Barren and uncultivable land covers all those lands which cannot be brought under cultivation except at a high cost. Such land may be isolated blocks or within cultivated property. Mostly they are mountainous or arid.

1.4 Types of Land Resources

Based on the availability of the kind of resource on an area, the land resources may be classified into following categories:

- Forest Resources
- Mineral Resources
- Cropland resources
- Water resources
- Soil resources

1.4.1 Forest Resources

Forest resources are very important resource of land and perform the ecological duties with fulfillment for the need of people. Forest provides various services to the ecosystem like providing food, shelter, cover, fodder, wood fiber to the human society. The word forest is derived from a latin word "Foris" means outside. Forests are one of the most important natural resources of the earth. Approximately 1/3rd of the earth's total area is covered by forests. In India, overall 21.02% of the total geographical area of the country is now under green cover (as per 2009 data). The total forest cover in India is 6, 90, 899km^2. Forest cover in India is defined as, "all lands with more than one hectare in area with a tree canopy density of more than 10%".

Talking about "resources" makes sense only when human interest gave them that role. Thus, forestland resources are all those attributes of forests that have any kind of present or potential value to people. The available resources are continuously changing because culture and knowledge change and evolve. Some resources become obsolete, and on the other hand, some resources emerge and develop with new needs and knowledge. The UN Conference on Environment and Development held in Rio de Janeiro in 1992 has given forests an increasingly important role in the context of sustainable development and environmental conservation. The concept of sustainable forest management has been recognized as a fundamental guiding principle by all participating countries. Forests play an important role in maintaining fertility of soil by shedding their leaves which contain many nutrients. Forests are also helpful in binding up of soil particles with the help of roots of vegetation. Therefore, cutting of forests will affect the soil adversely.

1.4.1.1 Definition of Forests

All lands which are more than 1 hectare in area and with a canopy density of more than 10% irrespective of the ownership and legal status is called Forest Cover.

The resources make sense only when the human interest gave them that role. Thus forestland resources are all those attributes of forest that have any kind of present or potential values to the people. No doubt, forest plays a key role in providing a number of resources and services to human kind. The resources and services from forests are shown in table 1 through the words starting from the alphabets in the word 'Forest'.

Table 1: Forest resources

F	O	R	E	S	T
Fuel	Oxygen	Rain	Energy	Soil	Timber
Food	Oil seed	Resin	Employment	Sleepers	Tourism
Fiber	Oiled resin	Rayon	Entertainment	Sericulture	Transport
Fodder	Ornamentation	Rubber	Environment	Ship building	Turpentine
Fertilizer	Organic matter	Recreation	Erosion control	Sports good	Tools

1.4.1.2 Forest Resource of India

The total forest and tree cover is about 79.42 million hectare, which is 24.16% of the total geographical area. The total carbon stock in the country's forest is estimated to be 7, 044 million tonnes with an increase of 103 million tonnes (1.48 percent) over the previous assessments.

The maximum increase in forest cover has been observed in Tamil Nadu –2, 501 sq km, followed by Kerala – 1, 317 sq km and Jammu & Kashmir – 450 sq km. Madhya Pradesh has the largest forest cover of 77, 462 sq km in the country, followed by Arunachal Pradesh, with a forest cover of 67, 248 sq km and Chhattisgarh – 55, 586 sq km. Mizoram, with 88.93 percentage of forest cover has the highest forest cover in percentage terms, followed by Lakshadweep with 84.56 per cent. The states where forest cover has decreased substantially are Mizoram, Telangana, Uttarakhand, Nagaland, and Arunachal Pradesh.

1.4.1.2 Types of Forests

Forest resources play an important role in the economy of any country. It is highly complex, changing environment made up of a living and nonliving things. Living things include trees, shrubs, wildlife etc. and non-living things include water, nutrients, rocks, sunlight and air. Forest varies a great deal in composition and density and is distinct from meadows and pastures. Forest is important to humans and the natural world. For humans, they have many aesthetics, recreational, economic, historical, cultural and religious values. Forest provides fuel, wood, timber, wildlife, habitat, industrial, forest products, climate regulations, medicinal etc. On the basis of geographic structure the forest may be classified into the following:

A. Tropical Wet Evergreen Forests

These are the typical rain forests of India, where the annual rainfall is above 250 cm. and mean annual temperature is 27°C.Dry season is very brief. Some part like Western Ghats, parts of Karnataka (Anamalai Hills, Coorg, Mysore Plateau), Cachar and Brahmaputra valley of Assam and Andaman-Nicobar islands of India will be considered in this category.

B. Tropical Moist Semi-Evergreen Forests

These forests are intermediate between the evergreen and the deciduous forms where the annual rainfall is between 200-250 cm. and mean annual temperature is 26°C.Some trees shed their leaves for brief periods in winter and spring. Some parts of India like Western Ghats, parts of upper Assam, Bengal, Bihar, Orissa and Andaman falls in this category.

C. Tropical Moist-Deciduous Forests

Tropical moist deciduous forest found on those places where the annual rainfall is 150-200 cm. and drought period is for 1-2 months. These forests distributed at Eastern side of Western Ghats, Chhota Nagpur, Khasi Hills and a narrow belt along the foothills of Himalayas. On the basis of dominant species, they are generally of 3 types: Sandal, Teak and Sal forests.

D. Littoral and Swamp Forests

These forests may be subdivided into 3 categories: beach, tidal and fresh water swamp forests.

(i) Beach Forests: These forests are distributed nearby the sandy sea beaches and sandy flats of river deltas.

(ii) Tidal Forests: These grow over the deltas of various rivers, creeks along the coast and swampy margins of islands.

(iii) Fresh Water Swamp Forests: These forests grow in depressions where rain-water or swollen river-water gets collected for some period. Elephant grass (*Typha* species) is quite common in these forests.

E. Tropical Dry Deciduous Forests

They cover about 40% of total land in India, where the annual rainfall is found 75-125 cm. Dry season extends for about 6 months. They spread from foot of Himalayas to extreme South (except Western Ghats, Rajasthan, Kashmir, Bengal and other Eastern States).

F. Tropical Thorn Forests

These forests occur on rocky substrata where annual rainfall ranges from 25-75 cm. In these areas the vegetation is dominated by *Acacia* and *Euphorbia* (thorny plants). These forests are in plenty in Punjab, Haryana, Rajasthan, Gujarat, Delhi, Bundelkhand part of Uttar Pradesh, parts of Madhya Pradesh, Maharashtra and Tamil Nadu.

G. Tropical Dry Evergreen Forests:

These forests receive rain from retreating monsoon. Found in Parts of Andhra Pradesh and Tamil Nadu.

H. Montane Subtropical Forests:

These are intermediate between tropical and temperate forests and therefore, exhibit mixed vegetation of both types. They are divisible into three sub-types:

(i) Broad-Leaved Hill Forests: Nilgiri and Palni Hills of South, Mahableshwar and other areas of Maharashtra, Mount Abu in Rajasthan, Pachmarhi in M.P., Parasnath in Bihar, kalimpong and Darjeeling in West Bengal.

(ii) Pine Forests: Foothills of Himalayas and in the East over Khasi, Naga, Manipur and Lushai hills.

(iii) Dry Evergreen Forests: Shiwalik Hills, Punjab, Haryana, Himachal Pradesh and Jammu andKashmir.

I. Montane Temperate Forests

These forests develop at a height of 1700 meters in the hills of both north and south India. These are not humid forests and are of three types:

(i) Montane Wet Temperate Forests: these are found in both north and south regions. The Southern wet temperate forests are called Shoals. They occur in Nilgiris, Annamalai, Palni, Tinnevelly hills of both Tamil Nadu and Kerala.

(ii) Himalayan Moist Temperate Forests: Western and central Himalaya.

(iii) Himalayan Dry Temperate Forests: Inner Himalaya.

J. Sub-Alpine Forests

They are found throughout Himalaya till the timber line. It spreads from Ladakh in west to Arunachal Pradesh in East. Annual rainfall is less than 65 cm. Snowfall occurs for several weeks in a year. It has two types of forests: Silver fir-Birch Forest and Birch-Rhododendron Forest.

K. Alpine Forest

These are found above the timber line and up to snow line in Himalaya. Rainfall are almost absent. Snowfall is common. The vegetation is commonly known as elfin scrub (short stems; branches come out of soil and creep along the ground and form tangled masses).This vegetation is divided into four types: moist alpine scrub, dry alpine scrub, alpine stony deserts and alpine meadows.

L. Desert Vegetation

These forests are found in such areas where the rainfall is scanty, infrequent and irregular (10cm).The vegetation cover used to be very sparse and vegetation is of thorny type. Natural vegetation contributes to productivity of trees like Khejri (*Prosopis cineraria*).

1.4.2 Mineral Resources

As we know that minerals are the most important land resources available in nature, which not only the essential part of earth but an excellent source of energy for different biota.

Without minerals there will be no life on this planet. Mineral resources are broadly defined as elements, chemical compounds, minerals or rock concentrated in a form that can be extracted to obtain a sustainable commodity. The origin and distribution of minerals is intimately related to the history of the biosphere and to the entire geologic cycle. Almost every aspects and process of the geologic cycle is involved to some extent in producing local concentrations of minerals. Some mineral elements are essential for the formation and functioning of the body of all organisms, plants as well as animals including human beings. You will study the mineral resources in unit 2 in detail.

1.4.3 Cropland/Agricultural Resources

Another most important land resource is cropland, which is fulfilling the need of millions people. The people are directly dependent on crops for food, fodder and economic growth. Cropland includes areas used for the production of adapted crops for harvest. Cropland may be divided into: cultivated and non-cultivated. Cultivated cropland comprises land in row crops or close-grown crops and also other cultivated cropland, for example, hay land or pastureland that is in a rotation with row or close-grown crops. Non-cultivated cropland includes permanent fodder land and horticultural cropland. As Per the 2007 National Resources Inventory there are 357, 023,500 acres of cropland in the United States. The cropland acres produce most of the food and fiber production for the US and an export to other countries. About 80% of diet is provided by the seeds of less than a dozen plant species." Over the years man has invented new machines and techniques to increase the amount and variety of crop production. As per the availability of land resources, the land can be classified on the basis of their quality as following.

Table 2: Global availability & quality of land resources suitable for crop production

Sl. No.	Land Quality	Cultivated land (billion hectare)	Grassland & Woodland ecosystem (billion hectare)	Forest land (billion hectare)	Other land (billion hectare)	Total (billion hectare)
1	Prime land	0.4	0.4	0.5	0.0	1.3
2	Good land	0.8	1.1	1.1	0.0	3.1
3	Marginal land	0.3	0.5	0.3	0.0	1.1
4	Not suitable	0.0	2.6	1.8	3.4	7.8
	Total	1.5	4.6	3.7	3.4	13.3

Source: Agriculture statistics at a glance-2000, Directorate of Economics & Statistics, Ministry of Agriculture, Govt. of India, New Delhi, April 2000).

In Indian context during 2004-2010, out of total GDP, agriculture contributed 15.90% in 2004-05, 15.30% in 2005-06, 14.50% in 2006-07, 13.90% in 2007-08, 13.20% in 2008-09 and 12.80% in 2009-10. So the agricultural system shows a large contribution in GDP of India. According to the survey of Government of India there was 127 million cultivators in 2001 (Agriculture statistics at a glance-2000, Directorate of Economics & Statistics, Ministry of Agriculture, Govt. of India, New Delhi, April 2000). On the other hand about 106 million people worked as a laborer in cropland/agricultural resources. According to estimation out of total population, about 58% are dependent on cropland resources for their financial growth.

1.4.4 Water Resources

As we all know that water is essential source of life, human body contain about 70%. Water is elixir of life and in the present context, there is a lot of crisis on water resources. Drinking water is not in plenty on this planet. So the water is most important thing of land resources. Land is providing a substratum to all living and nonliving components, the entire living component has been established in the form of families, group and clusters and use the surrounding land absolutely free of cost. Nobody pay the charges of natural land resources. With providing the surface area to the living beings, the land contain different types of resources in her lap like as water, minerals, soil etc. as a non-living component, the water resources are present in plenty on the land surface as well as inner side of the land in the form of ground water. All the rivers are flowing freely due to the existence of land on this planet. As we know very well that very little amount of water is present in the form of fresh water, which is directly consumed by human beings. Approximately 70.8% of the earth surface is covered with water mainly in the form of ocean. It is estimated that the hydrosphere contains about 1360 million cubic km of water. Of this about 97% is in the oceans and inland seas, where the high salt content does not permit it for human consumption.

Water flows through the landscape. The condition of the land surface affects the flow and quality of water. Land surface condition can be characterized at any location by the type of land use, soils, and climate and terrain conditions prevailing there. The effects on water resources can be measured by the water yield (mean annual flow), flooding (peak discharges and water surface elevations), groundwater (recharge and pumping), pollution (constituent concentrations and loads), and sediment (rate of erosion, sediment transport and deposition). The connection between land and water resources can thus be viewed on two axes i.e., land characteristics and water characteristics. Both of these characteristics are interconnected. Land characteristics tend to be relatively fixed in time, and spatially extensive. Water characteristics tend to be spatially concentrated, such as at points of measurement of stream flow or water quality.

1.4.5 Soil Resources

A substratum is important because it provides space for living, attachment, feeding grounds, shelter places etc. The substratum influences coloration causing mimicry – an eco-protective phenomenon.

It is matter of common observation that the living organisms show a very specific liking, disliking, preferences or sort of repulsion towards a particular type of substratum. It is mainly because in most of the cases the substratum is the fundamental part of the habitat of the organism, hence the substratum is deeply associated with most of organisms, and hence the substratum is deeply associated with most of the biological and behavioral activities of the organisms. It is not a mere base for standing, but basis of existence in general.

Soil is a common name for a highly generalized uppermost surface or layer of the earth, which comes in most intimate contact of all living terrestrial biotic components. It is a dynamic system which is capable of sustaining the producers and consumers of the biosphere in particular, as an integral part of our ecosphere.

a) **Definition:** The soil is the upper most layer of our terrestrial environment, which formed by the weathering of rocks. It is an admixture of humus, inorganic contents and organic debris which provides a surface over the land for the growth of vegetation and habitat for living animals. It comes in immediate contact with biotic and abiotic factors. According to a famous Russian soil scientist / Pedologist, Dokuchayev, (1889) "The soil is a result of action and reciprocal influences of parent rocks, climate, topography, plants, animals and age of the land." It can be represented by the following formula:

Soil = (Geology + Environment + Biological actions) x Time

b) **Soil Formation:** The nature takes about two hundred years to make one inch of the top layer of the soil, from the parent rock system. Soil formation is quite a complex process. It is shared by both biotic and abiotic components; the later factors play a major role in it. The co-action and inter action on the land surface by light, temperature, water, air, wear and tear, geological activities cumulatively lead to the process of fragmentation. This can be added by growing vegetation, fauna, their decay, and succession these all lead to the formation of soil. This second step is called as corrosion. This is the process of oxidation, reduction, hydrolysis, hydration, sulfonation, carbonation etc. Third step is addition of organic matter to it. Thus gradually the soil attains its best form. However, systematically speaking the process of soil formation is usually divided in two major steps:

c) **Weathering**- That is break down of large complex rocks into smaller units and dust. The weathering process can be physical as well as chemical and in fact combination of cooling, freezing and glaciations, erosion and corrosion and dissolution. These activities are side by side helped by the chemical processes like hydration, hydrolysis, oxidation-reduction, carbonation, chelation etc.

d) **Pedogenesis or Soil Development** – This includes changes in raw forms of the rock material due to combined effect of climatological, biological and other abiotic factors, through various types of actions, co-actions, interactions and reactions. In fact pedogenesis is basically on account of biological activities of lichens, algae, fungi, bacteria, protozoan, insects, mollusks, annelids etc. which use larger parent rock material or their parts for various of their biological requirements, varying from habitat, niche and substratum to food synthesis, derivation of trace or micronutrients to reproductive activities. All these activities gradually change the physical and chemical nature of the raw soil ingredients.

Add ultimately through the processes like humus formation addition of organic matter to the soil converts it into a perfect balanced soil as we require for our basic agricultural purpose. Colloidal complex addition is the phenomena in soil formation which is carried out by the living organisms in it. During this course partially decomposed material known as humus is formed and gets homogeneously mixed with the land surface. According to Waksman (1936), as a result of addition of humus and colloidal complexes the soil is formed in its best form. It is for this reason that the humus and the colloidal complexes of soil are called as the heart and soul of the soil.

All these activities make the colloidal soil complex. The different constituents of soil complex can be grouped as:

(i) Minerals, (ii) Soil Water, (iii) Soil Air, (iv) Soil Organic Matter and (v) Soil Organisms (biota of the soil)

The physical nature of soil depends on the size of the constituents its texture and structure. Texture is determined by the size of particles & structure is attributed to the aggregation of these particles and their distribution. On the basis of the size, soil contains following types of particulates:

Table 3: Soil particulates with their size

Sl. No.	Particulates	Particle size
1	Stones and gravels size	More than2.0 mm
2	Coarse sand	0.20 –2.00 mm
3	Fine sand	0.02 –0.20 mm
4	Silt	0.002 –0.02 mm
5	Clay	0.002 mm

e) Soil Profile: The makeup of the soil as observed in its habitable area in a vertical section is studied as soil profile. This shows various layers / strata of the soil at varying depths. This process of layer / profile formation may be of recent origin; few decades or very ancient say thousands of years. It is chiefly affected by the climate, specific geological up-levels and activities of its biotic communities.

The soil profile is only few feet deep layer system of varying coloration and sometimes components also. Soil profile is the sequence and nature of the various soil layers (horizons) covered. The soil profile is generally divided in the following five horizons:

O- Horizon	Fresh material
A-Ozone	Un-decomposed matter
A-O zone	Partly decomposed
A- Horizon	Mineral Soil layer
A 1- zone	Dark & rich with Humus
A 2- zone	Soil Raw Material
B- Horizon	Mineral Strata
C- Horizon	Weathered /broken Rock
R- Horizon	Parent Rock

O-Horizon consists of the fresh or only partially decomposed organic matter and is highly variable in most of its physico-chemical characteristics. This horizon is very dynamic and full of biotic activities. The O-horizon consists of the following sub divisions:

Oi zone: This is the uppermost layer consisting of the freshly fallen leaves, dead animals, fruits etc. It does not contain any decomposed material.

Oe zone: It is just below the Oi zone, in which decomposition of organic matter has set in. Hence this layer contains partially decomposed organic matter and biotic populations of small insects, fungi, and bacteria etc. which play important role in decomposition of organic matter. This layer is thus composed of detritus and duffy substances at various stages of decomposition.

A-Horizon is the first mineral layer and is rich in accumulated organic matters. This zone also shows a downward loss of various soluble salts, clay, iron etc. and usually lower layers of this zone are richer in components like silica. This layer is also called as zone of eluviation – or the layer of downward loss. This zone is further sub-divided in the following two sub zones:

A1 zone: This layer is dark and rich in organic matter, amorphous and finely divided organic matter becomes mixed with mineral matter in this zone. This is the zone of richest humus matter. Sometimes it is also called humic layer.

A2 zone: In this zone usually raw mineral material of light colors is found and has less amount of the organic material.

B-Horizon is the mineral strata of the soil, immediately below the – A Horizon and is rich in iron, aluminum compounds etc along with clay and humus.

C-Horizon is mainly composed of weathered or broken down parental rock material in loose texture.

R-Horizon is the parent rock zone from which that particular soil has been formed.

Soil in relation to animals: Great diversity in the animal distribution and their adaptation is mainly attributed to soil nature. For example a hard substratum requires strong and smaller feet, offers better running ground, but inhibits burrowing, such as for rodents, rat, rabbits, earthworms etc. It has low water retention capacity and poor humus.

1.5 History of Land Resources on Earth

According to Rig Veda there is two types of soil on the basis of fertility first productive and second is non-productive soil (Sharma, 1991). The Amarakosha (c. 400 BC) (Jha, 1999) described 12 types of lands in its content on Bhumivargaha, depending upon the fertility of the soil, irrigation, and physical characteristics. Amarkosha classified the soil as urvara (fertile), ushara(barren), maru (desert), aprahata (fallow), shadvala (grassy), pankikala (muddy), jalaprayah (watery), kachchaha (land contiguous to water), sharkaravati (sandy), sharkara (full of pebbles and pieces of limestone), nadimatruka (land watered from a river), and devamatruka (rainfed). In the chapter on Vaisyavargaha, soils based on suitability for specific crops are mentioned. Surapala'sVrikshayurveda (c. 1000 AD) (Sadhale, 1996) mentions three types of land – jangala (arid), anupa (marshy), and samanya (ordinary) – further subdivided by color into black, white, pale, dark red, red, and yellow and by taste into sweet, sour, salty, pungent, bitter, and astringent. It is important to note that one of the most sustained land use practices, since the days of Kautilya has been the use of river beds for raising cucurbits throughout India.

1.6 Land Resources in India

The total geographical area of India is 328 mha. According to a survey report about 305.67 mha has been reported. Out of the 305.67 mha land 69.63 mha declared as a forestland, 43.22 mha (25.92 mha for non-agricultural use and 17.29 mha barren and uncultivable land) is not available for cultivation. In other uncultivated land, excluding fallow land, 26.82 mha (10.39 mha is permanent pasture and other grazing land and 3.31 mha being used for miscellaneous tree crops and grooves left 13.12 mha for cultural waste land). Fallow land is available 25.15 mha, out of this land area 10.34 mha land used as a fallow land other than current fallow and 14.81 mha used as a current fallow thus, the 140.86 mha is a net sown area and used directly for crop production. India has a total land area of 2.4% of the world total, but supports a population over 17% of the world. Thus the per capita land availability was only 0.48 ha. as against 8.43 ha in former USSR and 0.98ha in china. The major land use categories and aerial estimation of wasteland is as follows:

Table 4: Aerial estimation of wasteland in India

Aerial estimate of wasteland in India		
Sl. No.	**Categories**	**Area (Mha)**
1	Salt affected land	3.99
2	Gullied or ravine land	6.73
3	Undulating upland with or without scrub	11.74
4	Jhum or florset blank	6.24
5	Sandy area	13.94
6	Barren hill ridge	2.70
7	Snow covered or glacial area	10.07
	Total	**55.41**
	% of state area-	**16.85%**

Source: NRSA Data1986

1.7 Importance of Land Resources

Land is not a 'produced' or man-made resource; therefore, we have to use it judiciously. No doubt man tries to improve and modify nature, but he cannot completely master it. A poor soil and a bad climate are great handicaps in the way of industrial and commercial prosperity. Land as a factor of production is of immense importance. Everything that we use can be traced ultimately to land. Land may be rightly called the original source of all material wealth. The economic prosperity of a country is closely linked with the richness of her natural resources. Generally speaking, it is true to say that a country is what nature has made it. It is possible that a country, rich in natural resources, may remain poor (e.g., India) owing to some unfavorable factors. But if nature has been unkind and has not given rich resources to a country, it will not be easy to make it prosperous.

Obviously, the quality and quantity of agricultural wealth in a country depends on the nature of the soil, climate, and rainfall. Agricultural products, in their turn, form the very basis of trade and industry. Industrial prosperity further depends on the presence of rich coal-mines or waterfalls from which electricity can be generated. Localization of industry depends on the proximity of power and raw materials and they are largely determined by nature. The presence of cheap and efficient means of transport is largely conditioned by the topography of a country. Thus, all aspects of economic life-agriculture, trade and industry—are generally influenced by natural resources which the economists call 'land'. Land or nature has a determining influence in molding the life, occupations and standard of living of a people.

1.7.1 Agriculture

For decades, agriculture has been associated with the production of essential food crops. At present, agriculture above and beyond farming includes forestry, dairy, fruit cultivation, poultry, bee-keeping, mushroom and arbitrary, etc. Today, processing, marketing, and distribution of crops and livestock products etc. are all acknowledged as part of current agriculture. Thus, agriculture could be referred to as the production, processing, promotion and distribution of agricultural products. Agriculture plays a critical role in the entire life of a given economy. Agriculture is the backbone of the economic system of a given country. In addition to providing food and raw material, agriculture also provides

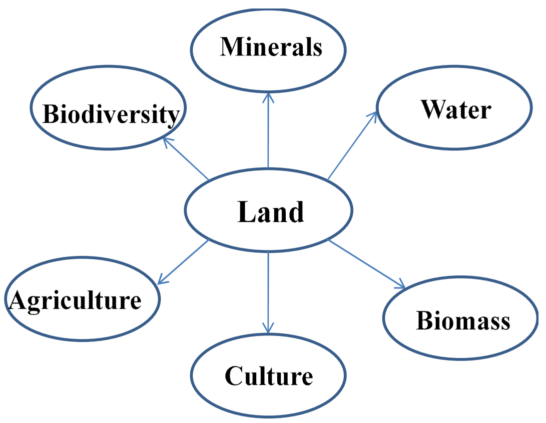

Fig 3: Resources provided by land

employment opportunities to very large percentage of the population. Below is the value of agriculture as a land resource:

- Source of livelihood
- Contribution to national revenue and GDP.
- Supply of food as well as fodder
- Significance to the International Trade
- Marketable surplus
- Source of raw material
- Foreign exchange resources
- Great employment opportunities
- Food Security

1.7.2 Minerals

Mineral resources are amongst the most important natural resources that dictate the industrial and economic development of a country because these provide raw materials to the primary, secondary and tertiary sectors of the economy. The use of mineral is as old as civilization. Minerals provide the basic needs — food, clothing, shelter and energy to mankind. "Minerals are indispensable to man. The food he eats, the clothes he wears, nay even his own body are all constituted a variety of minerals and or of their salts. You will study the mineral resources in unit II in detail.

1.7.3 Biomass

According to a report of EUEI (European Union Energy Initiatives 2006), Africa is the world's largest consumer of biomass energy. The reliance on biomass energy, especially for cooking and heating, is strongest in sub-Saharan Africa where the majority of the population has no access to, or cannot afford to pay for, alternatives such as modern fossil fuels or electricity. While biomass plays a vital role in meeting basic energy needs and has the potential to contribute to sustainable development and rural livelihoods. However, in many areas the sustainable supply of biomass energy is at risk because of poor resource management and the excessive clearing of forests and woodlands through logging activities and agricultural expansion.

1.7.4 Water

Water is another very important resource of land. It is important because it is needed for life to exist. Many uses of water include agricultural, industrial, household, recreational and environmental activities. Virtually all of these human uses require fresh water. Only 2.5% of water on the Earth is fresh water, and over two thirds of this is frozen in glaciers and polar ice caps. Water demand already exceeds supply in many parts of the world, and many more areas are expected to experience this imbalance in the near future. It is estimated that 70% of world-wide water use is for irrigation in agriculture. Climate change will have significant impacts on water resources around the world because of the close connections between the climate and hydrologic cycle. Due to the expanding human population competition for water is growing such that many of the world's major aquifers are becoming depleted. Many pollutants threaten water supplies, but the most widespread, especially in underdeveloped countries, is the discharge of raw sewage into natural waters.

1.7.5 Culture

The culture of any place always dependent on the land resources availablity as the resources will be available in and around of any society , the culture develops on the basis of these resources. There is agreat relationship between Land resources and social, mental, emotional, physical, spiritual wellness of human being. These all thing provide harmony and balance in the society and result in the development of a culture.

1.7.6 Biodiversity

Biodiversity is another very important resource of land. Biodiversity may be defined as variety and variability among the living organism. These varieties and variability are playing an important role to maintain the ecosystem. As various components of ecosystem are doing their professional work and without them there is no possibilities to run the natural cycles. Biodiversity has various importances in nature, some of them are following:

- Biodiversity supports food security, dietary health, livelihood sustainability.
- Biodiversity provides important resources for medical research.
- Biodiversity plays a role in the regulation and control of infectious diseases.

- Biodiversity has social, cultural and spiritual importance within the communities.

1.7.7 Other Importance

The land area of the earth about 140 million sq km, occupies less than a third of its surface yet, it is vital to our existence since it is land that:

- Preserve terrestrial biodiversity and the genetic pool
- Regulates the water and carbon cycle
- Acts as the store of basic resources like groundwater, minerals and fossil fuels
- Becomes a dump for solid and liquid waste
- Forms the basis for human settlements and transport activities
- Even more important, the topsoil, just a few centimeter thick, support all plant growth and is hence the life support system for all organisms, including humankind.

1.8 Threat to Land Resources

Land provides us various types of resources to fulfill our daily needs but in overloaded desires, we forgot that land has a specific carrying capacity. We are consuming all the resources carelessly without thinking about the degradation of land resources. In Leopold land ethics, Leopold said that the earth planet is working as a boat and in this there are two types of boats, rich and poor. These boats are the rich and poor countries and people are moving from one side to another on the basis of carrying capacity of the boat/country.

1.8.1 Conditions of World's Land Surface

UN studies estimates that 23% of all usable land (excluding mountains and desert) has been degraded to such an extent that is productivity is affected. The main causes of this degradation are deforestation, fuel wood consumption, overgrazing agricultural mismanagement (planting unsuitable crops, poor crop rotation, poor soil and water management, excessive use of chemicals, frequent use of heavy machineries like tractor etc.) the establishment of industries and urbanization.

Soil erosion and degradation, which occurs due to loss of green cover, strong winds, chemical pollution etc., have severe effects on the environment. They affect the soil's ability to act as a buffer and a filter of pollutants, regulator of water and nitrogen cycles, habitat for biodiversity etc.

About one quarter land highly degraded. Another 8 percent are moderately degraded, 36 percent are stable or slightly degraded and 10 percent are ranked as "improving." The remaining shares of the earth's land surface are either bare (around 18 percent) or covered by inland water bodies (around 2%). Large parts of all continents are experiencing land degradation, with particularly high incidences down the west coast of the Americas, across Mediterranean region of Southern Europe and North Africa, across the Sahel and the Horn of Africa, and throughout Asia. The greatest threat is the loss of soil quality, followed by biodiversity loss and water resources depletion. Some 1.6 billion hectares of the world's best, most productive lands are currently used to grow crops. Parts of these land areas are being degraded through farming practices that result in water and wind erosion, the loss of organic matter, topsoil compaction, salinization and soil pollution, and nutrient loss.

Summary

- FAO/UNEP, (1997) or FAO and UNEP (1997) defined land and land resources as an area of the earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface, including those of the near-surface climate, the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, and swamps), the near-surface sedimentary layers and associated groundwater and geo-hydrological reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity (terracing, water storage or drainage structures, roads, buildings, etc.).
- Land use defined in this way establishes a direct linkage between land cover and the people's actions in their environment. Thus, it can be defined as the human use of land that involves both the manner of including biophysical attributes of land and purposes for use of land (Weng, 2010).

- On the basis of use land may be classified as Net sown area, Forest, Current fallow, Other Fallows land, Cultivable wasteland, Miscellaneous tree crops and groves, Permanent pasture and grazing land, Land under non-agricultural use and Barren and uncultivable land.
- On the basis of availability, land resources may be classified as Forest Resources, Mineral Resources, Cropland resources, Water resources and Soil resources.
- Forest resources are very important resource of land and perform the ecological duties with fulfillment for the need of peoples. Forest provides various services to the ecosystem with giving the food, shelter, cover, fodder, wood fiber to the human society. The word forest is derived from a Latin word “Foris” means outside.
- All lands which are more than 1 hectare in area and with a Canopy density of more than 10% irrespective of the ownership and legal status is called Forest Cover.
- Mineral resources are broadly defined as elements, chemical compounds, minerals or rock concentrated in a form that can be extracted to obtain a sustainable commodity.
- Cropland includes areas used for the production of adapted crops for harvest. Cropland may be divided into: cultivated and non-cultivated.
- Water is essential source of life, human body contain about 70%. Water is elixir of life and in the present context, there is a lot of crisis on water resources. Drinkable water is not in plenty on this planet. So the water is most important thing of land resources. Land is providing a substratum to all living and nonliving components.
- The soil is the upper most layer of our terrestrial environment, which is formed due to weathering of rocks and is an admixture of humus, inorganic contents and organic debris which provides a surface over the land for the growth of vegetations and habitat for living animals and comes in immediate contact of biotic and abiotic factors.
- Amarkosha classified the soil as urvara (fertile), ushara(barren), maru (desert), aprahata (fallow), shadvala (grassy), pankikala (muddy), jalaprayah (watery), kachchaha (land contiguous to water), sharkaravati (sandy), sharkara (full of pebbles and pieces of limestone), nadimatruka (land watered from a river), and devamatruka

(rainfed). In the chapter on Vaisyavargaha, soils based on suitability for specific crops are mentioned.

- The total geographical area of India is 328 mha. According to a survey report about 305.67 mha has been reported. Out of the 305.67 mha land 69.63 mha declared as a forestland, 43.22 mha (25.92 mha for non agricultural use and 17.29 mhabaren and uncultivable land) is not available for cultivation.
- In other uncultivated land excluding fallow land is 26.82 mha (10.39 mha permanent pasture and other grazing land and 3.31 mha using for miscellaneous tree crops and grooves left 13.12 mha for cultural waste land). Fallow land is available 25.15 mha, out of this land area 10.34 mha land used as a fallow land other than current fallow and 14.81 mha used as a current fallow and the 140.86 mha is a net sown area and used directly for crop production.
- Land is not a 'produced' or man-made agent. It follows, therefore, that we have to accept it as it is. No doubt man tries to improve and modify nature. But he cannot completely master it. A poor soil and a bad climate are great handicaps in the way of industrial and commercial prosperity. Land as a factor of production is of immense importance.

Terminal question

1 (a) Fill in the blank spaces with appropriate words.

The vast and diverse size of India is its most important resource. About ……….of the land area, which is plain, provides opportunity for cultivation. The mountainous areas, accounting for about …………of the surface area of the country are storehouses of natural resources; they are also important for their scenic beauty and………………. The plateau area has rich reserve in ……………….besides forest and arable lands. The mountains and plateau also have fertile river valley offering favorable location for……………….. The heavy burden of the population and increasing demand of the same have been created a lot of burden on land resources as in …………..per capita availability of land was ………………but it has been sharply declined with time, the per capita availability of land was only …………….In the availability of land area, there is about ……………declination.

So this is clearly shown that the growing population is inversely proportion to the availability of land. As the population will be rise the land availability will be decrease and vice versa.

2. (a) What do you understand by land resources?

   (b) Describe the classification and utilization pattern of land.

3. (a) Describe the forest resources of India.

   (b) Discuss the cropland resources of India.

4. (a) What are soil resources? Explain the soil profile with suitable diagram?

5. (a) Explain the quantity and quality of land resources with special reference of India.

   (b) Discuss the importance of land resources at global level.

   (c) Describe the benefits of agriculture provided by land.

6. (a) Fill the blank spaces with appropriate words.

The total geographical area of India is …………According to a survey report about ………….has been reported. Out of the 305.67 mha land ………….declared as a forestland, ………….(25.92 mha for non agricultural use and ………..barren and uncultivable land) is not available for cultivation. In other uncultivated land excluding ………………is 26.82 mha (10.39 mha …………………..and other grazing land and 3.31 mha using for miscellaneous tree crops and grooves left 13.12 mha for cultural waste land). Fallow land is available ………… out of this land area 10.34 mha land used as a fallow land other than current fallow and 14.81 mha used as a current fallow and the ………….is a net sown area and used directly for crop production.

(b) In 1951 per capita availability of land was 0.89 per hectare (Yes/No)

(c) The category of include all grazing lands-meadows; village commons etc. about 4% of the reporting area comprises such lands known as. (Permanent pasture and grazing land/other fallow land)

(d) Which state of India has the largest forest cover? (Madhya Pradesh/Tamilnadu)

(e) Explain the condition of world land surface?

7. (a) Describe the waste land.

(b) Write a short note on history of land resources.

Answers of Terminal question

1(a) 43 %/30 percent/ ecological aspects/ mineral resources/ human concentration/1951/0.89 per hectare/0.37 ha/60%

2 (a) See section 1.2

(b) See section 1.1

3 (a) See section 1.3.1

(b) See section 1.3.3

4 (a) See section 1.3.5

5 (a) See section 1.5

(b) See section 1.6

(c) See section 1.6.1

6 (a) 328 mha./305.67 mha/69.63 mha/43.22 mha/17.29 mha/ fallow land/ permanent pasture/25.15 mha/ 140.86 mha

(b) Yes

(c) Permanent pasture and grazing land

(d) Madhya Pradesh

(e) See section 1.1

7 (a) See section 1.5

(b) See section 1.4

UNIT 2: The Mineral Resources

Unit Structure

2.0 Learning Objectives

After studying this unit you will be able to find the answers of following questions:

- What is mineral?
- What is the utilization and classification of minerals?
- What are mineral resources?
- What are the types of mineral resources?
- What is the significance of mineral resources?
- What are the threats to mineral resources?
- How can we conserve the mineral resources?

2.1 Introduction

As you know from your study of unit 1 that the land resources are very important for human survival and the minerals are inseparable part of land resources. The mineral resources are found at different places of land and play a key role to maintain the life standard of human being. In this unit you would find the certain terms and concept about the mineral resources. Minerals are valuable natural resources. They constitute the vital raw materials for many basic industries and are a major resource for development. The history of mineral extraction in India dates back to the days of the Harappa civilization. The wide availability of the minerals provides a base for the growth and development of the mining sector in India. The country is endowed with huge resources of many metallic and nonmetallic minerals. Mining sector is an important segment of the Indian economy. Since independence, there has been a pronounced growth in the mineral production both in terms of quantity and value.

Almost all earth materials are used by human beings in various forms. We require metals for making machines, sands and gravels for making roads and buildings, silicon, nickel for making computer chips, limestone and gypsum for making concrete, clays for making ceramics, gold, silver, copper and aluminum for making electric circuits, and diamonds and corundum (sapphire, ruby, emerald)for abrasives and jewelry.

A mineral resource is a volume of rock enriched in one or more useful materials. In this sense a mineral refers to a useful material, here the word mineral can be any substance that comes from the earth.

2.2 Definition of Mineral Resources

As you have studied in unit first various types of land resources and their importance, mineral resources are one of them and very important to fulfill the need of human society as human being has been more civilized. Some minerals are essential for the formation and functioning of the body of all organisms, plants as well as animals, including human beings. In today's context, humans use a wide variety of minerals, many in large amount to sustain his industry based civilization. Availability of mineral resources directly dependent on modern society depends on the, which can be considered a nonrenewable heritage from the geologic past. Although new deposits are still forming from earth processes, but these processes are producing new minerals deposit too slowly to be of use to us today. However large the deposit of a given mineral is, continuous mining will exhaust the ores, so minerals are thus a finite and declining resource.

Naturally occurring solid inorganic substances are known as mineral. A mineral is any substance that is naturally present in the earth's crust and is not formed from animal or vegetable matter. During the course of evolution, the planet earth has passed through various geological processes. These processes formed the minerals in over millions to billions of year and hence they are nonrenewable. Mining is the process of extracting and processing minerals. Over 100 minerals are mined and these include metals like gold, iron, copper and aluminum and nonmetals such as stone, sand and salt. Apart from minerals, another major material that mined is coal.

Mineral resources are essential naturally occurring materials or commodity found on or in the earth in such amounts which are mined for their potential uses or their intrinsic values. Minerals resources come in different shapes and sizes and are divided into two major categories such as metallic and nonmetallic mineral resources. Examples of Metallic resources include minerals like Gold, Silver, Tin, Copper, Lead, Zinc, Iron, Nickel, Chromium, and Aluminium. Examples of Nonmetallic resources include minerals like sand, gravel, gypsum, halite, Uranium, gems and stones.

Table 1: Contribution and rank of India in world production of principal minerals and metals in 2014

Commodity	Unit	Production		Contribution (%)	India's rank
		World	India		
Mineral fuels					
Coal and Lignite	million tones	8,085	659	8.0	3rd
Petroleum crude	million tones	4197	38	0.9	24th
Metallic minerals					
Bauxite	000 tones	2,60,000	22,226	8.5	4th
Chromites	000 tones	30,000	2164	7.2	4th
Iron ore	million tones	3378	129	3.8	4th
Manganese ore	000 tones	54,700	2,345	4.3	7th

Industrial mineral					
Barites	000 tones	9,300	910	9.8	3rd
Kyanite, and alusite & silimanite	000 tones	403	72	17.8	3rd
Magnesite	000 tones	47,700	276	0.5	12th
Apatite & rock phosphate	000 tones	2,45,000	1580	0.6	17th
Talc/steatite/Pyrophyl lite	000 tones	8,300	774	9.3	3rd
Mica crude	tones	3,43,000	636	0.2	17th
Metals					
Aluminium	000 tones	53,000	2027	3.8	5th
Copper (refined)	000 tones	22,600	766	3.4	6th
Steel (crude/liquid)	million tones	1667	81.7	5.3	4th
Lead (refined)	000 tones	10,600	127	1.2	15th
Zinc	000 tones	13,600	733	5.4	3rd

Source: World minerals production data compiled from world mineral production, 2010-2014, British Geological Survey

As you know very well, minerals are the combination of different elements. In the earth's crust and mantle eight elements {Oxygen (O), Silicon (Si), Potassium (K), Calcium (Ca), Sodium (Na, Aluminum (Al), iron (Fe) and Magnesium (Mg)} play a key role to form the above said earth layer. These eight elements combine to each other in different ways to make the various minerals. These minerals are called silicate minerals.

2.3 Origin of Mineral Resources

Mineral resources may be divided on the basis of the processes, responsible for accumulation of these substances. These processes may be classified on the basis of deposition of the minerals as follows:

2.3.1Magmatic Ore Deposits

As per name of this deposition the substances are accumulated within the body of igneous rock as magma. In the magmatic ore deposition, the minerals will concentrate by taking the elements that were once widely depressed at low concentration in the magma. The depressed substances from the magma will come outside and increase the concentration of particular substances. This phenomenon is known as Magmatic ore deposit.

Examples: **Pegmatite**–Because in the fractional crystallization* water and other substances or elements do not enter to the minerals separated from the magma. In this process the residue (the remaining substances) will form and this residue rich in silica and water along with other rare earths elements. From this residue, some elements are important for making phosphorescent picture tube of color T.V. These are lithium, Tantalum, Niobium, Boron, Beryllium, Gold and Uranium.

Crystallization: Minerals will crystallize from a magma body due to heavy weight, some heavy minerals sink to the bottom of magma chamber. So these elements will attain higher concentration in the layer, which has been formed at the bottom of magma chamber.

2.3.2 Hydrothermal Ore Deposits

Through the fracture and pore space in rocks, the concentrated hot aqueous (water rich) fluid flows. When the ground water circulates to depth and heats up by coming in contact with igneous body, the hydrothermal ore deposit on a particular place may be occurred. By coming in contact with igneous body, if the cooling takes place rapidly, this resulted in the accumulation of elements in the rocks.

Examples:

Massive Sulfide Deposits: This deposition takes place at oceanic spreading centers. In earth hot fluids circulating above the magma chamber at oceanic ridge and can remove various elements like Cu, S. Zn, etc. from the rocks through which they can pass. These hot fluids as coming back to the seafloor and come into contact with cold groundwater or oceanic water and suddenly precipitate the metals like as sulfide minerals (Zinc sulfide) and Chalcopyrite (Cu, Fe and Sulfide)

2.3.3 Strata Bound Ore Deposits

This type of deposition found in lakes and oceanic sediments. Such type of mineral may contain lead, zinc and copper in higher concentration. This concept is known as strata bound deposition.

2.3.4 Sedimentary Ore Deposits

In lake or seawater, substances are concentrated by chemical precipitation, known as sedimentary ore deposition.

Example: Evaporate Deposits – As you know that evaporation is the process in which the water vaporized from its natural place. The evaporate deposition is the result of evaporation of water from lake or sea. After evaporation of water, the remaining substance will be concentrated or deposited on a particular place. This process is known as evaporate deposition. Examples are halite (table salt), gypsum (used in plaster and wall board) and borex (used in soap).

2.3.5 Placer Ore Deposits

This type of deposition found in flowing water either of stream or along coastline. In this deposition, the deposition will be according to the velocity of water, if the speed is slow the large minerals or the minerals of higher density are deposited. Thus the heavy minerals will be deposited in lower current velocity of water. This concept is known as placer ore deposit.

2.3.6 Residual Ore Deposits

Residual is known as remaining part. After the weathering process a large part of substances will be removed and the remaining substance is in concentrated form this concept is known as residual ore deposition.

During chemical weathering original body of rock is greatly reduced in volume by the process of leaching, which removes ions from the original rock. Elements that are not leached form the rock thus occur in higher concentration in the residual rock. The most important ore of Aluminum, *bauxite*, forms in tropical climates.

2.4 Types of Mineral resources

Mineral resources are classified into three major classes such as:

- Metallic Mineral Resources
- Nonmetallic Mineral Resource
- Fuel/Energy Mineral Resource

2.4.1 Metallic Mineral Resources

Metallic mineral resources are minerals resources that contain metals in raw form, their appearances have metallic shine and they can be melted to obtain new products. They also contain metals in their chemical composition; the only way you can extract them is through mining. Some examples of metallic mineral resource include Gold, Silver, Copper, Tin, Iron, Lead, Zinc, Nickel, Chromium, and Aluminum.

2.4.2 Nonmetallic Mineral Resources

Nonmetallic mineral resources are minerals that do not contain extractable metals in their chemical composition; they contain nonmetallic shine or luster in their appearance. Examples of nonmetallic mineral resource include sand, stone, gravel, clay, gypsum halite, and Uranium. These minerals can be reprocessed through grinding, mixing, cutting, shaping for intermediate use.

2.4.3 Fuel Mineral Resource

Fuel mineral resource are the basic mineral resources in the world, some examples of these include fossil fuels such as coal, crude oil (petroleum) and natural gas; these are primarily obtained from the remains of dead plant and animal, they are often referred to as fossil fuels and are formed from hydrocarbon. When fossil fuels are burnt they particularly give rise to a great source of heat energy. The proper use of fossil fuels has enabled large-scale industrial development and largely supplanted water-driven mills, as well as the combustion of wood or peat for heat.

2.5 How mineral resources are mined?

Mineral resources are mined once the deposit has been discovered in the ground or in the sea; this process is usually done by different methods most times using the opencast quarrying or underground mining method or by pumping. The mining process depends on the type of mineral discovered. For instance, salt is usually extracted by pumping; in this case, the salt is dissolved in water and pumped from underground just like in the case of oil and gas.

After these minerals have been extracted from the ground, they are processed and purified to a form useful material in which we use on a daily basis. The mining process usually involves the removing any unwanted impurities and further processing to increase the concentration of the economic mineral. Metallic minerals may be smelted or refined to produce metal close to the mine, or the concentrate may be transported to another site for further processing.

Oil and gas are also further refined before use. Finally, once a mineral deposit has been found it has to be extracted from the ground to access the valuable minerals it contains. The way minerals are transported from one place to another depends on their value and bulkiness. It is not economic to transport heavy low-cost minerals like aggregates over long distances, whereas expensive minerals like metals or oil can be transported internationally using ship (water transport) or air transport.

2.5.1 Environmental Problems Due to the Mining

Surface mining destroy all vegetation in the area and pollutes the landscape with the dust that is thrown up. Once the available material is mined out, large craters are left behind. When hills that act as watershed are mined away, the water table goes down as in the case of Aravallis in Rajasthan.

The Rajasamand Lake in Rajasthan had not dried up for at least 300 years. However, this did finally happen in 2001. The likely reason: a decade of marble mining in the Rajnagar area. The aravalli hills, spread across Haryana, Rajasthan and Gujarat are the lifeline of the three states as they control the climate and drainage system of the region. The hills act as a watershed for the region. Unfortunately the hills are also repositories of immense mineral wealth, including talc, marble and granite. Mining and other related industries employ about 1,75,000 workers and 600,000 others are indirectly dependent on mining operations. In Rajasthan alone 9700 industrial units are connected with mining.

Forest cover has been depleted by 90% over the past 20 years since large scale mining began. When the mines reach below the underground water level, a cone of depression is formed that sucks water from the surrounding areas, drying up well and affecting agriculture. Several studies have pointed out that the natural drainage system and the ground water table of the entire region has been badly affected over the years. Pollution level has also increased.

The processing of the mined material often done onsite, using in many cases mercury, cyanide, and large quantities of water, pollutes river and other water bodies. The waste material like slag is often far greater in quantity than what is usable and is left behind as unsightly unstable and dangerous heaps. The mining of precious metals is today more intense and widespread than in centuries past with far reaching consequences of particular concern is heap leach gold mining, in which rivers of cyanide are poured over huge piles of low grade ore to extract the metal. Heap leach mining is on the increase and has already caused several serious accidents. Two examples are:

In 1984 on the OK Tedi Island in new Guenia, 1000 cu.m of concentrated cyanide were released into a river and the ecosystem was devastated. This gold and copper project, which is tearing down a whole mountain, has already caused extensive environmental damage. It has also destroyed the culture and lifestyle of the native people.

In 2000, at the Baia Mare gold mine in Romania, the dam holding the heap leach waste broke, releasing 80 million liter of cyanide into the Tisza River. The cyanide flowed 500 km into Hungary and Serbia.

Mineral resources are useful and natural materials for making valuable goods; these resources play an important role in our economic sector, majority of the countries in the world solely depend on mineral resources for their economic growth and development. Minerals are refined into finished goods for making most of the industrial products which we use in our society such as railways, roads, cars, computers, plastics, pots, cans, metals, coins, and fertilizers etc. Minerals resources are found in different parts of the world in the earth's crust but usually in such small amount and they can only be extracted, where they are found with the help of certain geological processes.

However, mineral resources are categorized based on their chemical composition, color, hardness, affiliation and elemental. Different minerals resources are extracted from the earth differently and certain activities are usually done in the soil or in the water to survey certain mineral deposits and availability before exploration can take place; such activities include remote sensing (aerial photography and satellite imagery), gravity meters, magnetometers and geochemical surveys.

2.6 Mineral Resources in India

As you know that India is a mega diversity nation in context of plants, animals and minerals, so we can say India is a rich nation naturally. In the country, there are various languages, cultural and other social activities. All the state shows the variation in mineral resources and contributes in mineral production differently. As Andhra Pradesh, Assam, Chhattisgarh, Gujarat, Jharkhand, Madhya Pradesh, Odisha, Rajasthan, Other state and offshore area contribute 4%, 8%, 7%, 7%, 6%, 12%, 13%, 16% and 21% respectively in case of production of mineral resources (Fig: 1).

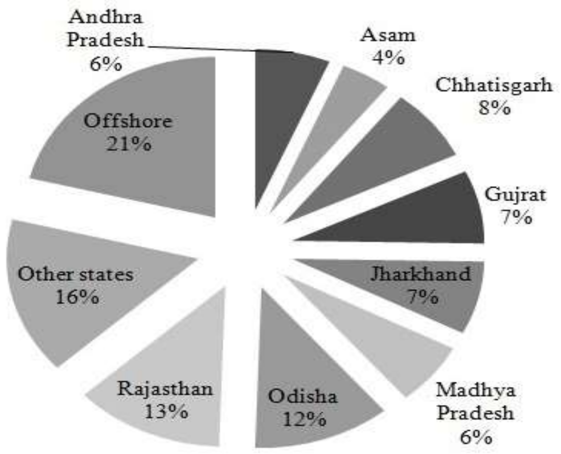

Fig 1: Share of state in mineral production during 2016-17 (Source: Ministry of mines, Annual report 2016-17)

The country is endowed with huge resource of many metallic and nonmetallic minerals. Mining sector is playing an important role in the Indian economy. There has been a pronounced growth in the mineral production both in terms of quantity and value, since independence. The country produces as many as 95 minerals, which includes 4 fuels, 10 metallic, 23 nonmetallic, 3 atomic and 55 minor minerals (including building and other materials). Indian mining industries are characterized by a large number of small operational mines. The number of mines which reported mineral production (excluding atomic, fuel and minor minerals) in India was 1531 in 2017-18 as against 1508 in previous year. Out of 1531 reporting mines, 230 were located in Tamilnadu, followed by Madhya Pradesh (197) Gujarat (191) Karnataka (142), Odisha (132), Andhra Pradesh (129), Chhattisgarh (112), Goa (87), Rajasthan (85), Maharashtra (75) and Jharkhand (58). These 10 states together accounted for 94% of total number of mining in the country in 2017-18. The numbers of reporting mine are following:

Table 2: The number of reported mines in India during 2015-2018

Sl. No.	Sector	2015-16	2016-17	2017-18
1	All minerals	1619	1508	1531
2	Metallic minerals	715	644	657
3	Nonmetallic minerals	904	864	874

India has a rich variety of mineral resources due to its varied geological structure. On the basis of chemical and physical properties, minerals can be classified under two main categories (i) metallic and (ii) non-metallic. Metallic minerals are the sources of metals. Iron ore, copper, gold produce metal and are included in this category. Metallic minerals are further divided into ferrous and non-ferrous metallic minerals. All those minerals which have iron content are ferrous such as iron ore itself and those which do not have iron content are non-ferrous such as copper, bauxite, etc. Non-metallic minerals are either organic in origin such as fossil fuels also known as mineral fuels which are derived from the buried animal and plant life such as coal and petroleum. Other types of non-metallic minerals are inorganic in origin such as mica, limestone and graphite, etc.

2.6.1 Mineral Belts of India

The mineral belts of India are as follows:

(i) **North-Eastern Peninsular Belt:** This belt includes the Chhotanagpur plateau and Orissa plateau in Jharkhand, West Bengal and Orissa. It contains a rich variety of mineral belt of India.Due to the richness of minerals the Chhotanagpur plateau is known as the mineral heart land of India, and contains large quantities of coal, iron, manganese, mica, bauxite, Copper, Chromites, and Kyanite.

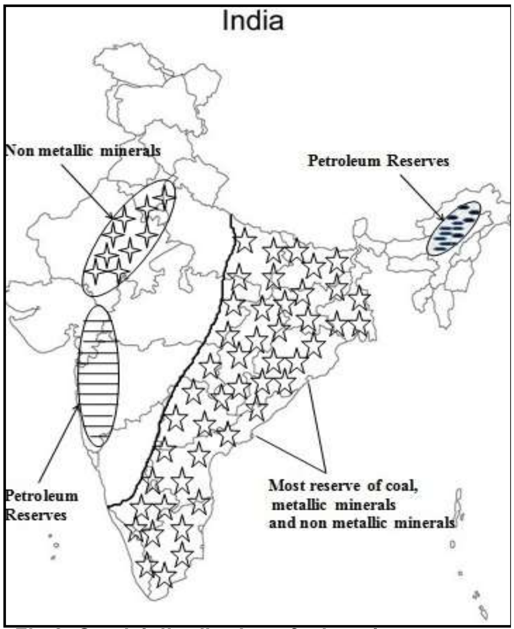

Fig 2: Spatial distribution of mineral resources

(ii) **Central Belt:** It is the 2nd largest mineral belt of India, comprises of Chhattisgarh, Madhya Pradesh, Andhra Pradesh and Maharashtra. This belt contain large deposits of Manganese, bauxite, limestone, marble, coal, gems (Panna), mica, iron ore, graphite, etc.

(iii) Southern Belt: It comprises mostly of Karnataka plateau and contiguous Tamilnadu upland. It lacks coal deposits except lignite at Neyveli (Tamilnadu.). This belt is too much similar to northeastern peninsular belt.

(iv) South-Western Belt: Southern Karnataka & Goa are included. It has deposits of iron-ore and clay.

(v) North-West Belt: This belt contains the Aravallis of Rajasthan and adjoining parts of Gujarat. Important minerals of this belt are copper, lead, zinc, Uranium, mica, bauxite, gypsum, manganese and salt.

(vi) The Indian Ocean: Along with availability of petroleum and natural gas in the off shore areas the sea bed contains manganese nodules, phosphorite nodules and barium sulphate concentration.

The distribution of various mineral resources in India has been given in Table 3.

Table 3: Types and distribution of minerals resources in India

Sl. No.	Name of Minerals	Distribution
1.	Iron	a) Orissa– Mayurbhanj, Keonjhar, Sundergarh, Cuttak, Karaput. b) Jharkhand– Singahbhum- Notu- Buru, Noamundi, AnsiraBaru, Brajamda, Gua, Sasangda. c) Madhya Pradesh– Bastar- Bailadila, Raoghat, Aridongri; Durg- Dhalli-Rajhara. d) Goa (Black iron /Magnetite)-North Goa: Pirna- Adolpale- Asnora; Central Goa: Tolsai- Dongarvado; South- Goa: Borgadongar, Netarlim,. e) Karnataka- Bellary (Sandur-Hospet area), Chikmanglur, Kemmangundi(in Bababudan Hills), Kudremukh, Shimonga. f) Andhra Pradesh-Jaggayapeta, Ramallakota, Veldurti, Nayudupetta, Baygarm. g) Tamilnadu- Coimbatore— Madurai, Tirunelveli, Ramnathpuram districts. h) Maharashtra– Chandrapur, Ratnagiri.
2.	Manganese	a) Odisha-Sundargarh, Kalahandi (Nishikhal), Koraput (Kutinga), Bolangir, Keonjhar, Mayurbhanj. b) Maharashtra-Nagpur (Kodergaon, Gumgaon, Ramdongiri), Bhandara, Ratnagiri. c) Karnataka-Shimoga, Chitradurga, Tumkur, Bellary, N. kanara. d) Andhra Pradesh-Srikakulam, Visakhapatnam e) Madhya Pradesh-Balaghat, Chindwara, Jhabua, Jabalpur. f) Gujarat-Panchmahal. g) Jharkhand-Singhbhum.

3	Chromite	a) Orissa-Contributes 90% of the country's total production, main centers are Sukinda (between Daiteri&Mahagiri Range) in cuttak, Nausahi in Keonjhar. b) Karnataka-2nd largest producer. c) Maharashtra d) Jharkhand-Singhbhum e) Tamilnadu- 96% of chromite is exported to Japan and the rest to Australia.
4	Pyrite	a) Jharkhand-Sahabad (Amjhor, Kasisiyakoh, Kurriari). b) Tamilnadu –Arcot (Polur), Nilgiri (Pandalur- Devala- Nadghani region). c) Karnataka – N. Kanara (Kaiga), Chittradurga (Indldhal). d) Himachal Pradesh –Ashmi river. e) Rajasthan-Sikar. f) Meghalaya-Khasi, Jaintia.
5	Nickel	a) Cuttak & Mayurbhanj districts of Orissa have the major reserves of Nickel. The total reserves is of 5.8% croretonnes of which 4.08 croretonnes are in Kausa block and 1.5% crore tonnes in Saruabil – Sukaragi area. Sirkinda is another famous mine. b) Some amount is also produced in Maharashtra, Jammu &Kashmir, Madhya Pradesh c) India imports nickel to fulfill its domestic demand.
6	Tungsten	Deganal near Rawat Hills in Rajasthan.
7	Bauxite	a) Madhya Pradesh-Amarkantak Plateau- Sargujar, Raigarh, Bilaspur; Maikala Range – Balaghat; Katni Range – Jabalpur. b) Jharkhand- Palamu, Lohardagga, Ranchi, Sahabad (Netarhat Plateau). c) Gujarat- Jamnagar, Khaira, Kutch. d) Maharashtra- Kolhapur, Kolaba, Satara, Ratnagiri, e) Karnataka- Belgaum (Karle Hills, Jamboti, Bakur- Navge- Ridge) f) Tamilnadu- Salem, Nilgiri, Madurai (Palni Hills, Kodaikanal Hills), Coimbatone (Sandabkuli). g) Goa-Quepem, Canacora.
8	Copper	Jharkhand- Singhbhum(50% of total country's reserves at Mosabani, Rakha, Dhobani, Rajdah, Surdah, Pathargara, Tamapahar, Turamdih), Lota- pahar- Fault. Rajasthan- Khetri- Singhana Area (Kolihan, Mandhan, Akwali, Berkhera), Kho- Dariba Area, Delwara- Kerovle Area. Madhya Pradesh- Balaghat (Malanjkhand, Madarkhand)
9	Zinc, Lead	a) Rajasthan- Zawar deposit of Udaipur(Mochia-Mogra, Balaria, Zawarmala, Baroi,Baba-Hill), Taragarh Hill area (lead ore), Ajmer (Taragarh, Ganeshpura, sawar), Alwar (Jodhawas). b) Andhra Pradesh- Zangamarajupalle (in Chuddapah district) c) Bihar- Bhagalpur (Dudiar, Gauripur) d) Jharkhand- Hazaribagh (Hatasu, Parasia), Santhal. Paragana (Panchpahar, Bhairkuhi, Sankera)

10	Gold	Karnataka- Kolar Gold field/KGF (since 1871 when mining first started in Ooregum mines, Marikuppam quartz vein bearing gold, Champion, Nandidroog, Mysore), Hutti, Topuldedi, wondalli. b) Andhra Pradesh- Ramagiri Gold field (Anantapuram district). c) Jharkhand- Alluvial gold in the beds of Garra-Nadi, S-Koyel, Sanjai, Sona-Nadi, ubarnarekha rivers in Singhbhum district. d) Kolar & Hutti goldfields all together produce 98% of total country production.
11	Silver	a) Produced as by product during the smelting of galana, also produced from lead ore of Kurnool, Cuddapah and Guntur of Andhra, Singhbhum &Ranchi of Jharkhand and Vadodara of Gujarat. Quartzite's of Mysore gold field and cupriferous pyrites of Chitradurga are also yield some amount of silver.
12	Mica	a) Jharkhand- A belt existing over 150 km in length and 20-22 km in width from Gaya in west through Hajaribag and Mungar districts to Bhargalpur districts in the east; Kodarma, Damchanch, Maenodils, Parsabad, Tisri, Mohesari, Chakai are the main centres. Kodarma is the world largest Mica market. Ruby – mica &Bangal- mica,which is of high quality is found in Jharkhand. b) Andhra Pradesh-Gudur ,Sangam& Nellore are the main producing regions of Green- mica, also called Electrical- mica (lightest of all types). c) Rajasthan- chief mining centres are Barla, Naukhand. Sohlenwara, Barani, Palmin in Tonk and Jaipur districts. Bhilwara is also the important centre. In Rajasthan green or pink colour high quality mica is found.
13	Limestone	Andhra Pradesh – (13 of total reserves)- Cuddapah, Guntur, Krishna,Khammam, Kurnool, Godavari b)Karnataka-(1/3 of total reserves) Gulbarga, Bija-pur, Shimoga. c) Gujarat- (13% of total reserves)-Junagarh, Amreli, Kutch, Banas- Kantha, Surat. d) Rajasthan – (6% of total reserves) – Ajmer, Jaipur, Pali, Madhopur, Banswara, Jodhpur, Bundi B. Flux-Grade Limestone a) Madhya Pradesh-(36% of the total reserves)-Belaspur, Jabalpur, Rewa, Satna, Raipur. b) Meghalaya-(30% of the total reserves) Khasi&JaintiaHillls.
14	Asbestos	a) Rajasthan-Ajmer, Bhilwara, Dungarpur, Pali, Sirohi, Udaipur. b) Karnataka-Gopalpur, Mavinhalli, Hassan, Mandya, Shimoga, Chikmanglur. c) Andhra Pradesh-Cudapah, Anantapur, Mehbubnagar. d) Jharkhand-Singhbhum, West Bengal, Purulia.
15	Sillimanite	a) Meghalaya-Sonapahar, Nagpur, Nangbain in the Nongtoin area. b) Madhya Pradesh.-Sidhi & Reewa. c) Maharashtra-Bhawara, Nagpur. d) Tamilnadu-Coimbatore, South Arcot. e) Kerala-Palghat, Kottayam.

16	Kyanite	a) Jharkhand-A belt extending from Lapsa Buru to Kharasawan in Saraikala. with the important mines at Lapsa-Buru, Ghagidih, Bachia- Bakro & Mauyaluka. b) Maharashtra-Pahergaon & Pipalgaon in Sakohi Tehsil and Gorkha- Buranga and Asvalpain in Bhandara districts.
17	Salt	a) Sea-salt- Mithapur, Jamnagar, Dharsana, Okha, Bulsar in Gujarat; Bhandrup, Uran, Bhayandar in Maharashtra; Madras & Taticorin in Tamilnadu. b) Salt- lake- Sambhar, Didwana, Pachbhadra, Lankaesara lakes in Rajasthan. c) Rock-salt- mined at present in Mandi District at Drang &Guna in Himachal Pradesh.
18	Rare-Earths	In the South-west tip of India on the Kerala and Tamilnadu cost, an extremely rich minerals like Ilmenite and Monazite. Ilmenite- from Quilon to Kanyakumari

2.7 Importance and Uses of Mineral Resources

As you know that the minerals are playing very important role in survival of human being. On the basis of their chemical composition and uses, the mineral may be classified into three categories - Metallic, Nonmetallic and Energy resources (as explained in 2.4 in this chapter). The metallic minerals are very important and used in different manner, like as aluminum, copper, gold, iron, lead, nickel, thorium, uranium, zinc etc. are used in building material, alloys and electrical product, monetary purposes, jewelry, nuclear bombs, electricity generation etc. The nonmetallic group contains Asbestos, Corundum, Feldspar, Fluorspar, Nitrates, Phosphates, sulfur etc. used in roofing, insulation, abrasives, fertilizers, chemicals, steel industry etc. Minerals are using as energy resource as diesel, petrol, compressed natural gas (CNG) fuel for different vehicles. Coal is used for power generation and steel production, oil for heating, electricity generation and for vehicles (Table 4).

Table 4: Important minerals and their uses

Mineral Resources	Uses
A) Metallic Resources	
Aluminum	Building materials, electrical wiring, utensils, aircrafts, rocket
Beryllium	Refractories, Copper alloys
Chromium	Refractory, metallurgy, chemicals
Cobalt	Alloys, radiography, catalysts, therapeutics
Columbium	Stainless steel, nuclear reactor
Copper	Alloys and electrical products
Gold	Monetary purposes, jewelry, dentistry
Iron	Steel, building materials, numerous industrial uses
Lead	Batteries, paints, alloys, public health fitting, gasoline

Magnesium	Structural refractories
Manganese	Alloy steels, disinfectants
Molybdenum	Alloy steel
Nickel	Used in over 8000 alloys
Thorium	Nuclear bombs, electricity generation
Tin	Soldering, chemicals, tin plate
Tungsten	Alloys, chemicals
Titanium	Alloys, Pigments and aircraft
Uranium	Nuclear bomb, Electricity generation
Vanadium	Alloys
Zinc	Gal vanishing, chemicals, soldering and die casting
B) Non Metallic Resource	
Asbestos	Roofing, insulation, ceramics, textile, gasoline
Corundum	Abrasives
Feldspar	Ceramic flux, artificial teeth
Fluorspar	Flux, refrigerants, Propellants, acid
Nitrates	Fertilizers, Chemicals
Phosphates	Fertilizers, Chemicals
Potassium	Fertilizers, Chemicals
Salt	Chemicals, glass, metallurgy
Sulfur	Fertilizers, acid, iron and steel industry
C) Energy Resources	
Coal	Power generation, steel production
Oil	For heating, Electricity generation and for vehicle
Natural gas	Vehicles as CNG, cooking, heating

The mineral resources have a lot of importance as we have discussed above, with all the importance, mineral resources contribute to the economy of the country and definitely enhance the financial status of the country. As you can, clearly see in table 5 that the increasing trend of financial contribution by different states of India. Chhattisgarh, Odisha and Rajasthan are the major contributor during 2013-2017 as these states have the contribution of Rupees 1, 07,364/-, 3, 41,343/-, and 1, 86,575/- in the year of 2015-16.

Table 5: Growth of royalty for last four year of major minerals (other than minor minerals coal, lignite and sand for stowing) (Value in ₹ lakh).

State	2013-14	2014-15	2015-16	2016-17
Andhra Pradesh	48,784.20	33,571.00	26,650	29,527
Assam	44.87	139.67	248	512
Bihar	128.17	107.31	NA	NA
Chhattisgarh	1,14,535.52	1,55,634.52	1,07,364	1,11,517
Goa	3,650.62	4,838.24	4,288	31,475
Gujarat	35,031	43,476	NA	NA

Haryana	8	40.3	NA	NA
Himachal Pradesh	6,625	9,740	NA	NA
Jharkhand	62,706.56	82,870.25	NA	NA
Jammu & Kashmir	914.49	1,182.14	NA	NA
Karnataka	74,304	92,594	79,766	1,01,534
Kerala	1,239.31	1,390.53	757	NA
Madhya Pradesh	36,527	46,697	39,185	37,735
Maharashtra	16,825.87	14,100	16,241	16,925
Meghalaya	2,465.59	2,199.58	2,998	NA
Odisha	3,76,765	3,44,338	3,41, 343	2,47,678
Rajasthan	1,59,147	1,97,024	1,86,575	NA
Telangana	--	19,702.72	19,015	20,126
Tamilnadu	16,741.50	18,087.4	NA	NA
Uttarakhand	1,522	1619	NA	NA
Uttar Pradesh	1,410	1037	NA	NA

Source: Ministry of mines, Annual report 2017-18

2.7.1. Global Mineral Needs

When we consider the annual world consumption of few selected elements, the following picture emerges:

Sodium and iron are used at a rate of about 0.1 to 1.0 billion metric tons per year. Nitrogen, sulfur, potassium and calcium are used at a rate of about 10 to 100 million metric tons per year, primarily as fertilizers. Zinc, copper, aluminum and lead are used at a rate of about 3 to 10 million metric tons per year or even less; and of all the metallic minerals, iron makes up 95% of all the metals consumed. Because the processes that form ores operate on geologic time scales, the most economic mineral resources are essentially nonrenewable. New deposits cannot be generated in human timescales. But, as mentioned previously, as the reserves of materials become depleted it is possible to find other sources that are more costly to exploit. Furthermore, mineral resources are not evenly distributed. Some countries are mineral-rich; some are mineral-poor. This is a particular issue for strategic mineral resources. These strategic metals are those for which economical source do not exist in the U.S., must be imported from other potentially non-friendly nations, but are needed for highly specialized applications such as national security, defense, or aerospace applications. These metals include Manganese, Cobalt, Platinum, and Chromium, all of which are stockpiled by the U.S. government in case supplies are cut off. How long current mineral resources will last depends on consumption rates and reserve amounts. Some mineral resources will run out soon, for example global resources of Pb, Zn, and Au will likely run out in about 30 years. U. S. resources of Pt, Ni, Co, Mn, Cr in less than 1 year. Thus, continued use of scarce minerals will require discovery of new sources, increase in price to make hard-to-obtain sources more profitable, increased efficiency, conservation, or recycling, substitution of new materials, or doing without.

2.7.2 Threat to Mineral Resources

At first glance, sustainability and mineral resource development appear to be in conflict. Mining depletes finite resources and in a strict sense, therefore, is inherently unsustainable. For instance, there is only a finite amount of copper in the earth's crust, and each unit of copper extracted increases the fraction of the total copper resource base that is in use. Thus, it can be argued that if we continue to mine we will eventually exhaust the available supply of minerals. This perspective, however, ignores the dynamics of mineral supplies. In practice the non-renewable character of minerals may be less constraining than it might seem. Five factors make the benefits from mining much more sustainable than they initially appear to be. First, through the process of exploration and development, mining companies continually reinvigorate, augment, or "sustain" their reserves. Current reserves represent only a small portion of the mineral resources remaining in the earth's crust. Exploration and development lead to the discovery and proving up of previously unknown mineral deposits and—perhaps just as important—additional reserves at existing mines and known deposits. Technological improvements in exploration increase the discovery rate of mineral deposits and at the same time reduce discovery costs. Predictive models for massive sulfide deposits, for example, allow targeting of completely buried deposits by using the combination of structural projections and favorable stratigraphic horizons in volcanic rocks.

2.7.3 Problems Posed by Mineral Resources

- Depletion of Minerals
- Rapidly growing mining activity has rendered large agricultural tracts almost useless.
- Miners have to work under most hazardous conditions.
- Many mineral producing areas lead to air and water pollution.
- Huge displacement of tribal people.

2.7.4 Sustainable Minerals Mining

Sustainable mining is defined as "Mining that is financially viable; socially responsible; environmentally, technically and scientifically sound; with a long term view of development; uses mineral resources optimally; and, ensures sustainable post-closure land uses. Also one based on creating long-term, genuine, mutually beneficial partnerships between government, communities and miners, based on integrity, cooperation and transparency".

It includes:

- Mining operations that have a broad-based social license to operate- creating lasting social and economic wealth which will outlast the life of the mine.
- Environmentally, technically and scientifically sound implying proper management of natural resources. And the last one uses of mineral resources optimally.

2.8 Summary

- In this unit we have examined various aspects of mineral resources so far you have learnt that a mineral resource is a volume of rock enriched in one or more useful materials. In this sense a mineral refers to a useful material, here the word mineral can be any substance that comes from the Earth.
- A mineral is any substance that is naturally present in the earth's crust and is not formed from animal or vegetable matter.

- Metallic mineral resources- are minerals resources that contain metal in raw form, their appearances have metallic shine and they can be melted to obtain new products.
- Nonmetallic mineral resources are minerals that do not contain extractable metals in their chemical composition; they contain nonmetallic shine or luster in their appearance.
- Fuel mineral resources are the basic mineral resources in the world; some examples include fossil fuels such as coal, crude oil (petroleum) and natural gas.
- Mineral resources are mined once the deposit has been discovered in the ground or in the sea; this process is usually done by different methods most times using the opencast quarrying or underground mining method or by pumping. The mining process depends on the type of mineral discovered. For instance, salt is usually extracted by pumping; in this case, the salt is dissolved in water and pumped from underground just like in the case of oil and gas.
- Surface mining destroy all vegetation in the area and pollutes the landscape with the dust that is thrown up. Once the available material is mined out, large craters are left behind. When hills that act as watershed are mined away, the water table goes down as in the case of Aravallis in Rajasthan.
- In Andhra Pradesh, Assam, Chhattisgarh, Gujarat, Jharkhand, Madhya Pradesh, Odisha, Rajasthan, Other state and offshore area contribute 4%, 8%, 7%, 7%, 6%, 12%, 13%, 16% and 21% respectively in case of production of mineral resources (Fig: 1).
- The number of mines which reported mineral production (excluding atomic, fuel and minor minerals) in India was 1531 in 2017-18 as against 1508 in previous year. Out of 1531 reporting mines, 230 were located in Tamilnadu, followed by Madhya Pradesh (197) Gujarat (191) Karnataka (142), Odisha (132), Andhra Pradesh (129), Chhattisgarh (112), Goa (87), Rajasthan (85), Maharashtra (75) and Jharkhand (58). These 10 states together accounted for 94% of total number of mining in the country in 2017-18.

- The metallic minerals are very important and used in different manner, like as aluminum, copper, gold, iron, lead, nickel, thorium, uranium, zinc etc.
- The nonmetallic group contains Asbestos, Corundum, Feldspar, Fluorspar, Nitrates, Phosphates, sulfur etc. used in roofing, insulation, abrasives, fertilizers, chemicals, steel industry etc.
- Minerals are using as energy resource as diesel, petrol, compressed natural gas (CNG) fuel for different vehicles.
- Mining depletes finite resources and in a strict sense, therefore, is inherently unsustainable. For instance, there is only a finite amount of copper in the earth's crust, and each unit of copper extracted increases the fraction of the total copper resource base that is in use.

Terminal question

1. (a) Fill in the blank spaces with appropriate words.

India is endowed with huge resource of many metallic and nonmetallic minerals. Mining sector is playing an important role in the Indian economy. There has been a pronounced growth in the mineral production both in terms of quantity and value, since independence. The country produces as many as……………, which includes ……….fuels,………...metallic, 23 nonmetallic, 3 atomic and ……….minor minerals (including building and other materials). Indian mining industries are characterized by a large number of small ……………... The number of mines which reported mineral production (excluding atomic, fuel and minor minerals) in India was …………..in 2017-18. Out of 1531 reporting mines, ………..were located in Tamilnadu, followed by Madhya Pradesh (197) Gujarat (191) Karnataka (142), Odisha (132), Andhra Pradesh (129), Chhattisgarh (112), Goa (87), Rajasthan (……..), Maharashtra (75) and Jharkhand (……..). These 10 states together accounted for ……….% of total number of mining in the country in 2017-18.

2. (a) Discuss the types of mineral resources.
   (b) How mineral resources are mined?
3. (a) Describe the environmental problems due to the mining.
   (b) Discuss the mineral belts of India.
4. a) What do you meant by distribution of mineral resources? Explain the types and distribution of minerals resources in India?
5. (a)Explain the role of mineral resources in financial growth.
   (b)Discuss the need of mineral resources at global level?
   (c) Discuss the threat to mineral resources.
6. (a) Fill the blank spaces with appropriate words.

When we consider the annual world consumption of few selected elements, the following picture emerges: Sodium and iron are used at a rate of about……………..billion metric tons per year. Nitrogen, ………….,………., potassium and calcium are used at a rate of about ……………million metric tons per year, primarily as fertilizers. ………., ………., ……….. and lead are used at a rate of about ……to………million metric tons per year or even less; and of all the metallic minerals, iron makes up …………% of all the metals consumed. Because the processes that form ores operate on geologic time scales, the most economic mineral resources are essentially…………………. New deposits cannot be generated in human timescales. But, as mentioned previously, as the reserves of materials become depleted it is possible to find other sources that are more costly to……….. Furthermore, …………………are not evenly distributed. Some countries are mineral-rich; some are mineral-poor. This is a particular issue for strategic……………….... These strategic metals are those for which economical source do not exist in the………….., must be imported from other potentially non-friendly nations, but are needed for highly specialized applications such as national security, defense, or aerospace applications.

(b) Minerals will crystallize from a magma body due to heavy weight(Yes/No)

(c) Deposition found in flowing water either of stream or along coastline.is called (Placer Ore Deposits /Strata ore deposit)

(d) Which one mineral heart land of India (Chhotanagpur/ Neyveli/Jharkhand)

(e) What do you understand by Mining?

7. (a) Describe the metallic and nonmetallic mineral resources.

(b) Give the use and distribution of Gold, Mica, Asbestos, Silver and Bauxite in India

Answers to the Terminal questions

1 (a) 95 minerals, 4 fuels, 10 metallic, 55 minor operational mines. 1531 230, (85), (58), 94%

2 (a) See section 2.4

(b) See section 2.5

3 (a) See section 2.5.1

(b) See section 2.6.1

4 (a) See section 2.6 (Table 1)

5 (a)See section 2.7

(b) See section 2.7.1

(c) See section 2.8

6 (a) 0.1 to 1.0 billion/ sulfur, / 10 to 100 million / Zinc, copper, aluminum / 3 to 10 / 95% nonrenewable/ Exploit. Mineral resources, /mineral resources./ U.S.

(b) Yes

(c) Placer ore deposit

(d) Chhotanagpur

(e) See section 2.5

7 (a) See section 2.7

(b) See section 2.6 (table)

UNIT 3: The Water Resources and Wetland Case Study: The Sundarbans and Bharatpur Sanctuary

Unit Structure

3.0 Learning Objectives

After studying this unit you will be able to:

- Define Wetland
- What are the Characteristic features of wetlands?
- Describe about Wetlands in India
- What is Ramsar Convention?
- How may Ramsar conservation sites in India
- About Sundarbans
- Flora and Fauna of Sundarbans
- About Bharatpur Sanctuary
- Flora and Fauna of Bharatpur Sanctuary

3.1 Introduction

There are various natural resources on land such as forest resources, water resource, land resource, mineral resource, energy resource etc. Water resource is one of the greatest resources among all resources and it is not only important to human being but also for all living creatures, and all ecosystems. About 97.5% of water occurs in sea and oceans which is called salt water, on the other hand remaining 2.5% regarded as freshwater. Most of the freshwater acts as water sources and these resources include rivers, lakes, ponds, wetlands, groundwater etc. Wetland is a land area which is saturated with water. Wetlands are found on every part of earth except Antarctica. These wetlands are ecologically, socially and economically very important. Wetlands recharge the ground water, act as flood controlling wall, increase biological diversity etc. Therefore, it is necessary to conserve, protect, and preserve, these wetlands at local, national and global levels. World Wetlands Day celebrated on February 2 of every year to spread mass awareness about the importance of wetlands. Wetlands are very important reservoir not only for human being but for the ecological sustainability also. In this unit you will learn about various types and importance of wetlands, wetlands in India, the case studies of Sundarbans and Bharatpur Sanctuary.

Definitions

Man has long history of wetlands. Human civilization developed near the water bodies or wetlands. Most of these civilizations were established on the coasts, along rivers or in prime agricultural lands and rich forests, all of which possess areas which can be called "wetlands." In more recent years, especially about 1960, the term "wetlands" has come into widespread usage and means all types of land areas which are characteristically high in water content. Various agencies have defined wetlands, some of the important definitions of wetland are given below:

- According to Ramsar Convention wetlands may be defined as “Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static, flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six metres”.
- According to Tidal Wetlands Act (1969), "wetlands" defined as: "Wetland" means those areas which border on or lie beneath tidal waters, such as, but not limited to, banks, bogs, salt marshes, swamps, meadows, flats or other lowlands subject to tidal action, including those area snow or formerly connected to tidal waters, and whose surface is

at or below an elevation of one foot above local extreme high water; and upon which may grow, or be capable of growing.

- Ramsar convention stated that “Wetland may incorporate riparian and coastal regions adjacent to wetlands and islands or bodies of marine water deeper than 6 meters at low tide lying within the wetlands”
- According to Inland Wetlands and Watercourses “Wetland is land, including submerged land which consists of any of the soil types designated as poorly drained, very poorly drained, alluvial and flood plain.

Terms related to "Wetlands"

(i) **Bog:** Bog is wet, spongy ground in which soil made up of decayed vegetable matter; an area or stretch of such ground. Bog has a poorly drained usually acid area rich in plant residues, frequently surrounding a body of open water, and has characteristic flora. Main floras in bog are sedges, heaths and sphagnum.

(ii) **Bottom:** The ground below any aquatic body; usually Bottoms, also called Bottom land.

(iii) **Everglade:** Everglade is swampy land characterized by clumps of tall grass and numerous branching waterways. Everglade usually, containing saw-grass and at least seasonally covered by slowly moving water.

(iv) **Fen:** Fen is lowland completely or partially covered with water.

(v) **Fenland:** A low area of marshy ground.

(vi) **Heath:** Health is a tract of open and uncultivated land, waste land over-grown with shrubs. A tract of wasteland is an extensive area of rather level open uncultivated land usually with poor coarse soil, inferior drainage, and a surface rich in peat or peaty humus.

(vii) **Marsh:** Marsh is a tract of low wet land, generally treeless and periodically inundated: characterized by grasses, sedges and rushes.

(viii) **Marshland:** A region, area, district, etc. characterized by marshes, swamps, bogs or the like.

(ix) Meadow: Meadows are tracts of grassland used for pasture. These are tracts of grassland in an upland area near the timber line. These meadows are predominantly in grass; especially a tract of moist low-lying usually level grassland.

(x) Mire: Mire is a section of wet, swampy ground; bog; marsh; ground of this type as wet, slimy soil of some depth; deep mud, etc.

(xi) Moor: Moor is a tract of open, peaty, waste land, often overgrown with heath, common in high latitudes and altitudes where drainage is poor. These are usually peaty and dominated by grasses and sedges.

(xii) Moorland: It is an area of moors, especially country abounding in heather.

(xiii) Morass: Morass is a tract of low, soft wet land; a marsh or bog; marshy ground.

(xiv) Muskeg: A bog of northern North America, commonly having sphagnum mosses, sedges and sometimes stunted black spruce and tamarack trees.

(xv) Quagmire: An area of miry or boggy ground whose surface yields under the tread;

(xvi) Quicksand: Quicksand is a bed of soft or loose sand saturated with water and having considerable depth, yielding underweight and therefore apt to engulf persons, animals, etc., coming upon it.

(xvii) Salt marsh: Salt marsh is a marshy tract that is wet with salt water or flooded by the oceans or seas.

(xviii) Slough: Slough is an area of soft, muddy ground; muddy ground; swamp or swamp like region.

(xix) Sump: Sump is a swamp, bog or muddy pool.

(xx) Swale: Swale is a low place in a tract of land, usually moister and often having a ranker vegetation than the adjacent higher land.

(xxi) Swamp: Swamp is a tract of wet, spongy land; marshy ground, a tract of soft, wetground having a growth of certain types of trees and other vegetation, but unfit for cultivation.

(xxii) Swampland: Swampland is a land or an area covered with swamps.

(xxiii) Wetland: Wetland is generally, wetlands a tract of land having wet and spongy soil, as a marsh, swamp or bog.

3.2 Types and characteristics of wetlands

3.2.1 Natural Wetlands

There are various natural wetlands which are described below:

(i) **Marine:** Marine and coastal wetlands are generally found in regions between land and sea. These wetlands are not influenced by rivers. The examples of marine wetlands are open Ocean, continental shelf, including beaches, rocky shores, lagoons, and shallow coral reefs. These marine wetlands have hyper-saline water chemistry and minimal influence from rivers or estuaries. Mangroves, mudflats or sabkhas may be present in these wetlands.

(ii) **Estuarine**: Estuarine wetlands are found where freshwater (especially rivers) meets with and mixes with salt water from the sea. Eastuarine wetlands include mangroves, saltmarsh wetland etc. There are deep-water tidal habitats with a range of fresh-brackish-marine water chemistry and daily tidal cycles. The examples of estuarine wetlands are: Salt and brackish marshes, intertidal mudflats, mangrove swamps, bays, sounds, and coastal rivers.

(iii) **Riverine**: Riverine wetlands are associated with running water such as rivers and streams. Freshwater, perennial streams comprised of the deep-water habitat contained within a channel, this restrictive system excludes floodplains adjacent to the channel as well as habitats with more than 0.5% salinity.

(iv) **Lacustrine**: Lacustrine wetlands are related with lakes and ponds. These wetlands are dominantly occupied by submerged macrophytes, diatoms, algae, herbs and floating ferns. These wetlands include inland water bodies that are situated in topographic depressions, lack emergent trees and shrubs, have less than 30% vegetation cover, and occupy at least 20 acres (8 ha). The examples of this type of wetlands are lakes, larger ponds, sloughs, lochs, bayous, etc.

(v) **Palustrine**: The word "Palustrine" has been taken from Latin word "Palus" which means Marsh. Palustrine wetlands may include any inland wetland that lacks running water. These wetlands contain ocean derived salts (less than 0.5 ppm). These wetlands are non-tidal wetlands that are substantially covered with emergent vegetations such as: trees, shrubs, moss, etc. Most bogs, swamps, floodplains and marshes categorized as Palustrine wetlands. Water chemistry of these wetlands is normally fresh but may range to brackish and saline.

All of the above wetlands may interface with each other, so that an environmental continuum exists across the surface of earth. There are various types of terms related to wetlands and their characteristics are given in Table-1.

Table 1. Showing different types of wetlands and their characteristics

Type of Wetland	Characteristics
Bog	Peat generally dominated by moss. Bog receives only direct rainfall/precipitation; characterized by acid water, low alkalinity and low nutrients.
Fen	In fen peat accumulation dominated by sedge, reed, shrub or forest. Fen receives some surface runoff and ground water. Fen has neutral pH and contains moderate to high nutrients.
Mire	This term is mainly used in Europe to include any peat-forming wetland (bog or fen).
Marsh	Permanently or periodically inundated site characterized by nutrient-rich wetlands.
Playa	Playa is shallow, ephemeral ponds or lagoons that experience significant seasonal changes in semi-arid to arid climates. Generally they have high salinity. They may be completely dry.
Slough	This term is used for wetland environment in a channel or series of shallow lakes. Water is stagnant or may flow slowly on a seasonal basis.
Swamp	Swamp is characterized by forest, shrub and reed cover. These are particularly a forested wetland in North America. Depends on nutrient-rich ground water derived from mineral soils.
Wet Meadows	Wet Meadows are grassland or savannah with waterlogged soils. These are without standing water for most of the year.
Open Water	Deeper, normally perennial pools within wetlands and shallow portions of lakes and rivers. Typically provide habitats to submerged macrophytes.

(Mitsch and Gosselink (1993)

3.2.1 Peat Land Classification

According to Charman, (2002) the term peatland indicates those wetlands in which substantial peat accumulation-at least one foot (30 cm)--has taken place. The peatland substrate is an organic structure built by biological activity. Peat is intrinsic to many wetlands around the world. Peat is partly decomposed plant remains that consist of more than 65% organic matter. Moss, grass, herbs, shrubs and trees may contribute to the buildup of organic remains. Through time, the accumulation of peat creates the substrate, influences ground-water conditions, and modifies surface morphology of the wetland.

According to (Charman 2002), several factors are considered important for classification of peatland types. These characteristics are Floristics, physiognomy, morphology, hydrology, stratigraphy, chemistry and peat characters. These characters are described below:

(i) Floristics: Floristic characters include: Plant composition of vegetation communities, which may be used as substitute or indicators for environmental factors.

(ii) Physiognomy: Physiogamy is generally structure, morphology of the dominant plants.

(iii) Morphology: This is also important characters in peat character. This is three-dimensional shape of the peat deposit and geomorphology of the wetland surface.

(iv) Hydrology: Hydrology consists the source of the supply and flow regime for surface and ground water.

(v) Stratigraphy: This is vertical layering, composition, and nature of underlying peat deposits.

(vi) Chemistry: Chemical characteristics of surface water, particularly acidity and nutrients in water bodies.

(vii) Peat characteristics: This includes: botanical composition, nutrient content and structure. This is also important character for human applications.

On the basis of factors, the water supply and nutrient concentration are the most fundamental elements for classifying peat lands. According to Charman 2002, peat lands are divided in to two classes:

(a) Ombrotrophic: Ombrotrophic receive all water and nutrients from direct precipitation. Neither ground water nor runoff from surrounding land reaches the surface of the bog. Rain and snow provide the water source, and nutrients are derived from whatever blows in--dust, leaves, bird droppings and feathers, spider webs, animal fur, etc. Water chemistry tends to be acidic, and nutrients for plant growth are in short supply. Few plants can survive such extreme conditions, namely *Sphagnum* and pine.

(b) Minerotrophic: Fens located in depressions that receive surface runoff and/or ground-water recharge from surrounding mineral-soil sources. Nutrients are more abundant and water is more alkaline--conditions that are suitable for a wide range of plants and which give rise to greater floralistic diversity as compared to ombrotrophic.

Wetlands are wet, and since they are wetlands because of the position of the water table relative to the ground surface, it follows that sub-surface water flow. According to MoEFCC Wetland' is a generic term for water bodies of various types, and includes diverse hydro-logical entities, namely, lakes, marshes, swamps, estuaries, tidal flats, river flood plains, and mangroves. Freshwater, which holds the life-line for human beings and for that matter for all living organisms is a rapidly shrinking resource and likely to be the cause of competing claims and resultant conflicts.

3.3 Importance and Functions of Wetlands

Wetlands are important ecosystems that provide numerous beneficial benefits for people and for fish and wildlife. Some of these functions include protecting and improving water quality, provides habitats to wildlife, storing water, flood control and recharge groundwater etc. These valuable functions are the result of the unique and specific characteristics of wetlands.

On the other hand, wetlands are among the most productive ecosystems in the world. These wetlands are comparable to rain forests and coral reefs. A great variety of species of microbes, plants, insects, amphibians, reptiles, birds, fish and mammals may be part of these wetland ecosystems. Climate, landscape shape, geology and the movement and abundance of water help to determine the plants and animals that inhabit each wetland. The complex, dynamic relationships among the organisms inhabiting the wetland environment are called food webs.

Wetlands can be regarded as "biological supermarkets". They provide food that attracts many animal species. These animals use wetlands for part of or all of their life-cycle. Dead plant leaves and stems break down in the water to form small particles of organic material called "detritus." This enriched material feeds by aquatic insects, shellfish and small fish that are food for higher tropic level animals such as predatory fishes, amphibians, reptiles, aquatic birds and mammals. The functions of a wetland and the values of these functions to humans depend on a complex set of relationships between the wetland and the other ecosystems in the watershed. A watershed is a geographic area in which water, sediments and dissolved materials drain from higher elevations to a common low-lying outlet or basin a point on a river, lake, underlying aquifer or estuary.

Wetlands are very important and play a vital role in the ecology of the watershed. The combination of stagnant water, high concentrations of nutrients and primary productivity is important for the growth of plants and animals that form the basis of the food. Many species of birds and mammals depend on wetlands for food, water and shelter especially during breeding seasons, they migrate towards these wetlands.

Microbial diversity, plant diversity and animal diversity are part of global cycles for water, nitrogen and sulfur. Scientists discovered that atmospheric maintenance may be an additional function of wetlands**.** As it is earlier mentioned wetlands store carbon within their plant communities and soil instead of releasing it to the atmosphere as carbon dioxide. Thus wetlands help to reduce global warming. There are very importance on account of their diversity of services and functions. A summary of functions of wetlands is summarized in Table 2, Fig1 and Fig2.

Table 2. The importance and functions of wetlands

Function	Definition
Recharge Ground Water	The capacity of processes in a wetland to influence the volume of water and the rate at which it moves between the ground water and surface water system
Flood Control	The capacity of wetland to store large volumes of water especially during floods. Wetlands modify the flow in streams by decreasing peak discharge and increasing time of concentration (time between rainfall/flood event and release of water to streams)
Improved Water Quality	Removal of total dissolved and nutrients from and conversion into other less toxic forms, such as plant and animal biomass or gases.
Sediment Stabilization and Retention	The capability in a wetland to cause the deposition and retention of inorganic and organic sediments from the water through physical processes.
Provide Habitat to Aquatic organisms	The capability of a wetlands to produce diversity of hydrophytic floral species and communities, and aquatic habitats for animals
Wildlife Diversity and Habitat	Wetlands provide habitats to animal species and communities that spend some part or whole part of their life cycle in wetlands

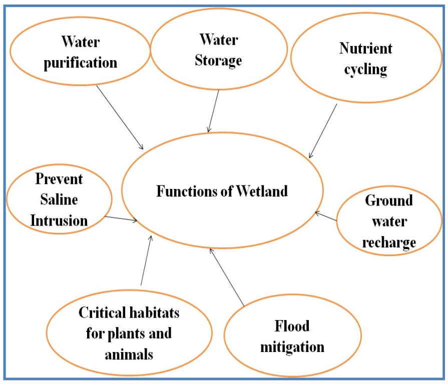

Fig:-1: Different functions of wetlands

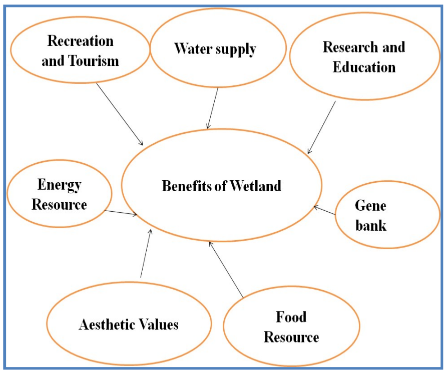

Fig:-2: Benefits of wetlands

(a) Water Purification: Wetlands are variable to human being because they have greatly influence the water quality. Literally, the wetlands are Kidneys of Earth Ecosystem. They recharge the ground water through leaching, percolation etc. Wetlands are act as water filtration, these wetlands also intercepting surface runoff and removing the toxic substances from the water.

(b) Water Storage and Supply: Wetlands provide water supply to local communities. As you know these wetlands are natural ecosystems and stores sufficient amount of water. The water quality of the wetlands is good and used for different purposes such as drinking, irrigation, hydropower generation etc. The wetlands release the water and retain the water from precipitation or rainfall.

(c) Flood Control: Wetlands store huge amount of water and slowly release the water on earth's surface. Vegetation of wetland slows down the speed of water and distributes and channelizes the water more slowly over flood plains. Therefore, these wetlands are very important in flood control.

(d) Habitats for Plants and Animals: Many species of fish, birds and other wild animals are depending of wetland ecosystems. Wetland provides different macro and microhabitats, foods, water, cover and other vital components to wild animals. Many species such as migratory waterfowl, wood duck, cattail swamp, song birds, beaver, muskrat, geese, swans etc. are main inhabitants of wetlands.

(e) Recreation, Research and Tourism: Wetlands provides recreational and research opportunities to local people and researchers. Wetlands are beautiful ecosystems of earth therefore; these ecosystems are attraction points to tourists. As you know that tourism industry is fastest growing industry of the world. Eco-friendly or natural based recreation is fastest growing activity in tourism industry. Therefore, Wetlands are also important for economical point of view.

(f) Food Resource: Wetlands are important sources of food. These wetland ecosystems provide food not only to wild species but to the human being. Many freshwater fish species such as *Labeo rohita, Catla catla, Cirrhinus mrigala, Channa punctatus, Channa marulius, Heteropneusteus fossils, Mystus cavasius, Mystus aor, Mystus, tengara, Mystus mystus, Clarias batrachus, Rita rita, Xenetodon cancilla, are* main edible fish species of these ecosystems. On the other hand many marine species are also found in wetlands. These species also edible and being used as food in many parts of the world.

3.4 Wetlands in India

India is also endowed with numerous wetlands. The important character of wetland is vegetation in and around the aquatic body. The water in wetlands may be freshwater, brackish water or saltwater. There are about 94 wetlands in India which are given below in Table-3

Table-3: State wise list of wetlands in India

States	Name of Wetland
Andhra Pradesh	Kolleru
Assam	Deepar Beel, Urpad Beel
Bihar	Kabar, Barilla, Kusheshwar Asthan
Gujarat	Nalsarovar, Great Rann of Kachh, Thol Bird Sanctuary, Khijadiya Bird Sanctuary, Little Rann of Kachh, Pariej, Wadhwana, Nanikakrad
Haryana	Sultanpur, Bhindawas
Himachal Pradesh	Renuka, Pong Dam, Chandratal, Rewalsar, Khajjiar
Jammu & Kashmir	Wullar lake, Tso Morari, Tisgul Tso & Chisul Marshes, Hokersar, Mansar-Surinsar, Ranjitsagar, Pangong Tsar
Jharkhand	Udhwa, Tilaiya Dam
Karnataka	Magadhi, Gudavi Bird Sanctuary, Bonal, Hidkal & Ghataprabha, Heggeri, Ranganthittu, K.G. Koppa wetland
Kerala	Ashtamudi, Sasthamkotta, Kottuli, Kadulandi, Vembnad Kol
Madhya Pradesh	Barna, Yashwant Sagar, Wetland of Ken River, National Chambal Sanct., Ghatigaon, Ratapani, Denwa Tawa wetland, Kanha Tiger Reserve, Pench Tiger Reserve, Sakhyasagar, Dihaila, Govindsagar

Maharashtra	Ujni, Jayakawadi, Nalganga wetland
Manipur	Loktak
Mizoram	Tamdil, Palak
Orissa	Chilka lake, Kuanria wetland, Kanjia wetland, Daha wetland
Punjab	Harike, Ropar, Kanjli
Rajasthan	Sambhar
Sikkim	Khechuperi Holy Lake, Tamze Wetland, Tembao Wetland Complex, Phendang Wetland Complex, Gurudokmar Wetland, Tsomgo wetland
Tamil Nadu	Point Calimer, Kaliveli, Pallaikarni
Tripura	Rudrasagar
Uttar Prdaesh	Nawabganj, Sandi, Lakh Bahoshi, Samaspur, Alwara Wetland, Semarai Lake-Nagaria lake Complex Keetham Lake, Shekha wetland, Saman Bird Sanctuary & Sarsai Nawar Complex
Uttarakhand	Ban Ganga Jhilmil Tal
West Bengal	East Calcutta Wetland, Sunderbans, Ahiron Beel, Rasik Beel, Santragachi
UT (Chandigarh)	Sukhna

(Source: Ministry of Environment, Forests and Climate Change)

India is also a signatory of the Ramsar Convention. As you know Ramsar Convention is an international treaty for the conservation of wetlands at global level. Ramsar convention on Wetlands of International importance specially as water fowl habitat is international treaty for conservation of wetlands. Ramsar is named after Ramsar City, Iran. This convention was signed in the year 1971. There are 47 Ramsar wetland sites are located in India which are listed in Table-4.

Table-4: List of Ramsar Sites in India

Sl. No.	**Name of Site**	**State Location**	**Date of Declaration**	**Area (*in Sq. km.*)**
1	Kolleru Lake	Andhra Pradesh	19.8.2002	901
2	Deepor Beel	Assam	19.8.2002	40
3	Kabartal Wetland	Bihar	21.07.2020	26.20
4	Nalsarovar Bird Sanctuary	Gujarat	24.09.2012	120
5	Thol Lake Wildlife Sanctuary	Gujarat	05.04.2021	6.99
6	Wadhvana Wetland	Gujarat	05.04.2021	6.30
7	Sultanpur National Park	Haryana	25.05.2021	1.425
8	Bhindawas Wildlife Sanctuary	Haryana	25.05.2021	4.12
9	Chandertal Wetland	Himachal Pradesh	8.11.2005	0.49
10	Pong Dam Lake	Himachal Pradesh	19.8.2002	156.62
11	Renuka Wetland	Himachal Pradesh	8.11.2005	0.2
12	Wular Lake	Jammu & Kashmir	23.3.1990	189
13	Hokera Wetland	Jammu & Kashmir	8.11.2005	13.75
14	Surinsar-Mansar Lakes	Jammu & Kashmir	8.11.2005	3.5
15	Tsomoriri Lake	Jammu & Kashmir	19.8.2002	120
16	Asthamudi Wetland	Kerala	19.8.2002	614
17	Sasthamkotta Lake	Kerala	19.8.2002	3.73

18	Vembanad Kol Wetland	Kerala	19.8.2002	1512.5
19	Tso Kar Wetland Complex	Ladakh	17.11.2020	95.77
20	Bhoj Wetlands	Madhya Pradesh	19.8.2002	32.01
21	Lonar Lake	Maharashtra	22.7.2020	4.27
22	Nandur Madhameshwar	Maharashtra	21.6.2019	14.37
23	Loktak Lake	Manipur	23.3.1990	266
24	Bhitarkanika Mangroves	Orissa	19.8.2002	650
25	Chilka Lake	Orissa	1.10.1981	1165
26	Beas Conservation Reserve	Punjab	26.9.2019	64.289
27	Harike Lake	Punjab	23.3.1990	41
28	Kanjli Lake	Punjab	22.1.2002	1.83
29	Keshopur-Miani Community Reserve	Punjab	26.9.2019	3.439
30	Nangal Wildlife Sanctuary	Punjab	26.9.2019	1.16
31	Ropar Lake	Punjab	22.1.2002	13.65
32	Keoladeo Ghana NP	Rajasthan	1.10.1981	28.73
33	Sambhar Lake	Rajasthan	23.3.1990	240
34	Point Calimere Wildlife and Bird Sanctuary	Tamil Nadu	19.8.2002	385
35	Rudrasagar Lake	Tripura	8.11.2005	2.4
36	Haiderpur Wetland	Uttar Pradesh	8.12.2021	69.08
37	Nawabganj Bird Sanctuary	Uttar Pradesh	19.9.2019	2.246
38	Parvati Agra Bird Sanctuary	Uttar Pradesh	2.12.2019	7.22
39	Saman Bird Sanctuary	Uttar Pradesh	2.12.2019	52.63
40	Samaspur Bird Sanctuary	Uttar Pradesh	3.10.2019	79.94
41	Sandi Bird Sanctuary	Uttar Pradesh	26.9.2019	30.85
42	Sarsai Nawar Jheel	Uttar Pradesh	19.9.2019	16.13
43	Sur Sarovar	Uttar Pradesh	21.8.2020	4.31
44	Upper Ganga River (Brijghat to Narora Stretch)	Uttar Pradesh	8.11.2005	265.9
45	Asan Conservation Reserve	Uttarakhand	21.7.2020	4.444
46	East Kolkata Wetlands	West Bengal	19.8.2002	125
47	Sunderbans Wetland	West Bengal	30.1.2019	4230

(Source: Ministry of Environment, Forests and Climate Change, Government of India)

3.5 Ramsar Convention

Ramsar Convention is an Inter-governmental treaty which provides framework for the conservation of wetlands. This convention also emphasized on the use of wetlands in sustainable ways. It is global nature conservation treaty started in 1971, came into force 1975. The Ramsar Convention was adopted in the Iranian city of Ramsar. It is the oldest inter-governmental conservation convention. It came into being due to serious decline in population of waterfowl and need for conservation of habitats of migratory waterfowl. The convention provides the framework for national action and international cooperation for the conservation and wise use of wetlands and its resources including biodiversity. Ramsar

Convention also defined the wetlands as "areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed 6 m".

3.5.1 A Case Study of Sundarbans

Mangroves are one of the diverse and highly productive ecological communities. These mangroves provide various ecosystem functions. These are located at the land, sea and land-sea interface. They also act as barrier against natural hazards such as cyclones and tsunamis. They retain terrestrial sediment and recycle nutrients, thus supporting clear offshore waters, which in turn favors the photosynthetic activity of phytoplankton as well as growth and robustness of coral reefs. They serve as an important habitat, providing food for many organisms including men. These ecosystems are also act as carbon sinks, either storing carbon Because of these collective ecosystem services, mangroves are also of great economic value. Due to both anthropogenic and natural factors, mangroves the world over are severely threatened, and, with current global annual loss rates of 1%–2%.

The Sundarbans is a great forest in the region of the Bay of Bengal and regarded as one of the, natural wonders of the world. Sundarbans located in the delta region of Ganga, Meghna and Brahmaputra river systems. This special forest extends across districts of Bangladesh and districts of West Bengal in India. The Sundarbans are located on the delta made by the River Ganga, Brahmaputra and Meghna rivers in the Bay of Bengal. It consists of a network of mudflats and islands created by accumulated sediment loads that these rivers carry from their Himalayan headwaters separated by anastomotic channels and tidal waterways. The Sundarbans, lies at coordinates of 21°32' to 22°40'N and 88°05' to 89°51'E. These forests cover an area of 10,000 km^2, of which 62% lies within Bangladesh and 38% in India, The Sundarbans is characterized by a tropical climate with a dry season between November and April. The total annual amount of precipitation of Sundarbans is between 1500 and 2000 mm. During the monsoon season, tropical cyclones and smaller tidal events regularly hit the area, causing severe flooding and wind damage. Seasonal mean minimum and maximum temperatures vary from 12°C to 35°C, respectively.

Flora and Fauna of Sundarbans: The Sundarbans is the largest Halophytic mangrove forest in the world. Literally, The Sundarban can be translated as "beautiful jungle" or "beautiful forest". The name may have been derived from the Sundari trees that are found in Sundarbans in large numbers. The Sundarban forest lies at the feet of the River Gangaand are spread across areas of Bangladesh and India, forming the seaward fringe of the delta. The seasonally flooded Sundarbanslie inland form the mangrove forests. The Sundarbans forest covers 10,000 km of which about 6,000km are in Bangladesh and 4000km are in India. The Sundarbans was designated a Ramsar Convention Site on 21 May 1992. The Sundarbans designated as a UNESCO world heritage site in 1997. Sundarbans of both the countries (Bangladesh and India) are separately listed in the UNESCO world heritage sites. The main and important characteristic tree of the forest is the Sundari *(Heritiera littoralis)*, from which the name of the Sundarbans had probably been derived. The Sundarbans flora is characterized by the large numbers of *Heritiera fomes*, *Excoecaria agallocha*, *Ceriopus decandra* and *Sonneratia apetala*. David Prain (1903) documented 245 genera and 334 species of plants in the Sundarbans. Since the 1903 the considerable changes occurred in the Sundarbans however very few exploration of plant diversity of Sundarbans has been made to keep up with these changes. Sundarbans also provides great habitat to wild animals especially to endangered Bengal tiger. It is estimated that thereare now 500, Bengal tigers and about 30,000 spotted deer in the area. The high productive soils of the delta have been subject to intensive human use for centuries, and the eco-region has been mostly converted to intensive agriculture, with few enclaves of forest remaining. The remaining forests, together with the Sundarbans mangroves, are important habitat for the endangered tiger.

Table 5. Important Floral Diversity of Sundarbans

Name of Species	***Common Name***
Heritiera fomes	*Sundari*
Excoecaria agallocha	*Gewa*
Ceriopus descandra	*Goran*
Sonneratia apetala	*Keora*
Xylocarpus granatum	*Dhundul or Passur*
Bruguiera gymnirhiza	*Kankra*
Nypa fruticans	*Golpata*
Imperata cylindrica	*Spear Grass*
Phragmites karka	*Khagra*
Poresia coarctata	-

Table 6. Important Faunal Diversity of Sundarban

Name of Species	Common Name
a) Mammals	
Panthera tigris tigris	Bengal tiger
Prionailurus viverrinus	Fishing cat
Prionailurus bengalensis	Leopard cat
Axis axis	Chital Deer
Muntiacus muntjak	Indian muntjacs
Sus scrofa	Wild boar
Platanista gangetica gangetica	Gangetic dolphin (National aquatic animal of India)
Macaca mulatta	Rhesus Macaque
b) Birds	
Pelargopsis amauroptera	Brown-Winged kingfishers
Leptoptilos javanicus	lesser adjutants
Heliopais personata	Masked Fin foots
Pandion haliaetus	Ospreys
Haliaeetus leucogaster	White-Bellied sea eagles
Ichthyophaga ichthyaetus)	Grey-Headed Fish Eagles
Anastomus oscitans	Open billed storks
Threskiornis melanocephalus	Black-headed Ibis
Anaurornis phoenicurus	Water hen
Fulica atra	Coot
Hydrophasianus chirurgus	Pheasant-Tailed Jacana
Corvus culminatus	Jungle crows
Turdoides striata	Jungle babbler
Pluvialis fulva	Golden Plover
Anas acuta	Pintail
Aythya nyroca	White-eyed Pochard
Dendrocygna javanica	Lesser whistling duck
c) Reptiles	
Lepidochelys olivacea	Olive ridley turtle
Eretmochelys imbricata	Hawksbill turtle
Chelonia mydas	green turtle
Cerberus rynchops	dog-faced water snake,
Crocodylus porosus	estuarine crocodile,
Ophiophagus hannah	King Cobra
Daboia russelii	Russell's viper
Varanus species	Monitor lizard
Python species	Python
d) Amphibians	
Bufo Bufo	Common toad
Hyla species	Tree frog
e) Fishes	
Pristis species	Sawfish
Torpedo	Electric ray
Hypophthalmichthys molitrix	Silver carp

The Sundarbans provide a special and unique ecosystem and a good habitat to plants and animals. The Sundarbans are home to about 500 Bengal tigers, one of the biggest populations of tigers. Tiger attacks are generally in the Sundarbans, about 100 and 250 people are killed per year by the tiger attack. However, various measures taken for safety, there have been no official report of death since 2004 in the Indian portion of the Sundarbans due to tiger attack. According to Recent studies the Sundarbans at Bangladesh support diverse biological resources including at least 120 species of commercially important fishes, 275 species of birds, 40 species of mammals, 35 species reptiles and 08 species amphibian. This represents a significant proportion of the species present in Bangladesh (i.e. about 30% of the reptiles, 37% the birds and 34% of the mammals).

Importance of Sundarbans: Mangroves are diverse and productive ecosystem at the land-sea zone. The Sundarban forests are the largest in the world and provide important ecosystem services, they have great importance and some of the importance of Sandarbans is given below:

- They provide food and water for millions of its inhabitants;
- They provide protection against the worst effects of natural hazards, such as with cyclones and tsunamis;
- They provide the ability to act as a giant long-term carbon sink; the retention of terrestrial sediments; and as a habitat for many species, including for the rare and protected Royal Bengal tiger.
- The importance of the Sundarbans extends from the local to the global level.

During the last 2-3 centuries, the Sundarban has been impacted by anthropogenic activities, climatic change and extreme weather events. Human activities in the Sundarbans have a greater incremental impact on forests. Such activities can increase the salinity, rise in sea level and land degradation, etc. Conservation of Sundarbans is extremely complicated because of the influence of climatic factors, path-dependent development regimes and environmental components.

The Sundarbans are not only ecologically important but they are socio-economically very important to Nation. It is the single largest source of forest resource in the country. As you know the forest provides raw materials for industries. In addition to traditional forest produce like timber, fuelwood, pulpwood etc., large-scale harvest of non-wood forest products such as thatching materials, honey, beeswax, fish, and crustacean and mollusk resources of the Sundarbans takes place regularly. The vegetated tidal lands of the Sundarbans function as an essential habitat produce, nutrients and purifies water. The forest also traps nutrient and sediment, acts as a storm barrier, shore stabilizer and energy storage unit. Last but not the least, the Sundarbans provide an aesthetic attraction for tourists at local, National and global level.

A number of industries such as: newsprint mill, match factory, hardboard, boat building, furniture making are entirely based on raw materials obtained from the Sundarbans ecosystem. The various products help to generate significant employment and income opportunities for about half million poor coastal people.

3.5.2 Case Study: Bharatpur Sanctuary

The Bharatpur Sanctuary or Keoladeo National Park, popularly known as the Bharatpur Bird Sanctuary is located in the Bharatpur district of Indian state of Rajasthan, The origin of this Bharatpur Sanctuary is due to artificial flooding of a natural depression. The development of Ajan Bandh, a temporary reservoir, approximately 1 km from the Bharatpur Sanctuary 250 years ago led to the flooding of this depression creating a waterfowl habitat. Subsequently, a number of earthen bunds and sluice gates were developed to regulate the water. The Bharatpur Sanctuary receives water through a canal from the dam. It has been recognized as a World Heritage site in 1985. This wetland became a Ramsar Site on 1st October, 1981. There are the three criteria of Bharatpur sanctuary and on the basis of these criteria this Sanctuary became Ramsar Convention site in 1981. These criteria are as:

- It supports threatened ecological communities.
- Bharatpur Sanctuary regularly supports about 20, 000 waterbirds.
- Bharatpur Sanctuary regularly supports 1 % of the individuals in a population of one species or subspecies.

The Bharatpur Sanctuary lies at coordinates at 27°10'N, 77°31'E is a World Heritage Site situated in Rajasthan. The Bharatpur Sanctuary is 2 km south-east of Bharatpur and 55 km west of Agra. The Bharatpur Sanctuary is spread over approx 29 sq km area. The Bharatpur Sanctuary is part of the Keoladeo National Park habitat is wetland systems with varying types of microhabitats having trees, mounds, dykes and open water with or without submerged or emergent plants.

The Bharatpur Sanctuary was established as a national park on 10 March 1982. Earlier it was the private duck shooting preserve of the Maharaja of Bharatpur since the 1850s; the area was designated as a bird sanctuary on 13 March 1976 and a Ramsar Convention site under the Wetland Convention in October 1981. It is also a reserve forest under the Rajasthan Forest Act, 1953 and therefore, is the property of the State of Rajasthan. In 1982, grazing was totally prohibited in the Bharatpur Sanctuary; this led to violent clashes between farmers and the government.

Keoladeo National Park or Bharatpur Sanctuary is a man-managed wetland and one of the great National parks of country. This Bharatpur Sanctuary protects Bharatpur from floods, provides grazing for village cattle. The 29 km^2 reserve is locally known as Ghana, and is a mosaic of dry grasslands, woodlands, woodland swamps and wetlands. These diverse habitats provide home to 366 bird species, 379 floral species, 50 species of fish, 13 species of snakes, 5 species of lizards, 7 amphibian species, 7 turtle species, and a variety of other invertebrates. Every year thousands of migratory birds visit the park for wintering and breeding. The sanctuary is one of the richest bird areas in the world and is known for nesting of resident birds and visiting migratory birds including water birds. The rare Siberian cranes used to winter in this park but this central population is now extinct. According to founder of the World Wildlife Fund Peter Scott, Bharatpur Sanctuary is one of the best bird areas in the world.

The sanctuary was established 250 years ago and it is named after a Keoladeo (Lord Shiva) temple within its boundaries. Initially, it was a natural depression; and was flooded after the *Ajan Bund* was constructed by King Suraj Mal. This ajan bund established at the confluence of two rivers namely: Gambhir and Banganga. It is also a big tourist spot.

The Bharatpur Sanctuary supports about 400 species of birds. The Sanctuary also supports enormous flocks of migratory birds specially in winter. More than 25 species of ducks and goose such as coots, greylag goose, mallard, pintail duck, shoveller, brahminy duck, gadwal, wigeon, bar-headed goose, and others are known to winter here yearly The Sanctuary is the only wintering ground for the Siberian crane. Other important fauna in the

Sanctuary are the Sambhar, Cheetal, Blue-Bull, Golden Jackel, Wild Boar, etc. Besides, from the aquatic vegetation that flourishes during monsoon season, the other vegetation is characteristic of semi-arid zone dominated by *Acacia nilotica, Zyziphus mauritiana, Prosopis cineraria, Salvadora* etc. The Bharatpur Sanctuary also provides habitat to *Cynodon dactylon* and *Dicanthium annulatum*. Woodlands with thickets of huge *Neolamarckia cadamba* (Kadam trees) are distributed in scattered patches. The Sanctuary is covered with tropical dry deciduous forests intermixed with dry grasslands. In the places where forest has degraded, the greater part of the region is covered with shrubs and medium-sized plants.

Flora and Fauna of Bharatpur Sanctuary: A semi-arid biotype, the park is the only area with significant vegetation, hence the term 'Ghana' meaning 'thicket'. The principal vegetation types are tropical dry deciduous forest, intermixed with dry grassland in areas where forest has been degraded. Apart from the artificially managed marshes; much of the area is covered by medium-sized trees and shrubs.

Table-7: Important flora of Bharatpur Sanctuary

Name of Species	Common Name
Mitragyna paryifolia	Kalam or kadam
Syzygium cumini	Jamun
Acacia nilotica	Babul
Prosopis cineraria	Kandi
Zizyphus jujuba	Ber
Capparis decidua	Kaira
Salvadora oleoides	Piloo, Pilu

Bharatpur Sanctuary is dominated by Ber and Kaira trees. It is unlikely that the site would support such numbers of waterfowl as it does without the addition of water from Ajan Bund. Soil of the Sanctuary is predominantly alluvial. The mean annual rainfall/precipitation of Bharatpur Sanctuary is about 662 mm.

3.8 Summary

In this unit we have discussed various aspects of types and importance of wetlands degradation. So far you have learnt that:

- The wetland is "Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static, flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six metres".

- On the basis of unique characters the important terms related to wetlands are Bog, Bottom, Everglade, Fen, Fenland, Heath, Marsh, Marshland, Meadow, Mire, Moorland, Morass, Muskeg, Quagmire, Quicksand, Salt marsh, Slough, Sump, Swale, Swamp and Swampland.
- There are various types of wetlands such as Marine and coastal wetlands, Estuarine wetlands, Riverine wetlands, Lacustrine wetlands and Palustrine wetlands.
- According to, Charman 2002, several factors are considered important for classification of peat land types. These characteristics are floristic, physiognomy, morphology, hydrology, stratigraphy, chemistry and peat characters.
- There are various functions and importance of wetlands such as recharge ground water, flood control, improved water quality, sediment stabilization and retention, provide habitat to aquatic and riparian organisms.
- In India various wetlands are found and some of the important wetlands of India are Deepar Beel, Urpad Beel, Thol Bird Sanctuary, Khijadiya Bird Sanctuary, Little Rann of Kachh, Pariej, Wadhwana, Nanikakrad, Wullar lake, Bonal, Hidkal & Ghataprabha, Heggeri, Ranganthittu, K.G. Koppa wetland, Tamze Wetland, Tembao Wetland Complex, Phendang Wetland Complex, Gurudokmar Wetland, Tsomgo wetland, Ban Ganga Jhilmil Tal, Loktal lake, Sukhna lake, etc.
- India is also a signatory of the Ramsar Convention and there are 47 Ramsar Convention sites in India.
- The Sundarbans is a great and located in the delta region of Ganga, Meghna and Brahmaputra river systems. This special forest extends across districts of Bangladesh and districts of West Bengal in India. The Sundarbans are located on the delta made by the River Ganga, Brahmaputra and Meghna rivers in the Bay of Bengal.
- The main floral diversity of Sundarbans are *Heritiera fomes, Excoecaria agallocha, Ceriopus descandra, Sonneratia apetala, Xylocarpus granatum, Bruguiera gymnirhiza, Nypa fruticans, Imperata cylindrical, Phragmites karka, Poresia coaractata, Myriostachya wightiana.*

- The main faunal diversity of Sundarbans are: *Panthera tigris tigris, Prionailurus viverrinus, Prionailurus bengalensis, Axis axis, Muntiacus muntjak, Sus scrofa, Platanista gangetica gangetica, Macaca mulatta, Pelargopsis amauroptera, Leptoptilos javanicus, Heliopais personata , Pandion haliaetus, Haliaeetus leucogaster, Ichthyophaga ichthyaetus, Anastomus oscitans, Threskiornis melanocephalus, Anaurornis phoenicurus, Fulica atra, Hydrophasianus chirurgus, Corvus culminatus , Turdoides striata, Pluvialis fulva, Anas acuta, Aythya nyroca, Dendrocygna javanica, Lepidochelys olivacea, Eretmochelys imbricate, Chelonia mydas, Cerberus rynchops, Crocodylus porosus, Ophiophagus Hannah, Daboia russelii, Varanus species, Bufo Bufo, Hyla species, Pristis species, Torpedo, Hypophthalmichthys molitrix*
- The Bharatpur Sanctuary or Keoladeo National Park, popularly known as the Bharatpur Bird Sanctuary is located in the Bharatpur district of Indian state of Rajasthan, The origin of this Bharatpur Sanctuary is due to artificial flooding of a natural depression.
- The main floral diversity of Bharatpur Sanctuary is: *Mitragyna parvifolia, Syzygium cumini, Acacia nilotica, Prosopis cineraria, Zizyphus, Capparis deciduas, Salvadora oleoides.*

Terminal Questions

1 (a) Fill in the blank spaces with appropriate words.

The Bharatpur Sanctuary or……….., popularly known as the Bharatpur Bird Sanctuary is located in the……… district of Indian state of……… The origin of this Bharatpur Sanctuary is due to artificial flooding of a natural depression. The development of Ajan Bandh, a temporary reservoir, approximately 1 km from the Bharatpur Sanctuary 250 years ago led to the flooding of this depression creating a……….. Subsequently, a number of earthen bunds and sluice gates were developed to regulate the water. The Bharatpur Sanctuary receives water through a canal from the dam. It has been recognized as a World Heritage site in………….. This wetland became a Ramsar Site on………….. There are the three criteria of Bharatpur sanctuary and on the basis of these criteria this Sanctuary became Ramsar Convention site in 1981.

2 (a) Define the wetland.

(b) Give the terms related to wetland

3 (a) Describe the types and characteristic features of wetlands.

(b) Give the peat land classification of wetlands

4 (a) Describe the importance and functions of wetlands.

5 (a) Give the list of wetlands in India.

(b) Write about Ramsar Convention.

(c) Write about the Sundarbans.

6 (a) Fill the blank spaces with appropriate words.

The Sundarbans is the largest …………..forest in the world.Literally, The Sundarban can be translated as "…………". The name may have been derived from the ………that are found in Sundarbans in large numbers. The Sundarban forest lies at the feet of the River Gangaand is spread across areas of …………..and………..,forming the seaward fringe of the delta. The seasonally-flooded Sundarbanslie inland from the mangrove forests. The Sundarbans forest covers ……….of which about ……….are in Bangladesh and …….. are in India. The Sundarbans was designated a Ramsar Convention Site on……………. The Sundarbans designated as a ………………….in 1997. Sundarbans of both the countries are separately listed in the UNESCO world heritage sites. The main and important characteristic tree of the forest is the Sundari *(Heritiera littoralis)*, from which the name of the Sundarbans had probably been derived. The Sundarbans flora is characterized by the large numbers of *Heritiera fomes*, *Excoecaria agallocha*, *Ceriopus decandra* and *Sonneratia apetala*. documented 245 genera and 334 species of plants in the Sundarbans.

(b) World Wetland Day celebrated on (2nd February/5th June/21 May/21 June)

(c) Loktak Lake is located in the Indian state (Manipur/Mizoram /Uttarakhand/Uttar Pradesh)

(d) Maximum Ramsar Conservation sites are located at (Jammu and Kashmir/Uttar Pradesh/Punjab/Bihar)

(e) Write about the flora and Fauna of Sundarbans?

7 (a) Write the descriptive essay on Bharatpur Sanctuary

(b) Give the list of Ramsar Convention sites in India

Answers to terminal questions

1 (a) Keoladeo National Park, Bharatpur, Rajasthan, waterfowl habitat, 1985, 1st October, 1981.

2 (a) see section 3.2

(b) See section 3.2

3 (a) See section 3.3.

(b) See section 3.3

4 (a) See section 3.4., Table-2, Fig-1 and Fig-2

5 (a) See the section 3.5 and Table-3

(b) see the section 3.6

(c) See section 3.7.

6 (a) Halophytic mangroves, beautiful jungle, Sundari trees, Bangladesh India, 10,000km, 6,000km, 4000km, 21 May 1992, UNESCO world heritage site

(b) 2nd February

(c) Manipur

(d) Uttar Pradesh

(e) See the section 3.7.1

7 (a) See the section 3.8

(b) See the section 3.5 and Table-4

Unit-4: The Land Cover changes

Unit Structure

4.0 Learning Objectives

After studying this unit you will be able to find answer of the following:

- What is land cover change?
- What are the reasons of land cover change?
- What is the relation between increasing population and land cover change?
- How can we do more sustain to land cover change?
- What is the relation between Land cover and climate change?

4.1 Introduction

As we have learnt in previous chapter, land resources are very essential for human being and from the beginning of civilization, human carried out a lot of activities on land and now we can see the result in form of dam, building, and road construction. As human population is increasing various land use planning was made to fulfill the human need to provide them basic amenities. Human are directly or indirectly dependent on natural resources by using these resources in different manner. But in the series of rapid development man forgotten his moral duty and doing all the activities of his welfare, therefore all these activities have created lot of burden on this planet and now there is a diversity of concrete jungle, if we compare the 18^{th} century with present time, there is a big change in land cover. The land was being used for agriculture forest colonies, orchard etc. Due to heavy demand of big population, we have exhausted the land resources very fast and now the situation is worst as we have converted a big part of agriculture land into constructional activities for human welfare. In this phenomenon we have degraded very fertile land without future planning. Now days it is the time to rethink about management of natural resources

Infrastructure across the country is expanding rapidly. Industrialization, especially based on manufacturing has also to accelerate. Urbanization is inevitable. Land is an essential requirement for all these processes. Government also needs to acquire land for a variety of public purposes.

The world population grew by four times from 1.6 billion to 6.1 billion persons during 1900 to 2000 (United Nations, 2001). Decreases in famine related deaths and infant mortality rates are partially responsible for this rapid population growth. In addition, advances in public health and medicine have increased the life expectancy of countries worldwide. Industrialization has provided better economy and has sustained human development. However, this rapid population growth and development has occurred unevenly throughout the world simultaneously with increasingly unsustainable utilization of world's natural resources and its adverse impact on environment. Land uses are primarily the result of human actions and decisions on land. In fact human activities arising from a multiplicity of social objectives are the immediate source of land cover change. To understand these social objectives one needs to analyse the underlying driving forces that motivate or constrain the associated human activities. Biophysical driving forces and shocks (such as geomorphic processes, global and local climate change/variability, etc.) are also responsible for changes in land cover and ultimately the land use.

During the last two decades there has been a rapid economic and industrial development in Delhi. Delhi, being the National Capital Territory (NCT), is one of the important centres for commerce, trade and industries in northern India. In fact industrial development in Delhi and adjoining areas has emerged in somewhat haphazard and unplanned manner thereby leading to increased population and environmental problems of concern. In fact about 60% of its most productive agricultural land has been transformed into non-agricultural uses. It is estimated that between 1970 – 1971 and 1993-94, industrial units have increased from about 26,000 to 93,000 while net sown area has decreased from 85,000 ha to 46,000 ha. In order to take care of these problems, the Government of India carved out an inter-state National Capital Region (NCR) comprising NCT-Delhi (in centre) and the surrounding six districts of Haryana, three districts of Uttar Pradesh and Alwar district of Rajasthan. The prime objective of this regional plan was to locate economic activities associated with large scale population and environmental problems outside the NCT region.

4.2 Definition of Land cover change

Human activities are transforming earth's surface at unprecedented rate by ubiquitous exploitation of earth's biotic and abiotic resources. The cumulative impacts of land use change have global consequences, altering the structure and functioning of ecosystem, which in turn can influence the climate system due to the strong linkages between land cover energy exchange and biogeochemical cycles. Because of the long time scale dynamics of ecosystem process, land disturbances can affect ecosystem and climate processes for years to centuries.

Over geological time scales, climatic changes in earth's orbit around the sun have led to large scale vegetation changes. For example, the little ice age that ended in the 1700's eliminated forest in Iceland and a previous lush green landscape became the now arid region of Sahara desert 6000 years ago. On shorter time scale severe weather events fires, herbivore and human activities have modified earth's land scape and converted them to new ecosystem. The impact of ancient human activities on the landscape is well known including the use of fires to maintain open landscape and the extinction of large Pleistocene mammals after the arrival of human in North America.

More recently, over the last 300 years, human influence on the land has become globally extensive and intensive. Deforestation, agriculture expansion are all significant global environmental issue today. Nearly 40% of the global land surface is exploited for agriculture and tropical deforestation continuous unabated especially in the Amazon basin and Southeast Asia. Such large scale changes in land use and land cover can modify regional and global climate, degraded fresh water resources cause air pollution, fragments habitat cause species extinction and biodiversity loss and lead to the emergence of infectious disease. It's very clear that land use and land cover change is a major driver to global change.

Land cover refers to the physical characteristics of earth's surface, captured in the distribution of vegetation, water, soil and other physical features. Land use refers to the way in which land has been used by humans' habitants. Although land use is generally inferred based on the cover, yet both the terms land use and land cover being closely related are interchangeable.

Land use/cover and its dynamics are important factors that affect ecosystem conditions and functions. In the past 40 years, land use cover change dynamics has been considerably changing the biogeochemical cycling leading to changes in surface atmospheric energy exchanges, carbon and water cycling, soil quality, biodiversity, ability of biological systems to support human needs and, ultimately the climate at all. Land cover consisting- roofs, pavement, grass and trees. For a hydrologic study of rainfall-run off characteristics, it would be important to know the amount and distribution of roofs, pavement, grass and trees.

Land cover change (LCC) also known as land change) is a general term for the human modification of earth's terrestrial surface. The intensity of land cover change directly linked with the development of human civilization. Human has modified a large part of land to gain edibles and other essentials having the effect on environment (increasing population, climate change, biodiversity loss and soil, water and air pollution).

4.2.1 What is land cover change?

(a) Land cover: Vegetation and structure that cover land area is known as land cover.

(b) Land use: Human activities that occur on land known as land use.

Human changes land cover, especially in urban area. These changes have environment and economic effect. The land cover may be classified into six categories i.e., rangeland, forest land, cropland, parks and reserves, wetland mountain desert, and urban land, and these land areas being used by human being for livestock grazing, harvesting wood, growing plants, recreation, preservation of native animal and plants and residence etc. respectively (Table 1)

Table1: The land Cover type and human use of land

Land cover type	Human use of land
i) Rangeland	Grazing livestock
ii) Forest land	Harvesting wood, wild life, fishes and other resources
iii) Cropland	Growing plants for food and filter
iv) Parks and preserves	Recreation, preservation of native plants and animal communication and ecosystem
v) Wetlands, mountain desert & others	Preservation of native animal and plant communication and ecosystem
vi) Urban land	Residences, other buildings and roads

4.3 Land Cover change in India

Trends of Population Growth in India, 1951-2001 At the time of its independence in 1947, India's population was about 345 million. The decades following the 1940s have seen great changes. Even the poorest people experienced some improvements in their living conditions. For example, average levels of calorie availability and income have risen. Water supplies and sanitation facilities and rural electrification have well progressed. In addition, the control of certain communicable diseases has been important. As the death rate decreased after 1947 it resulted in a significant rise in the rate of population growth, which reached almost 2 percent during 1951-61. In this context, India's population growth after independence can be classified into the following two phases:

- **1951-1981:** Rapid high growth
- **1981-2001:** High growth with sure signs of slowing down of the growth rate.

It needs to be noted that during the decade of 1981-91, the population of India increased by 23.86 percent and the average annual exponential growth rate was 2.14 percent per annum. It was lower than that observed during 1971-81. It can be further noted that the lowering of the population growth has continued during 1991-2001, with the average annual exponential growth rate being 1.93 percent per annum. The population of rural India increased around two and half times from 298.7 million in 1951 to 741.7 million in 2001, whereas the urban population has grown more than fourfold during the same period, which is from only 62.4 million in 1951 to 285.3 million in 2001. The density of population has increased from 117 in 1951 to 312 persons in 2001. Despite the fall in the growth rate; the absolute addition to the population is quite high over the decades, because of the age structure of the population, which is still fairly young. According to (Dyson, 2004) the standard projection, India's population will increase from 1027 million to 1419 million during 2001-26, a total rise of 38 percent or 1.3 percent per year. The projections also suggest that by 2026 the average population density of India will be 448 persons per square kilometre. States like Bihar and Uttar Pradesh are projected to be well over 900 persons per square kilometre, greater than the density of both Kerala and West Bengal in 2001.

Table 2: Trend of growing population in India

Census Year	Population in million			Growth rate
	Total	Rural	Urban	
1951	361.1	298.7	62.4	--
1961	436.4	360.3	77.8	1.96
1971	547.9	439.1	109.0	2.20
1981	685.1	523.9	159.7	2.22
1991	838.5	628.7	215.7	2.14
2001	1028.6	741.7	285.3	1.93

In 1950-51 the reported area for land was 284.32 mha, out of the total area 14.21% area was covered by forest, 16.7% area was not available for cultivation, and 17.39% was available as other uncultivated land, 9.9% area as a fallow land and net area sown was 41.77%. On the other hand in 2000-2001the values are different in comparison of 1950. In 2001 there was 306.54 m ha land area was reported, which was 22.22 m ha more than the previously reported area. The land covered by forest was 22.51%, (28.54 m ha more than 1950), 13.83% land was not available for cultivation. Other uncultivated land was 9.29% out of the total area of 2000-2001. Fallow land and net area sown was 8.12% and 46.07%, respectively. As you can see clearly in the study of India during 1950 -2000, there is a significant change in land use pattern and land cover. In India, the forests area is increasing with time as various efforts are made to conserve the forest while the barren land was observed less either due to human activities or other reasons and non-agricultural land increased as human population is growing day by day due to the extension of facilities for the human being in form of house, medical, education, entertainment etc.

Table 3: Land use pattern of last decades in India

Classification	n million hectare (mha)					
	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01
Reported area for land utilization statistics	284.32	298.46	303.76	304.15	304.86	306.54
1) Forest	40.48	54.05	63.91	67.47	67.80	69.02
2) Not available for cultivation	47.52	50.75	44.64	39.62	40.48	42.40
a) Nonagricultural use	9.36	14.84	16.48	19.66	21.09	22.40
b) Barren and unculturable land	38.16	35.91	28.16	19.66	19.39	19.31
3) Other uncultivated land (excluding fallow land)	49.45	37.64	35.06	32.31	30.22	28.47
a) Permanent pastures and other grazing land	6.68	13.97	13.26	11.97	11.40	11.04
b) Land under miscellaneous tree crops and groves not included in net area sown	19.38	4.46	4.30	3.60	3.82	3.61
c) Culturable waste land	22.94	19.21	17.50	16.74	15.00	13.82
4) Fallow land	28.12	22.82	19.88	24.75	23.36	24.89
a) Fallow land other than current fallow	17.44	11.18	8.76	9.92	9.66	10.10
b) Current fallow	10.68	11.68	11.12	14.83	13.70	14.79
5) Net area sown	118.75	133.20	140.27	140.0	143.0	141.23

4.4 Reasons of land cover change

Land cover change is the need of hour and changing with time and increasing population. There may be various reasons of land cover change in form of industrialization, agriculture, urbanization, increasing population and others.

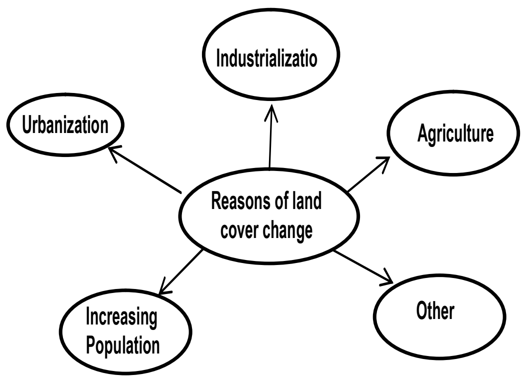

Fig.1: Reasons of land cover change

4.4.1 Urbanization

Most of the developing countries are urbanizing much faster than the developed countries, which are already predominantly urban. Most of the South Asian countries are predominantly rural in character and are experiencing rapid urbanization, particularly compared to metropolitan cities.

According to Squires (2002) and Yuan (2005) the rapid urbanization, therefore, brings opportunities for new urban development; however, it has also brought serious losses of arable land, forest land and water bodies. Urban growth, particularly the movement of residential and commercial land to rural areas at the periphery of metropolitan areas, has long been considered a sign of regional economic vitality. But, its benefits are increasingly balanced against ecosystem impacts, including degradation of air and water quality and loss of farmland and forests, and socioeconomic effects of economic disparities, social fragmentation and infrastructure costs.

Urbanization is the process of movement from the rural areas to urban areas to attain more facilities, which are not available in nearby periphery of rural area. No doubt urban areas are a gift to the human society if it is in controlled manner, coordinated and well planned. However, the unplanned urbanization may cause the serious threats to the environment. In 2008 more than half of the world's population was urban dwellers and the urban population is expected to reach 81% by 2030. Due to the acceleration of the global urbanization in both intensity and area, there is a growing interest in understanding its implications with respect to a broad set of environmental factors including loss of arable land, habitat destruction, decline in natural vegetation cover and climate at local, regional, and global scales. The developmental activities has converted either the rural areas in urban or attract the peoples of rural area to come in the urban areas. Both situations are dangerous for the environment as the peoples are leaving their houses in villages and constructed new house in urban areas, sometimes the left houses of village not in use. Ultimately the huge pressure of population gave birth to the urbanization; the peoples have been created a lot of burden to the environment in a specific area. Now a day's these areas are not able to fulfill human need even for survival as of pollution is increasing rapidly and the groundwater is drained at a faster rate.

Thus the ecosystems in urban areas are strongly influenced by anthropogenic activities, consequently more attention is being given towards monitoring changes in urban land use/ land cover (LULC). LULC change, due to human activities, is currently happening at faster rate in developing countries than in the developed world, and it has been projected that by the year 2020, most of the world's megacities will be in developing countries. In developing countries, where urbanization rates are high, urban sprawl is a significant contributor of the land use change. In the fast developing countries like India, there is a mass migration of people from rural to urban and also from smaller to bigger urban areas and then to metropolises like Delhi, Bangalore, Mumbai etc. The process of urbanization in India gained momentum with the start of industrial revolution way back in 1970s followed by globalization in 1990s. Forests were cleared, grasslands ploughed or razed, wetlands drained and croplands encroached upon under the influence of expanding cities, yet never as fast as in the last decade. In 1991, there were 23 metropolitan cities in India, which increased to 35 in 2001.Some of the prominent ones are Delhi (13.82 million), Mumbai (11.90 million) and Chennai (4.21 million) with Delhi being the most populated megacity (competing with Mumbai) in the country in terms of human population and vehicular traffic density.

Delhi is one of the many metropolitan cities struggling with rapid urbanization and higher levels of pollution through industrial, residential and transportation sources. According to Census of India 2001, the population of Delhi has increased by 47.02% in the decade 1991-2001 (from 9.4 million in 1991 to 13.82 million in 2001). The rise in the population of Delhi is mainly due to the migration of people to the capital in search of better living standard. The population of Delhi has reached to 21.7 million in 2009 (increased by 57% from 2001-2008). After independence, when Delhi witnessed a large influx of migrants, within a very short time the population of Delhi was approximately doubled. To house such a large migrating population, city has expanded in a very unplanned and uncontrolled manner. Such types of unplanned expansions have a direct impact on quality of urban environment affecting the efficiency of the people and their productivity in the overall socio-economic development. In the light of its past experiences and current trends of development, future of Delhi is one of the most important issue requiring attention from the authorities to improve the overall quality of life. Land use which is highly dynamic entity in nature is one of the key parameters to quantify development.

Fifty percent of the world population lives in urban areas and this figure is expected to go up. Urban areas constantly need more land for settlements infrastructure, industries, and leisure activities etc. which increase the pressure on land. More and more agricultural land gets converted into urban colonies. Larger cities affect even larger areas surrounding them.

We see solid waste piled up on many urban streets. Outside cities, there are large dumping grounds of waste brought from the cities. It is estimated that about 2 million hectare of land has been degraded due to waste disposal and landfills.

Urban agriculture has been expanding globally over the past 25 years. In Sau Paulo in Brazil and Havana in Cuba, for example urban home gardens have been very successful. While urban agriculture provides locally grown food and help recycle organic matter however, it may cause soil and water pollution if chemicals are used.

4.4.2 Industrialization

According to Kuskovaa, Gingrichb, & Kraus (2008) Industrialization goes along with sweeping changes in society's interrelations with its environment. The transition from an agrarian to an industrial society leads to fundamentally new patterns in social metabolism, a process which has been described as socio-metabolic transition. Industrialization has been one of the major factors in the development of the countries, and has caused a population increase in cities, resulting in urban sprawl. According to Kavzoğlu (2008) because industrialization and urbanization often advance in an uncontrolled or unorganized way in developing countries, they can have destructive effects on the environment, particularly on basic ecosystems, wildlife habitat, and global biodiversity. Land use change does not occur evenly, neither temporarily nor spatially. In fact, it has become clear that in some parts of the world, the process of massive conversion of natural land cover has stopped, or has even been reversed, the so-called “forest transition”.

4.4.3 Agriculture

According to Makowski (2013) globally, agriculture is facing an increasing demand for food, bio-based energy and fiber products. Numerous studies predict that agricultural techniques will adapt to the increasing demand. However, adaptation poses challenges for the integration of environmental and socio cultural services into agricultural production. Farmers’ adaptation to the increasing demand may include changes in the choice of crops, crop rotations, utilization of crops, and intensification of production. Trends include technical solutions to remove yield limiting factors, such as water availability for crops, and increasing use of agricultural biomass as a source of renewable energy. The latter is often supported by government legislation. For example, in Germany, the introduction of the renewable energy in 2000 resulted in threefold increase of the area of maize (*Zea maize*) and of rape seed (*Brassica napus*) for bio-energy, reaching 17.5% of the German cropland area in 2012 (FNR, 2012). Also, the use of irrigation to increase and stabilize crop yields is becoming more attractive, especially in areas with limited rainfall and with soils with limited water holding capacity. Additional reasons for these changes are related to an increasing water demand of new, more productive cultivars, and the prospect of more irregular precipitation patterns due to climatic change. For example, at the current market prices for agricultural goods, irrigation in the German federal state of Brandenburg is already on the verge of becoming economically viable (Münch et al., 2014). Also, a connection between the production of bio-energy and irrigation exists: as farmers become fuel suppliers for power plants, it becomes more important to achieve stable yields even in dry years. Agriculture is multifunctional. This means that in addition to (private) economic production, it contributes to public goods such as the character of rural landscapes and its ecosystem services (Wiggering et al., 2006; Van Zanten et al., 2013). A simple focus of agricultural management aimed solely at maximizing economic returns can lead to depletion of groundwater resources, erosion, loss of water quality, loss of biodiversity and a reduction of socio-cultural services. Although these services become evident at landscape level, which has a spatial scale larger than a farm, it is the decision-making at farm level that affects these services. Sustainable development therefore requires consideration of the balance between the economic production functions of agriculture and environmental and social services. Policies are implemented to incentivize farmers to respect this balance by remunerating for the provision of public goods.

4.4.4 Increasing population

Linkages between population growth, socioeconomic development and agricultural intensification are examined using district level data for India for 1951, 1961, 1971, 1981 and 1991. Results clearly indicate that population pressure has positive and significant effects on each dimension of agricultural intensification (cropping frequency, artificial irrigation and chemical fertilizer use) for each census year between 1951 and 1991. Results of a analysis for 1961–91 indicate that population growth has a positive effect on changes in each of the three intensification dimensions. The results hold even after controlling for the effects of regional differences in agro climatic conditions and levels of social and economic development. The effects of socioeconomic variables are generally insignificant and do not alter the effects of population growth. Global land use has significantly changed during the past decades. Population growth is often used as a proxy for land use change, but at lower scales, a set of complex drivers are important too. Increasing demand on food as a result of population growth has created more pressure on land resources.

Overpopulation, an unwanted condition where the ever increasing human population exist affects the carrying capacity of Earth. Overpopulation is the difference between natality and mortality in populations. Environmental degradation occurs not only due to population growth but also on other impacts that contribute to environmental degradation. The results of such population growth for developing countries like India span in three areas;

- Changes in land use,
- Disposal of harmful waste to the environment and
- Depletion of natural resources.

As growth of population occurs, this extended growth begins to alter our environment. This concept draws upon the idea that every individual has certain basic needs. As natural resources are used, wastes are generated and disposed off. Thus, the misuse of resources, generation of waste and environmental damage relies on that society's lifestyles and pattern of consumption. Population growth is determined by number of individuals added to the population by birth (natality) and immigration from other area and subtracted by the population decreases by death rate (mortality) and emigration to other area. It increases the size of population and population lost by deaths (mortality) and emigration, reduces the population size.

As per Indian census 2011, the density of Indian population has increased from 325 persons per square kilometres in 2001 to 382 persons/square kilometres. It may occur by rural to urban migration. Environmental stress, biodiversity loss, change in climate and pressure on natural resources strongly distress the population of any area and various survey shows that the population of all countries in total is already overpopulated. But population of human are still increasing. World population counted 6.8 billion in 2009, and are predictable to climb to 9.2 billion in 2050. According to Prospects of World Population, this growth will take place in the developing countries (United Nations, Department of Economic and Social Affairs, Population Division

(2015). The ease of use of sustainable resources which is placing competitive stress on the basic resources support to biodiversity and reduces the way of life, do not affect the population growth. Overpopulation influences land use patterns with consumption behaviours and productive activities of people. “Consumption by human had far exceeded resources available for every individual on land and requires 1/3 of land more to complete their needs than mother earth provides (United Nations, 1992).”

Population Development and Environmental Exploitation

Below are listed a number of the effects of population development and environmental exploitation by human populations.

- Loss of crop lands, forest lands, wetlands for industrial expansion and extraction of minerals use.
- Fragmenting diversity and wildlife habitats.
- Increasing impermeable surfaces means more flooding.
- More resources extraction, manufacturing and consumption.
- Destruction of habitat due to change of temperature and adaptation in food chain.
- Extinction of different flora and fauna of different area and some species become endangered due to loss of habitat and disturbance in their food chain and environmental benefits like availability of medicinal plants, fire wood, sandal wood, etc.
- Change in global climate leads to increase the temperature of earth which in turn leads to polar ice melting, rise in sea level, ice cap melting, decrease in biodiversity, change in temperature of earth, etc.
- Burning of fossil fuel leads to air pollution and overexploitation of available resources.

4.5 Effects of Land cover change

As you know that land cover is the phenomenon related to physical and biological changes as the population of human being is growing the pattern of use is also changing. Land is the direct sufferer of changing pattern of land by human being. The land cover will be affected by the both activities either the increasing or decreasing population. But in today’s context it is changing with increasing population. No doubt this is the need of hour to enhance the basic facilities to provide the food, clothes and houses for the human being. Changes in land use and land cover date to prehistory and are the direct and indirect consequence of human actions to secure essential resources. This may first have occurred with the burning of areas to enhance the availability of wild game and accelerated dramatically with the birth of agriculture, resulting in the extensive clearing (deforestation) and management of earth's terrestrial surface that continues today. Due to industrialization the density of human population has been increased on earth in general and in urban areas in particular. As the population increases the land cover is changing very fast with serious effects on land cover.

4.5.1 Biodiversity

Biodiversity is the phenomenon of variety and variability of living organism. As the land has been converted into concrete jungle, a major part of land area has lost the biodiversity. Habitat destruction and habitat degradation are the main effects of land cover change. Human being made a drastic change to the land cover and occupied various areas of land surface. The forest land has been converted into either farm land or for residential purposes. Diverse flora and fauna have been houseless due to the habitat distraction. Increasing population is the main cause of biodiversity loss, because the human being required basic facilities to survive on this planet and all these requirements are being fulfilled by using the biodiversity. The habitat suitability of forests and other ecosystems surrounding those under intensive use are also impacted by the fragmenting of existing habitat into smaller areas (habitat fragmentation), which exposes forest edges to external influences and decreases core habitat area. Smaller habitat areas generally support fewer species (island biogeography), and for species requiring undisturbed core habitat, fragmentation can lead to local and even general extinction.

4.5.2 Climate change

Land Cover Change (LCC) plays a major role in climate change at global, regional and local level. At global scale, LCC is responsible for global warming as the land cover change is releasing greenhouse gases to the atmosphere. LCC can increase the release of carbon dioxide to the atmosphere by disturbance of terrestrial soils and vegetation, and the major driver of this change is deforestation, especially when followed by agriculture, which causes the further release of soil carbon in response to disturbance by tillage. Land cover change is also behind the major changes in terrestrial emissions of other greenhouse gases, especially methane (altered surface hydrology: wetland drainage and rice paddies; cattle grazing), and nitrous oxide (agriculture: input of inorganic nitrogen fertilizers; irrigation; cultivation of nitrogen fixing plants; biomass combustion).

Land cover change also disturbs the reflection of sunlight from land surface (known as albedo) another an important changer of global climate. Basically, this phenomenon directly dependent on land covers. If the land is covered by vegetation, water, buildings and other constructional activities. The concern area reflects a different albedo as the vegetation will give a different albedo in comparison of water and other barren land. These changes made a significant change in surface heat balance not only by changing surface albedo, but also by altering evaporative heat transfer caused by evapo-transpiration from vegetation (highest in closed canopy forest), and by changes in surface roughness, which alter heat transfer between the relatively stagnant layer of air at earth's surface (the boundary layer) and the troposphere. An example of this is the warmer temperatures observed within urban areas versus rural areas, known as the urban heat island effect.

4.5.3 Pollution

Changes in land use and land cover are important drivers of water, soil and air pollution. Perhaps the oldest of these is land clearing for agriculture and the harvest of trees and other biomass. Vegetation removal leaves soils vulnerable to massive increases in soil erosion by wind and water, especially on steep terrain, and when accompanied by fire, also releases pollutants to the atmosphere. This not only degrades soil fertility over time, but reduces the suitability of land for future agricultural use, and releases huge quantities of phosphorus, nitrogen, and sediments to streams and other aquatic ecosystems, causing a variety of negative impacts (increased sedimentation, turbidity and eutrophication). Mining can produce even greater impacts, including pollution by toxic metals exposed in the process. Modern agricultural practices, which include intensive inputs of nitrogen and phosphorus fertilizers have substantially increased the pollution of surface water by runoff and erosion and the pollution of groundwater by leaching of excess nitrogen (as nitrate). Other agricultural chemicals, including herbicides and pesticides are also released to ground and surface waters by agriculture and in some cases remain as contaminants in the soil. The burning of vegetation biomass to clear agricultural fields (crop residues, weeds) remains a potent contributor to regional air pollution wherever it occurs, and has now been banned in many areas.

4.5.4 Ozonelayer

The ozone layer found in stratosphere and the occurrence of this layer in the atmosphere is between 20-50 km. As you know the ozone layer destruction is the major area of concern nowadays. This layer is in danger by the presence of CFC, nitrous oxide etc. Nitrous oxide is releasing from agricultural land and altered regional and local hydrology (dam construction, wetland drainage, irrigation projects, increased impervious surfaces in urban areas), which are, ultimately the result of land cover change.

4.5.5 Other effects

Perhaps the most important issue for most of earth's human population is the long term threat to future production of food and other essentials by the transformation of productive land to non-productive uses, such as the conversion of agricultural land to residential use and the degradation of rangeland by overgrazing. Land-use is a process of turning natural ecosystem into social ecosystem. The process is a complicated procedure by the synthetic effect from nature, economy and society. The manner, degree, structure, area distributing and benefit of land-use are not only affected by natural condition but also restricted by diversified natural, economic and technologic condition. Land-use is the most direct and leading driving factor to the land-cover change. With an increasing world population, there will be intense pressure on land, particularly in Africa and Asia. More intensive land use will be needed to feed the people. More land may also be brought under agriculture by the conversion of forest and grasslands.

Summary

In this unit we have examined various aspects of land cover change. So far you have learnt that

- Land cover refers to the physical characteristics of Earth's surface, captured in the distribution of vegetation, water, soil and other physical features. Land use refers to the way in which land has been used by humans and their habitats.
- Trends of Population Growth in India, 1951-2001 At the time of its independence in 1947, India's population was about 345 million. The decades following the 1940s have seen great changes. Even the poorest people experienced some improvements in their living conditions.
- In 1950-51 the reporting area for land was 284.32 mha, out of the total area 14.21% area was covered by forest, 16.7% area was not available for cultivation, and 17.39% was available as other uncultivated land, 9.9% area as a fallow land and net area sown was 41.77%. On the other hand in 2000-2001the values are different in comparison of 1950.
- In 2001 there was 306.54 m ha land area was reported, which was 22.22 m ha more than the previously reported area. The land covered by forest was 22.51%, (28.54 m ha more than 1950), 13.83% land was not available for cultivation. Other uncultivated land was found 9.29% out of the total area of 2000-2001. Fallow land and net area sown was available 8.12% and 46.07%, respectively.
- Land cover change is the need of hour and changing with time and increasing population. There may be various reasons of land cover change in form of industrialization, agriculture, urbanization, increasing population and others.
- The process of urbanization in India gained momentum with the start of industrial revolution way back in 1970s followed by globalization in 1990s. Forests were cleared, grasslands ploughed or razed, wetlands drained and croplands encroached upon under the influence of expanding cities, as in the last decade.

- According to Squires, (2002) and Yuan, (2005) the rapid urbanization, therefore, brings opportunities for new urban development; however, it has also brought serious losses of arable land, forest land and water bodies.
- According to Kavzoğlu (2008) Because industrialization and urbanization often advance in an uncontrolled or unorganized way in developing countries, they can have destructive effects on the environment, particularly on basic ecosystems, wildlife habitat, and global biodiversity. Land use change does not occur evenly, neither temporarily or spatially.
- Linkages between population growth, socioeconomic development and agricultural intensification are examined using district level data for India for 1951, 1961, 1971, 1981 and 1991. Results clearly indicate that population pressure has positive and significant effects on each dimension of agricultural intensification (cropping frequency, artificial irrigation and chemical fertilizer use) for each census year between 1951 and 1991.

Terminal question

1 (a) Fill in the blank spaces with appropriate words.

Delhi is one of the many…………………….. struggling with rapid urbanization and higher levels of pollution from industrial, residential and transportation sources. According to Census of India 2001, the population of Delhi has increased by ……………in the decade 1991-2001 (from 9.4 million in 1991 to ………………….in 2001). The up rise in the population of Delhi is mainly due to the ……………………to the capital in search of better living standard. The ……………..of Delhi has reached to ………………..in 2009 (increased by 57% from 2001-2008). After independence, when Delhi witnessed a large influx of within a very short time the population of Delhi was approximately doubled. To house such a large ……………………….city has expanded in a very unplanned and ……………………………Such types of unplanned expansions have a direct impact on quality of affecting the efficiency of the people and their productivity in the overall …………………development.

2 (a) Discuss the concept of land cover change.

(b) What do you understand by land cover and land use?

3 (a) Describe the land cover change with special reference of India.

(b) Discuss the forest and fallow land of India.

4. Explain the reasons of land cover change.

5 (a)What is the role of urbanization in land cover change? Explain!

(b)Explain the role of agriculture in land cover change.

6 (a) Fill the blank spaces with appropriate words.

In 1950-51 the reporting area for land was ……………….out of the total area …………....was covered by forest, 16.7% area was not available for ………………and ……..was available as other uncultivated land, 9.9% area as a fallow land and net area sown was ……………..On the other hand in 2000-2001the values are different in comparison of…………... In 2001 there was ………………..land area was reported, which was ………………..more than the previously reported area. The land covered by forest was ……………..(28.54 m ha more than 1950), …………land was not available for cultivation. Other uncultivated land was found 9.29% out of the total area of …………………Fallow land and net area sown was available ……………………..respectively. As you can see clearly in the study of India during …………………there is a significant change in land use pattern and land cover.

(b) 1981-2001: High growth with sure signs of slowing down of the growth rate. (Yes/No)

Physical characteristics of earth's surface, captured in the distribution of vegetation, water, soil and other physical features. Land use refers to the way in which land has been used by humans and their habitats. (Land cover /land use)

(d) The land with growing plants for food/fodder (cropland/ rangeland/fallow land)

(e) What is the effect of land cover change on climate change?

(a) What is the linkage between pollution and land cover change?

Answers to terminal questions

1 (a) metropolitan cities, 47.02%, 13.82 million, migration of people, population, 21.7 million, migrants, migrating population, uncontrolled manner, urban environment, socio-economic.

2 (a) See section 4.1, (b) See section 4.2.1

3 (a) See section 4.3, (b) See section 4.3

4 See section 4.4

5 (a)See section 4.4.1, (b) See section 4.4.3

6 (a) 284.32 mha, 14.21% area, cultivation, 17.39%, 41.77%, 1950, 306.54 mha, 22.22 mha, 22.51%, 13.83%, 2000-2001, 8.12% and 46.07%, 1950 -2000.

(b) Yes, (c) Land cover, (d) Cropland, (e) See section 4.5.2

7 (a) See section 4.4.4

Unit-5: Causes and Consequences of Land Degradation

Unit Structure

5.0 Learning Objectives

After studying this unit you will be able to find answer of the following:

- Define Land degradation and explain
- Explain the causes of land degradation
- Explain the relationship between deforestation and land degradation
- Discuss desertification and land degradation
- How overgrazing leads in to land degradation?
- How dumping of solid waste responsible for land degradation?

5.1 Introduction

As you know nature has been so kind to man since prehistoric times, the varieties of natural resources such as: forest, land, water, mineral, energy, etc. on this earth provide everything for survival of human beings. These natural resources are not only beneficial to human being but also provide home to millions of species. Water, land, minerals, energy, wind, forest and wildlife were existed much before the evolution of man on the earth. Therefore, human being used these natural resources right from their existence in the nature.

Land has been a very important resource for human and other species of earth. Land resource may occur in the form of forest, agriculture, mountainous, hilly, plains, plateau etc. Land resources are important for human beings and it provides agricultural land, forest land, which are being used for forestry, agriculture, minerals extraction etc. Besides these, land also provides food and shelter to other plants and animals, it is used as watershed or reservoir, land also acts as reservoir for solid wastes created by the human activities, and also used for construction of buildings, industries, roads and other infrastructures.

On the basis of ecological condition land is categorized as: cropland, barren land, wetland, arid dry land, rangeland, grassland, snowy land and wasteland. In India, land degradation, loss of biodiversity, environmental pollution and solid waste generation are very important environmental issues. Land degradation is one of the serious issues at international level and it will remain an important international issue for the upcoming time.

Land resources are not only economically important but ecologically and socially also play very important role. As you know that many important biogeochemical cycles such as carbon, nitrogen, sulphur, phosphorus, calcium, magnesium, etc. are completed in land. But in the last few decades land has been over exploited by human being.

Due to manmade or anthropogenic activities the land is being degraded and these activities may include: deforestation, mining, faulty agricultural practices, population explosion, urbanization, industrialization, dumping of solid waste etc. Land degradation also happens due to natural hazards such as earthquake, landslides, floods and forest fires. Overgrazing, desertification, water logging also contribute to land degradation. Total geographical area of India is about 328.73 million hectares (2.5% of the world's geographical area) out of this 304.89 million hectare comprises the reported area and 264.5 million hectare only is under use for different purposes (Sharma, PD., 2018 Ecology and Environmental). As you know that India is country of villages and country supports approximately 16% of human population and 20% of the livestock population of world. Out of the total geographical area of India (328.73 million hectare) about 178 million hectares (54%) is already converted into wastelands. This also includes about

40 million hectares of degraded forest. The total cultivable land of the country is about 144 million hectares of which 56% (80.6 million hectares) is degraded due to faulty agricultural practices. The dense forest cover has been reduced to 11% (36.2 million hectares) of the total geographical area (Sharma, 2018).

As, it is earlier mentioned that population explosion, poor agricultural practices, urbanization, industrialization, deforestation, over-grazing, shifting cultivation, mining activities, dumping of solid waste etc. are the main causes of the land degradation in India. Land degradation not only reduces the productivity of land but also leads in to ecological, social and economical impacts. These impacts include loss of biodiversity, diseases, soil acidification, soil alkalization etc.

On the basis of above account it is now clear that most of the land resources are degraded, are undergoing degradation or are at the risk of degradation. In this unit you will learn about various causes and consequences of land degradation in detail.

5.2 Definitions of Land Degradation

There are various definitions of land degradation given by different international bodies/agencies and scientists. Some of the important definitions of land degradation have been given below:

- According to the Organization for Economic Cooperation and Development (OECD) “Land degradation is the reduction or loss of the biological or economic productivity resulting from natural processes, land uses or other manmade activities and habitation patterns such as land pollution, soil erosion and the destruction of the vegetation cover”.
- As per United Nation Convention to Combat Desertification (CCD) “Land degradation as a global development and environment issue and desertification is the most severe form of land degradation”.
- According to World Health Organization (WHO) “Land degradation caused by extreme drought and human activities that degrade the quality of land which negatively affecting food production, livelihoods, and the production of other ecosystem services”.
- Land degradation may be defined as "the collective reduction of the productive potential of the land, including its major uses, its farming systems and its value as an economic resource."

- In other words land degradation may be defined as "It is the process of deterioration of soil or loss of fertility of soil in which physical, chemical and biological properties are degraded due to natural or manmade activities".

5.3 Causes of Land Degradation

There are different causes of land degradation, but first of all you should understand the categories of land degradation. In this list first category is physical degradation which refers to deterioration in physical properties of soil. Physical properties include landscape, structure, texture, bulk density, moisture content, water holding capacity etc. of soil. Second category is chemical degradation which is basically due to the nutrient depletion. Chemical properties of land include chlorides, nitrates, phosphates, magnesium, zinc, calcium and other nutrients. Third category of land degradation refers to biological degradation in which soil organic matter and biodiversity of soil degraded. Biological properties of land include all the flora and fauna which are inhabited in land ecosystems.

5.4 Natural Causes of Land Degradation

The causes of land degradation may be categorized as: Natural and manmade or anthropogenic. There are various natural causes of land degradation which are described below:

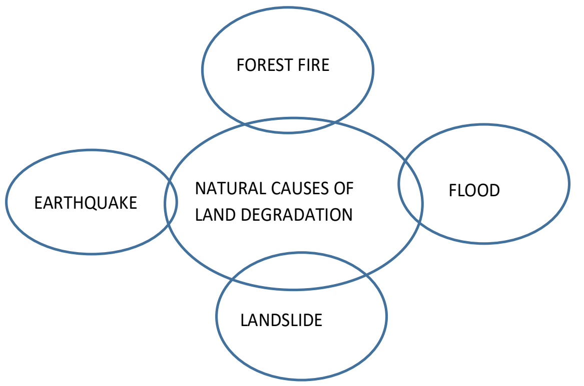

Fig1: Natural Causes of Land Degradation

1) **Earthquake:** Earthquake is "shaking of the surface of the earth, resulting from the sudden release of energy in the lithosphere that create seismic wave". Earthquake is the most fearful natural phenomena in the human life. The maximum destruction generally occurs near the epicenter, the place where the vibrations arise and spread. Earthquake may lead in to land degradation. Because it can change the structure of land of any area. Earthquake also leads in to landslides and catastrophic flood, which ultimately destroy the land.

2) **Landslides**: The sudden movement of the soil and the weathered rock material down the slope due to the force of gravity is called landslide. Landslides are common in mountainous regions especially those which are situated along the river banks or near the coastline. The flow of water continuously goes on doing the eroding work which results in landslides sooner or later. Especially when the rivers are in flood they greatly add to landslides. In India, landslides are common in the mountainous regions of the north and north-eastern parts. Human induced activities are also responsible for landslides. Landslides remove fertile soil of the land and cause land degradation.

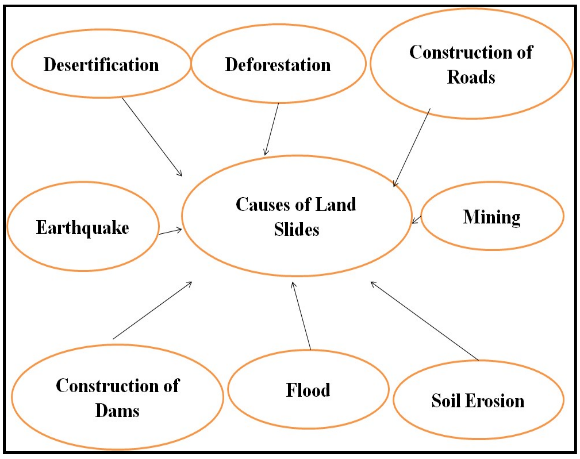

Fig-2. Causes of Land slides

3) **Effects of Landslides on Land:** Landslides generally takes place in the hilly or mountainous regions. Landslide is regarded as natural. Landslides causes significantly changes in the landscape of earth. Landslides are also responsible for deficiency of nutrient in land ecosystem.

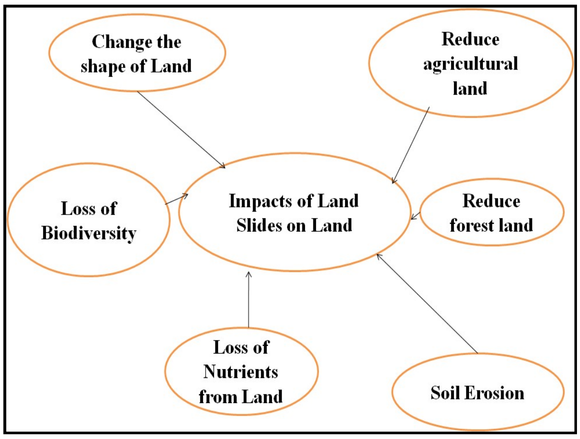

Fig-3. Effects of landslides on land

4) **Flood:** A flood is an overflow of water that submerges land that is generally dry. According to European Union Floods Directives “flood is covering of land by water not normally covered by water”. According to Central Water Commission, Ministry of water resources, Government of India flood affects about 7.351 million hectare area of country. Flood is also responsible for causing trouble to 40.96 million population 1800 number human live lost, 85599 number cattle Lost, 14 Lakh

House damaged, Crop area damaged 3.7 million hectare, Public utility damaged 1186.45 corer. Therefore, flood is responsible for land degradation (Sharma, 2018).

5.5 Manmade or Anthropogenic Causes of Land Degradation

There are various manmade or anthropogenic causes of land degradation and some of the important manmade or anthropogenic causes of land degradation are summarized in Fig.4 and Table 1 and also described below.

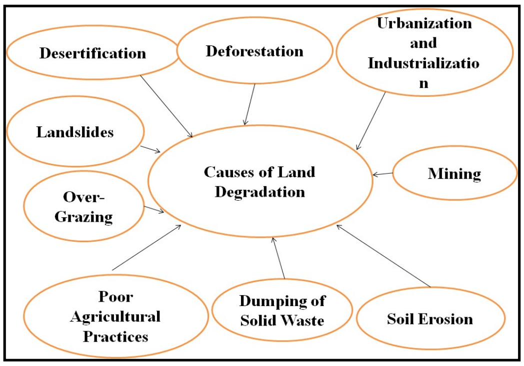

Fig-4: Manmade causes of land

Table-1: Important manmade causes of land degradation and their impacts

Causes of land degradation	Impacts
Deforestation	Soil quality degradation Landslides Loss of biodiversity desertification
Desertification	Loss of moisture content Loss of water holding capacity of soil Loss of biodiversity Low of productivity of land
Overgrazing	Desertification Loss of biodiversity Low productivity
Dumping of Solid waste	Waste land Low productivity Diseases
Faulty Agricultural Practices	Water logging Soil erosion Loss of valuable nutrients from soil Deforestation Toxic nature of soil Loss of biodiversity
Soil Erosion	Loss of fertile soil Loss of agricultural land Low productivity of land
Landslides	Loss of fertile soil Loss of agricultural land Loss of forest land
Urbanization and Industrialization	Soil degradation Loss of agricultural land Loss of forest land Toxic chemicals in land
Mining	Loss of valuable nutrients Soil erosion Land degradation

5.5.1 Deforestation

As you know forests are very important resources which are not only responsible for purification of air but also play an important role in keeping fertility of land by shedding their leaves which contain many valuable nutrients. Forest Survey of India (FSI) defines a forest as 'all the lands, more than one hectare in area, with a tree canopy density of more than 10%'.

According to the State of Forest Report (2011), produced by FSI, area under forests in India is estimated to be 69.20 mha, making up 21.02% of the total geographical area of the country.

Forests are helpful in binding up of soil particles with the help of their roots. The areas of root (rhizosphere) also keep the soil moist and full with nutrients. Rhizosphere also contains many valuable microbes (bacteria, algae and fungi) which are important biotic communities responsible for recycling of nutrients in soil. The term "Deforestation" refers to the loss of tree cover. Deforestation is conversion of forest land in to non-forest for different purposes such as agriculture pasture, urbanization, industrialization, commercial products etc. According to United Nations Environment Programme (UNEP) about 7.3 million hectares of rich tropical forests every year and about 14 hectare of closed forest every minute are lost. Therefore, deforestation will affect the land adversely. The deforestation may be anthropogenic or natural.

According to United Nations Framework Convention on Climate Change (UNFCCC, 2010) subsistence farming is responsible for 48% of deforestation, commercial agriculture is responsible for 32% of deforestation, water logging is responsible for 14% of deforestation and fuel wood gathering make up 5% of deforestation.

Causes of Deforestation: There are several causes of deforestation; these causes may include urbanization, industrialization, agricultural practices, over exploitation etc. As population rises, demand for food, infrastructure, transportation etc. also

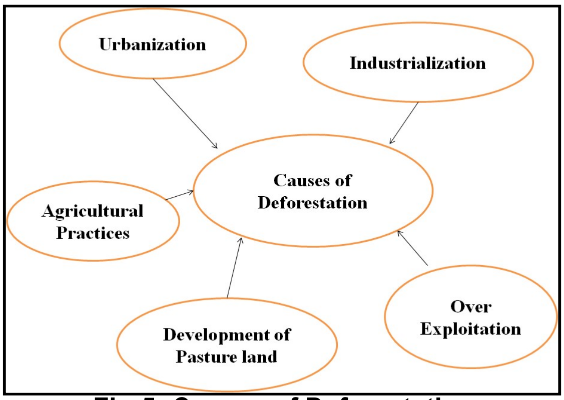

Fig-5: Causes of Deforestation

increases. Many forests of world have eroded due to the constructional activities. For the fulfillment of demand of food, forest land is also being converting in to agricultural land.

Effects of Deforestation on Land:_ Annually, about 5.37 million ton of NPK (Nitrogen, Phosphorus and Potassium) lost from land in India due to deforestation and over grazing. There are various effects of deforestation on land which are summarized in Fig-6 and also discussed below:

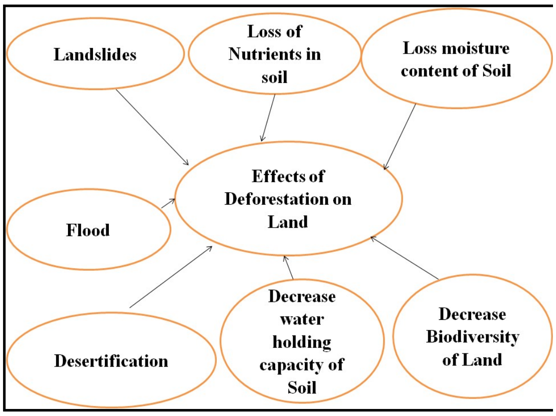

Fig 6. Effects of deforestation on land

(i) It consequences in changes in the composition and structure of the vegetation cover.

(ii) Deforestation also affects the hydrological cycle. As you know that trees extract groundwater and release it into the environment, due to deforestation the trees no longer evaporate water, resulting in a much drier weather. Deforestation reduces the content of water in the soil and cause desertification and drought like condition in an area.

(iii) As you know that forests are important resource and play vital role in protecting land. Deforestation results to soil erosion, flooding and landslides. Deforested areas become sources of surface water runoff which moves much faster than subsurface flows.

(iv) Due to deforestation soil losts its quality. Reduction in soil organic matter status, leading to decline microbial populations of soil.

(v) Deforestation causes degradation in soil physical properties (structure, aeration, water holding capacity).

(vi) Deforestation causes adverse changes in soil nutrient, including reduction in availability of the major nutrients, micronutrient deficiencies and nutrient imbalances.

(vii) Due to deforestation the soil loses its capacity to check surface runoff. This trend, apart from causing erosion, reduces the fertility of the top soil and its ability to replenish vital nutrients.

(viii) Deforestation is also responsible for loss of biodiversity.

(ix) Deforestation is also responsible for soil erosion.

(x) Deforestation increases frequency of flood in an area.

5.5.2 Desertification

Desertification is biggest threat to land degradation. The term "desertification" was first used by Aubreville (1949) to show excessive soil erosion due to deforestation. Desertification is a process of land degradation in arid, semiarid, and dry sub-humid areas. The UNO Conference on Desertification (1977) has defined desertification as the "destruction of the biological potential of land, and can lead ultimately to desert like conditions."

United Nations define desertification as "a process leading to reduced biological productivity with reduction in plant diversity in the lands, carrying capacity for livestock, in crop yields, and human".

According to United Nations Conference on Environment and Development (UNCED, 1992) "land degradation in arid, semi-arid, and dry sub-humid areas is resulting from various factors, including climatic variation as well as human activities". The desertification gets manifested as rapid soil erosion by wind and water, a reduction in species diversity and a reduction in the overall productivity of land ecosystems.

United Nation Environment Programme (UNEP) classified desertification as:

- **None to slight:** Biological production largely not altered
- **Moderate**: Loss of production up to 25% of that expected
- **Severe**: Loss of Production between 25% and 50% of that expected
- **Very severe**: loss of production more that 50% of that expected

Besides biological production, relevant criteria of ground cover, salinization, soil status and cost of reclamation also used in each of the land categories.

Effects of Desertification

(i) Desertification may leads in to floods, environmental pollution, storms and several other natural disasters, which can contaminate the land.

(ii) Due to desertification soil becomes unsuitable for agriculture, and there may be a huge loss of food.

(iii) Desertification leads to water scarcity and human, as well as animal life is endangered due to shortage of water.

(iv) Due to desertification, the soil changes and the rain no more penetrate the soil. As a result, plants don't receive the required amount of water for proper development. One or two seasons of infertile land can be tackled, but if the land experiences repeated spells of desertification, it may lose its fertility completely.

(v) Desertification causes aridity of soil.

(vi) It decreases the moisture content of land. As you know that moisture is very important for survival of organisms. Many species of earthworms, bacteria, fungi etc. live in moist land; moisture also provides water to plants and other biological communities. Due to desertification all the moisture evaporate from the land.

(vii) It causes biodiversity degradation of land. Organisms such as bacteria, fungi, molluscs, annelids, arthropods etc. remains alive in land and some of them play important role in enhancing the productivity of land. Due to desertification many species can’t survive in land.

(viii) It decreases the productivity of land.

5.5.3 Over-Grazing

Overgrazing refers to excessively feeds on pasture. It is also the practice of grazing livestock on vegetation before it has recovered from a former grazing state. It is also called as “intensive grazing”. Overgrazing takes place when vegetation or pasture is continuously removed from the land.

Tremendous growth in livestock population results in overexploitation of pastures. Due to this, grass and other types of vegetation are unable to survive, and lack of vegetation cover leads to soil erosion. It has many effects on the environment and specifically on vegetation and soil parameters. Over grazing is considered to be the major cause of soil degradation worldwide. According to Oldemann, (1991) overgrazing accounted for 35.8% of all forms of degradation. It is observed that the first signs of overgrazing are a decrease in legumes and an increase in forbs.

Increased livestock numbers in arid regions cause overgrazing which results in reduced infiltration and accelerated runoff and soil erosion. Soil microorganisms play significant role in developing soil fertility. The dominant characteristics influencing the existence and activity of soil microbes are soil water content and storing capacity, texture, size etc. Heavy grazing can cause grassland degradation because of heavy defoliation and treading, and is often used for herb control. Overgrazing is responsible for removal of natural vegetation.

Animal grazing is a natural process of forage utilization, because herbivores produce in the environment where evolution formed them. This is the most appropriate, low cost tool for meat production at global level. A large portion of grasslands are utilized by livestock population. Overgrazing has detrimental effects on soil and vegetation but changes are reversible. High grazing pressure decreases plant density, and often enhances the invasion of unpalatable species. However, all these negative impacts can be prevented by proper management practices.

Effects of Overgrazing on land: There are various effects of overgrazing on land which are summarized in Fig-7 and also discussed below:

(i) Soil erosion: As you know that soil erosion is process in which top soil remove from land. One of the most severe impacts of overgrazing is soil erosion. Trampling of numerous animals in a land will act to enhance the death of plants and vegetation cover, because the animals graze even on the slightest, finest and smallest shoots of new plants. Due to complete degradation of plants, the land is left bare and exposed to harsh weather such high temperatures which disintegrates the

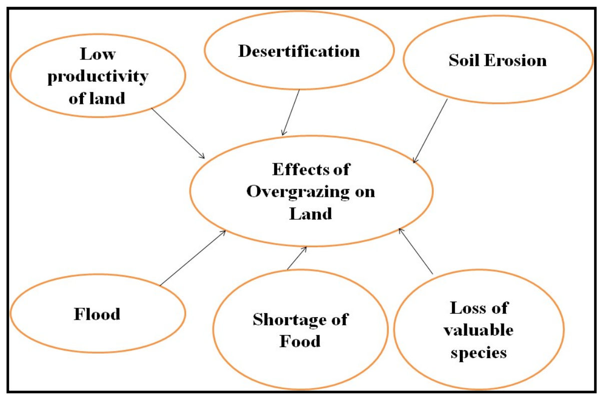

Fig-7: Effects of Over Grazing on land

rocks and carries the top soil away. Animals also prefer gathering at specific areas, like near to water sources, and such areas can get degraded.

(ii) **Land degradation:** The acts of soil erosion as a result of overgrazing can cause land degradation. In drier areas, the experience is even bad as a large percentage of pasture and land cover is destroyed, contributing to relentless progression of desertification and overgrazing has led to desertification. Overgrazing combined with overstocking has the most damaging results to the natural environment. Intensive or over grazing disrupts the water cycle and diminishes the replenishment capability of ground water resources. In the some areas of earth, overgrazing is associated with nitrogen and phosphorous contamination.

(iii) **Loss of valuable species:** The composition of plant and their regeneration capacity is affected by overgrazing. The original pasture vegetations are composed of high quality pastures and herbs with great nutritional value. When animals excessively graze on such pastures, even the root stocks which contain the reserve food or regeneration capacity get eroded. Therefore, some other more adaptable species such as weeds and unpalatable plants take up their place. These secondary plant species have low nutritional values and because they are highly adaptive, they replace the native/endemic/useful species thereby causing the loss of valuable plant diversity.

(iv) **Food shortage/famine:** As earlier stated, overgrazing is a main contributor to desertification because it converts arable or pasture land into unproductive land. The overgrazed soil is thus not suitable for growing food because it loses its essential nutrients. The loss of land productivity directly results in the loss of food available for consumption. Overgrazing also leads in to economical loss.

(v) **Death of people and livestock:** The long term effects of overgrazing are shortage of food which can make man and cattle die of starvation. In the absence of sufficient pasture for livestock grazing, cattle lack the vital nutrients for survival. The nutrient deficiencies make the animals unable to gain weight appropriate to them which lowers their chances of survival. Human survival levels and health are as well affected when there is inadequate food supply for consumption.

5.5.4 Dumping of Solid Waste

Dumping of Solid waste is another important cause of land degradation. Due to rapid growth in developmental activities such as urbanization and industrialization millions of tons solid wastes are being dumped in and around the land. Dumping of solid wastes on land is a common waste disposal method and practiced almost by all the cities around the world. Solid waste may occur in form of biodegradable and non-biodegradable in which non-biodegradable waste is regarded as more harmful as compare to biodegradable waste.

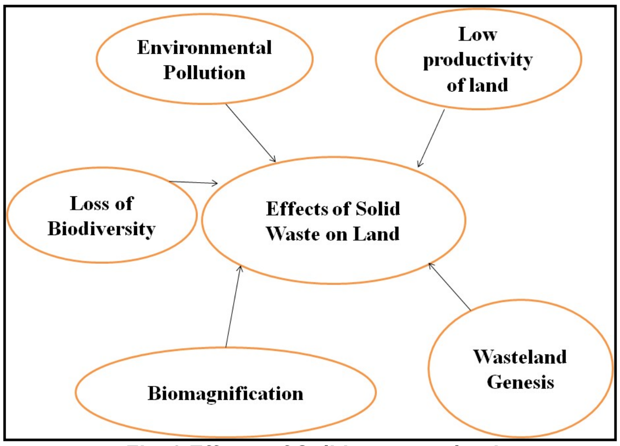

Fig. 8 Effects of Solid waste on land

Effects of Solid waste on Land: There are various effects of solid waste on land which are summarized in Figure 8 and also described below:

(i) Pollution: Solid waste contains various harmful chemicals especially in hazardous waste, industrial waste, non-biodegradable waste and radioactive waste. When solid waste dumped in to any land it cause serious soil pollution. Dumping of Solid waste in land is not only responsible to soil pollution but also responsible to air and water pollution. Dumping sites gradually is converting in to wasteland.

(ii) Bio-magnification: Bio-magnification is process in which concentration of toxic chemicals increases in each trophic level of food chain. When harmful chemicals dumped in to soil they can reach up to plants and then animals and cause several diseases in animals.

(iii) Loss of biodiversity: As you know that biodiversity is variety and variability among living organism from all sources. Biodiversity found in land as well as in water. It is estimated that one teaspoon of fertile soil contains 100 million bacteria (Eriksson, 2017). These bacteria are certainly helpful in rotating the valuable minerals. Bacteria such as *Pseudomonas, Azotobacter,* *Nitrosomonas, Nitrobacter* (involved in nitrogen cycle), *Thiobacillus thiooxidans, Arthrobacter, Chlorbium, Chromatium, Rhodopseudomonas* (involved in sulphur cycle), Fungi species like *Aspergillus, Fusarium, Flavobacterium* (involved in phosphorus cycle), many species of earthworm (*Eisenia fetida, Lumbricus rubellus, Dendrobaena veneta, Perionyx excavatus, Eudrilus eugenia)* are important biodiversity of land. Due to dumping of solid waste many diversity of living organism going threatened and are at the verge of extinction. .

(iv) Low productivity of soil: Solid waste not only responsible for pollution, biodiversity loss but also cause low or no production of crop at dumping sites. It is found that crop production is badly affected by non-biodegradable wastes.

5.5.5 Agricultural Practices

As you know that, agriculture plays very important role in development of any Nation. India is dominantly agricultural based country. Varieties of agricultural; practices such as: subsistence farming, shifting cultivation, plantation agriculture, intensive farming, dry agriculture, mixed and multiple agriculture, crop rotation and terrace cultivation have been used in India since prehistoric time.

Fertilizers are now become essential for increasing crop production but excessive use of chemical fertilizers is causing an imbalance in the quantity of certain nutrients in the soil. This unevenness adversely affects the vegetation. The word pesticides includes any form of chemical used for the control of unwanted herbaceous plants (herbicides), woody plants (arboncides), insects (insecticides), rodents (rodenticides), molluscs (molluscides) or any chemical that has biocidal activity affecting any other population. Moreover, excessive use of these pesticides, results in an increase in the level of resistance by certain pests and it may kill some useful species like earthworm, insects, honeybees etc. These species are certainly helpful in land ecosystems. Thus, the use of pesticides leads to decline in the fertility status of soil. Excess use of alkaline fertilizers like sodium nitrate, basic slag etc. may cause higher alkalinity in soils, which ultimately affect the productivity of land.

Effects of Agricultural Practices on Land: There are various agricultural practices such as, shifting cultivation, uncontrolled or unplanned irrigation, use of agro-chemicals are responsible for land degradation. There are various effects of these practices on land and some of the important effects are summarized in Fig. 9 and also given below:

(i) Deficiency of soil nutrients due to intensive farming.

(ii) Imbalance in soil nutrients particularly the deficiency of micro- nutrients.

(iii) Decline in the organic matter in the soil.

(iv) Deforestation and overgrazing.

(v) Decline in underground water due to over exhaustion for high water using crops.

(vi) Loss of valuable species.

(vii) Excessive uses of nitrogen and water have caused percolation of nitrogen up to water table thus polluting it even for men and other species.

(viii) Bio-magnification

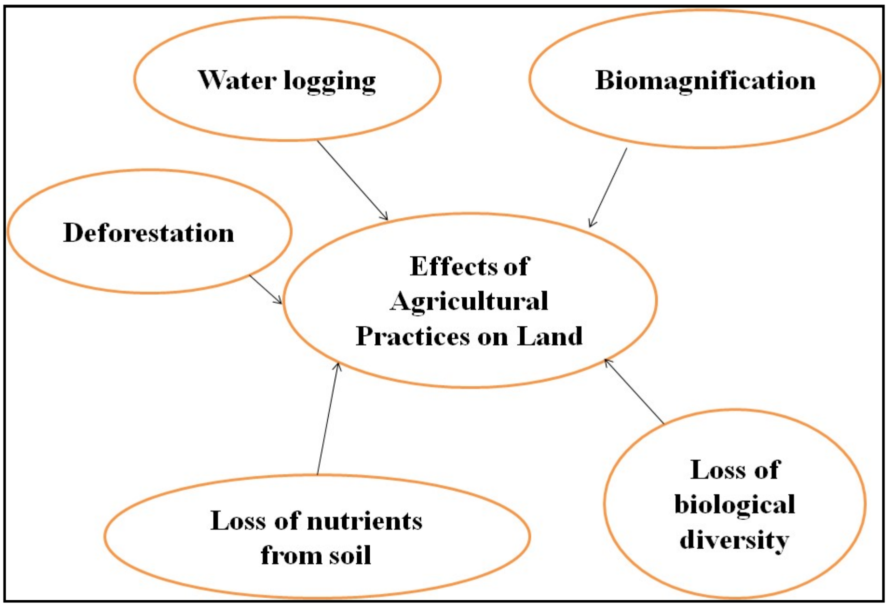

Fig. 9 Effects of agricultural practices on land

5.5.6 Soil Erosion

It is just displacement of upper layer of soil. Soil erosion may be due to high rain fall, wind flow, animal and human activities. The top layer of soil is vital because all the essential nutrients required by plants are present in this layer.

Soil erosion depends on various factors like topography, rainfall, gravity, nature of soil etc. Accelerated soil erosion by water and wind is the major land degradation process and this is a consequence of changed relationship between environmental factors which occur as a result of human activities. Out of total geographical area (328.7 million hectare), about 43% of land (141.3 million hectare) subject to water and wind erosion, water logged area about 2.6% (8.5 million hectare), alkali soils about 1.1% (3.6 million hectare), acidic soils 1.4% (4.5 million hectare), saline soils including coastal sandy areas 1.7% (5.5 million hectare), ravine and gullies 1.2% (4.0 million hectare), area subject to shifting cultivation 1.5% (4.9 million hectare), riverine and torrents 0.8% (2.7 million hectare). In USA over 77 million acres of land has become seriously eroded.

Types and causes of soil erosion:

As, it is earlier mentioned, that the soil erosion is the removal of top fertile layer of the soil. Soil erosion by wind and water is the most common. There are various types of soil erosion which are given below:

A) Soil erosion by Water: This type of soil erosion may categorized as followings:

- **Sheet Erosion:** In this type of soil erosion, the layer of fertile soil removed by running water. It is severe type of soil erosion because in this erosion finer fertile layer of soil is removed.
- **Rill erosion:** This is second type of sheet erosion, in this erosion small finger like rills begin to appear on land. Gradually these fine rills increase in number and also become deeper and wider which makes the land unculturable or unproductive.
- **Gully Erosion:** In this type of soil erosion water flowing along with definite path downs. Gully erosion also makes land unfit for cultivation.
- **River stream erosion:** In this category the soil erosion take place at the river bed and banks. This type of soil erosion generally occurs through rivers, streams and tributaries.
- **Shore Erosion:** This type of erosion also called coastal erosion, in which the wearing away of material from a coastal profile including the removal of beach, sand dunes, or sediment by wave action, tidal currents, wave currents, or high winds.

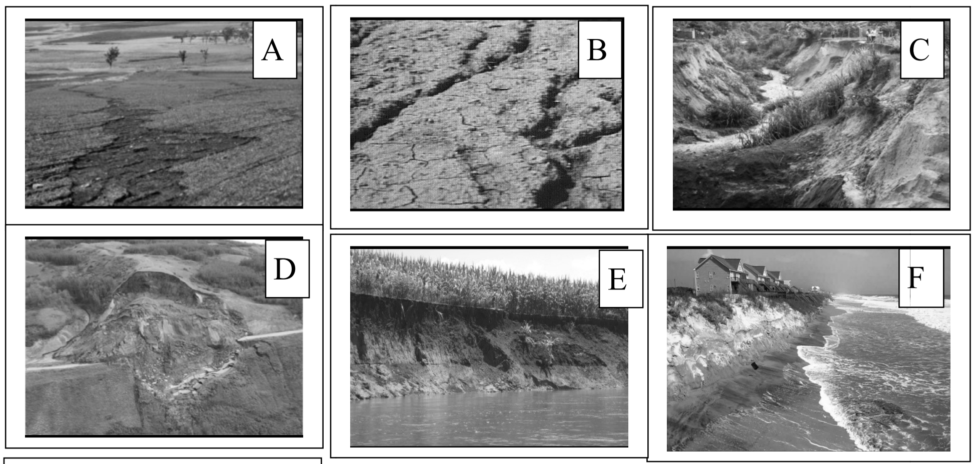

Fig 10. Types of soil erosion
A-Sheet Erosion B-Rill Erosion
C-Gullies Erosion D-Slip Erosion
E-Stream Erosion F-Shore Erosion
G-Wind Erosion

B) Soil erosion by wind: In this type of erosion wind is responsible for displacement of soil. This type of erosion usually takes place in bare, drier areas of land. It is regarded as less harmful as compared to soil erosion by water.

Effects of Soil Erosion on Land: Soil erosion has various harmful effects on land which are summarized in Fig-11 and also given below:

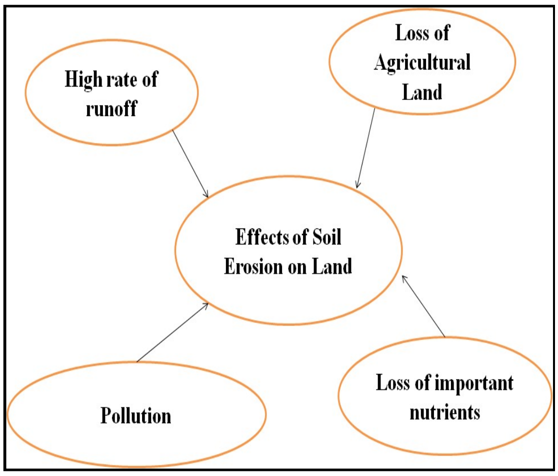

Fig-11: Effects of Soil Erosion on Land

As you have learnt about the sheet erosion in which finer and fertile soil eroded due to water. In this erosion many valuable nutrients like phosphorus, nitrates, calcium, magnesium,_chlorides, etc. are lost from the soil. Therefore, loss of nutrients is one of the major impacts of soil erosion.

Continuous erosion from the river banks reduces the agricultural lands. Various rivers of India like Ganga, Yamuna, Brahmaputra, Kaveri, Krishna, Kosi etc. degraded large amount of land from their banks. Stream erosion leads in to loss of agricultural land especially in hilly regions of earth.

5.5.7 Urbanization and Industrialization

There are various effects of urbanization and industrialization on land which are summarized in Fig-12 and also discussed below:

Urbanization and industrialization are also important causes of land degradation. As it is mentioned 32% of Indian population lives in urban area. Urbanization is process in which rural area convert in to urban area. Urban area is that area where population of human being has more density and most of the persons have non-agricultural occupation. Urbanization increasing day by day and leads in to several environmental problems including land fragmentation and land degradation. Urbanization alters the physical, chemical and biological properties of the land and thereby degrading the quality of land. Urbanization leads in to loss of vegetation, generation of solid waste, excessive water runoff, soil erosion. These factors affect the land significantly. Industrialization is just development of industry in an area. Rapid growth in industries ultimately leads in to air, water and soil pollution. Besides this, industrialization requires more and more land to establishment of industries which change the structure as well as quality of land. Many industries such as leather industries, paper and pulp industries, agricultural industries, battery recycling industries produce large amount of solid waste on land and degrade quality of soil, significantly.

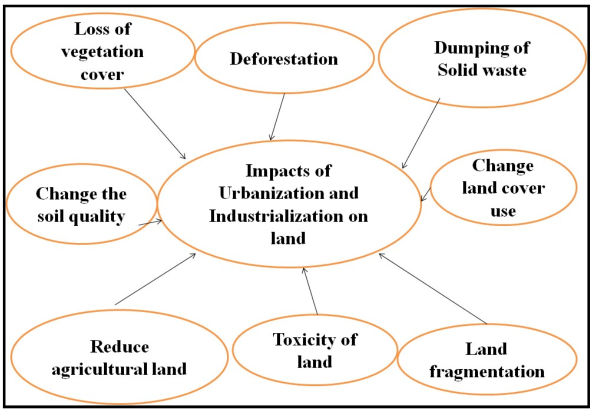

Fig-12: Effects of Urbanization and Industrialization on land

5.5.8 Mining

Mining is extraction of valuable minerals from the earth. Mining can affect land in various ways in the form of soil erosion, sinkholes, loss of biodiversity, contamination of soil etc. Impacts of mining on land get reflected in land use pattern of area because land gets exposed to erosion by losing its vegetation cover. According to Department of Environment, Govt. of India mining of certain minerals such as coal, iron ores, zinc, lead, copper, gold, limestone manganese, rock phosphates, chromites, silica are mostly responsible for land degradation in India.

5.6 Consequences of Land Degradation

As you know that Land degradation apparent itself in many forms such as soil erosion, increased sediment loading of water bodies, desertification etc. If we conclude the consequences of land degradation we will find land degradation is serious issue at international level. There are various consequences and outcomes of land degradation, some of the important consequences of land degradation are described below:

(i) Effect on Human Health

It is one of the important consequences of land degradation. As you know that we are entirely depends on land resources not only for transportation, forests but also for the food and fruits. Human being added various types of toxic chemicals in land. Such wastes contain toxic chemicals, and metals that have adverse effects on humans. Plastic waste, for instance, might contain acrylic, polyvinyl chloride, polycarbonate, and phthalates that are associated with cancers, skin diseases, respiratory disorders, and birth defects. Chemical components such as cadmium, arsenic, mercury, cyanide and chromium commonly found in pharmaceutical, pesticides, and fertilizer industrial wastes also have devastating effects on human health. They have cancer causing elements and can also lead to lung and kidney disease as well as liver damage. Many toxic chemicals which are being released in to land ecosystems can reach up to higher trophic level through bio-magnification and cause certain diseases in human being. Whenever land is polluted with agricultural and industrial waste, it leads to increase in dumping sites. These dumping sites also become breeding grounds for mice, flies, mosquitoes and birds that can transmit diseases. Therefore, land pollution may lead in to epidemic diseases such as cholera, typhoid, amoebiasis, etc. These dumping sites are contaminated with such kind of toxic chemicals that they can accumulate in human body via vegetables and foods that are grown in polluted lands.

(ii) Pollution

It is also one of the major consequences of land degradation. Soil Pollution is categorized under land pollution. Hence, when there is overuse of fertilizer chemicals or lands are degraded through toxic chemical and solid waste, the upper layer of the soil is degraded, causing soil pollution. The effects of agricultural and chemical wastes are the principal land pollution aspects cause soil pollution. Ultimately, the land losses its fertility and vegetation cover.

Land degradation may lead in to other types of pollutions. Landfills and dump sites generate appalling smells and odors in the areas which they are located which cause air pollution. In cities and towns located near huge dump sites and landfill areas, residents have experienced high scores of pungent smell. On the other hand, burning of solid waste contributes to air pollution. Land pollution can spread in all directions so that it results in an adverse impact on the immediate environments. It can contaminate water and significantly reduce its quality. It happens when the chemicals and other toxic substances from the landfills and solid wastes are mostly carried into waterways by surface rainwater runoff. At the same time, leaching takes place which makes the toxic chemicals to infiltrate into aquifers and water bodies. Also, the contaminated water evaporates and falls back as precipitation with the lot of impurities and contamination. In marine ecosystems, coastal zones are the most susceptible to pollution-related impacts arising from land degradation. There is evidence of global impacts as large stretches of coast can be affected, extending to reef and large marine ecosystems. The contamination of water, ecosystems and food-chains by agro-chemicals (chemicals used in agriculture such as insecticides, pesticides etc.) applied to or accumulating in soil is the huge impact associating land degradation with organic pollutants.

(iii) Loss of Biodiversity

During last few decades, the biodiversity have tremendously affected as they have persistently faced a serious threat regarding the loss of their natural habitat. As you know that habitat loss is major threats to biological diversity. The constant human economic activities on land have increasingly left the lands degraded forcing wildlife to move away and adapt to new areas. Consequently, many species have died while trying to adapt, some have gone extinct, and several are presently on the verge of extinction. As you know that land is home to millions of species, many organisms such as plants (Algae, Fungi, Bryophytes, Pteridophytes, Gymnosperm and Angiosperm), bacteria and animals (Nematodes, Earthworms, Arthropods (Butterflies, Moths, Honeybees, Dragon Flies, Amphibians, Reptiles, Birds and Mammals) are live on land ecosystems. These life diversities are certainly helpful to land ecosystem. Discharge of toxic chemicals on land makes the ecosystem unpleasant to the survival of plants and animals within their interactive food chain. The chemicals contaminate plants and waters which are then consumed by lower animals, and the food chain continues up the ladder in the ecosystem. The process is known as biomagnifications and is reported to be a serious threat to ecological sustainability. Disruption to land ecosystem functions unavoidably diminishes the diversity of above and below-ground biodiversity, as well as affecting aquatic milieu.

(iv) Loss of Nutrients and Land Productivity

It is estimated 6,000 Mt of soil is lost annually from the Indian subcontinent. This eroded material carries several valuable nutrients along with it, which are lost forever. Several nutrients are lost due to surface runoff and also due to leaching. In the areas where water percolation is high, the potentiality for leaching is also high. Soil properties also have a definite effect on nutrient-leaching losses. There is a greater nutrient loss in sandy soil than clay, because of higher rate of percolation and lower nutrient absorbing power of the sandy soil. Therefore, in sandy soil, the nutrients in the top soil are lost due to wind erosion and also due to more rapid leaching.

There are several other things lost due to land degradation and it is difficult to assess their economic value. These are:

- Loss of fodder and forage production, decline in production of timber.
- Loss of species of flora and fauna.
- Loss of water resource points as evident by drying up of springs and natural water bodies, and lowering of water level in wells.
- When the land is lost due to wind erosion or water erosion, apart from- physical, chemical and biological degradation, there is loss of employment opportunities. This leads to migration towards cities and towns, causing social problems related to unplanned urbanization.

(v) Economic loss

As you know land is economically very important. Land degradation causes loss of million dollars at global level. Landfills and dump sites also reduce air quality and can potentially threaten human health. Besides the loss of agriculture, land degradation also responsible for loss of biodiversity, diseases and deforestation etc. The cost of curing diseases, forests, biodiversity is immeasurable. Some studies showed that land degradation is directly correlated with tourism industry. Land degradation declines the numbers of visitors in an area. Therefore, land degradation put extra burden not only on local communities but on the economy of the Nation.

(vi) Natural Disasters:

Land degradation may lead in to different types of natural disasters such as earthquake, flood, landslides, landslips, etc. Flood is most occurring disaster of India. Due to land degradation, water runoff also increases which lead in to flood like conditions in an area. Floods may basically be due to unusually heavy rainfall, but intensity, frequency and severity of flood generally in land degraded area. However, many of the anthropogenic activities, that negatively affect the ability of land surface and soil profile to absorb, hold and utilize rain water. Land degradation also responsible for landslide, this is because land degradation reduces the water holding capacity of soil which cause landslips or landslides. You will find the details of land related hazards in unit-7 of this course.

Summary

In this unit we have discussed various aspects of various causes and consequences of land degradation. So far you have learnt that:

- Land is useful resource and may occur in the form of forest land, crop land, barren land, grass land, range land, snowy land, arid land and waste land.
- Land degradation is process in which land losses its productive capacity.
- Sources of land degradation may be categorized as natural causes and anthropogenic or manmade causes.
- Natural causes of land degradation include earthquake, landslides, land slips and flood
- Anthropogenic causes of land degradation may include deforestation, desertification, overgrazing, soil erosion, several agricultural practices, urbanization & industrialization, mining etc.
- There are various impacts of deforestation such as loss of nutrients in soil, landslides, loss of moisture content of soil, decrease in water holding capacity of soil, flood, desertification etc.

- There are various impacts of desertification such as flood, landslides, loss moisture content of soil, loss of biodiversity etc.
- Overgrazing may lead to desertification, low production, loss of valuable species, soil erosion etc. on the other hand solid waste also affected land and the main impacts of solid waste on land are: soil pollution, loss of biodiversity, bio-magnification, wasteland genesis etc.
- Various agricultural practices such as shifting cultivation, improper irrigation, water logging, and excessive use of agro-chemicals are also responsible for land degradation.
- Soil erosion may be categorized as erosion by water (sheet erosion, rill erosion, gully erosion, river stream erosion, and shore erosion) and erosion by wind.
- Loss of fertile soil is the main impact of soil erosion.
- Urbanization and industrialization also leads in to land degradation. There are various impacts of urbanization and industrialization on land such as deforestation, loss of vegetation cover, change in the soil quality, dumping of solid waste, reduced agriculture land, land fragmentation etc.
- Main consequences of land degradation are diseases, low production, loss of biological diversity, economic loss and natural disasters.

Terminal Questions

1 a) Fill in the blank spaces with appropriate words.

As you know that forests are very important resource which are not only responsible for purification of air but also play an important role in keeping fertility of land by shedding their leaves which contain many ……….. Forest Survey of India (FSI) defines a forest as ‘all the lands, more than ……. in area, with a tree canopy density of more than ……’. According to the State of Forest Report (2011) produced by FSI, area under forests in India is estimated to be 69.20 m ha, making up 21.02% of the total geographical area of the country. Forests are helpful in binding up of soil particles with the help of their roots. The areas of root (…….) also keep the soil moist and full with nutrients. Rhizosphere also contains many valuable microbes (…….., ………and…….) which are important biotic communities responsible for cycling of nutrients in soil. The term “Deforestation” refers to the loss of tree cover. Deforestation is conversion of forest land in to …… for different purposes such as agricultural pasture, urbanization, industrialization, commercial products etc. According to ………………(UNEP) about 7.3 million hectares of rich tropical forests every year and about 14 hectare of closed forest every ……… are lost. Therefore, deforestation will affect the land adversely. The term deforestation means removal of vegetative cover in the forest which may be anthropogenic or natural.

2 (a) Discuss the causes of land degradation.

(b) What are the impacts of desertification?

3 (a) Describe the causes and impacts of deforestation.

(b) Give the types of soil erosion

4 a) Define land degradation? Write about causes and impacts of agricultural practices on land?

5 (a) Discuss the impacts of urbanization and industrialization on land.

(b) What are the effects of solid waste on land?

(c) What are the natural causes of land degradation?

6 (a) Fill the blank spaces with appropriate words.

Soil erosion is just ………………... Soil erosion may be due to high rain fall, wind flow, animal and human activities. The top layer of soil is vital because all the ………… required by plants are present in this layer. According to Rama Rao (1962) soil erosion is creeping ……. of soil. Soil erosion depends on various factors like ………., ………, …….., nature of soil etc. Accelerated soil erosion by ……and …… is the major land degradation process and this is a consequence of changed relationship between environmental factors which occur as a result of human activities. Out of total geographical area (328.7 million hectare), about ………. of land (141.3 million hectare) subject to water and wind erosion, water logged area about ……… (8.5 million hectare), alkali soils about ……. (3.6 million hectare), acidic soils 1.4% (4.5 million hectare), saline soils including coastal sandy areas 1.7% (5.5 million hectare), ravine and gullies 1.2% (4.0 million hectare), area subject to shifting cultivation 1.5% (4.9 million hectare), riverine and torrents 0.8% (2.7 million hectare).

(b) Total geographical area of India is about 328.73 million hectare (Yes/No)

(c) Excessive feeding on pasture is called (desertification/overgrazing)

(d) Which one is severe form of soil erosion (Sheet erosion/rill erosion/gully erosion/shoreerosion)

(e) What do you understand by biomagnification?

7. (a) Describe the consequences of land degradation

(b) give the definitions of land degradation according to OECD, CCD and WHO

Answers to Terminal Questions

1 (a) valuable nutrients, one hectare, 10%, rhizosphere, bacteria, algae and fungi, non-forest use, United Nations Environment Programme, minute, space, air, fire, water and earth.

2 (a) see section 5.3, 5.4. and 5.5, (b) See section 5.5.2

3 (a) See section 5.5.1, (b) See section 5.5.6

4 (a) See section 5.2. and 5.5.5

5 (a) See the section 5.5.7, (b) see the section 5.5.4

(c) See section 5.4.

6 (a) Displacement of upper layer of soil, essential nutrients, death, topography, rainfall, gravity, water and soil, 43%, 2.6%, 1.1%,

(b) Yes, (c) Overgrazing, (d) Sheet erosion

(e) See the effect of solid waste on land in section 5.5.4

7 (a) See the section 5.6, (b) See the section 5.2.

References:

Aubreville, A. (1949). Climate, forests, desertification de Afrique tropicale, Society Editions Geographiques et Coloniales, Paris. Land Degradation & Development

Balasubramanian (2015). The Wastelands in India. University of Mysore.

Development of Wastelands and Degraded Lands. Ministry of Agriculture, Government of India (1985).

Eriksson, M. (2017). The role of soil biology to soil and plant health. Report of Sweden University.

Oldemann L.R., Hakkeling R.T.A., Sombroek W.C. (1991). World Map of the Status of Human-induced Soil Degradation: An Explanatory Note, 2nd revised edn. International Soil Reference and Information Centre, Nairobi/United Nations Environment Programme, Wageningen.

Sharma, P.D. (2018). Text book on Ecology and Environment 13th edition. ISBN: 978-93-5078-122-7.

States of forest report (2011). Forest Survey of India (Ministry of Environment & Forests). https://www.fsi.nic.in/forest-report-2011.

UNCD., (1977). United Nations Conference on Desertification (UNCOD). 1978. *Round-up, plan of action and resolutions*. New York: United Nations.

UNCED., (1992), United Nations Conference on Environment and Development (UNCED), Earth Summit Rio de Janeiro, Brazil 3-14 June 1992.

(UNFCCC), (2010). United Nations Framework Convention on Climate Change "Report of the Conference of the Parties on its sixteenth session, held in Cancun from 29 November 10 December 2010 http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf.

Unit 6: Waste Land Genesis: Types, Extent, Conservation and Management

Unit Structure

6.0 Learning Objectives

After studying this unit you will be able to find answer of the following:

- Define waste land
- Types of Wasteland
- Wasteland in India
- Factors are responsible genesis of wasteland
- Describe conservational methods of Wasteland
- Describe management of Wasteland

6.1 Introduction

You have learnt various causes and consequences of land resource in Unit-5 of this course. As you know, land is terrestrial bio-productive ecosystem. It comprises of soil, water, plants and other biotic communities. On the basis of ecological conditions, the land may be categorized as cropland, barren land, wetland, arid dry land, range land, grassland, snowy land and wasteland. Cropland is type of land in which crops are regularly planted and harvested. Barren land is areas characterized by exposed bed rocks, talus and other accumulation of rock without vegetative cones. Wetland is an area of land where soil is saturated with moisture either seasonally or permanently. Wetland includes swamps, marshes, bogs, etc. Various natural and anthropogenic causes are responsible for wasteland genesis. Land may be converted into wasteland by naturally or by anthropogenic activities. According to Food & Agriculture Organization of United Nations (FAO, 2014), 33% of the land is covered by forests, 26% by grasslands and pastures and 20% area is desert, 10% is covered by wetlands, 10% cropland and 20% is urban land. Wasteland is that land which has been used for production, but which has been abandoned and not suitable for cultivation. In this unit, you will learn about definitions, types and genesis of waste lands. You will also learn about the conservation and management of waste land.

6.2 Definitions of Wasteland

“Wasteland” has been defined by different workers in different ways. Some of the important definitions of wasteland are given below:

- It may be defined as “Wasteland is that land which has been previously used, but which has been abandoned, and for which no further use has been found.”
- Wasteland Survey and Reclamation Committee, Ministry of Food and Agriculture, Govt. of India (1961) has defined wastelands as “those lands which are either not available for cultivation or left out without being cultivated for some reason or other”.
- According to Bhumla and Khare (1987) “Those lands are wastelands

  (a) Which are ecologically unstable (b) whose top soil has nearly been completely lost, and (c) land which have developed toxicity in the root zones (rhizosphere) or growth of most plants, both annual crops and trees”.
- According to the National Wastelands Development Board (NWDB, 2007) “Wastelands those lands which are presently lying unutilized due to different constraints”.
- As per National Remote Sensing Agency (2000) “Wasteland is the degraded land, which can be reclaimed with reasonable effort, and which is currently under utilized/land, which is deteriorating for lack of appropriate water and soil management or on account of natural causes.

- In other words "Wastelands are those miscellaneous lands which are presently not suitable for, or capable of, producing materials or services of value due to some constraints ranging from geo-environmental to socio-economic causes".
- Wasteland is lying unproductive or not being utilized to its potential.
- Wasteland may be defined as the Land which has been abandoned and for which there is no further use. Or Wasteland is that land which produces < 20% of economic potential.
- Waste lands are those lands which are ecologically unstable, badly eroded and degraded.

6.3 Types of Waste Lands

The wastelands may include degraded forests, overgrazed land, eroded land, hilly slopes, waterlogged marshy lands, barren land, etc. The types of wastelands are created due to the natural and anthropogenic factors. Wasteland may also be valuable, however some of serious categories of wastelands are:

- **Degraded land**
- **Salinized land**
- **Waterlogged land**
- **Desert land**
- **Soil eroded land**

The factors responsible for the development of wastelands are numerous. An analysis of the factors reveals that the development of wasteland occurs through an unhealthy interaction of three forces viz., man, nature and technology. Though, the natural factors are of importance, man's ability to utilize land with the help of technological innovations also plays a major role in the development of wastelands. In order to enumerate and monitor the responsible factors of wasteland genesis some important physical variables like relative relief, drainage density, slope, and geological basis of the study area are considered.

6.3.1 Categories of Wasteland for Identification

A) Culturable Wasteland: The land which has potential for the development of vegetative cover and is not being used due to different constraints of varying degrees, such as erosion, water logging, salinity, etc. These are cultivable wastelands which are not being utilized to their full potential or are being mismanaged due to various reasons such as State or private occupation or having being declared as notified forest area. Such culturable wastelands include gullied, surface water logged marshy, undulating and saline lands. Also included in this category are the wastelands based on ecological limitations such as degraded forests and pastures, shifting cultivation areas, sand dunes or mining spoils, etc.

Table 1. Categories of wasteland for Identification
(Based on causative agents)

Water	Wind	Man	Others
Sheet Erosion	Sand Dunes	Mine Spoils	Land Slides
Rill Erosion	Sand Bar	Shifting Cultivation	Shallow Soils
Gully Erosion	Coastal	Industrial Wasteland	
Ravinous Land	Sand		
Saline Soil			
Marshy Land			
Water Logged			
Alkali Soil			

B) Unculturable Wasteland: The land that cannot be developed for vegetative cover, for instance the barren rocky and snow covered glacier areas. These are the wastelands, which are not available for cultivation. These include barren rocky lands, steep sloping areas and areas covered by snow or glaciers. Formation of wastelands leads to the deterioration of the ecological balance by adversely affecting the various components of the ecosystem directly or indirectly dependent on that particular land.

Table 2. Different types of waste lands created due to limiting factors) Source: Ministry of Agriculture, Government of India (1985)

Type of waste land	Area in Mha	Percentage
Gullied or ravenous land	2.06	0.65
Land with\ without scrub	19.40	6.13
Water logged\marshy land	1.66	0.52
Land affected by salinity	2.04	0.65
Shifting cultivation land	3.51	1.11
Degraded notified forest land	14.07	4.44
Degraded grazing land	2.60	0.82
Degraded land under plantation	0.58	0.18
Sandy area	5.00	1.58
Mining industrial waste land	0.12	0.04
Stony land/barren rocky/sheet rocky land	6.46	2.04
Steep sloping area	0.77	0.24
Snow covered glacier area	5.58	1.76
Total	**63.84**	**20.16**

6.4 Waste Land in India

In India, the total area under degraded and wasteland is **114.01Mha**. Extent of area under water erosion is **23.61 Mha** and under wind erosion is about **8.89 Mha.** There are various types of wastelands such as gullied or ravenous, water logged, land affected by salinity, shifting cultivation land, over grazed land, sandy land, wasteland due to mining and industrial activities, snowy land and barren land found in India, which are summarized in Table-2.

Table-3: Showing Extent of degraded land (FSI, 1996)

Type of land degradation	Area in mha
Water eroded	111.26
Wind eroded	38.74
Water logged	6.00
Alkali soil	2.50
Saline soil	2.50
Ravines & gullies	3.97
Shifting cultivation	4.36
Reverine& torrents	2.73
Total problem area	**175.06**
Total geographical area of India	**328.6**

In India, the total area under degraded and waste lands is 114.01Mha. Water eroded area formed due to localized overland flow of water. Flow of water can degrade/erode the soil and formed channels called Gullies. M.P, and Rajasthan are the states of India having more ravine land, followed by Uttar Pradesh (Fig-1). The land with or without scrub maximum in Madhya Pradesh (19%), followed by Maharashtra (16%), Rajasthan (14%) and Gujarat (11%) (Fig-2). This type of land is eroded due to erosion (Ministry of Agriculture, Government of India,1985).

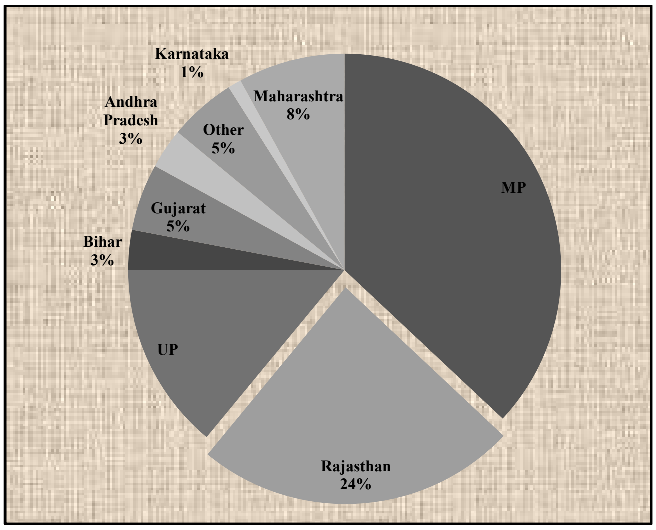

Fig-1: Showing percentage of water eroded area in different states of India (Ministry of Agriculture, Government of India (1985)

Water logged area is mostly covered by wetlands. This water logged land is ecotone/transitional zone between aquatic and terrestrial ecosystems. The highest water logged land is found in

Uttar Pradesh (30%), followed by Gujarat (16%) and West Bengal (12%). Soil salinity or alkalinity severe affects the growth of plants. As you know, salinity of soil is controlling factor of agriculture. Mainly, Gujarat (38%), Uttar Pradesh (29%), Rajasthan (13%) and Tamil Nadu (12%) states are having this type of waste land.

Land degraded due to shifting cultivation is result of cyclical land use with felling of trees and burning of forests for cultivation this type of wasteland land found in north states of India. Maximum wasteland due to shifting cultivation is found in Manipur (34%), followed by Assam (24%), Nagaland (15%), Mizoram (11%), Arunanchal Pradesh (9%), Meghalaya (6%) and Tripura (1%). Underutilized wasteland is maximum in Andhra Pradesh (16%), followed by Madhya Pradesh (15%) and Maharashtra (10%).

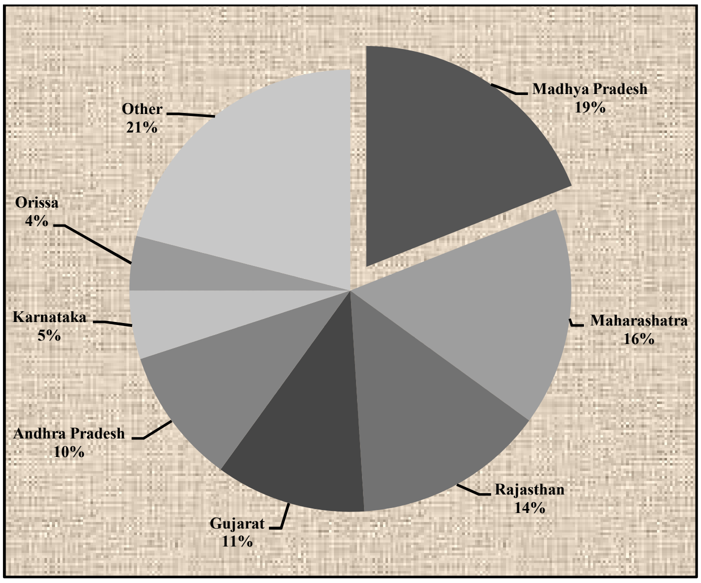

Fig-2: Showing percentage of land with or without scrub area in different states of India

Over grazing also responsible for genesis of wasteland, grazing land is maximum in Rajasthan (47%) followed by Himachal Pradesh (16%), Assam (9%) and Arunachal Pradesh (8%). Land degraded due to plantation is maximum in Himachal Pradesh (42%), followed by Madhya Pradesh (16%), Maharashtra (12%) and Jammu & Kashmir including Ladakh (11%).

Table-4: Estimated Area under the Wastelands provided by different organizations

Source	Area (mha)
Ministry of Agriculture and the JNU, Deptt. of Geography (1986)	175
National Land Use and Wasteland Development Council (First Meeting 1986)	123
Society for Promotion of Wasteland Development (1982)	145
Ministry of Rural Development & NRSA (2000)	64

Table 5.State-wise wasteland of India (Source: Wasteland atlas of India)

State wise wastelands of India- NRSA (Information as on year 2003)			
State	**Wasteland (Area: In square km)**	**State**	**Wasteland (Area: In square km)**
Andhra Pradesh	45267.15	Manipur	13174.74
Arunachal Pradesh	18175.95	Meghalaya	3411.41
Assam	14034.08	Mizoram	4469.88
Bihar	5443.68	Nagaland	3709.40
Chhattisgarh	7584.15	Orissa	18952.74
Goa	531.29	Punjab	1172.84
Gujarat	20377.74	Rajasthan	101453.86
Haryana	3266.45	Sikkim	3808.21
Himachal Pradesh	28336.80	Tripura	1322.97
J & K including Ladakh	70201.99	Tamil Nadu	17303.29
Jharkhand	11165.26	Uttarakhand	16097.46
Karnataka	13536.58	UP	16984.16
Kerala	1788.80	WB	4397.56
Madhya Pradesh	57134.03	UTs	314.38
Maharashtra	49275.41		
Manipur	13174.74		
		Total wasteland (sqkm) =	**552692.26**

Sand areas are expected along the coasts and riverine area. Most of the sand area land is found in state Rajasthan (81%). Mining and industries are also responsible for genesis of wasteland. Dumping of mines waste and effluent discharge creates land unproductive. Bihar (15%) having maximum waste land due to mining followed by Madhya Pradesh (11%), Rajasthan (10%) and Tamil Nadu (10%), Goa (9%), Maharashtra (8%) and Andhra Pradesh (8%).

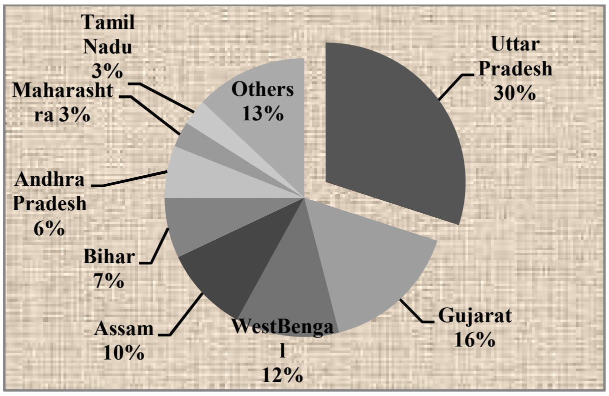

Fig-3: Water logged area (%) in different states of India

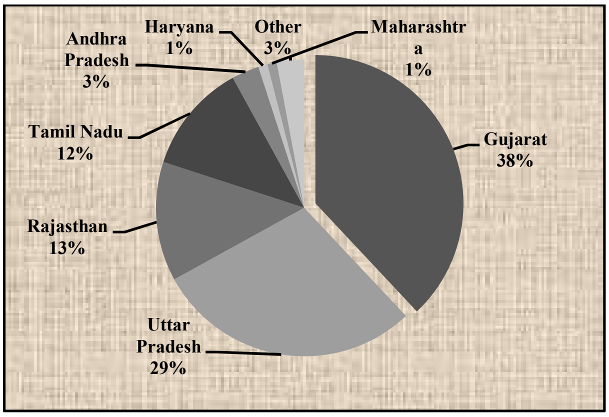

Fig-4: State wise saline land (%) in different states of India

Barren lands exposed to rocks and stones. This type of wasteland mostly found in states like Jammu & Kashmir (51%), Andhra Pradesh (8%), Rajasthan (7%), Himachal Pradesh (6%), Gujarat (5%), Madhya Pradesh (5%), Karnataka (4%) and Maharashtra (4%). Steep slopes are also responsible for wasteland genesis. Landslides may not allow any production in this type of land. Generally this type of land found in hilly states of India. These types of wasteland are maximum in Jammu & Kashmir including Ladakh (20%), followed by Himachal Pradesh (18%), Maharashtra (16%) and UP & Uttarakhand (12%).

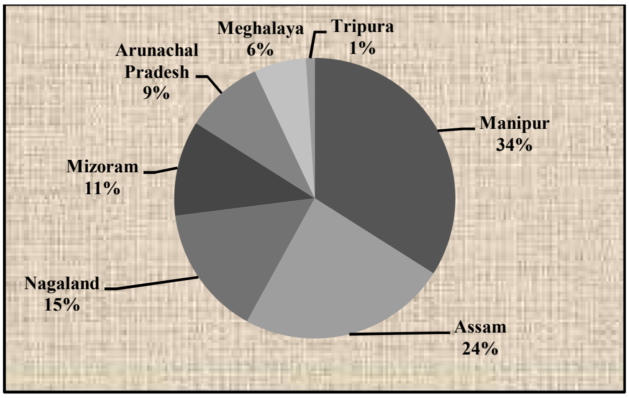

Fig-5: Percentage of shifting cultivation land in different states of India

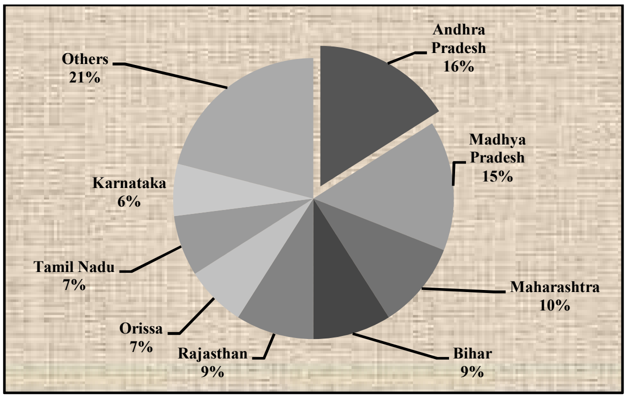

Fig-6: Percentage of underutilized land in different states of India

Land also covered by snow which is also regarded as wasteland. This type of wasteland is maximum in Jammu & Kashmir Including Ladakh (38%), followed by Uttarakhand (24%), Himachal Pradesh (23%), Arunachal Pradesh (12%) and Sikkim (3%). The data collected can be Climatic (rainfall, temperature, wind velocity); Topography

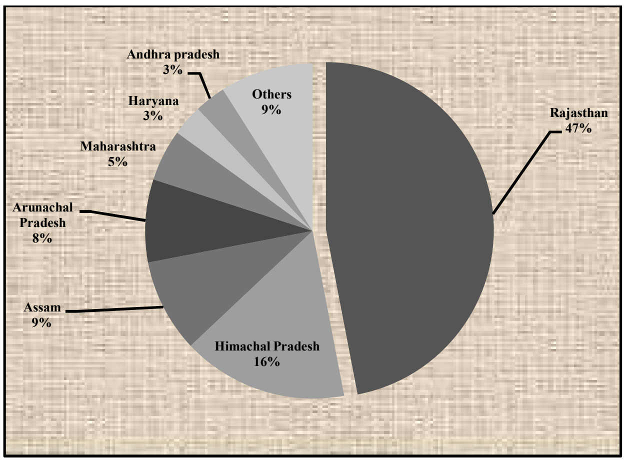

Fig-7: Percentage grazing wasteland in different states of India

(angle of slope, length of slope); Erosion (the extent and intensity of erosion); Soil Properties (physical and chemical). There is a need for site-matched technology to make the soil productive at a rapid rate because in nature the changes that occur rapidly take 200 – 400 years to attain equilibrium. The method used for improvement of wasteland will depend on the type of wasteland. Some traditional methods can be the in-situ conservation methods for improving the moisture content of soil (bunding, terracing, etc.); to promote natural regeneration, water harvesting and promoting agro-forestry.

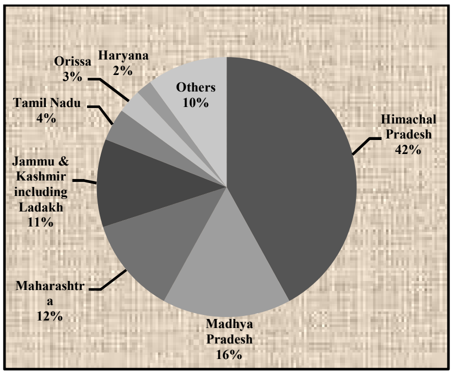

Fig-8: Percentage of wasteland due to plantation in different states of India

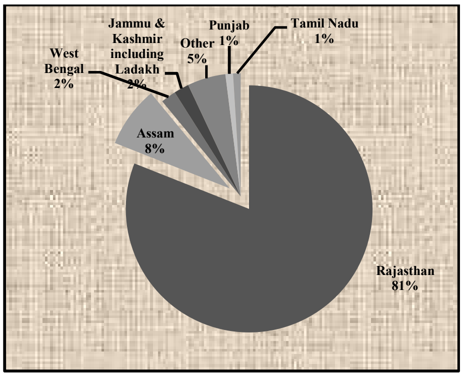

Fig-9: Percentage of sandy area in different states of India

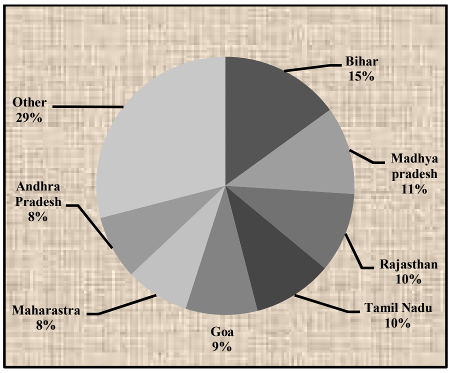

Fig-10: Percentage of waste land due to mining in different states of India

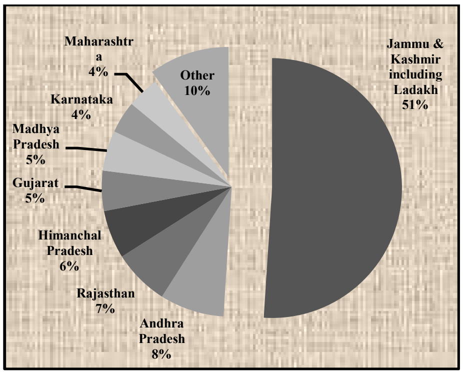

Fig-11: Percentage of barren land in different states of India

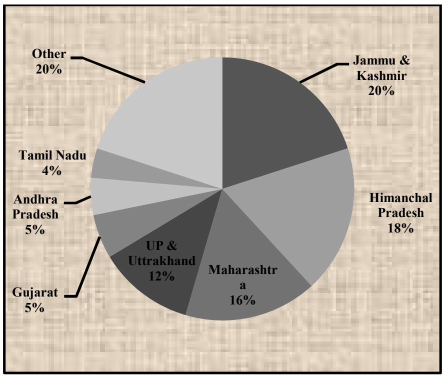

Fig-12: Percentage of steep slopes in different states of India

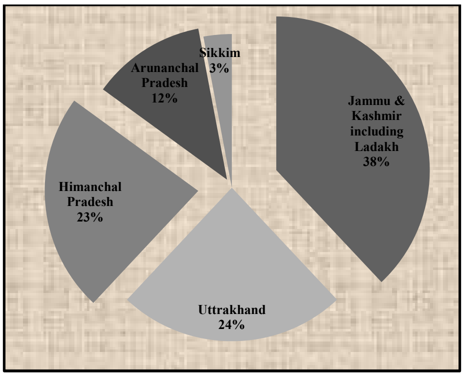

Fig-13: Percentage of land covered by snow in different states of India

6.5 Waste land Genesis

6.5.1 Genesis of waste land

There are various factor of waste land formation viz., utilization of forest products, overgrazing, developmental projects, misuse & unscientific land management wasteland genesis may either by naturally or by anthropogenic activities. The undulating upland, sandy land, snow covered land, coastal saline land, are caused by naturally on the other land formation of gullied or ravenous land, Jhum/shifting cultivation and barren hill ridges are caused by manmade or anthropogenic activities.

There are four important anthropogenic activities that lead to waste land genesis. These activities are deforestation, overgrazing, over cultivation, and unscientific irrigation. Waste land genesis may also takes place by over exploitation of natural resources, industrial and sewage waste, soil erosion, water logging, scientific, etc.

6.5.2 Extent of Waste Land

National Remote Sensing Centre (NRSC) estimate put waste land at 20.17% of the total area of country, out of this 16.74 % is cultivable and rest 4.4% is uncultivable. The wasteland is found maximum in Jammu & Kashmir including Ladakh (60.10%).

1. Salinity: Improper irrigation and high rainfall in the absence of proper drainage can leads to salinization of soil. Salinization can cause high concentration of salts in soil profile. Salinity of soil is also responsible for genesis of waste land. Seepage from canals high underground water level, saline ground water also responsible for salinity. Salinity makes the land unproductive and unculturable **(**Ministry of Agriculture, Government of India (1985).

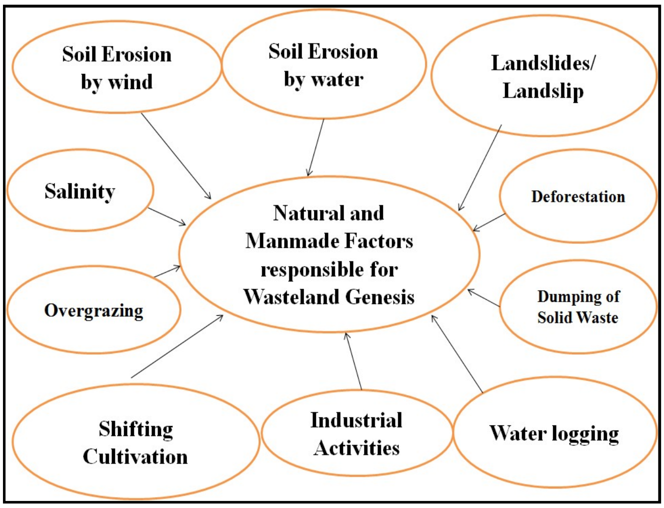

Fig-14: Factors contributing to waste land genesis

2. **Water logged Areas:** About 6 million hectare area of India is water logged. Water logging restricts the normal circulation of air in soil. It is also responsible for high salinity in soil and leads in to genesis of waste land **(**Ministry of Agriculture, Government of India (1985)**.**
3. **Shifting Cultivation:** Shifting cultivation is type of agriculture in which dense forest cleared for the cultivation of crops. After using the fertile soil of forests farmers look for another forest and practiced similar activity in another part of forest. This type of agriculture practice is also responsible for the genesis of waste land. In India this type of agriculture practice mainly takes place in North-East states. Shifting cultivation or jhuming is a primitive form of cultivation practiced in north-eastern states of India or in regions where land is not a limiting factor. The dense forest and other vegetation on the slopping or other land is cleared and crops raised without any management. For management of jhumed land the suitable land for intensive cultivation have to be identified. Depending on the climatic factors, soil characters and other related features intensive system of land use and cropping pattern will have to be evolved for each specific site without being damaging to environment. **(**Ministry of Agriculture, Government of India, 1985**)**
4. **Deforestation:** Due to rapid destruction of forest, huge amount of land converted is to waste land. As you know forest are important to maintain of fertility of soil, but due to high demands of infrastructure, food the forest land converting is to wasteland. Forests are also home to many species, these species also helpful in maintaining soil fertility. Due to deforestation, these valuable species can’t survive for longer time. Therefore, deforestation is also important factor of wasteland genesis. (Ministry of Agriculture, Government of India, 1985)
5. **Excessive use of Agro-chemicals:** Agrochemicals refer to chemicals which are used in the agriculture. These chemicals may include fertilizers and pesticides. Excessive use of these agro chemicals is not only responsible for extinction of valuable species of land but also responsible for genesis of waste land (Balasubramanian, 2015).
6. **Industrial activities:** Various types of industries release their effluent on land ecosystem, sometimes industrial effluent contains very toxic chemical which destroy the overall biodiversity of land. Industrial waste material makes land unproductive and infertile and cause genesis of wasteland (Balasubramanian, 2015)

7. Landslides: The problem of landslides and landslips is common especially in the hilly areas posing threat to agricultural lands, highways and village habitants. The main causes for land-slides are weak geological formations, seismic disturbances, improper land use, deforestation, mining, etc. Landslides and landslips may change the structure of landscape, and responsible for waste land genesis (Balasubramanian, 2015).

6.6 Conservation of Land

Land conservation may comprise as preservation, restoration, remediation and mitigation. In preservation process the land and their related resources, are not exploited by man and should instead be maintained in their natural form. Restoration involves the process in which land ecosystems and related communities rather to their natural conditions. In remediation process, we use various techniques to remove contamination from the land. These techniques may include: Bacteria, remediation, phyto-remediation, compost remediation and myco-remediation. These techniques collectively called as bio-remediation.

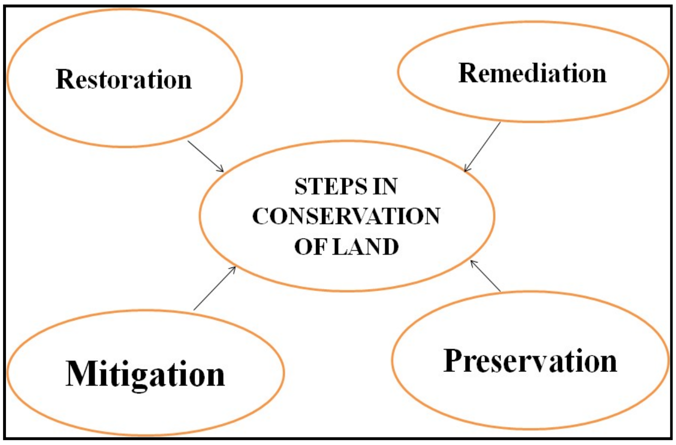

Fig-15. Different steps in Land conservation

Waste land reclamation and development in our country falls under the purview of Waste land Development Board, which works to fulfill the following objectives.

- To improve the physical structure and quality of the marginal soils
- To improve the availability of good quality water for irrigating these lands
- To prevent soil erosion, flooding and landslides
- To conserve the biological resources of the land for sustainable use

Some important reclamation practices are discussed below.

1. **Soil Erosion Control:** As you know soil erosion is responsible for land degradation and waste land genesis. If we control the soil erosion, we certainty

conserve the land. Soil erosion can be controlled by various agriculture techniques like contour farming, strip cropping, terracing, gully reclamation and shelter belts. Contour farming generally takes place across the slope. Strip cropping is also effective agriculture methods in which agricultural field partitioned into long, narrow strips to prevent soil erosion. Terracing method applied in sloped plane. This method decreases soil erosion and surface run off.

Gullies are the sign of rapid eradication of soil. If gullies appear on the land, we should seeded it quickly growing crops. Shatter belts are the belt of plants which prevent the force of wind and water and reduce the chance of soil erosion. Soil erosion may also control by plantation, control over grazing and flood control.

2. **Land Slide Control:** Landslide is also responsible for genesis of wasteland. It is regarded as both type of natural disaster i.e., natural or manmade. Naturally, landslide may happen due to heavy rainfall, geographic conditions and gravity on the other land deforestation, mining and agricultural practices are manmade causes of landslides. We can reduce the anthropogenic activities which are responsible for landslides. If we can control land slide, we can conserve the land, significantly. Landslide generally occurs in hilly regions. Landslides cab be controlled by plantation, we should maintain the vegetation as much as possible on slopes. In addition to that uncontrolled or excessive irrigation must be avoided in landslide prone areas. (Balasubramanian, 2015)
3. **Afforestation:** Forests play very important role in conservation of land. Forest maintains the fertility of land, and keeps the soil moist and fertile. Afforestation also contributes to sustainable management of land. Ministry of Environment, Forest and Climate Change (MoEFCC) has target at 5 million hectare waste land recovery through afforestation.
4. **Improve agriculture practices:** Conservation of land can be done with modern, sustainable and appropriate agricultural practices. In these sustainable agricultural practices, farmers use bio-fertilizers, bio-insecticides, bio-pesticides and micro-irrigation techniques.
5. **Solid Waste management:** For the conservation of land, we should manage the solid waste. As are know, solid waste is responsible for genesis of wasteland and it contains very harmful chemicals, which gradually degrade the quality of soil. If, we

can manage the solid waste of the cities and industries, then we can conserve the land resources significantly.

6.7 Management of Wasteland

Management of land is a process in which we can manage the land resource and also can develop land resources for the present generation as well as for future generations. Land management can be done if we consider the factors responsible for wasteland generics. There are various methods which are certainly helpful in land management. These methods are described below:

1. **Forest Conservation:** Forest conservation is a best tool to conserve land resources. Increasing degradation of forests specially, in the hilly regions contribute to heavy soil erosion. It causes acute shortage of firewood and loss of productivity due to degraded land. The National Forest Policy clearly identified the various uses of forests, rights of communities, including the inadvisability of protecting forest resources without their active participation, and the role that forests play in the survival strategies of the poor. The major systems in the Wildlife division focus on conservation, protection and development of wildlife and their habitats. The main strategy for conversation of bio-diversity is protection of variable habitats in representative ecosystems. A wide network of 103 National Parks, 503 Wildlife Sanctuaries, 30 Tiger Reserves and 18 Biosphere Reserves has contributed towards conservation of these species and forest resources too. Finally, environmental resource management must be seen as a measure for the optimum utilization of the scarce natural resources available in India and to safeguard and preserve the environment around us. It is well observed that a large area in the country is eroded due to soil erosion by water.

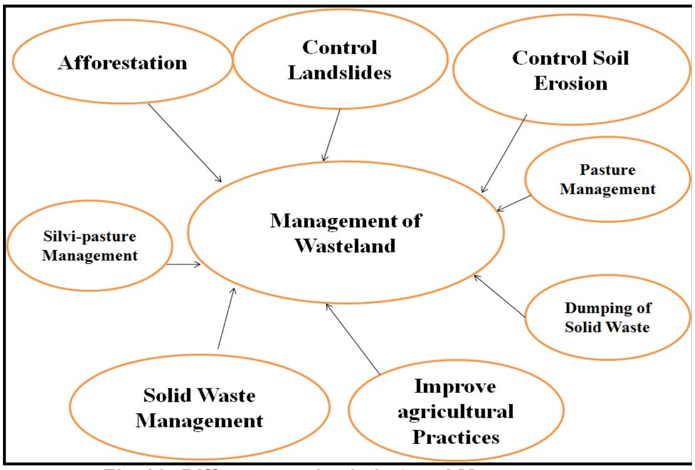

Fig-16- Different methods in Land Management

The causes of this erosion are mainly lack of vegetative cover, slope, nature of soil, rainfall, and its intensity, cropping system and land management. Depending upon intensity of soil erosion, it may be categorized into;

i) Sheet erosion

ii) Gully erosion

iii) Ravines

Appropriate measures may be suggested based on these categories to check runoff and loss of soil. Cultural practices used for checking runoff and soil loss include planting erosion-resistant crops, like legumes and grasses, adopting suitable cropping system, management and use of mulches. Mechanical measures involving some degree of earth movement like bunding terracing, etc. are found effective in checking runoff and soil loss by increasing the time of concentration and reducing velocity of runoff. Contour cultivation and graded trenching (diversion) are also effective for erosion control.

2. **Grassland development:** Development of grassland ecosystem also important aspect to manage the land resources. Grass binds the soil particles and prevents the soil erosion. Grasses like *Cenchrus ciliaris, Lasiurus sindicus, etc.* were found effective in arresting drifting of soil. It is suggesting that degraded lands in wind erosion prone areas may be kept back under the grasses. If we develop grassland ecosystem, then we can manage the land resources significantly (Ministry of Agriculture, Government of India, 1985).
3. **Strip cropping:** Strip cropping is also effective method in land management. The field strip cropping of grain legumes or cereals in grass strips developed at the Central Arid Zone Research Institute (CAZRI) is very effective tool for controlling wind erosion.
4. **Mulching:** Mulching is found very effective in reducing the wind erosion.
5. **Agro-horticultural forestry in waste land:** This system is the combination of food and vegetable crops with related to horticultural crops. This system is noticed more common in the developing orchards in which trees have not started fruiting. Most commonly legumes and oil seeds are grown in such fields/orchards. The tall growing fruit trees are pruned in such a way to facilitate easy cultural operations and any seasonal crop like wheat, gram, etc. is cropped in inter-row space. These

crops not only enhance per unit land income, but also manage the land by covering the field.

6. **Agro-forestry:** Agroforestry is effective method for the management of land. Indeed, it is land management system in which trees or plants are grown within pasture land. It is a self sustaining land management system which combines production of agricultural crops with trees, livestock and plants simultaneously or consequently on the same area of land. This type of approach increases the biodiversity, soil productivity and economy.
7. **Agronomic Approach for vegetative cover**: As it is earlier mentioned that plants, trees and grasses play very significant role in land management. Bringing the land resources under proper vegetation check or prevent most of the degradation of the land. The vegetative cover may be for various uses like for forage and fuel, sustained crop production, pasture, silviculture and other socio-economic uses.
8. **Forage and fuel production:** The degraded lands and wastelands are ecologically unbalanced and have lost their top fertile soils and have developed toxicity which hinders growth of the plants, crops and trees. Under managed conditions with basic inputs, it has been found possible to grow high-yielding grasses, legumes and trees for forage and fuel purposes. The suggested species of trees, grasses and legumes are: *Acacia tortilis, A. lebbek, Hardceikia binata, Leucaena leucocephala, Dalbergia sissoo, D. latifolia, Azadirachta indica, Cenchrus ciliaris, Sehima nervosum, Stylosanthes hamata, Phaseolus atropurpureus, etc. (*Ministry of Agriculture, Government of India, 1985)
9. **Sustained Land Use:** Human being entirely depends on land resources for their daily needs. Unfortunately, human being over exploited these resources. If we can reduce the extra needs and greeds of human being then we can manage the natural resources. We should minimize the burden on fuel, fodder, food etc. Excessive use of chemicals (pesticides, insecticides, rodenticides, molluscides, herbicides, chemical fertilizers) should be avoided.
10. **Pasture Management: By pasture management technology, we can manage the land resource.** It involves a combination of number of steps, package of practices and inputs like renovation of degraded range lands and their restructuring with mosaic flora or species or cultivars of grasses and legumes in

pure and mixed stand and upgrading the soil and plant nutrients through fertilizer application. In this technology, pasture kept free from unwanted weeds, toxic substances, solid waste, etc. Various types of plants are also grown in pasture management technology. The desirable species for pasture management are *Conchrus setigerus*, *C. ciliaris*, *Lasiurus sindicu*, *Panicum antidetab,* etc.

11. **Silvipasture Management:** Greater demand for fuel wood and small timber for human consumption and the forage and fodder for livestock and wildlife and also contribute the land degradation. Silvipasture seems to be the best system for economic utilization of degraded or waste lands. Silvipasture system of land management covers three major items:
    - Trees valuable in themselves as conserver of land and for improving the climate specially in arid and semi-arid zones besides their fuel and timber values.
    - Animals grazing on the pasture and feeding on the leaves of nutritious trees and shrubs.
    - Occasional production of cash crops. In this system, the plant components chosen are trees, shrubs, grasses and legumes.
12. **Socio-economic consideration for optimum land use:** Land management can be done with optimum use of land. For a balanced ecological system, it is a well established fact that 33% total geographical area should be under forest. To a big amount farmers are choosing cash crops like wheat and paddy to get more profit but still there is a gap between the production and requirement of oilseeds, pulses and forage crops. Depending upon the suitability and other regional factors like soil, available facilities and need, growing oilseeds, forage and pulses on partially degraded land may balance the social and economic aspects of human life. While bringing the uncultivable land under forest will definitely improve our ecology and environment.

Summary

In this unit we have discussed types, genesis, conservation and management of Waste land. So far you have learnt that:

- Land is useful resource and may occur in the form of crop land, barren land, grass land, range land, snowy land, arid land and waste land.

- Land is terrestrial bio-productive ecosystem. It comprises of soil, water, plants and other biotic communities. On the basis of ecological conditions, land may be as: Cropland, Barren land, wetland, arid dry land, Range land, Grassland, Snowy land and Waste land.
- According to Dudley Stamp (1954), "Waste land is that land which has been previously used, but which has been abandoned, and for which no further use has been found."
- Waste land Survey and Reclamation Committee, Ministry of Food and Agriculture, Govt. of India (1961) has defined waste lands as those lands which are either not available for cultivation or left out without being cultivated for some reason or other. Or "Those lands are waste lands; (a) which are ecologically unstable, (b) whose top soil has nearly been completely lost, and (c) which have developed toxicity in the root zones or growth of most plants, both annual crops and trees".
- Waste land may be as culturable Waste land which has potential for the development of vegetative cover and is not being used due to different constraints of varying degrees, such as erosion, water logging, salinity, etc. and unculturable Waste land, the land that cannot be developed for vegetative cover, for instance the barren rocky areas and snow covered glacier areas.
- There are various types of waste land found in India, waste land of India may be categorized as Gullied or ravenous land, Land with/without scrub, Water logged\marshy land, Land affected by salinity, Shifting cultivation land, Degraded notified forest land, Degrading grazing land, Degraded land under plantation, Sandy area, Mining industrial waste land, Stony land/barren rocky/sheet rocky land, Steep sloping area, Snow covered glacier area. About 63 million hectare area of India regarded as waste land.
- Genesis of waste land may cause naturally or by anthropogenic activities. The causes of waste land genesis are: Salinity, Water logging, Shifting Cultivation, Deforestation, Excessive use of fertilizers, Industrial activities, Water logging and Landslide,
- Land conservation may be done through various process such as soil erosion control, land slide control, Afforestation, Improve agriculture practices, Solid Waste management, Water Logging Control etc.

- Management of land may be done through forest conservation, grassland development. strip cropping, mulching, agro-horticultural forestry in waste land, agroforestry, agronomic approach for vegetative cover, forage and fuel production, sustained land use, pasture management, silvi-pasture management, socio-economic consideration for optimum land use, etc.

Terminal Questions

1. (a) Fill in the blank spaces with appropriate words.

In India, the total area under degraded and waste lands as………. Water eroded area formed due to localized overland flow of …….. Flow of water can degrade/erode the soil and form channels called Gullies. The land with or without scrub maximum in ……..(19%), followed by Maharashtra (16%), Rajasthan (14%) and Gujarat (11%). This type of land eroded due to erosion. Water logged area mostly covered by…….... This water logged land is ecotone/transitional zone between ……and ……..ecosystems. The highest water logged land is found in ………(30%), followed by Gujarat (16%) and West Bengal (12%). Soil salinity or alkalinity severe_affects the growth of plants. As you know, salinity of soil is controlling factor of agriculture. Mainly, Gujarat (…….), Uttar Pradesh (29%), Rajasthan (13%) and Tamil Nadu (12%) states having this type of ……..

2 (a) Give the definitions of waste land.
(b) What are the types of waste land? Explain

3 (a) Differentiate between culturable and unculturable waste land.
(b) Give a note on waste land of India

4 a) Define waste land genesis. Write about factors which are responsible for waste land genesis.

5 (a) Write about steps involved in land conservation.
(b) Write a note on Land Conservation.
(c) What are objectives of Waste land Development Board?

6 (a) Fill the blank spaces with appropriate words.
Land degraded due to ……is result of cyclical land use with felling of trees and burning of forests for cultivation this type of waste land land found in ……. of India. Maximum waste land due to shifting cultivation is found in Manipur (……), followed by …….(24%), Nagaland (……), Mizoram (11%), Arunanchal Pradesh (9%), Meghalaya (6%) and Tripura (1%). Underutilized waste land is maximum in Andhra Pradesh (16%), followed by Madhya Pradesh (15%) and Maharashtra (10%). Over grazing also responsible for genesis of……., grazing land is maximum in ……(47%), followed by Himachal Pradesh (16%), Assam (9%) and Arunachal Pradesh (8%). Land degraded due to plantation is maximum in Himachal Pradesh (42%) followed by Madhya Pradesh (16%), Maharashtra (12%) and Jammu & Kashmir including Ladakh (11%). Land also covered by snow which is also regarded as waste land. This type of waste land is maximum in ……….(38%)

followed by ………..(24%), Himachal Pradesh (23%), Arunachal Pradesh (12%) and Sikkim (3%).

(b) Which part of the Country has maximum waste land due to shifting cultivation? (North-East/South-West/Eastern Part/Northern Part)

(c) Which state of India has maximum waste land? (Jammu & Kashmir including Ladakh/Gujarat/ Uttarakhand/ Madhya Pradesh)

(d) Which one is not responsible for waste land genesis? (Bio-remediation/Deforestation/Overgrazing/Water logging)

(e) What do you understand by shifting cultivation?

7 (a) Write a detailed essay on Land management.

Answers to the terminal questions

1 (a) 114.01Mha, water, Madhya Pradesh, wetlands, aquatic, terrestrial, Uttar Pradesh, 38%, Uttar Pradesh

2 (a) See the section 6.2, (b) See the section 6.3.

3 (a) See the section 6.3, (b) See section 6.4

4 (a) See section 6.5

5 (a) See the section 6.6 (b) See the 6.6, (c) See section 6.6

6 (a)Shifting cultivation, North-East states, 34%, Assam, 15%, wasteland, Rajasthan, Jammu & Kashmir including Ladakh and Uttrakhand, (b) North-East, (c) Jammu & Kashmir including Ladakh, (d) Bio-remediation, (e) See the section 6.5 (Shifting Cultivation)

7 (a) See the section 6.7.

References:

1. Balasubramanian (2015): THE WASTELANDS IN INDIA. University of Mysore.
2. Bhumbla, D.R. and Khare, A. (1987) Estimate of Wastelands in India. Society for Promotion of Wastelands Development, New Delhi.
3. Development of Wastelands and Degraded Lands. Ministry of Agriculture, Government of India (1985).
4. FAO (2014). State of the World's Forests 2014. Rome (available at www.fao.org/forestry/sofo/en/).
5. Forest Survey of India (1996). http://fsi.nic.in
6. Ministry of Rural Development and National Remote Sensing Agency (NRSA), Wastelands Atlas of India 2000, National Remote Sensing Agency, Dept. of Space, Govt. of India, Hyderabad 2000.
7. *National Wastelands Development Board (2007): Government of India. https://dolr.gov.in/integrated-wasteland-development-programme*
8. Sharma, P.D. (13th edition): A text book on Ecology and Environment. ISBN: 935078122.
9. Wasteland Atlas of India (2003). India Environment Portal.

Unit 7: Land Related Hazards and Mitigation: Landslides, Landslips, Earthquake and Droughts

Unit Structure

7.0 Learning Objectives

After studying this unit you will be able to:

- Describe land related hazards
- Define landslides, landslips, earthquake and drought
- Discuss the types of landslides, landslips and drought
- Discuss the causes, impacts and mitigation measures of Landslides
- Discuss the causes, impacts and mitigation measures of Earthquake
- Discuss the causes, impacts and mitigation measures of drought

7.1 Introduction

The Earth is the repository of the raw materials that support life. Our natural resources and habitats are ultimately the result of dynamic processes within our planet and processes that are also source of natural disasters. According to estimation, thousands of people will be lost in the upcoming times from catastrophic earthquakes, droughts, floods, and landslides. Billions or millions of dollars will be needed to mitigate losses from these natural disasters as well as from slower ongoing processes such as land subsidence, soil and water contamination, and erosion. Basic scientific advances are needed to inform these investments to protect life and infrastructure. Landslides, earthquakes and droughts are regarded and classified as natural disasters. These are natural phenomena that might have great negative impacts on ecology and socio-economy on any Nation. Natural disasters mainly categorized as two broad types. First category is Geophysical disaster and these may include earthquake, drought, landslides, volcanic eruption, flood, forest fires, etc. Second category of natural hazard is biological hazard which may include diseases and infections.

According to Kates (1978), environmental hazard is "the threat potential posed to manmade or natural activities by event originating of nature. Literally, hazard means "risk" hazard may be categorized as:

- On the basis of source of energy, these may be biological (energy source are living organisms examples are: diseases and infections); chemical (energy source are chemical components) physical (energy sources are physical activities of earth examples: Earthquake, cyclones).
- On the basis of origin these may be natural (Earthquake, floods, Tsunamis) and Manmade (Chemical hazards, industrial hazards, etc).

There are various land related hazards which originate on land and can affect the ecological, social and economical conditions of the area. You know that earthquake, landslides, landslips and droughts are the natural disasters which happen in land ecosystem. The causes and effect of land related hazards are enormous and uncountable. In this unit, you will learn about land related hazards and their mitigation measures with special reference to landslides, landslips, earthquake and drought.

7.2 Land Related Hazards

Land related hazards are those natural hazards which happened in land and destroy the land ecosystems. There are various types of land related hazards such as landslides, landslips, earthquakes, droughts, floods, volcanic eruptions, etc. These land related hazards caused by natural and manmade activities. There are various types of Land related hazards are such as Landslide / Landslips, Earthquake and droughts. They are described in the following subheads.

Table-1: Definitions, types and causes of Land related Hazards.

S.N.	Name of Hazard	Definition	Types	Causes
1.	Landslide/Landslips	Landslide is a general term for a wide variety of down slope movements of earth materials that results in downward and outward movement of soil, rock and vegetation under the influence of gravity.	Falls, Flows, Creep, Debris flow, Debris avalanches, Lahar, Mudflow and Lateral Spreads,	Natural causes landslides: ➢ Gravity ➢ Geological factors ➢ Heavy and Prolonged rainfall ➢ Earthquake ➢ Forest fires ➢ Volcanoes ➢ Waves Anthropogenic causes of landslides: ➢ Inappropriate drainage system ➢ Deep Excavation on slopes for buildings roads, canals and mining: ➢ Change in slope/land use pattern, deforestation, agricultural practices on steep slopes
2.	Earthquake	Earthquake also called tremor or temblor. Earthquake is "shaking of the surface of the earth, resulting from the sudden release of energy in the lithosphere that create seismic wave".	Strike slip fault, Normal Fault and Reverse Fault	Earthquake happens when two blocks of the earth suddenly slip past one another. The surface where they slip is called fault or fault plane.
3.	Drought	It's a long period when precipitation is lower than average, usually more than a season.	Meteorological drought, Agricultural drought , Hydrological drought and Socioeconomic drought	

7.2.1 Landslide / Landslips

Landslides/ landslips are defined as, **"**Landslide is a general term for a wide variety of down slope movements of earth materials that results in downward and outward movement of soil, rock and vegetation under the influence of gravity".

Landslide is a general term for a wide variety of down slope movements of earth materials that results in downward and outward movement of soil, rock and vegetation under the influence of gravity. Some landslides are rapid, occurring in seconds, whereas others may take hour, weeks or even longer time. Debris flows are fluid mass of rock, earth and other debris saturated with water. Mudflows or debris flows are characters of steep, scanty vegetated slopes on which heavy rainfall initiates movement in thick layer of weathered material. They develop when water rapidly accumulates in the ground, such as during heavy rainfall or rapid snowmelt, changing the earth into a flowing river of mud or slurry. Slurry can flow rapidly down slopes or through channels, and can strike with little or no warning at avalanche speeds. The landslides occur in mountainous hilly regions of the Himalaya or at the western Ghat. However, landslides occur more frequently in Himalayan region due to their fragile nature. **.**

7.2.1.1 Types of Landslides/Landslips

As per Varnes (1978) landslides may be of following types:

(i) **Falls:** It is huge movement of materials that become detached from steep slopes or cliffs, moving by free fall, bouncing and rolling.

(ii) **Flows:** In this type, many types of mass movements take place such as creep, debris flow, debris avalanches and mudflow.

(iii) **Creep:** In this types, slow steady down slope movement of soil or rocks.

(iv) **Debris flow:** In this type of landslide, rapid mass movement, in which loose soils, rocks and organic matters combine with entrained air and water to form slurry that then flows down slope, usually associated with steep gullies.

(v) **Debris avalanches:** A variety of very rapid to extremely rapid debris flow.

(vi) **Lahar:** Mudflow or debris flow that originates on the slope of a volcano, usually triggered by heavy rainfall eroding volcanic deposits, sudden melting of snow and ice due to heat from volcano vents or the breakout of water from glaciers, crater lakes or lakes dammed by volcanic eruption.

(vii) **Mudflow:** Rapidly flowing mass of wet material that contains at least 50% sand, silt and clay sized particles.

(viii) **Lateral Spreads:** Often occur on very gentle slopes and result in nearly horizontal movement of earth materials. Lateral spreads usually are caused by liquefaction, where saturated sediments (usually sand and silts) are transformed from a solid into a liquefied state, usually triggered by an earthquake. .

7.2.1.2 Causes of Landslides/Landslips

Many factors such as geography, gravity, weather, ground water, wave action, type of soil, wave action and human activities, are responsible for landslides. Although, landslides usually occur on steep slopes, they also can occur in areas of low relief. Landslides can occur as ground failure of river bluffs, cut and fill failures that may accompany highway and building excavation, collapse of mine waste piles and slope failures associated with quarries and open pit mines. Underwater landslide usually involves areas of low relief and small slope gradients in lakes and reservoirs or in offshore marine settings. . The causes of landslides may be natural or anthropogenic as follows:

A) Natural Causes of Landslides/Landslips: The natural causes of landslides include:

(i) **Gravity**: Gravity works more effective on steeper slopes, but more gradual slopes may also be vulnerable.

(ii) **Geological factors:** Many slides occur in geological setting that places permeable sands and gravel above impermeable layer of silt and clay or bedrock. Water seeps downward through the upper materials and accumulates on the top of the underlying units, forming a zone of weakness.

(iii) **Heavy and Prolonged rainfall**: Water is commonly the primary factor triggering a landslide. Slides often occur following intense rainfall, when storm water runoff saturates soils on steep slopes or when infiltration causes a rapid rise in ground water levels. Ground water may rise as a result of heavy rains or a prolonged spell. As water tables rise, some slopes become unstable.

(iv) **Earthquake:** Seismic activities have always been a main cause of landslides throughout the world. Any time tectonic plates move the soil that moves with it. When earthquakes occur on areas with steep slopes, many times the soil slips causes landslides. Furthermore, ashen debris flows caused by earthquakes can also trigger mass movement of soil.

(v) **Forest Fires:** Forest fires cause soil erosion and induce floods and landslides due to the destruction of natural vegetation.

(vi) Volcanoes: Strato volcanoes are prone to sudden collapse, specially during wet conditions. The conditions commonly prevail after volcanic eruption that kill vegetation over extensive areas and spread loose volcanic rocks over the landscape. During subsequent rainy seasons, swollen rivers will erode the new deposits and sometimes generates lahars that are dangerous to people downstream.

(vii) Waves: Wave action can erode the beach or the toe of a bluff, cutting into the slope and setting the stage for future slide.

B) Anthropogenic causes of landslides/landslips: Human actions most notably those that affect drainage or groundwater can trigger landslides. Some of the important manmade actions which are responsible for landslides are described below:

(i) Inappropriate drainage system: Natural drainage lines on slopes are blocked by terracing/contour bounding adopted to prevent soil erosion and enhance percolation during dry season for cultivation, without adequate provision for surface drainage of excess storm water during high intensity rains increase the landslide vulnerability.

(ii) Deep Excavation on slopes for buildings roads, canals and mining: Developmental activities like construction of buildings, roads, embankment, cut and fill structures cause modification of natural slopes. These types of activities are highly responsible for landslides.

(iii) Change in slope/land use pattern, deforestation, agricultural practices on steep slopes: Deforestation and cultivation of seasonal crops and increase in settlement course the change in land use pattern. Improper land use practices such as heavy tilling, agricultural practices and settlement patterns have contributed to creep and withdrawal of toe support in many cases.

7.2.1.3 Impacts of Land Slides

There are various effects of landslides which are given below:

(i) Change the shape of land: Landslides can change the whole structure of landscape. It completely abrupt the structure of mountains and hilly areas. Many beautiful ecosystems such as ponds, lakes, forests, etc. may damage and loss their structure due to heavy landslides. Uttarakhand, Jammu and Kashmir including Ladakh, Himachal Pradesh Manipur and

Mizoram are prone to landslides. Landslides frequently occur in hilly regions.

(ii) Loss of human life: Landslide is type of natural disaster which may lead to loss of human life. People who are living in the foot of hills and mountainous region are at great risk of death due to landslides.

(iii) Ecosystem Impacts: Landslides can impact the forests, lands and aquatic ecosystems. The debris can find way in the natural rivers and springs and block their natural ecological flow. Many water parameters such as transparency, turbidity, total solids, total dissolved solids and dissolved oxygen can be affected due to landslides.

(iv) Economical impacts: Landslides can damage the infrastructure of schools, educational institutions, hospitals, industries, roads and other transport systems. The repairing of these things is very costly and disturbs the economy of the states or countries.

7.2.1.4 Mitigation Measures of Landslide/Landslips

A landslide is caused by combination of various factors . (I.e., topography, geology, geological structure, ground water, etc.). Accordingly, measures to be taken for landslide prevention come in a variety of types. Landslides can be controlled by following preventive measures.

Before Landslide/Disaster

(i) Identify the area where you live and note the frequencies of landslides in your area.

(ii) Plantation should be done over slope; therefore roots can stabilize the soil.

(iii) Cover slope with concrete, while putting pipes in it to let the water from the top out.

(iv) Don’t live in landslide hazard area.

(v) Don’t construct anything in an area where landslide has occurred previously.

(vi) Make sure that all water pipes do not leak.

(vii) Make a strong wall in front of the bottom of slope to prevent any lahars or flow to run rapidly, which also change the direction of flow.

(viii) Make sure to stay indoors when the landslide warning is given.

(ix) Stay away from mountainous area where there is heavy rain.

(x) Water pipes could also be put in to slope, so the water can be taken out, preventing it from flowing too high which provides a slimmer chance of a landslide.

During landslide/Disaster

(i) Stay alert and awake, many debris flows occur when people are sleeping. Listen to a weather radio or portable radio or television for warnings of intense rain fall. Be aware that intense, short burst of rain may be particularly dangerous, specially after long period of heavy rainfall and damp weather.

(ii) If you are in area at risk to landslides and debris flows, consider leaving if it is safe to do so. Remember that driving during heavy rain can be hazardous. If you remain at home, move to a second story if possible.

(iii) Listen for any unusual sounds that might indicate moving debris, such as trees cracking or boulders knocking together. A trickle of flowing or falling mud or debris may precede larger landslides. Moving debris can flow quickly and sometimes without warning.

(iv) If you are near a stream or river, be alert for any sudden increase or decrease in water flow and for a change from **clear to muddy water**. Such changes may indicate landslides in upstreams.

(v) Be especially alert when driving. Embankments along roadsides are particularly susceptible to landslides. Watch the road for collapsed pavement, mud, fallen rocks and other indications of possible debris flow.

After the landslide

(i) Keep yourself and family members away from the landslide area. There may be danger of further landslide.

(ii) Check for injured and trapped person near the landslide, without entering the direct slide area.

(iii) Help a neighbor who may require special assistance-infants, elderly people, and people with disabilities.

(iv) Listen or watch to local radio or television stations for the latest emergency information.

(v) Watch for flooding and heavy rain, which may occur after a landslide or debris flow. Flood and heavy rain sometimes follow landslides and debris flows because they may both be started by the same event.

(vi) Check the foundations of building, chimney and surrounding land for damage. Damage to foundations and chimney or surrounding land may help to assess the safety of the area.

7.2.2 Earthquakes

Earthquake is also called tremor or temblor. Earthquake is "shaking of the surface of the earth, resulting from the sudden release of energy in the lithosphere that create seismic wave". **.** Earthquakes are most dangerous and devastating form of natural disaster it can destroy millions of lives, buildings and infrastructures within a few minutes. Therefore, Earthquake is the most fearful natural phenomena in the human life. It is more so because it is unpredictable and occurs with any presumptive signs. When the earth shakes due to the movements of tectonic plates below the earth's crust, it is known as earthquake. The maximum destruction generally occurs near the epicenter, the place where the vibrations arise and spread. Seismology is the study of earthquakes and seismic waves that move through and around the earth. A seismologist is a scientist who studies earthquakes and seismic waves.

About 50-60% of India is vulnerable to seismic activity of varying intensity and most of the vulnerable areas are located in the Himalayan and Sub-Himalayan regions. The states whose area do fall in the most risky seismic zones are North East states (Arunachal Pradesh, Meghalaya, Nagaland, Sikkim, Tripura, Manipur and Mizoram), Andaman and Nicobar of Islands, western part of Gujarat, Himalayan foot hills of Uttarakhand, Himachal Pradesh, Uttar Pradesh and Bihar. The Deccan Peninsula and Rajasthan are least vulnerable areas.

7.2.2.1 Types of Earthquakes

(a) Earthquake fault types: There are three main types of fault that may cause earthquake. Types of earthquake are given below:

(i) Strike slip fault: In this type, the fault is vertical and the tectonic plates slide past one another horizontally. This occurs in areas where the crustal blocks are sliding past another.

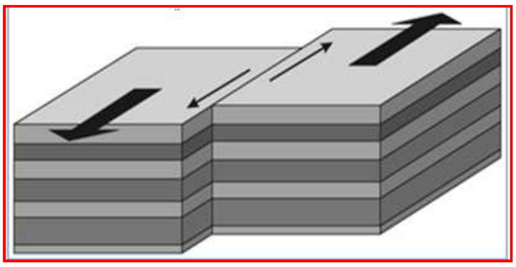

Fig. 1- Strike slip fault

(ii) **Normal fault:** In this type, the fault is at an angle and the tectonic plate above the fault (the hanging wall) moves down relative to the block below the fault (the foot wall). This occurs in area where there is extension or pulling of the crustal blocks or in the area such as divergent boundary.

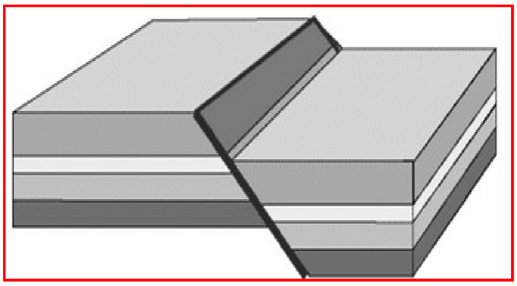

Fig. 2- Normal fault

(iii) **Thrust (reverse) fault:** In this type, the fault is at an angle, and the hanging wall moves up relative to the foot wall. This occurs in area where the crustal blocks are being pushed together. Reverse fault occur in area where the crust is being shortened such as at a convergent boundary.

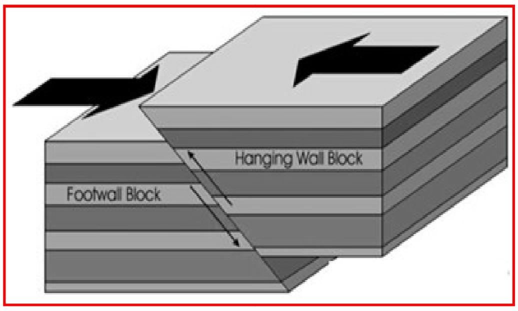

Fig. 3- Reverse fault

(b) Aftershocks: An aftershock is an earthquake that occurs after a previous main earthquake. An aftershock is in the same region of the main shock, but always of a smaller magnitude. If an aftershock is larger than the main shock, the aftershock is re-designated as the main shock and the original main shock is re-designated as aftershock.

(c) Frequency of occurrence of Earthquake: It is estimated that around 5,00,000 earthquakes occur each year. About 1,00,000 of these can be felt. Minor earthquakes occur nearly constantly around the world in places like California and Alaska in the U.S. Gutenberg-Richter law stated that an earthquake of 3.7–4.6 magnitudes every year, an earthquake of 4.7–5.5 magnitudes every 10 years, and an earthquake of 5.6 magnitudes or larger every 100 years. This Gutenberg-Richter law described the relationship between magnitudes and total number of earthquakes in any given region and time period. This law was developed by Beno Gutenberg and Charles Francis Richter in 1956.

(d) Seismic Waves: Every earthquake produces different types of seismic waves, which travel through rocks and liquids with different velocities:

(e) P-Waves or Primary waves or Pressure waves: The first kind of body wave is the P-wave or primary wave. This is the fastest kind of seismic wave, and, consequently, the first to 'arrive' at a seismic station. The P-wave can move through solid rock and fluids, like water or the liquid layers of the earth. Sometimes animals can hear the P-waves of an earthquake.

Table-2: Different seismic zone in India

Zone	Area of India	Probability of Risk
Zone-1 (II)	No Area of India is classified as Zone-1	Least damage risk
Zone-2 (II)	Karnataka	Low damage risk
Zone-3 (III)	Some part of some part of Uttar Pradesh	Moderate damage risk
Zone-4(IV)	J&K, Uttarakhand, Himachal Pradesh, Sikkim, Punjab and some part of Uttar Pradesh	High Damage risk Zone
Zone-5(V)	Kashmir, Himalayas, North and Middle Bihar, North East India, Rann of Kutch, Andaman & Nicobar group of Island	Highest Risk

Dogs commonly begin barking hysterically just before an earthquake. Typical values for P-wave velocity in earthquakes are in the range 5 to 8 km/s.

(f) S-Waves secondary waves, or shear waves: The second type of body wave is the S-wave or secondary wave, which is the second wave you feel in an earthquake. An S-wave is slower than a P-wave and can only move through solid rock, not through any liquid medium. It is this property of S-waves that led seismologists to conclude that the Earth's outer core is a liquid. The P and S waves are collectively called body waves. **.**

(g) Surface Waves: Travelling only through the crust and a lower frequency than body waves, and are easily distinguished on a seismogram as a result. Though, they arrive after body waves, it is surface waves that are almost entirely responsible for the damage and destruction associated with earthquakes. This damage and the strength of the surface waves are reduced in deeper earthquakes.

(h) Love Waves: The first kind of surface wave is called a Love wave, named after A.E.H. Love, a British mathematician who worked out the mathematical model for this kind of wave in 1911. Love waves produce entirely horizontal motion. Richter scale: The Richter scale was developed in 1935 by American seismologist Charles Richter (1891-1989) as a way of quantifying the magnitude or strength of earthquakes. It is mathematically based. **.**

Seismograph: It measures the motion of ground including above mentioned seismic waves generated by earthquake.

7.2.2.2 Causes of Earthquake

Earthquake happens when two blocks of the earth suddenly slip past one another. The surface where they slip is called fault or fault plane. The location below the surface of the earth where, an earthquake starts called hypocenter and the location directly above it, on the surface called epicenter. Earthquakes often occur in volcanic regions and are caused there, both by tectonic faults and the movement of magma in volcanoes.

Earthquakes are caused mostly by rupture of geological faults, but also by volcanic activity, landslides, mine blasts and nuclear experiments.

7.2.2.3 Impacts of Earthquakes

The effects of earthquakes include, but are not limited to, the following:

- **(i)** It destroys the life of human.
- **(ii)** It destroys infrastructure of school, educational institutions, hospitals, industries and other personal/private properties.
- **(iii)** It destroys the Hydro-power Projects or Dams.
- **(iv)** It may leads to landslides, flood cyclones, etc.
- **(v)** It may leads to catastrophic flood.
- **(vi)** It is responsible for great social and economical losses.
- **(vii)** It may cause epidemic diseases by destruction of sewage line systems.
- **(viii)** It completely destroys the electrical system and communication system.
- **(ix)** It destroys agricultural land.
- **(x)** Sometimes earthquake causes complete separation of family members, community and society.

7.2.2.3 Mitigation Measures of Earthquake

As you know that earthquake is fastest, quickest and sudden disaster and during the disaster, we cannot do so effective methods. Therefore, it is necessary to follow the rules and regulation before the disaster by which we can minimize the impacts of earthquake. There are various mitigation measures of earthquake and some important measures, which are certainly helpful to minimize the impacts of earthquake, are summarized below:

(a) Before Earthquake: As you know that earthquakes occur very fast without giving any signal and if we wait until the earth is start to shake, it may be too late. Following point should be kept in mind before earthquake especially in earthquake prone areas.

(i) Identify the zone and frequency of earthquake in area where you live.

(ii) Follow the rules and regulations prescribed by governments. Government of India prescribed various rules for construction of buildings in different seismic zones.

(iii) Disaster management training for people/communities must be organized at regular basis.

(iv) Keep the phone numbers of media and official of National Disasters Response Force (NDRF) etc.

(v) Always keep the following in a designated place: drinking water bottles, dry food, First aid kits, torchlight and battery operated radio.

(vi) Identify place in the house that can provide cover during earthquake.

(vii) It may be easier to make long distance calls during an earthquake. Identify an out of town relative or friend as a family's emergency contact. If the family members get separated after the disaster and are not able to contact each other, they should contact the designated relative/friend. The address and phone number of the contact person should be with all the family members.

(b) During Earthquake: Earthquakes give no warning at all. Sometimes, a loud rumbling sound might signals its arrival a few sounds ahead of time. Those few seconds could give us a chance to move to a safer location. **.** The following are some important tips for keeping safe during an earthquake.

(i) Take cover, go under a table or other solid furniture, kneel, sit or stay close to the floor. Hold on to furniture legs for balance. Be prepared to move if your cover moves.

(ii) Do not stand in doorways. Violent motion cause serious injury.

(iii) Move away from windows, mirrors, bookcases and other unsecured heavy objects.

(iv) Do not run outside the buildings if you are deep inside in room

(v) Never use the lift.

(vi) If you are living in a house which is not far from the open area, the best thing to do is to move an open area where there are no trees, electric and telephone wires.

(vii) If you then move outside into open, stay away from buildings, streetlights and utility wires. Once in the open, stay there until the shaking stops. Avoid place where there are loose wires and do not touch metal objects that are in touch with the loose wire. Stay away from badly damaged structures.

(viii) If you are in vehicle, then move to clear area from buildings, trees, overpasses. Avoid bridges or ramp that might have been damaged by the earthquake.

(c) After Earthquake: Here are a few things to keep in mind after an earthquake. The cautions you display in the aftermath can be essential for your personal safety.

(i) Wear shoes to protect feed from debris and other hazardous substances.

(ii) After the earthquake, be prepared for aftershocks. Aftershock cause additional damages and may bring down weakened structures. Aftershocks can occur in the first hours, day, weeks and even months after the earthquakes.

(iii) Check for fire hazards and use torch lights instead of candles or lanterns.

(iv) If the building you live in is in a good shape after the earthquake, stay inside and listen for radio advices. If you are not certain about the damage to your building, evacuate carefully.

(v) Help injured or trapped persons and give first aid. Do not move seriously injured persons unless they are in immediate danger of further injury.

(vi) Remember to help your neighbors who may require special assistance infant, the elderly, and people with disabilities.

(vii) Listen to a radio for the latest emergency information.

(viii) Stay out of damaged buildings.

(ix) Return home only when authentic agencies say it is safe. Clear up spilled medicines, bleaches or gasoline or other flammable liquids immediately. Leave the area if you smell gas or fumes from other chemicals.

(x) If you smell gas open windows and quickly leave the building. Turn off the switch on the top of the gas cylinder.

(xi) Look for electrical system damages if you see sparks, broken wires, or if you smell burning of amber, turn off the electricity at the main fuse box. Check for sewage and water lines damage. If you suspect sewage lines are damaged, avoid using the toilets. If water pipes are damaged, avoid using water from the tap.

(xii) Use the telephone only for emergency calls.

(xiii) In case family members are separated from one another during an earthquake develop a plan for reuniting after the disaster. Make sure everyone in the family know the name, address, and phone numbers of the contact person.

7.2.3 Drought

A drought occurs when precipitation is lower than average, usually more than a season. It generally comes with higher temperatures than normal. It can also be caused by people overusing or over-populating an area to the point where the water available is outstripped by what people need. Drought is widespread meteorological syndrome of prolonged period of water scarcity. **.**

7.2.3.1 Types of Drought

(i) Meteorological drought: It is specific to different regions. Meteorological drought is simply defined as "short fall of rain over a period of time. The amount of rainfall/precipitation and duration are specific to region.

(ii) Agricultural drought: It accounts for the water needs of crops during different growing stages. Agricultural drought links the characteristics of both meteorological and hydrological drought. This type of drought impacts the crops, live stock and forestry.

(iii) Hydrological drought: It refers to persistently low water volumes in streams, rivers and reservoirs. Various anthropogenic activities such as drawdown of reservoirs can worsen hydrological droughts. Hydrological drought is often linked with meteorological droughts. These types of droughts are characterized by changes in surface water supplies.

(iv) **Socio-economic drought:** It happens when the demand of water exceeds the water supply. Examples of socio-economical drought include too much irrigation or when low river flow forces hydroelectric power plant operators to reduce energy production.

7.2.3.2 Causes of Drought

Drought has many causes. . There are various natural and manmade causes of droughts which are given below:

(a) Natural and Human Causes of Drought

(i) **Deforestation:** As you know forests play a vital role in water cycle. Trees helps reduce evaporation, store sufficient water, etc. Therefore, deforestation causes drought like conditions in the area.

(ii) **Global Warming:** Global warming is phenomena in which average temperature of earth rises. Human activities contributed to more, green house gases in the atmosphere. As a result, there are increases in temperature of earth. These conditions also lead in to drought.

(iii) Land and water temperatures cause drought. As overall temperatures increase more water evaporates and severe weather conditions increase. Landscapes and crops need more water to survive and overall the demand for water increases.

(iv) Air circulation and weather patterns also cause drought. The events like El Nino or La Nina responsible for drought in the areas. Weather patterns move the water in the air around.

(v) Moisture level in Soil contributes to drought. Whenever moisture of soil is depleted, there is low evaporation of water to create clouds. It effects the rain cycle. Temperatures of earth rise, more water is needed and less is available which contributes to a more severe drought conditions.

(vi) Population explosion also responsible for drought. More population require more water to fulfill their needs. This may leads in to economical drought.

(b) Drought in India: About 5,11,300 km^2 area of India is prone to drought. 40 severe droughts have been occurred in India since 1801. The main drought affected regions of India are Maharashtra, Odisha, Telangana, Rajasthan, Madhya Pradesh, Jharkhand, Uttar Pradesh, Karnataka, Andhra Pradesh and Chattisgarh. In Maharashtra, out of 36 districts, 21 districts are facing drought. As you know Pani Panchayat movement was started in Maharashtra to mitigate the impacts of drought. . In Odisha about 16 districts are prone to drought. Chief Minister of Odisha Sh. Naveen Patnaik announced 100 crore rupees to farmers which were affected by drought. Almost all the district of Telangana except Adilabad and Kamman have affected by drought. Nineteen districts of Rajasthan were also affected by drought. Out of 52 districts in Madhya Pradesh, 46 are drought affected. In Jharkhand, 22 districts are facing drought like conditions. In Uttar Pradesh 50 districts are affected by drought. On the other hand 27 districts of Karnataka are facing drought. Gujarat, West Bengal, Haryana and Bihar states are also drought affected states of India.

Table-3: History of drought in India

Period	Drought years in India	Number of Drought
1801-1830	1801, 1804, 1806, 1812, 1819, 1825	06
1831-1860	1832, 1833, 1837, 1853, 1860	05
1861-1890	1862, 1866, 1868, 1873, 1877, 1883	06
1891-1920	1891, 1897, 1899, 1901, 1904, 1905, 1907, 1911, 1918, 1920	10
1921-1950	1939, 1941	02
1951-1980	1951, 1965, 1966, 1971, 1972, 1974, 1979	07
1981-2010	1982, 1987, 2002, 2009	04

7.2.3.3 Impacts of Drought

There are various effects of economical, environmental and social impacts of drought are given below:

(a) Economic Impacts

- **(i)** Farmers and people may lose money if a drought diminishes their vegetables, grains and other crops.
- **(ii)** If water supply is too low, the farmers may have to spend more money on irrigation.
- **(iii)** Ranchers may have to pay more cost on feed and water for their livestock.
- **(iv)** Commercialization that depends on farming, like industries that make tractors and food, may lose business when drought damages crops or livestock.

(v) People who work in the timber industry may be affected when wildfires destroy stands of timber.

(vi) Works that rely on boats and fishing equipment may not be able to sell some of their goods because drought has dried up lakes and other aquatic bodies.

(vii) Hydro-power companies that normally rely on hydro-electric power may have to pay out more money on other fuel sources if drought dries up too much of the water supply.

(viii) Water consuming companies may have to spend money on new or additional water supplies.

(ix) Navigation becomes difficult in rivers due to low quantity of water. Ships may have difficulty navigating streams, rivers, and canals because of low water levels, which would also affect economy that depend on water transportation.

(x) Communities might have to pay more for food items.

(b) Environmental Impacts: Drought also impacts the environment conditions in many different ways. As you know plants and animals depend on aquatic habitat or water. When a drought happens, food supply of animals can shrivel and their habitat can be eroded. Sometimes the harm is only momentary and their habitat and food return to normal level when the drought is over. But, sometimes droughts impact on the environment can last a long time may be forever. There are various environmental impacts of drought which are given below:

(i) Destruction of fish and wildlife habitat

(ii) Lack of food and drinking water for wild animals

(iii) Increase in disease in wild animals, because of reduced food and water supplies

(iv) Migration of wildlife

(v) Enhance the stress on endangered species

(vi) Low water levels in reservoirs, lakes, and ponds

(vii) Wetlands degradation

(viii) Drought enhances the chances of forest fire.

(ix) Soil erosion by water and wind

(x) Poor soil quality

(c) Social Impacts: Social impacts of drought include public safety, health, conflicts between people when there is not enough water to go around, and changes in life style. Social impacts of drought may be as following:

(i) Depression regarding economic losses caused by drought

(ii) Human health problems related to low water flows and deprived water quality

(iii) Human health problems related to dust

(iv) Loss of human life

(v) Threat to public safety from an increased number of forest and range fires

(vi) Reduced incomes of people

(vii) People migrate from farms into cities, or from one city to another city

7.2.3.4 Mitigation Measures of Drought

The impacts of drought can be mitigated through following steps.

Prediction of drought can be derived from climate studies which use coupled ocean/atmosphere models, anomalous circulation patterns in the ocean and atmosphere, soil moisture, and idea of stored water available for domestic, stock, and irrigation uses. The various Scientists and researchers can predict the drought on the basis of previous history of place, weather monitoring systems, etc. **.**

Monitoring can be done with the help of valuable information such as rainfall, weather, crop conditions and water availability. Satellite observations complement data collected by ground systems also helpful in monitoring of drought. **.**

Impact assessment is carried out on the basis of land-use type, demographics and existing infrastructure, intensity and areal extent, and its effect on agricultural yield, human health, quantity and quality of water. **.**

Response includes advanced drought monitoring, good water and crop management, augmentation of water supplies with groundwater, enhance public awareness and environmental education, watershed management, rain water harvesting and local planning, reduction in demand of water and water conservation.

Table-4: Showing preventive measures and preparedness plan for drought mitigation (Source Gupta et.al. 2011)

Preventive measures	Preparedness plan
1. Dams/reservoirs and wetlands to store water 2. Watershed management 3. Cattle management 4. Proper selection of crops for drought prone area 5. Soil conservation techniques 6. Reducing deforestation and forest fire 7. Alternative land use models for water sustainability 8. Education and training to local people.	1. Improvement in agriculture through modifying cropping systems and introducing drought resistant varieties of crops. 2. Management of rangeland with improvement of grazing patterns, introduction of feed and protection of shrubs and trees. 3. Development of water resource system with improved irrigation, development of improved storage facilities, protection of surface water from evaporation and introduction of micro-irrigation system 4. Animal husbandry facilities can help in mitigation with use of improved and scientific methods.

Before Drought

- Identify the history of drought in your area.
- Monitor the weather reports regularly.
- Crop management should include following points
    - Plant the trees which can hold the sufficient amount of water.
    - Crop rotation should be done in drought prone area.
    - Crop should be drought and flood resistant.
- Land management should include following points
    - Maintain the healthy soil
    - Do not allow over grazing
    - Establish the riparian vegetations around the land and water bodies.
- Weed and unwanted crops should be controlled.
- Minimize the loss of water during agriculture.
- Identify the alternate water sources in drought prone areas.

After Drought

- Regular testing of soil should be done during and after drought.
- Test the harvested crops and forages for nutrient quality.

Summary

In this unit we have discussed various aspects of land related hazards. So far you have learnt that:

- According to Kates (1978) environmental hazard is “the threat potential posed to manmade or natural activities by event originating in nature. Literally, hazard means “risk” hazard may categorized as: On the basis of source of energy these may be biological (energy source are living organisms examples are: diseases and infections); chemical (energy source are chemical components); physical (energy sources are physical activities of earth examples: Earthquake, cyclones). On the basis of origin, these may be natural (Earthquake, floods, Tsunamis) and Manmade (Chemical hazards, industrial hazards, etc).
- There are various land related hazards which are originated on land and can effects the ecological, social and economical conditions of the area. You know that earthquake, landslides, landslips, droughts are the natural disasters which happen in land ecosystem. The causes and effect of land related hazards are enormous and uncountable. In this unit, you will learn about land related hazards and their mitigation measures with special reference to landslides, landslips, earthquake and drought. **.**
- Landslide is a general term for a wide variety of down slope movements of earth materials that results in downward and outward movement of soil, rock and vegetation under the influence of gravity. Some landslides are rapid, occurring in seconds, whereas other may take hour, weeks or even longer time. Debris flows are fluid mass of rock, earth and other debris saturated with water.

- There are various types of landslides such as: Falls, Flows, Creep, Debris flow, and Debris avalanches, Lahar, Mudflow and Lateral Spreads. **.**
- The causes of landslides and landslips may be Natural causes such as Gravity, Geological factors, Heavy and Prolonged rainfall, Earthquake, Forest fires, Volcanoes and Waves.
- Anthropogenic causes of landslides may include: Inappropriate drainage system, Deep Excavation on slopes for buildings roads, canals and mining, Change in slope/land use pattern, deforestation and agricultural practices on steep slopes.
- The landslides may affect the structure of land, cause loss of human being, economical losses, etc.
- Earthquake also called tremor or temblor. Earthquake is "shaking of the surface of the earth, resulting from the sudden release of energy in the lithosphere that create seismic wave". Earthquake may be categorized as Strike slip fault, Normal Fault and Reverse Fault.
- Earthquake happens when two blocks of the earth suddenly slip past one another. The surface where they slip is called fault or fault plane.
- Drought a long period when precipitation is lower than average, usually more than a season. The drought may be categorized as Meteorological drought, Agricultural drought, Hydrological drought and Socio-economic drought. **.**

Terminal Questions

1 (a) Fill in the blank spaces with appropriate words.

Earthquake also called …….or……….. Earthquake is "shaking of the surface of the earth, resulting from the sudden release of …………in the lithosphere that create……. …………". Earthquakes are most dangerous and devastating form of natural disaster it can destroy millions of life, building, infrastructure within few minutes. Therefore, Earthquake is the most fearful natural phenomena in the human life. It is more so because it is ……..and occurs with any presumptive signs. When the earth shakes due to the movements of tectonic plates below the earth's crust, it is known as earthquake. The maximum destruction generally occurs near the ……….., the place where the vibrations arise and spread. …………….is the study of earthquakes and seismic waves that moves through and around the earth. A ………..is a scientist who studies earthquakes and seismic waves. About 50-60% of India is vulnerable to seismic activity of varying intensity and most of the vulnerable areas are located in the Himalayan and sub-Himalayan regions.

2 (a) What are land related hazards?

(b) Give the types of landslides

3. (a) Define the landslide. Describe the natural and anthropogenic causes of landslides.

(b) What are the impacts of landslides?

4. Describe the mitigation measures against landslides.

5 (a) Define the earthquake. What are the types of Earthquakes?

(b) Write about seismic waves of Earthquake.

(c) Describe the impacts of earthquake.

6 (a) Fill the blank spaces with appropriate words.

Landslides, earthquakes and droughts are regarded and classified as ………….. These are natural phenomena that might have great …….impacts on ecology and ………..on any Nation. Natural disasters mainly categorized as two broad types. First category is ……………… ………..and these may include earthquake, drought, landslides, volcanic eruption, flood, forest fires, etc. Second category of natural hazard is ………… ………which may include diseases and infections. According to Kates (1978) environmental hazard is "the threat potential posed to manmade or natural activities by event originating of nature. Literally, hazard means …………hazard may be categorized as: On the basis of source of ………..these may be biological (energy source are living organisms example are: diseases and infections); chemical (energy source are chemical components) and physical (energy sources are physical activities of earth examples: Earthquake, cyclones). On the basis of ………these may be natural (Earthquake, floods, Tsunamis) and Manmade (Chemical hazards, industrial hazards, etc.)

(b) Which waves are the fastest waves in Earthquake (P-waves/S-waves/surface waves/love waves)

(c) Uttarakhand lies under the seismic zone (Seismic zone-I/ Seismic zone-II / Seismic zone-III/ Seismic zone-IV)

(d) In India, maximum drought happened during the period of (1801-1830/1831-1860/1981-2010/1891-1920)

7 (a) Define the drought. Describe the causes and impacts of drought

(b) Write about the mitigation measures against drought.

(c) Write about the drought in India.

Answers to Terminal Questions

1 (a) Tremor, temblor, energy, seismic wave, unpredictable, epicenter, Seismology, seismologist

2 a) see section 7.2 and Table-1.

(b) See section 7.3.1

3 (a) See section 7.3 and 7.3.2

(b) See section 7.3.3

4 (a) See section 7.3.4

5 (a) See the section 7.4 and 7.4.1

(b) see the section 7.4.1 (seismic waves)

(c) See section 7.4.3

6 (a) Natural disasters, negative, socio-economy, Geophysical disaster, biological hazard, “risk”, energy, origin, (b) P-waves, (c) Seismic zone-IV, (d) 1891-1920

7 (a) See the section 7.5, 7.5.2 and 7.5.3, (b) See the section 7.5.4, (c) See the section 7.5.2 (Drought in India).

Unit 8 Land Husbandry: Soil Amelioration; Rehabilitation and Restoration of Wasteland

Unit Structure

8.0 Learning Objectives

After studying this unit you will be able to:

- What is concept of land husbandry
- What is Soil amelioration?
- Why soil amelioration is important?
- What are the techniques in soil amelioration
- How we can rehabilitate soil
- Methods of restoration of wasteland

8.1 Introduction

As you know, soil erosion has been perceived as the main cause of land degradation, yet the limited effectiveness and poor uptake of widely promoted physical and biological anti-erosion methods challenges this fact. As you know that, various anthropogenic activities and natural activities lead to land degradation. Excessive use of fertilizers, dumping of hazardous material in and around the land, deforestation and desertification are main causes of land degradation. These factors are responsible for low production in land ecosystems. Many hazardous materials such as mercury, arsenic, cadmium, chromium, nickel and zinc reach the land ecosystem and can reach up to higher trophic level through bio-accumulation. These toxic substances can cause several diseases in human being as well as in other animals. Therefore, it is necessary to manage and conserve the land ecosystems for this generation as well as for future generations.

According to Francis Shaxson (2014), land husbandry is active process of managing land use systems and production in such ways that there will be increase in productivity. There are various methods to improve land, soil and wasteland, which are certainly helpful to increase productivity of land. Various methods of land husbandry may include soil amelioration, rehabilitation and restoration of soil. Land husbandry includes the active management primarily of rain water, vegetation, soil and slopes. The land husbandry technique, takes place at variety of scales from the field to landscape and soil. Land improvement and vegetation output are the two main ways of land husbandry. In this unit, you will learn about, land husbandry, soil amelioration, rehabilitation of soil and restoration of soil.

8.2 Land Husbandry

Hugh Hammond Bennett is the father of soil conservation; the world has seen a host of erosion control manuals and describing practical experience, technical principles, mechanical methods to be used, and a series of practical recipes that have been adopted with varying degrees of success in specific regions. Bennett's approach to soil conservation was then applied, with no prior testing, in totally different circumstances with the very indifferent results that have been seen by all. The environmental deprivation is closely bound up with the growth of civilizations. They are of equal interest to ecologists, foresters, geographers, hydrologists and as well as to social economists. It is well said that "Every day the land dies silently, only our voices are left".

According to Shaxson, Douglas and Downes, 2005 **"**land husbandry is the active process of implementing and managing preferred systems of production in such ways that there will be increase – or at worst, no loss of productivity, stability or usefulness for the chosen purpose; also, in particular situations: existing uses or management may need to be changed so as to halt rapid degradation and to return the land to a condition where good husbandry can have fullest effect".

Hazards of local climate such as: Rainfall: high intensities; drought; excess rainfall volumes; Temperature: maximum, minimum, fluctuations and Wind: velocity is responsible for land degradation. On the other hand, Hazards of landscape include: slope, as affecting velocity of any runoff; Past erosion effects as affecting quality of remaining top soil; Inherent wetness, as limiting aeration in root-zone and Parent materials of soils: chemical limitations.

Limitations posed by "endemic" soil conditions: Effective rooting-depth; Surface hindrances – rocks, etc.; Top soil texture (sand through to clay);Upper sub soil texture (sand through to clay); Sub soil permeability (excessively-free through to restricted); and Material (if any) limiting rooting-depth: chemical, hydrologic or physical restrictions.

Land degradation may result due to degradation in physical, chemical and biological parameters of the soil. These parameters may include organic-matter content, organisms, acidification, loss of porosity, loss of soil particles, nutrients and water in runoff and erosion. Conversely, improvements to any, some, or all of these features will contribute to greater stability, conservation and sustainability of the affected land. Land husbandry is practice of cultivating the land or raising live stock.

8.3 Methods of Land Husbandry

The use of heavy construction machinery or the improper treatment of soils often results in soil compaction. This leads, on the one hand, to a pore volume too low for plant growth and on the other hand to too little oxygen content in the soil. Soils with low structure stability are especially vulnerable to damages by compaction, particularly to exposures in connection with unfavorable soil water content. The first step to re-cultivate compressed soils is physical soil amelioration, which primarily aims at improving air and water balance of the soil.

Soil improvements influencing the substantial properties of soils are summarized under the term chemical soil amelioration. Those are primarily measures for increasing or decreasing the soil pH, for optimizing the nutrition contents and reducing or eliminating harmful substantial influences like salinization or contaminations. These interventions improve the substantial prerequisites in soils extremely acidic, extremely alkaline, and poor in nutrients or contaminated, such that sound plant growth is possible with reclamation and erosion control measures. Chemical amelioration measures are dominantly requisite in mining areas (liming of acid soils), on raw soils lacking humus, in salinated sites (reduction of ion activity) and the decontamination of contaminated hazardous sites.

8.4 Soil Amelioration

Soil amelioration is technique in which we can improve the quality of soil. The word "melior" has been taken from Latin language which means “better,".

As you know, soil is made up of clay, silt and sand. Besides these components, humus, microbes, earthworms are essential part of soil. The functions of abiotic and biotic factors are different in land ecosystem. A Clay soil is responsible for soil amendments improve the soil aggregation, increase porosity and permeability, and improve aeration, drainage, and rooting depth. On the other hand, Sandy soils increase the water and nutrient holding capacity. Manure-based compost is readily available in the soil. These are often high in salts, limiting application rates. Plant-based composts are low in salt; these may be applied at higher application rates, more effectively improving the soil - typically higher cost. There are various reasons which cause soil degradation. Salinity of land may be harmful to growth of crops and it may increase due to excessive and uncontrolled irrigation, water logging, excessive use of fertilizers, poor drainage systems, etc.

Indicators of Soil Productivity: There are various indications by which we can determine the soil is polluted, water logged or higher salinity, etc. Drainage of water is indication in which we can observe the amount of water flowing slowly or quickly over soil. This may indicate saturated or unsaturated soil conditions. This can also cause erosion. Water left standing after a rain may also indicate excessive moisture in the soil. Edges of leaves turning brown may be indicator of too much soil moisture. We can identify the roots of plants; decayed roots are also indicator of waterlogged soils. The type of soil at a site influences moisture conditions. Sandy soils generally have a high infiltration rate with water moving quickly through, while clay soils may be likely to retain water. The pH is the scale to determine acidic or basic nature of any solution. It is a measure of the concentration of hydrogen ions in the solution. It is also indicator of soil productivity. The lower the pH of soil, the greater the acidity, pH of 4 has 10 times more acid than a pH of 5 and 100 times more acid than a pH of 6. Acidity caused by natural process, accelerated by agriculture, inefficient use of nitrates, followed by the export of alkalinity in produce. Microbial biodiversity is also indicator of soil productivity. As you know, most of the biological activity in the soil occurs in the top 10 cm. Farmers generally do not realize the amount of life and what type of organisms live in soil, because we do not see their activities. Many farmers do not understand the diversity of organisms present in the soil and their function. Microorganisms play various functions in soil. These functions may include: Nutrient recycling, maintaining soil structure, suppression of plant disease and soil detoxification

Amelioration Techniques for Saline Soil: There are various methods of soil amelioration for saline soil which are given below:

(i) **Scraping:** It is just removal of salt content by mechanically. This technique has limited success.

(ii) **Leaching:** This is the most effective management technique for removing salts from root zone of soil (rhizosphere). Stagnation of freshwater can dissolve the salt in agriculture field. Leaching should be done when soil moisture content is low and ground water is deep.

(iii) **Drainage:** Drainage is also effective method to minimize salt content in soil.

(iv) **Irrigation methods:** More frequent irrigation prevents the salt accumulation by keeping the soil at higher soil moisture content. Therefore, crops grow in high salinity must be irrigated more frequently.

(v) **Irrigated methods:** Sprinklers or drip irrigation or micro-irrigation or drop irrigation is good method for irrigating frequently and with small quantity of water at a time. Leaching of soluble salts is also accomplished more efficient when water application rate are lower than the infiltration capacity of soil and such capacity cannot be achieved by flood irrigation method.

(vi) **Proper use of Irrigation:** Salt free or less saline (if salt free water is not available) water only to be used. Moisture should be kept at optimum field capacity to check the salt accumulation. Management of soil fertility is to be done through proper fertilizers application. Generally saline soils are low in fertility status. Response of nitrogen is good when it is applied with green manures. However, an excessive fertilizer on a highly saline soil is of no value. Use of acid forming fertilizers such as ammonical and amide form help to below the pH level of soil.

(vii) Mulching: Soil salinization is particularly high when water table is shallow and salinity of ground water is high. Mulching can reduce evaporation from soil surface and encourage downward flow of soil water thereby check the accumulation of salts on soil surface.

Saline soils are barren but potentially productive soils. All the problematic soils are needed to be rectified and made to be productive to ensure the food supply/security of ever increasing population. Soluble salt concentration of saline soil can be minimized by the above mentioned amelioration technique and made in to productive.

Table - 1: Saline concentration and suitable crops

Highly salt content crops	Sugarcanes, Barley, Sesbania, Oats and Barley
Moderately salt content crops	Millets, Pearl, Maize, Wheat, Rice and Cotton
Low salt content crops	Pulses, White Clover, Radish, Beans, Peas and Seasam
Saline sensitive crops	Onion, Tomato, Potato and Carrot

There are various reasons to avoid Soil Compaction because soil compaction causes nutrient deficiencies, Reduces crop productivity, Restricts root development, Reduces soil aeration, Decreases soil available water, Reduces infiltration rate, Increases surface runoff, Increases sediment and nutrient losses and Damages soil structure. Soil compaction can be managed through Deep Tillage, Crop residue, addition of organic matter, vermin-compost etc. Compaction can correct with the help of adding gypsum or any chemical to a landscape, have soil analysis performed to identify texture, mineral deficiencies, toxicities, etc. Gypsum can improve heavy clay soil structure and remove sodium from saline soils. But, on the other hand addition of gypsum to sandy soils

Table - 2: Role of organisms in soil

Microbes	Role of Microbes
Microfauna	Breaking down organic matter in soil
Microfauna	Recycling of nutrients and release of nutrients for further biological transformation in soil
Mesofauna	Regulating and distributing microbes in soil. They also fragment OM in the soil, making it easier for microbes to decompose
Macrofauna	They are soil engineer as they are able to move soil particles

can be a waste of money, natural resources, and can have negative impacts on plant, soil, and ecosystem health.

8.5 Rehabilitation of Soil and Wasteland

“Rehabilitation” means the amends of ecosystem processes, services, and productivity, but it does not mean to restore the ecosystem to its pre-existing condition. Soil and wasteland rehabilitation is the process of returning the land in a given area to some degree of its former state, after some process has resulted in its damage. Various developmental projects such as mining, agricultural practices, etc., are responsible for land degradation.

Land rehabilitation is an interference intended to make a land improvement of land ecosystems. In most situations, this engages the mitigation of land degradation caused by poor land husbandry practices, especially agricultural practices. The important issues in land rehabilitation concern to what degree the land should be rehabilitated to self-sustaining natural control and to what degree to a sustainable economic after-use, where future land quality is sustained by careful management and repair. In many contexts, land rehabilitation works involve countering the physical symptoms of land degradation, which include losses of soil quality due to soil compaction, and also accelerated runoff and erosion on hill slopes and in watercourse. In other contexts the interventions include the mitigation of soil erosion and pollution.

8.5.1 Soil Rehabilitation

The soil is an important component in land rehabilitation. The soil controls growth of crops on the land and it determines land infiltrates into the soil, runs off as surface flow remains stored at the surface in ponds or in the soil attached to the soil particles through evaporation/transpiration of water into the atmosphere. Directly or indirectly, through the vegetative cover, the soil also regulates the rate at which soil is removed by water or wind erosion. Soil is a living resource; it is a living ecosystem, complex dynamic, evolving, biologically modulated open system.

The soil may be defined as **“a biotic build favoring net primary productivity”.** As you know, soil is important factor in bio-geochemical cycles. It is where the crucial links in most land-based biogeochemical cycles churn. Soil biological processes organize nutrient supply, chemical buffering, soil density, porosity, aeration, and water holding capacity. These factors affect soil structural stabilization, detoxification, and soil self-creation. Soil biology controls the quality of that soil and, in general, it makes the soil a better place for living organisms. This is why, in land rehabilitation, the central emphasis rests on the situation and vivacity of the soil.

Soils develop in a range of characteristic as the result of the vertical and horizontal movements of organisms, organic materials, water, chemicals, and soil particles. The self-development and evolution of soils is conditioned by following factors:

(i) Biological processes, the activities of organisms that develop on or in the soil, together with the enzymatic impacts of their secretions and waste products. Geological conditions, which through weathering, determine the character, availability and amount of the material from which the soil skeleton is created. Geomorphological and hydrological processes are determined by the position of the soil in the land ecosystem, which influence the amount of erosion, drainage or deposition it has experienced. Climatic and microclimatic processes that control the activities of the biological system and that encourage physical processes through wetting/drying.

Human impacts, because most soils have been distorted by land-use, in many cases, these disturbing activities, including cultivation, forest farming and grazing, have been sustained for many decades or centuries. Most of the soils that are found on land scheduled for rehabilitation have been damaged by inappropriate land use – poor land husbandry. Frequently, the solution to their problems and, by extension that of land degradation is simply to change the way they are managed.

(ii) Soil Qualities to be addressed in Land Rehabilitation: Shaxson (FAO, 1999) described the seven soil quality factors may be tackled during land rehabilitation. These characters are:

- Rate of soil formation
- Bio-productivity (soil fertility)
- Rainwater infiltration
- Moisture and biodiversity of Soil

- Water loss from the soil through evaporation
- Soil rhizosphere
- Toxicity of soil

(iii) Enhance Soil Depth: Land rehabilitation needs the occurrence of a self-sustaining soil, which means that there must be a balance between soil development and soil loss. This can be attained in two ways, by reducing the rate of soil erosion, the traditional soil conservation approach, or by enhancing soil formation. Scientists emphasize the function of organic acids in accelerating the weathering of bedrock as plants mine for the minerals they need and, in the process, accelerating soil formation. In recent time, there has been much success using *Mucuna beansto* regenerate soils in tropical steep lands. *Mucuna* is able of generating 100 tonnes ha of green manure each year and has been used to rehabilitate lands that were almost devoid of cultivatable soil. However, increasing effective soil depth can be achieved in many ways besides the incorporation of organic matter. On the other hand, soil depth can be changed by the physical collection of soils, as during the creation of agricultural terraces by cut and fill from hillsides. In industrial land reclamation, many sites are finished with top soil imported from other sites. Agricultural equivalent is to make a site, such as a dam, which collects the soil mobilized by wind and soil erosion and converts it into a flat depositional terrace that can be used for cultivation.

8.5.2 Rehabilitation of Waste land

According to Dudley Stamp (1954) "Waste land is that land which has been previously used, but which has been abandoned, and for which no further use has been found." As you know that waste land is land which was previously used for cultivation, but due to low productivity it has been abandoned. According to Vohra (1978), about 6000 million tones of fertile soil containing 5 million tonnes of NPK are displaced per year. Various developmental activities such as industries, urbanizations, agricultural practices, etc. are leading to waste land genesis. The rehabilitation of wasteland through the soil management of soil and vegetation would minimize siltation and enhance the water yield in catchment areas. It depends on the soil capability, climatic conditions and plant species. Deforestation is mainly responsible for genesis of waste land. Plants play very important role in rehabilitation of waste land. But, selection of plant species is most important aspect. Selection of plant species is based on local weather condition, adaptability, productivity and survivorship. The basic factors for the plant species are as follows:

(i) Plants should survive at nursery and growth level on wasteland.

(ii) Plants should have high reproductive fertility.

(iii) Plants should have high establishment rate.

(iv) Plants should have good regeneration power.

(v) Species should meet the local need of fuel, food and fodder.

Beside the basic factors, the decisive factors in selection of species for waste land rehabilitation are as follows:

(i) Local species should be site specific.

(ii) Potential and utilization of species should be identified.

(iii) Invasive species should be avoided as far as possible.

(iv) Afforestation should involve multi-specific approach. This is helpful to generation of soil.

(v) Silvi-characteristics of species should be cultured.

Table 3- Plant species suggested for rehabilitation of wasteland

Scientific Name	Local Name
Acacia catechu	Kher
Acacia concinna	Shikakai
Butea monosperma	Palash
Pogamia pinnata	Karanja
Schleichera oleasa	Kusum
Madhuca latifolia	Mahua
Emblica officinalis	Amla
Cassia fistula	Amaltash
Aegle marmelos	Bel Patthar
Sapindus laurifolius	Soap nut
Spondias mangifera	Wild mango
Mangifera indica	Mango
Dendrocalamus strictus	Male bamboo, solid bamboo
Bambusa arundinaceae	Bans
Strychnos nux vomica	Poison nut

(Source: Ramachandra and Kumar, 2003)

8.6 Restoration of Wasteland

In an ecosystem, “restoration” means the process of recovering an ecosystem that has been damaged, degraded, or destroyed may be because of soil erosion or human interference. Restoration of an ecosystem is an attempt to return it to its historical trajectory. The process of restoring an area of land back to its original state, following disruption or damage to it. This process entails the removal of toxins and other dangerous substances, the removal of other structures, and improvement of the soil. This process is typically used for rectifying issues that have been caused by processes such as drilling for oil, coal mining, and other activities, as well as for improving land following a natural disaster.

Many of our important resources, including those that are essential such as bricks or coal, come from the ground. As a result, land is destroyed even for the basic processes of living. This has gone on ever since civilization began. But, the pace of this destruction has depended on the pace of living, on both the type and the level of the activities which have contributed to a civilized existence.

(A) Land restoration is the process of ecosystem restoration of a site to a natural ecosystem and habitat of microbe, plants and animals. As you know ecological destruction is generally the effect of pollution, deforestation and other human activities.

(a) Methods of Wasteland Restoration: A degraded soil typically loses its ability to produce crops, food and habitation for living organisms, in its surroundings. This situation cause negative impact of ecology and socio-economy of area. Therefore, effort is made to restore the soil back to its natural state. Characteristics of a degraded soil include: high salinity, decline in fertility, and decline in organic matter, soil erodibility and increase in alkalinity and acidity. Soil degradation can be caused by man. For example, agricultural activities can disturb the soil structure and its drainage capacity; chemical use can increase soil salinity or alkalinity. It can also be of a natural cause like salinization or erosion.There are various ways of restoring damaged soil which include:

(a) Use of organic farming techniques: It involves the application of natural means in agricultural farming, to reduce harmful effect to the environment. Some organic farming techniques that help restore the soil include use of green manure, cover crops, crop rotation and organic compost. This is one of the best techniques of restoration of waste land. As you know that chemical fertilizers are responsible for land degradation therefore, organic farming is good for restoration of waste land.

(b) Green manure and cover crops: These manures and crops provide as mulch to the soil preventing the soil from erosion and moisture loss. They also increase the soil organic matter content as they decompose in the soil. Green manure and cover crops that are have nitrogen fixing ability. The nitrogen fixing bacteria in their root nodules help capture nitrogen from the atmosphere. These manure and crops suppress weed growth. It is an inexpensive and natural method of controlling weeds and restoration of waste land.

(c) Organic compost: It is a generally cheaper method of fertilizing the soils compared to inorganic fertilizers. The compost is a combination of decomposed plant and animal waste. The main benefit of composting is that it increases soil organic matter content. As you know, organic matter improves the soil fertility, the soil structure and its water holding capacity of soil. It is also an appropriate aspect of carbon in the soil. The compost reduces use of chemical fertilizers which if applied inappropriately, can contaminate rivers, tributaries, streams and ground water.

(d) Crop rotation: It is an agricultural practice which involves growing different types of crops in one location in succession. This agricultural practice reduces soil erosion, increases the soil fertility and subsequently crop yield.

(e) Soil remediation: This is the best technique of wasteland restoration. It includes the removal of contaminants such as, heavy metals, sewage sludge, carcinogenic hydrocarbons, liquors and petroleum from soils. Soil remediation can achieve using biological techniques. This method is also called bio-remediation.

(f) Bio-remediation: Bio-remediation is a technique in which microorganisms are used for the degradation of hazardous substances in soil, sediments, water or other contaminated matters. Certain species of bacteria fungi, algae and plants are used for bio-remediation. **Bio-augmentation** is process in which microorganisms are imported to polluted site to enhance degradation of hazardous material. On the basis of degradation procedure bio-remediation may be of following types:

(i) Bio-transformation: It is alteration of contaminants in to less or non-hazardous substances.

(ii) Bio-degradation: It is the breakdown of organic substances in smaller organic or inorganic molecules.

(iii) Mineralization: It is the complete bio-degradation of organic material in to inorganic substances such as CO_2 or H_2O_4.

On the basis of type of organisms used, bio-remediation may be of following types:

(i) Bacterial Remediation: It is the process of using bacteria to breakdown molecular contaminants like hydrocarbons in to simpler and safer components. *Deinococcus radiodurans* is genetically modified bacteria which can breakdown the heavy metals as well as toluene. *Geobacter sufurreducens* can turn uranium in to non-soluble form. Bacteria namely *Thermus brockianus* breaks down hydrogen peroxide 8000 times faster than current chemicals in use. *Alcaligenes eutrophus* another type of bacteria can degrade 2-4-D (Herbicide used in United States).

(ii) Myco-remediation: It is the process of using fungi to breakdown molecular contaminants in to simpler and safer components.

(iii) Phyto-remediation: It is the process of using plant species to breakdown molecular contaminants to simpler and safer components.

Table - 4: Different phyto-remediation techniques

Technique	Plant mechanism	Medium
Phyto-extraction	Uptake and concentration of metal via direct uptake in to plant with subsequent removal of the plants	Soil
Phyto-transformation	Plant uptake and degradation of organic compounds	Surface water and Ground water
Phyto-degradation	Enhance microbial degradation in rhizosphere	Soil and ground water within rhizosphere
Rhizo-filteration	Uptake of metals in to plant roots	Surface water and water pumped

Many plants are used for bio-remediation in which Transgenic Arabidopsis can transforms mercury in to gaseous state, Bamboo can accumulate silica, Indian mustard (*Brassica juncea*) can accumulate sulphur, lead, selenium, chromium, cadmium, nickel, zinc and copper, Chinese ladder fern (*Pteris vittata*) can accumulate arsenic, cottonwood can accumulate mercury, tomato and alpine can accumulates lead, zinc and cadmium.

(i). **Compost bio-remediation:** In this process large number of beneficial bacteria can be introduced in to soil by brewing something called compost tea. Compost tea is water based, oxygen rich culture containing large population of beneficial aerobic bacteria, nematodes, fungi and protozoa which can be used to bio-remediate toxins. This brew is applied to contaminated sites where microbial population breakdown the toxic substances.

(ii). **In Situ Bio-remediation:** In situ bioremediation techniques are those techniques in which "Bio-remediation applied to soil or water at the site with minimum disturbances. It is technologies that are used "in place" without removal contaminated matrix. These techniques are the most desirable options due to lower cost and lesser disturbance since they provide the treatment in place avoiding excavation and transport of contaminants.

(iii). **Ex Situ Bio-remediation:** These are the bio-remediation technologies that require removal of contaminated matrix by excavation so it can be manipulated in some way through the use of slurry reactors, compositing, biopiles, etc. In this technique the contaminants degraded the site of contaminated place.

- **Advantages of Bio-remediation:**

➢ Bio-remediation is natural process and has no harmful impacts on local communities or population. Various advantages of bio-remediation are given below:

➢ Bio-remediation is useful for the complete destruction of a wide variety of toxic substances. By using this technique many substances that are legally regarded as hazardous can be transferred in to harmless compounds.

➢ Bio-remediation can be used on site (in situ) and off site (ex situ).

➢ Bio-remediation is less expensive than other technologies that are used for cleanup of hazardous waste.

- Bio-remediation is fully based on natural microbes; therefore it has no side effect on plants, animals and human being.
- Disadvantages of Bio-remediation:
- Bio-remediation generally takes longer time as compare to other technologies.
- It may be possible that product of bio-remediation may high toxic as compared to parental product.
- Bio-remediation is limited to biodegradable compounds.

(iv). Bio-augmentation: This is the introduction of genetically modified micro-organisms into contaminated soils with the aim of degrading contaminants. The efficiency of this technique depends on a number of factors, some of which are the physico-chemical properties of the soil and the ability of the introduced micro-organisms to compete successfully with the indigenous soil micro-flora.

Summary

In this unit, we have discussed various aspects of land husbandry, soil amelioration, rehabilitation and restoration of soil and waste land. So far you have learnt that:

- According to Francis Shaxson (2014) land husbandry is active process of managing land use systems and production in such ways that there will be increase productivity. There are various methods to improve land, soil and waste land which are certainly helpful to increase productivity of land. Various methods of land husbandry may include soil amelioration, rehabilitation and restoration of soil. Land husbandry includes the active management primarily of rain water, vegetation, soil and slopes.
- Hugh Hammond Bennett, the father of soil conservation, the world has seen a host of erosion control manuals and describing practical experience, technical principles, mechanical methods to be used, and a series of practical recipes that have been adopted with varying degrees of success in specific regions.
- According to Shaxson, Douglas and Downes, 2005 "land husbandry is the active process of implementing and managing preferred systems of production in such ways that there will be increase – or at worst, no loss of productivity, stability or usefulness

for the chosen purpose; also, in particular situations: existing uses or management may need to be changed so as to halt rapid degradation and to return the land to a condition where good husbandry can have fullest effect".

- Soil amelioration is technique in which we can improve the quality of soil. The word "melior" has been taken from Latin language which means "better,".
- There are various indications by which we can determine the soil polluted, water logged or higher salinity, etc. Drainage of water is indication in which we can observe the amount of water flowing slowly or quickly over soil. This may indicate saturated or unsaturated soil conditions.
- Amelioration Techniques for Saline soil includes Scraping, Leaching, Drainage, Irrigation methods, Irrigated methods, Proper use of Irrigation and Mulching, etc.
- The soil is a important component in land rehabilitation. The soil controls growth of crops on the land and it determines land infiltrates into the soil, runs off as surface flow remains stored at the surface in ponds or in the soil attached to the soil particles through evaporation/transpiration of water into the atmosphere. Directly or indirectly, through the vegetative cover, the soil also regulates the rate at which soil is removed by water or wind erosion. Soil is a living resource; it is a living ecosystem, complex dynamic, evolving, biologically modulated open system.
- Shaxson (FAO, 1999) described the seven soil quality factors may be tackled during land rehabilitation, these characters are: Rate of soil formation, Bio-productivity (soil fertility), Rainwater infiltration, Moisture and biodiversity of Soil, Water loss from the soil through evaporation, Soil rhizosphere and Toxicity of soil.
- The basic factors for the plant species in waste land rehabilitation are as plant should survive at nursery and growth level on waste land, Plants should have high reproductive fertility, Plant should have high establishment rate, Plants should have good regeneration power and Species should meet the local need of fuel, food and fodder.
- In an ecosystem, "restoration" means the process of recovering an ecosystem that has been damaged, degraded, or destroyed maybe because of soil erosion or human

interference. Restoration of an ecosystem is an attempt to return it to its historical trajectory.

- There are various ways of restoring damaged soil include, Use of organic farming techniques, Green manure and cover crops, organic compost, crop rotation and soil remediation.
- Bio-remediation is technique in which micro-organisms are used for the degradation of hazardous substances in soil, sediments, water or other contaminated matters. Certain species of bacteria fungi, algae and plants are used for bio-remediation. Bio-augmentation is process in which micro-organisms are imported to polluted site to enhance degradation of hazardous material.
- There are various types of bio-remediation such as Bacterial Remediation, Myco-Remediation, Phyto-Remediation and Compost Bioremediation.
- Various advantages of bio-remediation are: Bio-remediation is useful for the complete destruction of a wide variety of toxic substances. By using this technique, many substances that are legally regarded as hazardous can be transferred in to harmless compounds, Bio-remediation can be used on site (in situ) or off site (ex situ), Bio-remediation is less expensive than other technologies that are used for cleanup of hazardous waste, Bio-remediation is fully based on natural microbes therefore, it has no side effect on plants, animals and human being.
- There are various disadvantages of Bio-remediation such as: Bio-remediation generally takes longer time as compare to other technologies, It may be possible that product of bio-remediation may be high toxic as compared to parental product and Bio-remediation is limited to bio-degradable compounds

Terminal Questions

1 (a) Fill in the blank spaces with appropriate words.

Hugh Hammond Bennett is the father of ……….., the world has seen a host of erosion control manuals and describing practical experience, technical principles, mechanical methods to be used, and a series of practical recipes that have been adopted with varying degrees of success in specific regions. Bennett's approach to soil conservation was then applied, with no prior testing, in totally different circumstances with the very indifferent results that have been seen by all. The environmental deprivation is closely bound up with the growth of ………….. They are of equal interest to Ecologists, foresters, geographers, hydrologists and as well as to…………. It is well said that "Every day the ………. dies silently, only our voices are left".

(b) Write note on land husbandry.

(c) Give the techniques of soil amelioration for saline soil

3 (a) Describe the rehabilitation of soil and waste land.

(b) What is restoration? Describe the restoration of waste land

4(a) Describe the types of bio-remediation.

5(a) Give the advantages and disadvantages of bio-remediation.

(b) Differentiate between ex-situ and in-situ bio-remediation.

6 (a) Fill the blank spaces with appropriate words.

According to ………….. (1954) "Waste land is that land which has been previously………., but which has been abandoned, and for which no further use has been found." As you know that waste land is land which was previously used for cultivation but due to low productivity it has been abandoned. According to Vohra (1978) about …………of fertile soil containing 5 million tonnes of ……….are displaced per year. Various developmental activities such as industries, urbanizations, agricultural practices, etc. are leading to waste land genesis. The rehabilitation of waste land through the soil management of soil and vegetation would minimize siltation and enhance the water yield in catchment areas. It depends on the soil capability, climatic conditions and plant species. …………is mainly responsible for genesis of waste land. Plants play very important role in rehabilitation of………. But, selection of ………is most important aspect. Selection of ……….is based on local weather condition, adaptability, productivity and survivorship.

(b) Myco-remediation is related with (Fungi/algae/protozoans/bacteria)

(c) Which is saline sensitive crop? (Wheat/Rice/Tomato/Oats)

(d) Hugh Hammond Bennett is regarded as father of soil conservation (Yes/No)

6 (a) Give the list of plant species which are used in wasteland rehabilitation.

Answers to Terminal Questions

1 (a) Soil conservation, civilization, social economists, land,

2 (a) see section 8.2, (b) See section 8.4

3(a) See section 8.5, (b) See section 8.6

4 (a) See section 8.6, (types of bio-remediation)

5 (a) See the section 8.6 (Advantages and disadvantages of bio-remediation)

(b) See the section 8.6 (Ex-situ and In-Situ bio-remediation)

6 (a) Dudley Stamp, used, 6000 million tones, NPK, Deforestation, waste land, plant species, plant species, (b) Fungi, (c) Tomato, (d) Yes

7(a) See the section 8.5 (Table-3)

Unit 9: Water and Water Resources: An Introduction, Status, Characteristics and Utilization

Unit Structure

9.0 Learning Objectives

After studying this unit you will be able to explain:

- What are Water Resources?
- Why water resources are important?
- The types of water resources
- The Water Resources at Global and national level
- How humans Utilized water Resources?

9.1 Introduction

Water is one of the most important natural resources and regarded as elixir of life. We can understand the importance of water through this sentence which stated that "Water is the Driving Force of all Nature". It means every activity of nature is performed by water. It is well said that Pure Water is the First and Foremost Medicine. Almost all of the water on Earth, more than 97.5% of water, is seawater in the oceans (NCERT text book). The rest water is called freshwater, because it does not have a high salt content. Most of the freshwater is frozen solid in large glaciers in Antarctica and Greenland. Almost all of the fresh water that is available for human use is either contained in soil and rock below the surface, called groundwater, or in rivers, streams and lakes called surface water. Water is most precious gift provided by nature, without water we cannot imagine the life on this planet. As you know, man uses water resources for the purpose of agricultural, industrial, household, recreational and environmental activities. Only 2.5% of water on the Earth is fresh water, and over two thirds of this is frozen in glaciers and polar ice caps. It is estimated that 70% of world-wide water use is for irrigation in agriculture (Wilson, et.al. 1997). Climate change will have significant impacts on water resources around the world because of the close relations between the climate and hydrologic cycle. Average runoff in the river system of the India is about 1869km3 and out of this; the utilizable portion is predictable to be about 690 km3. Due to various manmade or anthropogenic activities, this precious resource is depleting and contaminating at very fast rate. Various anthropogenic or manmade activities such as domestic sewage, industrial effluent, excessive use of chemical fertilizers, improper management of solid waste leading in to serious damage to water resource. As you know, we celebrate World Water Day on 22nd March every year to conserve this precious natural resource. In this unit, you will learn about water resources at Global and National levels, characteristics and utilization of water resources.

9.2 Water at a Glance

- Water is transparent, odourless, tasteless and inorganic compound.
- Its Chemical formula is H_2O.
- It is used for drinking, cleaning, agriculture, transportation, industry, recreation, and animal husbandry, producing electricity for domestic, industrial and commercial uses.
- About 70% of earth is covered by water.
- 1386 million cubic km water is available at global level.
- 97.5% water is marine or salt water.
- Hydrology is the study of movement, distribution and quality of water.

- The cycle of water is called hydrological cycle. In this cycle evaporation, precipitation, transpiration & runoff are common steps.
- 2.5 % of water is “Freshwater” in the form of rivers, lakes, ponds, ground water, glaciers and icecaps.
- Water is found in all three stages viz., liquid, solid and gas.
- About 70% of freshwater is used for irrigation in agriculture.
- In fact, only about 9,000-14,000 cubic km are economically available for human use - a mere teaspoon in a full bathtub when compared to the total amount of water on earth.
- The water needed for crops amounts to 1000-3000 cubic meters per ton of cereal harvested. It means, it takes 1-3 tonnes of water to grow 1kg of cereal.
- The daily drinking-water requirements per person are 3-5 liters.
- However, it takes 2,000 – 5,000 liters of water to produce a person’s daily food.

9.3 Water and Water Resources

Water resource is most precious resource among other natural resources. Water is the most widely distributed substance on our planet. Human life itself is impossible without it because it can be substituted by nothing else. Men have always consumed fresh water for different purposes. Water resources are sources of generally freshwater that are useful, or possibly useful, to human being, for example for domestic, agricultural and industrial uses.

In many parts of the earth water resources have become much polluted that they are already unable to meet the ever increasing demands. This has become the main factor hindering economic development and population growth. Water occurs in three states: liquid, solid, and gas. It forms the oceans, seas, lakes, rivers and the underground waters and water found in the top layers of the Earth’s crust and soil cover. In a solid state, it lies as ice and snow cover in Polar Regions. A certain amount of water is contained in the air as water vapor, water droplets and ice crystals, as well as in the biosphere (In living organisms).

To monitor the total water storage on the Earth reliably is a complicated task because water is very-very dynamic. It is in permanent motion, constantly changing from liquid to solid or gaseous phase or vice versa. It is essential to estimate the quantity of water found in the hydrosphere.

It is estimated that the hydrosphere contains a huge amount of water about 1386 million cubic kilometers. However, 97.5% of this amount is saline waters and only 2.5% is fresh water (Wilson, et.al. 1997). The greater portion of this fresh water (68.7%) is in the form of ice and permanent snow cover in the Antarctic, the Arctic, and in the mountainous regions, 29.9% exists as fresh groundwater and only 0.26% of the total amount of fresh waters at global level is concentrated in lakes, reservoirs and river systems where they are most easily accessible for our economic needs and vital for water ecosystems (Wilson, et.al. 1997).

As it is earlier mentioned, that water is dynamic and moves from one phase to another phase. Heat of Sun evaporates water into the atmosphere from the surface of earth. Land, lakes, rivers and oceans send up a steady stream of water vapors; this spreads over the surface of the planet before falling down again as precipitation/rainfall. Precipitation falling on land is the main source of the formation of waters found on land i.e., rivers, lakes, groundwater, and glaciers. A portion of atmospheric precipitation evaporates; some of it penetrates and recharges groundwater, while the rest runs as river flow and returns to the oceans where it evaporates: this process repeats continuously. On the other hand, some groundwater by passes river systems altogether and may be goes directly to the ocean or may evaporates in atmosphere.

These are the fundamental sources of fresh water to support life and as well as to economical activities. River water is of great importance in the hydrological cycle and for the supply of water to mankind. The time for complete recharge of sea water takes about 2500 years, for permafrost and ice about 10,000years and for deep groundwater and mountainous glaciers takes about 1500 years. Water storage in lakes is fully refilled over about 17 years and in rivers about 16 days. Based on water exchange characteristics, two concepts are often used in hydrology, first is the static storage component and second is the renewable water. The static storage conventionally includes freshwater with a period of complete renewal taking place over many years or

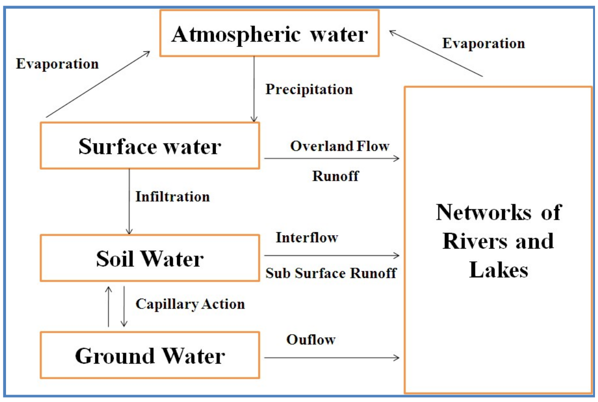

Fig-1: Water Movement or Water Cycle

decades such as large lakes and groundwater. Intensive use of this component unavoidably results in depleting the storage and has unfavorable results (Wilson, et.al. 1997).

If man suddenly stops contaminating rivers, then within sometimes water could return to its natural purity. Thus, river runoff, representing renewable water resources, is the most important component of the hydrological cycle. It exerts a pronounced effect on the ecology of the earth and on human economic development. It is river runoff that is most widely distributed over the land surface and provides the major volume of water consumption in the world.

9.4 Status of Water Resources at Global Level

Literally, the water is source of life on earth. It is the major constituent of hydrosphere that consists of the oceans, seas, rivers, streams, glaciers, lakes, reservoir, polar ice caps and the shallow ground water bodies that interflow with the surface water. Approximately 70.8% of the earth surface is covered with water mainly in the form of oceans. It is estimated that hydrosphere contains about 1,386 million cubic km of water, and out of this about 97.5% is in the oceans and inland seas, where high salt content does not permit its use for human consumption. About 2.5% of the water resource is locked in the glaciers and ice caps, rivers, streams, lakes and reservoir and as ground water sources (Wilson, et.al. 1997).

Table-1: Distribution of water at global level (Sharma, 2018)

Location	**Volume in million cubic km**	**% of total**
Freshwater and lakes	0.125	0.009
Saline lakes and inland seas	0.104	0.008
Rivers	$1.25X10^{-3}$	0.0001
Moisture in soil	0.067	0.005
Ground water	8.3	0.61
Glaciers and Ice caps	29.2	2.14
Total Land area water	**37.0**	**2.8**
Atmosphere water vapors	0.013	0.001
Oceans	1320	97.3
Total world water	**1360**	**100**

The stock of salt water and freshwater has been fairly steady right through history. But the small portion between sea water and freshwater has always changed according to climatic circumstances. Temperature plays very important role in hydrological cycle. You can understand this phenomenon by following given example. Whenever the climate is very cold, much of sea water is absorbed by glaciers and ice caps and freshwater increases at the expense of the sea water. On the other hand the in hot climate glaciers and ice caps melt and sea water gains at the cost of fresh water. Sea level observations during the last 100 years indicate that the sea level is rising, which means, the global climate is getting warmer continuously (Wilson, et.al. 1997).

9.4.1 Freshwater

Fresh water is naturally found in the form of ice caps, ponds, lakes, rivers, streams, and groundwater. It has low concentration of dissolved salts and TDS. About 2.5% water of this planet is Freshwater. It is also called “Sweet Water”. The main source of freshwater is precipitation/rainfall. Fresh water is a renewable and variable, but limited natural resource. Fresh water only is recharged through the process of the hydrological cycle, in which water from seas, lakes, forests, land, rivers, etc. evaporates, forms clouds, and returns as precipitation. Freshwater may classified as surface water (Ponds, lakes, rivers, streams, and reservoir) and Ground water.

9.4.2 Salt-Water

Saline water is that which contains a huge concentration of salts. About 97.5 % of the total water of the world is salt water. On the basis of salt concentration, saltwater may be categorized as following.

- **Slightly saline water:** In this category salinity is about 1,000 to 3,000 ppm or 0.1–0.3%.
- **Moderately saline water:** In this type of salt water, salinity is about 3,000 to 10,000 ppm or 0.4–1%.
- **Highly saline water:** In this type of salt water, salinity is about 10,000 to 35,000 ppm or 1.1–3.5%.

Importance of Water: Water is essential for life not only human life, but all ecological processes of this planet. It is part of life itself, since it is the medium in which all living processes occur. It dissolves nutrients and distributes them to cells, regulates body temperature, supports structure and removes wastes products. Even, about 60% of human body is made up of water. As you know that we start our daily activities with water. Any person can survive for week without food, but cannot survive more than few days without water. Since the earliest days in mankind, the availability of water has determined where human settlements were built and what food human being could rise. Many human civilizations were established near the water bodies. Without water neither the individual not the community can exist. The earth is only a planet where liquid water exists in sufficient quantities. Water bodies cover more than 70% of earth surface. Unfortunately, most of the water in earth is salt water, which is not suitable for drinking and other purposes. As you know every activity of man involves some use of water, and he needs water not only for drinking purpose, but also for bathing, washing, heating, air conditioning, agriculture, livestock, industrial activities, hydropower generations, steam power, navigation, recreation, aquaculture, and for disposal of waste. A community with a limited water supply is a community with a limited growth, because the overall food production and large scale generation of electrical energy still very much depend on the availability of water resources and also there is an increasing demand of water by industries.

There are great variations in current per capita water availability for each continent (Table-2). Oceania has over 70,000 cubic meters per person per year, the Africa has under 7000 m^3/person/year on the other hand Asia has only 3400 m^3/person/year. If the total amount of water is relatively fixed, larger and larger number of people will reduce total per capita water availability over time.

Fresh water crisis: If we compare with all other natural resources, water is used in tremendous quantities. In recent time, the total mass of water used on earth per year has been approximately 1000 times the global total production of minerals including coal, petroleum, metal ores and non-metals. On the global scale, total water abundance is not the problem. The problem is availability of water in the right place at the right time in the right form. As you know, Rainfall/Precipitation is seasonal and, therefore, the amount of water in inland water (surface and ground water sources) is variable. Irregularity in the time and intensity of rainfall generally causes flood or droughts. As you understand that Freshwater is limited at global level, on an annual basis, it is estimated that 12.5 to 14 billion cubic meters water is available for human use. On the other hand freshwater also sufficient to population of world, but equitable distribution is not possible because-firstly, two third of the global population lives in areas receiving only a quarter of the

Table-2: Per capita water availability by continent (Sharma, 2018)

Continent	Water Availability (Cubic meters per person per year)
Oceania	76000
South America	35000
North and Central America	16000
Africa	6500
Europe	4700
Asia	3,400

global annual rainfall; and secondly there is no proper rainfall throughout the seasons or from year to year.

According to World Health Organization (2020) about 40 countries in the world fall below the 2,000 cubic meters of good water per person per year, the minimum quantity of freshwater needed for a healthful life and about 2 billion people of global population lack access to secure drinking water or sanitation. The highest percentage of people in water poor countries are in Africa and Middle East. Unfortunately, growing population and stagnant economies meant that most countries only kept even or fall behind in the proportion of their people with acceptable water supplies. For conservation of water resources there are various strategies have made at global level. The UN proclaimed year 2003 as the “International Year of Freshwater”.

Water Resources at Global level: As per WHO (2020) There are various forms of water resources at global level which are described below and also summarized in Table-4.

- Freshwater resources are unevenly distributed, with much of the water located far away from human beings. Most of the larger river basins of World run through thinly populated areas. There are an estimated 263 major international river basins in the world, covering 23,10,59, 898 km2 or 45.3% of the Earth's land surface area (excluding Antarctica)
- Groundwater represents about 90% of the available freshwater resources, and some 1.5 billion people depend upon groundwater for their drinking water.
- Agricultural water use accounts for about 70% of total global consumption, mainly through crop irrigation, industrial use accounts for about 20%, and 5%, is used for domestic purposes and remaining 5% used for other purposes.
- It is estimated that two out of every three people will live in water-stressed areas by the year 2025.
- About 20% of the global population lacking access to safe drinking water. Water-borne diseases from fecal pollution of surface waters continue to be a major cause of illness in developing countries. Polluted water is estimated to affect the health of 1.2 billion people, and contributes to the death of 15 million children annually.

- Impacts of climate change may comprise a significant rise in the level of the oceans. This may cause some coastal areas to become completely submerged, and increase human vulnerability in other areas. Because human populations are highly dependent upon marine resources. Small Island Developing States (SIDS) are especially vulnerable, due to both the effects of sea level rise and to changes in marine ecosystems.

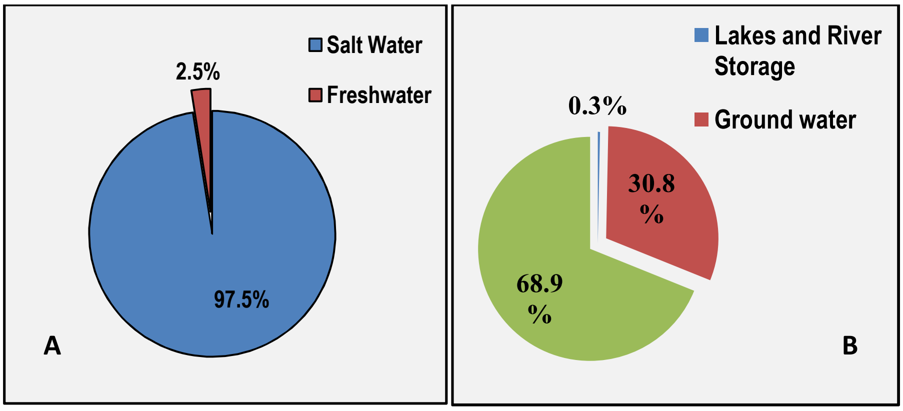

Fig 2. A- Showing percentage of Salt water and Freshwater at Global level; B. Showing percentage of Freshwater at Global level

Ground water is by far the most abundant and readily available source of freshwater, followed by lakes, reservoirs, rivers and wetlands (surface water). According to Boswinkel (2000), groundwater represents over 90% of the readily available freshwater resource at global level.

According to United Nations Environment Program (UNEP), 1.5 billion People depend upon groundwater for their drinking water supply. According to Shiklomanov (1999), the volume of freshwater resources is about 35 million km^3, or about 2.5% of the total volume. Out of these freshwater resources, 24 million km^3 (68.9%) is in the form of ice and permanent snow cover in mountainous regions, the Antarctic and Arctic regions. Freshwater lakes and rivers contain an estimated 1,05,000 km^3 (0.3%) of the freshwater at global level.

Table-3: Fresh water distribution and their percentage at global level.

Polar ice	68.6
Ground water	30.1
Other ice and snow	0.97
Lakes	0.26
Soil moisture	0.047
Atmospheric water	0.037
Marshes	0.33
Rivers	0.006
Biological Water	0.003

(Source: Sharma, 2018)

The total usable freshwater supply for ecosystems and humans is 2, 00,000 km^3 of water (< 1%) of all freshwater resources (Shiklovmanov, 1999).

Most freshwater occurs in the form of permanent ice or snow, locked up in Antarctica and Greenland, or in deep groundwater aquifers. The principal sources of water for human use are lakes, rivers, soil moisture and relatively shallow groundwater basins. The replenishment of freshwater depends on evaporation from the surface of the oceans. About 5,05,000 km^3, evaporates from the oceans annually. Another 72, 000 km^3 evaporates from the land. About 80% of all precipitation, or about 4,58,000 km^3/year, falls on the oceans and the remaining 1,19,000 km^3/year on land.

Table 4: Total water stock at global level (Shiklomanov, 1999)

	Volume 1000km^3	Percentage of Total Water	Percentage of Total Freshwater
Salt Water			
Oceans	1338000	96.54	
Saline/Brackish/Ground Water	12870	0.93	
Salt Water Lakes	85	0.006	
Inland Water			
Glaciers, Permanent snow cover	24064	1.74	68.7
Fresh Ground water	10530	0.76	30.06
Ground Ice/Permafrost	300	0.022	0.86
Freshwater Lakes	91	0.007	0.26
Soil Moisture	16.5	0.001	0.05
Atmospheric water vapors	12.9	0.001	0.04
Marshes/Wetlands	11.5	0.001	0.03
Rivers	2.12	0.0002	0.006
Incorporated in Biota	1.12	0.0001	0.003
Total Water	**13,86,000**	**100**	
Total Water	**35,029**		**100**

9.5 Status of Water Resources at National Level

India has about 4% of freshwater resources of world and ranking it among the top ten water rich countries. However, India has current utilizable freshwater 1,122 cubic meter per person per year and per capita while international standards for this utilization is as 1,700 cubic meter per person per year.

In future, at the current rate it is expected that India with high demands will be termed a 'water scarce region' as utilizable freshwater falls below the international standard of 1,000 cu m per year and per capita. Water demand is on a high due to rapid urbanization and industrialization along with the demand for agriculture. Overall, every year, precipitation in the form of rain and snowfall provide over 4,000 cu km of freshwater to India, of which 2,047 cu km return to oceans or is precipitated.

In India, rivers have been the lifelines of development and culture. India is drained by twelve major river systems with a number of smaller rivers and streams. The main river systems of North India are Ganga, Yamuna, Indus and Brahmaputra. The South India has Krishna, Godavari, and Cauvery while central India has the Narmada, Mahanadi and Tapti river system. Over 70% of rivers drain into the Bay of Bengal, mostly as part of the Ganges-Brahmaputra system. The Arabian Sea receives 20% of the total drainage from the Indus, Tapti. The remaining 10% drains into interior basins and natural lakes. Besides, the floods and droughts, most Indian rivers are cesspools of waste dumped from various urban and industrial centers. According to the Central Pollution Control Board, 18 major rivers are severely polluted. 44 rivers in State Kerala losing their quality through deforestation, sand mining, riverbank brick making and pollution.

As you know, the rivers are the sources of drinking water for urban and rural areas, raw water for industries, and irrigation. Many rivers of India suffer from silt deposition in its bed reducing flow, and disturbing the ecosystem. Deforestation at the riparian zone of the rivers is leading to soil erosion, landslide, floods, silt formation etc. In rivers of India, siltation rate is among the highest in the world. It has been predicted that about 135 thousand million metric tonnes of sediment load and 32 thousand million tonnes of soluble matter enter into ocean through various rivers. Numbers of large dams and barrages have been built on these rivers. The various dams of India and their impacts are discussed in Unit-10 of this course.

India is also home to most beautiful lakes of the world. They are there in the high Himalayan regions under the ice sheath, in northeast, semi-arid deserts of Rajasthan, coastal zones, small towns and villages. In India, lakes are important source of water for drinking, agriculture, and industries purposes. These lakes act as sewage absorbers, flood controller and recharger of groundwater. These are important ecosystems where a variety of birds and animals make their habitats. Lakes also provide pisciculture, and aquaculture which thrives leading to a source of income for people. In India, there are urban and rural lakes which have been categorized under the Ramsar Convention on Wetlands (1971) and are important mostly from ecological sustainability and as a source of livelihood for many communities. Water shortages in these lakes, which sources of replenishment are seriously impaired due to manmade activities. However, water resources of India mainly categorized as surface water and ground water.

A. Surface water resources: As you know, surface water is type of water which occurs on the surface of earth. This water present in the form of river, lake, wetlands or even ocean. The main source of surface water is rainfall or precipitation. After the rainfall, a sizable portion is captured by the vegetation, or temporarily detained in surface depressions. When soil become fully saturated the remaining water begins flow. This water reaches the rivers, streams, lakes, surface reservoirs, etc. Agriculture mainly depends on surface water resources. Water runoff from streams and rivers is stored in reservoirs or diverted through canal system for irrigation. Surface run-off generated by rainfall and snowmelt is estimated to be about 1869 billion cubic meters (BCM) in India. However, it is estimated that only about 690 billion cubic meter (BCM) or 37% of the surface water resources can actually be mobilized. Because, over 90% of the annual flow of the Himalayan Rivers occurs over a four month period and potential to capture such resources is complicated by limited suitable storage reservoir site. The average annual rainfall in India is about 1170 mm. Most rain falls in the monsoon season (June-September), necessitates the creation of large storages for maximum utilization of the surface run-off. However, it is possible to have both situations of drought and of floods in the same region. India has great variation in rainfall, ranging from a low value of 100 mm in Western Rajasthan to over 11,000 mm in Meghalaya. The Krishna basin leads in term of storage capacity (41.80 km^3), followed by Godavari basin (25.12 km^3) and Narmada basin (16.98 km^3) (Balasubramanian, 2007). The various water resources of India are discussed below:

B) River systems in India (Characterization of Rivers): The main character of river is the ability to erode and transport sediment. This is affected by many factors. The velocity of the water, gradient of river, discharge, and the shape of river are main characters of river. The velocity of water in a river is the distance that water travels in a given amount of time. The velocity of the water in a river is related to the amount of energy of water. As you know, fast-moving River can erode materials more rapidly and can carry larger particles as compare to slow-moving River. Many factors affect a velocity, including the steepness of the slope, the amount of water traveling downstream, and shape of the path where water travels. The steepness of the slope of a stream or river is called its gradient.

The discharge of river is the volume of water that passes a certain point in a given amount of time. Discharge is not always constant throughout the length of a river. In most of the rivers, discharge increases downstream because many tributaries continuously add more water in the river. During monsoon increased precipitation or at the times when snow is melting, more water runs into rivers. The velocity of the water also increases and river becomes wider and deeper and cause flood. The Ganga River has width about 700 meters at Haridwar and its width is about 5km at Patna (Balasubramanian, 2007).

Rivers are important sources of water supply, even though the water from these sources is generally more variable in quality. The water quality in rivers depends on various factors like geology and topography, seasonal variation, disposal of sewage, etc.

Rivers are the main source of surface water. A river basin has well defined watershed boundary and also has relationship with ground water resources. India has various river systems. On the basis of their path, these rivers may be as followings:

1. Flowing into the Bay of Bengal: Ganga, Mahanadi, Krishna, Kaveri, Godavari, and Brahmaputra.
2. Flowing into the Arabian Sea: Indus, Narmada, Tapti, etc.

There are various river systems of India, which are discussed below and also summarized in Table-1.

Indus River: Indus River is one of the longest rivers in the world, which originates from Mount Kailash in Tibet. It has total length of 3,199 km. It flows through the regions of Ladakh, Baltistan and Gilgit and runs between the Ladakh and the Zaskar Ranges. Total length of the river in India is about 1,114 km. The main tributaries of the Indus River in India are Jhelum, Chenab, Ravi, Beas and Sutlej. Its catchment area is about 11, 65,500 km^2. Its drainage area lying in India is 3, 21,289 km^2 (Balasubramanian, 2007). In India, the Indus basin lies in the Jammu and Kashmir, Ladakh, Himachal Pradesh, Punjab, Rajasthan, and Haryana Union Territories of Chandigarh.

Brahmaputra River System: The r Brahmaputra Rive originates from Angsi glacier. The river flows through China, India and Bangladesh. In India, it enters in the Arunachal Pradesh where it is called Siang. It flows through Arunachal Pradesh and Assam, and is joined by several tributaries. Its catchment area is about 5, 80,000km2 (Balasubramanian, 2007).

Ganga River: The Ganga River rises from the Gangotri Glacier in the Garhwal Himalayas, Uttarakhand at an elevation of some 4,100 meters above mean sea level. The main tributaries of the Ganga are Yamuna, Ram Ganga, Gomati, Ghaghara, Son, Damodar and Sapt Kosi. The river after traversing a distance of 2,525 kms from its source meets the Bay of Bengal. The major cities along its course are Haridwar, Kanpur, Varanasi, Patna, Bhagalpur, Sahibganj, Farakka and Haldia. About 40% of India's population depends on Ganga River Basin. The total catchment area of the Ganga River is about 11, 86,000km2. This is the longest river of India and regarded as National River of India (Balasubramanian, 2007).

Yamuna River: The Yamuna River originates from the Yamunotri glacier, 6,387m above mean sea level, at the Banderpoonch Peak in the Uttarkashi district of Uttarakhand. The catchment of the river extends to states of Uttar Pradesh, Himachal Pradesh, Haryana, Rajasthan and Madhya Pradesh and the entire union territory of Delhi. The river flows 1,367 km from here to its confluence with the Ganga River at Allahabad (Uttar Pradesh). The other main tributaries of the Yamuna River are: Hindon, Chambal, Sind, Betwa and Ken (Balasubramanian, 2007).

Table-5. Water resources of India

Estimated annual precipitation (including snowfall)	4,000 km^3
Average annual potential in rivers	1,869 km^3
Estimated utilisable water	1,123 km^3
Water demand ˜ utilization (for year 2000)	634 km^3

(Source: Water Resource information System of India)

Narmada River: The Narmada River is a river in central India and it is also called Rewa River. It forms the traditional boundary between North and South India, The total length of river is about 1,289 km. It originates from the peak of Amarkantak in Madhya Pradesh. It flows through the states of Madhya Pradesh, Maharashtra, and Gujarat and it empties into the Arabian Sea in Indian State Gujarat. Its total catchment area is about 98,796km^2. Sher, Skakkar, Dudhi and Tawar are the main tributaries of Narmada River (Balasubramanian, 2007).

Tapti River: The Tapti River is also river of central India and one of the major rivers of peninsular India. Its total length is about 724 km. This river is also mythologically very important and regarded as daughter of Sun. It originates in Muttai Satpura Range at Betul district of Madhya Pradesh. The Tapi or Tapti River basin lies mostly in northern and eastern districts of Maharashtra state. It flows in the states of Madhya Pradesh, Maharashtra and Gujarat. The Total catchment area of Tapti River is about 65,145 km^2 (Balasubramanian, 2007).

Godavari River: The Godavari River is second longest river of India after Ganga. This river flows about 1,465 km and originates from Trimbakeshwar, near Nasik in

Maharashtra around 380 km distance from the Arabian Sea and empties into the Bay of Bengal. It travels through various different states such as Maharashtra, Telangana, Andhra Pradesh, Chattisgarh, M.P., Orrisa, Karnataka and Puduchery. In Puduchery this river is known as Yaman. The Important tributaries of Godavari River are Indravati River, Manjira, Bindusara and Sabari. Its total catchment area is about 3,12,812 km2. It empties in to Bay of Bengal. (Balasubramanian, 2007).

Krishna River: The Krishna River is one of the longest rivers of India and it travels 1300 km in length. It originates at Mahabaleswar (ancient temple of Lord Shiva) in Maharashtra. This River flows through the states of Maharashtra, Karnataka and Andhra Pradesh. The main tributary of the river is Tungabhadra River Other tributaries of river are: Koyna, Bhima, Mallaprabha, Ghataprabha, Yerla, Warna, and Dudhganga rivers. Its total catchment area is about 2, 58,948km2 (Balasubramanian, 2007).

Cauveri River: The Cauveri River is one of the great rivers of India and flows through states of Karnataka and Tamil Nadu. It supports agriculture for centuries, and the Cauveri has been the lifeblood of South India. The source of the river is Talakaveri located in the Western Ghats. It flows generally south and east for around 765 km. The main tributaries of river are Shimsha, Arkavathy, Kapila, Lakshmana Tirtha, Kabini, Bhavani, Noyyal and Amaravati. Its total catchment area is about 81,155km^2. It empties in to the Bay of Bengal (Balasubramanian, 2007).

Mahanadi River System: The Mahanadi River is the third largest river in the peninsula of India and the largest river of Orissa state. The total length of Mahanadi River is about 851 km. The main branches of Mahanadi meet Bay of Bengal at Paradip and Nuagarh. Its total catchment area is about 1, 41,589km2 (Balasubramanian, 2007).

Lakes: There are various lakes which are also located in India. Lakes are formed by backrest of glaciers, blocked rivers, etc. In lakes, the soil is supersaturated with water, and there are small areas of still or slow moving water. In lakes, the water is standing, not flowing, which is called lentic ecosystem. The water in lakes, stratified according to temperature, oxygen and biotic components. Lakes are inland depression that holds standing freshwater throughout the year. Lakes are generally larger than the ponds and water of lakes generally more accessible than ground water or glaciers, they are considered as an important source of freshwater supply. Water from these sources is more in equity, in quality than the water from rivers and streams. There are various characteristics of lakes which are given below:

Lakes are usually stratified because they stand relatively still, compared with streams and rivers. If you swim in a lake where, the surface water warm, but you will feel the cooler water when you swim in deeper side of the lake. Typically, the coldest layers are found at the bottom. Changing temperatures in the spring and fall prevent stratification during those seasons, and the bottom waters rising to the top stir up nutrients. During the summer, ice warms and melts, and this water warms from 0^0C to

Table-6: The details of water resources potential of river basins in India

River Basin	Catchment area(km^2)	Average annual potential (km^3)	Utilisable surface water resources (km^3)
Indus (up to Border)	3,21,289 (1,16,5,500)	73.31	46.00
a) Ganga	8,61,452 (1,18,6,000)	525.02	250.00
b) Brahmaputra	1,94,413 (5,80,000)	-	-
c) Barak and others	41,723	585.60	24.00
Godavari	3,12,812	110.54	76.30
Krishna	2,58,948	78.12	58.00
Cauvery	8,1155	21.36	19.00
Subernarekha	29,196	12.37	6.81
Brahmani and Baitarni	51,822	28.48	18.30
Mahanadi	1,41,589	66.88	49.99
Pennar	55,213	6.32	6.86
Mahi	34,842	11.02	3.10
Sabarmati	21,674	3.81	1.93
Narmada	98,796	45.64	34.50
Tapi	65,145	14.88	14.50
WFR from Tapi to Tadri	55,940	87.41	11.94
WFR from Tadri to Kanyakumari	56,177	113.53	24.27
EFR between Mahanadi and Pennar	86,643	22.52	13.11
EFR between Pennar and Kanyakumari	1,00,139	16.46	16.73
WFR of Kutch and Saurashtra including Luni	3,21,851	15.10	14.98
Area of Inland drainage in Rajasthan	-	Negligible	Not applicable
Minor Rivers draining into Myanmar and Bangladesh	36,202	31.00	Not applicable
Total	**-**	**1,869.35**	**690.31**

(Source: Water Resource information System of India)

4^0C, it becomes denser and sinks. This causes the layers to mix. In the fall, the waters become colder. As the water temperatures drop below 4^0C, the colder layers rise to the top, and again the whole body of water is mixed.

The dissolved oxygen (DO) is generally highest near the surface of the water, where oxygen can diffuse with atmospheric air. However, the amount of dissolved oxygen varies quite a bit as the result of differences in temperature, sunlight, wind and the number of plants at various depths. Some fishes are bio-indicators of the amount of oxygen in the lake. Fishes such as trout (fast moving fish) need more oxygen; while fishes such as catfish (slow moving fish) can survive in areas with low dissolved oxygen. In a lake, you will find more producers (green plants), found near the top, and more consumers (animals) near the bottom of the lake. Producers require sunlight near the surface of the water for process of photosynthesis. The bottom layers contain consumers such as anaerobic bacteria and decomposers (fungi and bacteria). The biotic stratification consists of three zones.

Table-7: Some important Lake systems in India

S.No.	Location	Name of Lake
1.	Andhra Pradesh	Hussain Sagar Lake, Kolleru Lake and Cumbum lake
2.	Assam	Haflong Lake, Sivasagar Lake, Jaoysagar Lake, Gaurisagar Lake, Chandubi lake and Rudrasagar,
3.	Bihar	Kanwar Lake Bird Sanctuary
4.	Chandigarh	Sukhna Lake
5.	Gujarat	Hamirsar lake, Kankaria lake, Nal Sarovar and Thol Lake
6.	Haryana	Badkhal Lake, Blue bird lake, Damdana Lake and Karna Lake
7.	Himachal Pradesh	Brighu Lake, Chandra Tal, Dehnasar Lake, Ghadhasaru lake, Govind Sagar Lake, Kamrunag Lake, Kareri Lake, Lama Lake, Prashar lake, Manimahesh Lake and Mahakali Lake
8.	Jammu and Kashmir including Ladakh UT	Dal Lake, Anchar Lake, Wular lake (Largest freshwater lake in India), Satsar Lake, Nigeen Lake, Tulian Lake and Tarsar Lake
9.	Karnataka	Agara Lake, Bellandur Lake, Lalbagh Lake, Madiwala Lake, Puttenahalli Lake, Ulsoor Lake and Varthur Lake
10.	Kerala	Ashtamundi Lake, Vembanad Lake, Vellayani Lake, Punnamada Lake and Kuttanad Lake
11.	Madhya Pradesh	Bhojtal Lake
12.	Maharashtra	lonar lake, Pashan Lake, Powai Lake, Salim Ali lake, Tulsi Lake, Vihar lake and Chatri Lake
13.	Manipur	Loktak Lake
14.	Meghalaya	Umiam Lake
15.	Mizoram	Palak Lake
16.	Odisha	Anshupa Lake, Chilka Lake (Largest Saltwater lake in India) and Kanjia Lake
17.	Puducherry	Bahour lake, Oustery lake and Velrampet lake
18.	Rajasthan	Ana Sagar Lake, Balsamand lake, Man Sagar Lake, Nakki Lake, Pachpadra lake and Pushkar Lake
19.	Sikkim	Gurudongmar lake, Cholamau Lake (Highest lake of India) and Samiti Lake
20.	Tamil Nadu	Kaliveli Lake, Kodaikanal Lake, OOty Lake and Perumal Eri
21.	Telangana	Bhadrakali Lake, Durgam Cheruvu, Himayat Sagar and Hussain Sagar
22.	Uttar Pradesh	Bela Sagar Lake, Ramgarh Tal Lake, Moti Jheel and Bakhira Tal
23.	Uttarakhand	Bhimtal Lake, Naini Lake, Naukuchiya Tal, Sattal, Jhilmil jheel
24.	West Bengal	Senchal Lake, Mirik Lake, Santragacchi Lake

Limnetic Zone: This zone is inhabited by photosynthesizers, including phytoplankton (diatoms, chlorophyceae, bacillariophyceae, etc.) and zooplankton (rotifers, copepods, Cyclops, cladocerans and others).

Profundal Zone: This zone is too deep for photosynthesis to occur and this zone has limited life.

Table-8: List of Ramsar Sites of India

Sl. No.	Name of Site	State Location	Date of Declaration	Area (*in Sq. km.*)
1	Kolleru Lake	Andhra Pradesh	19.8.2002	901
2	Deepor Beel	Assam	19.8.2002	40
3	Kabartal Wetland	Bihar	21.07.2020	26.20
4	Nalsarovar Bird Sanctuary	Gujarat	24.09.2012	120
5	Thol Lake Wildlife Sanctuary	Gujarat	05.04.2021	6.99
6	Wadhvana Wetland	Gujarat	05.04.2021	6.30
7	Sultanpur National Park	Haryana	25.05.2021	1.425
8	Bhindawas Wildlife Sanctuary	Haryana	25.05.2021	4.12
9	Chandertal Wetland	Himachal Pradesh	8.11.2005	0.49
10	Pong Dam Lake	Himachal Pradesh	19.8.2002	156.62
11	Renuka Wetland	Himachal Pradesh	8.11.2005	0.2
12	Wular Lake	Jammu & Kashmir	23.3.1990	189
13	Hokera Wetland	Jammu & Kashmir	8.11.2005	13.75
14	Surinsar-Mansar Lakes	Jammu & Kashmir	8.11.2005	3.5
15	Tsomoriri Lake	Jammu & Kashmir	19.8.2002	120
16	Asthamudi Wetland	Kerala	19.8.2002	614
17	Sasthamkotta Lake	Kerala	19.8.2002	3.73
18	Vembanad Kol Wetland	Kerala	19.8.2002	1512.5
19	Tso Kar Wetland Complex	Ladakh	17.11.2020	95.77
20	Bhoj Wetlands	Madhya Pradesh	19.8.2002	32.01
21	Lonar Lake	Maharashtra	22.7.2020	4.27
22	Nandur Madhameshwar	Maharashtra	21.6.2019	14.37
23	Loktak Lake	Manipur	23.3.1990	266
24	Bhitarkanika Mangroves	Orissa	19.8.2002	650
25	Chilka Lake	Orissa	1.10.1981	1165
26	Beas Conservation Reserve	Punjab	26.9.2019	64.289
27	Harike Lake	Punjab	23.3.1990	41
28	Kanjli Lake	Punjab	22.1.2002	1.83
29	Keshopur-Miani Community Reserve	Punjab	26.9.2019	3.439
30	Nangal Wildlife Sanctuary	Punjab	26.9.2019	1.16
31	Ropar Lake	Punjab	22.1.2002	13.65
32	Keoladeo Ghana NP	Rajasthan	1.10.1981	28.73
33	Sambhar Lake	Rajasthan	23.3.1990	240
34	Point Calimere Wildlife and Bird Sanctuary	Tamil Nadu	19.8.2002	385
35	Rudrasagar Lake	Tripura	8.11.2005	2.4
36	Haiderpur Wetland	Uttar Pradesh	8.12.2021	69.08
37	Nawabganj Bird Sanctuary	Uttar Pradesh	19.9.2019	2.246
38	Parvati Agra Bird Sanctuary	Uttar Pradesh	2.12.2019	7.22

39	Saman Bird Sanctuary	Uttar Pradesh	2.12.2019	52.63
40	Samaspur Bird Sanctuary	Uttar Pradesh	3.10.2019	79.94
41	Sandi Bird Sanctuary	Uttar Pradesh	26.9.2019	30.85
42	Sarsai Nawar Jheel	Uttar Pradesh	19.9.2019	16.13
43	Sur Sarovar	Uttar Pradesh	21.8.2020	4.31
44	Upper Ganga River (Brijghat to Narora Stretch)	Uttar Pradesh	8.11.2005	265.9
45	Asan Conservation Reserve	Uttarakhand	21.7.2020	4.444
46	East Kolkata Wetlands	West Bengal	19.8.2002	125
47	Sunderbans Wetland	West Bengal	30.1.2019	4230

(Source: Ministry of Environment, Forests and Climate Change, Government of India)

Benthic Zone: This region is inhabited by decomposers and anaerobic bacteria. As lakes age, organic materials builds up on the bottom, the organic material causes eutrophification. The older lakes take on swamp like characteristics and produce methane. The age of a lake can be identified using bio-indicators. Types of phytoplankton and algae are good indicators of the age of a lake

Wetlands: India is also endowed with numerous wetlands. The main character of wetland is vegetation in and around the aquatic body. The water in wetlands may be freshwater, brackish water or saltwater. India is a signatory of the Ramsar Convention, an international treaty for the conservation and sustainable utilization of wetlands. Ramsar convention on Wetlands of International importance especially as water fowl habitat is international treaty for conservation of wetlands. Ramsar is named after Ramsar City, Iran. 26 Ramsar wetland sites are located in India (Table-8). This convention was signed in the year 1971.

Glaciers: Five states of India have glaciers and these glaciers are source of several rivers. Main characteristic feature of glaciers is ability to flow. When sufficient ice gets piled up, it exerts substantial pressure on the ice in the lower layers and it acquires plastic properties which enable the ice-mass to move outward or downhill and thus an active glacier comes into being. When there is thick accumulation of ice on a slope, the glacier under the influence of gravity begin to flow slowly down a valley until it reaches a point where the rate of melting exactly balances the increment of ice. A glacier may extend far below the snow-line. As you know, the accumulation of snow is more in the central part of the glacier and there is a decrease in the thickness of ice near the marginal parts. The rate of movement depends on a number of factors, such as: Thickness of the glacier; Gradient of the slope which it covers; Temperature of the ice; Rate of evaporation and melting and the intensity of retarding friction along the slope, etc. The rate of movement of the Himalayan glaciers varies from 2 to 4 metres per day. The glaciers of the Alps move at the rate of 0.1 -0.4 metres per day. Some of the glaciers of Greenland move at a rate of about 20 metres a day. There are various glaciers in India which are listed in Table-9:

Table-9. State wise important glaciers of India

State	Name of Glaciers
Arunachal Pradesh	Bichom and Kangto Glaciers
J & K	Nun Kun Massif, Machoi, Nubra and Sgataf glaciers
Himachal Pradesh	Bara Shigri Glacier, Chandra Glacier, Chandra Nahan Glacier, Chhota Shigri, Dhaka Glacier, Mukkila Glacier and Sonapani
Uttarakhand	Gangotri, Kalabaland, Namik, Panchchuli, Pindari, Sunderdhunga, Milam, Sona, Chorabari and Satopanth glaciers.
Sikkim	Zemu, Rathong and Lonak Glaciers

Indian Ocean: The Indian Ocean is the third largest oceanic division of the world. It covers 70,56, 0000 km^2. Various seas, gulfs, bays and straits of Indian Ocean are Andaman Sea, Arabian Sea, Bay of Bengal, Gulf of Mannar, Gulf of Kutch, Gulf of Khambat, Persian Gulf Red Sea, etc.

B. Ground Water Resources: As you know, ground water is that water which is found below the surface of earth. After Glacier, ice caps and snow fields, ground water is the next largest fresh water resource. When rainfall/precipitation that does not evaporate back into atmosphere or runoff over the surface percolates through the soil and either accumulates in an underground. Ground water source can be relatively simple to develop. Generally, ground water is clear and colourless, but harder than the surface water. The quality of ground water is generally uniform quality. Groundwater is the major source of freshwater for agriculture and domestic use in many areas of the world, particularly where surface water is insufficient.

The main source of ground water is Rainfall/Precipitation. However, ground water recharge is supplemented by other sources such as seepage from canals and field channels, ponds, tanks, deep percolation from irrigated fields, etc. A part of any of these water sources that infiltrates into surface soil may continue to move laterally at a shallow depth. This water which flows below the soil surface may eventually reach the stream channel.

The total run-off in the rivers includes melted snow, surface run-off, sub surface runoff and ground water runoff. Portion of run-off water, after infiltration reaches the ground water, together with the contribution made to ground water from a neighboring basins, effluent rivers, natural lakes, ponds, artificial storage reservoirs accounts ground water resources.

On the basis of geological consideration, the ground water in India is mainly categorized into following three categories:

a. Unconsolidated rocks: This region includes vast alluvial plains of the North India, from the West to East and between the Himalayan foot hills on the north and the peninsular to the south. The sediments carried out by the Indus, Ganga, and Brahmaputra are the most important rivers of unconsolidated rocks.

b. Semi-consolidated rocks: It is found in Andhra Pradesh, Rajasthan, Madhya Pradesh, Gujarat, Bihar, Orissa, Tamil Nadu, and West Bengal.

c. Consolidated rocks: Approximately, two-thirds of the country, including almost the entire peninsular India, is covered by consolidated rocks. The states includes in this region are: Rajasthan, Madhya Pradesh, Bihar, Gujarat, Maharashtra, Andhra Pradesh, Orissa, Karnataka, Kerala and Tami Nadu. Ground water is mostly pumped through open wells in these rocky areas.

Rain water percolates in the rocks and soils and is available to human being as ground water. According to Dr. A.N. Khosla (1949), total average annual run-off of all river systems in India is about 167.4 million hectare metre based on empirical formula which included both surface and ground waters.

Table -10. Classification of rocks and other geological formations of India

S.N.	Rock type formation	Assumed % rainfall contribution of ground water recharge
1	Hard rock formations and Deccan traps	10
2	Consolidated rock (sand stone)	5-10
3	River alluvia	15-20
4	Indo-Gangetic alluvium	20
5	Coastal alluvia	10-15
6	Western Rajasthan dune sand	2
7	Inter-montane valleys	15-20

According to the National Commission on Agriculture (1976), total ground water of the country as 67 m. ha m, excluding soil mixture and usable ground water resource, which was assessed as 35 mha m of which 26 m. ha m considered as available for irrigation.

State Governments and the Central Ground Water Board calculated the gross ground water recharge as 46.79 m. ha m and the net recharge (70% of the gross) as 32.49 m.

ha m. The rules and regulations recommended by the Ground Water Estimation Committee (1987) are currently utilized by the Central Ground Water Board and the State Ground Water Departments to compute the ground water Resources. Based on the recommendations of this committee, the annual replenishable ground water resources in the country work out to be 45.33 m. ha m. Keeping a provision of 15% (6.99 m. ha m) for drinking, industrial and other uses, the utilizable ground water resource for irrigation was computed 38.34 m. ha m per year.

As per the Planning Commission, the total 178 million hectare metres water resources are available but because of limitations of physiography, geology, dependability, quality and the present state of technology, only a small portion of it could be used. The demand of water for irrigation is increasing day to day due to population explosion and therefore, there is need of implementation of new technology which will have to be implemented for making appropriate use of the water resources.

According to the Central Ground Water Board in 2003, the total replenishable ground water resource in the country is more than 443 BCM/year and out of this, the ground water available for irrigation is about 362.4 BCM/year and for other uses including domestic and industrial purposes is about 71.2 BCM/year.

Some large states of India such as Uttar Pradesh, Andhra Pradesh, Madhya Pradesh and Maharashtra have total replenishable ground water resource more than 30 BCM/year. States are Assam, Bihar, Gujarat, Orissa, Tamil Nadu and West Bengal has 20 BCM/year or more replenishable ground water resource.

Table 11. Water demand in next thirty years (km^3) (Sharma, 2018)

Purpose	**Year**		
	2000	**2025**	**2050**
Domestic	42	73	102
Irrigation	541	910	1072
Industrial	8	22	63
Hydropower	2	15	130
Others	41	72	80
Total	**634**	**1092**	**1447**

Ground water resource of less than 1 BCM/year are Goa, Himachal Pradesh, Meghalaya, Nagaland, Tripura, Sikkim, Andaman & Nicobar Islands, Chandigarh, Dadra and Nagar Haveli, Daman and Diu, Delhi, Lakshadweep and Pondicherry. Uttar Pradesh has the largest ground water resources for irrigation which is as much as 68.95 BCM/year. Andhra Pradesh, Assam, Bihar, Madhya Pradesh, Maharashtra and Tamil Nadu have more than **20 BCM/year** ground water resources for irrigation.

9.6 Utilization of Water Resources

As you know water is an essential requirement of all living beings and indispensable for many human related activities. In nature, it transports eroded material from mountains and forests to the plains and to the sea. Man uses water to carry away his wastes, generate hydro-electric power, for navigation, industrial purposes and also as a source of recreation. Due to change in lifestyle of people, water consumption increases dramatically specially during summer period.

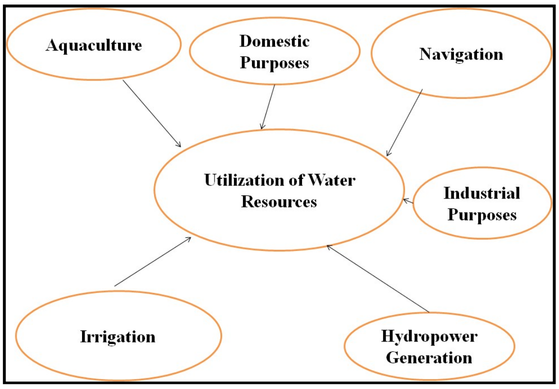

Fig 3.Different utilization of water resources

Water resources have been utilized by human being since their existence on this earth. There are several utilizations of water resources which are summarized in Fig-3 and also described below:

9.6.1 Domestic use

Domestic use of water may include drinking, washing, cleaning, bathing, cocking, etc. Community water supply is the most important requirement and it is about 5% of the total water use. About 7km^3 of surface water and 18 km^3 of groundwater being used for community water supply in urban and rural areas. Due to increase in population, another important change from the point of view of water supply is higher rate of urbanization. The higher is the economic growth, urbanization also increases. It is expected that nearly 61% of the population will be living in urban areas by the year 2050 in high-growth scenario as against 48% in low growth scenario.

The figure adopted by the National Commission on Integrated Water Resources Development (1999) was 220 litre per capita per day (lpcd) for class I cities. For the cities other than class I, the norms are 165 for the year 2025 and 220 lpcd for the year 2050. For rural areas, 70 lpcd and 150 lpcd have been recommended for the years 2025 and 2050, respectively. Based on these norms and projection of population, it is estimated that by 2050, water requirements per year for domestic use will be 90 km^3 for low demand scenario and 111 km^3 for high demand scenario. It is expected that about 70% of urban water requirement and 30% of rural water requirement will be met by surface water sources and the remaining from groundwater.

9.6.2 Irrigation

As it is earlier mentioned about 70% of water resource utilized in agricultural sector. In India irrigated area is about 22.6 million hectare (Mha) in 1950–51. Since the food production was much below the requirement of the country, due attention was paid for expansion of irrigation. The ultimate irrigation potential of India has been estimated as 140Mha out of this, 76Mha would come from surface water and 64Mha from groundwater sources. Water used for irrigation by the last century was of the order of 300 km^3 of surface water and 128 km^3 of groundwater, total 428km^3. The estimates indicate that by the year 2025, the water requirement for irrigation would be 561 km^3 for low-demand scenario and 611 km^3 for high-demand scenario. These requirements are likely to further increase to 628km^3 for low-demand scenario and 807 km^3 for high-demand scenario by 2050.

As you know, India has been an agriculture-based economy; development of irrigation to increase agricultural production for making the country self-sustained has been of crucial importance for the planners. Accordingly, the irrigation sector was assigned a very high priority in the 5-year plans. The schemes like the Bhakra Nangal, Hirakud, Damodar Valley, Nagarjuna Sagar, Rajasthan Canal Project, etc. were taken up to increase irrigation potential and maximize agricultural production. Long-term planning has to account for the growth of population. According to National Water Policy, the production of food grains has increased from around 50 million tonnes in the 1950s to about 203 million tonnes in the year 1999–2000. According to the National Commission on Integrated Water Resources Development (NCIWRD) by the year 2025, the population is expected to be 133 million in high-growth scenario and 1286 million in low growth scenario. For the year 2050, high rate of population growth is likely to result in about 1581 million people while the low growth projections place the number at nearly 1346 million.

9.6.3 Hydro-electric Power

Water resources have been used to generate hydro-electric power since prehistoric times. The hydro-power potential of India has been estimated 84,044MW at 60% load factor. At the time of independence, the installed capacity of hydro-power projects was

508MW. In the year 1998, the installed hydro-power capacity was about 22,000MW. The status of hydro-power development in major basins is highly uneven (Sharma, 2018).

According to an estimate, India has plans to develop 60,000MW additional hydro-power by the twelfth five-year plan. It includes 14,393MW during the tenth five-year plan (2002–2007); 20,000MW during eleventh (2007–2012) and 26,000 MW during the twelfth (2012–2017) five-year plans. A potential of the order of 10,000MW is available for the development of small hydro-power projects in the Himalayan and sub-Himalayan regions of the country. Therefore, it is not only desirable, but also a pressing need of time to draw a master plan for development of small, medium and large hydro--schemes for power generation. Indian rivers have fairly good hydro-power potential when they descend from their source mountains (Himalayan region, Western Ghat, Eastern Ghat, Vindhya Mountains, Aravali Range) before the water consumption or flowing to the sea (Levy and Sidel, 2011).

9.6.4 Industrial Purposes

Water is also used for various industrial processes, such processes may include: fabricating, washing, processing, diluting, cooling, etc. Agricultural industry is larger user of water in India, about 90% of water resource is used by agriculture and livestock. Average industrial use of water resource is about 19% at global level. United state uses 5% of water resource for industrial purpose. The surface water (41%) is major source for industrial purpose, followed by ground water (35%) and municipal water (24%). The industries that produce metals, wood, paper products, chemicals, oil, etc. are major users of water resources. Rough estimates indicate that the present water use in the industrial sector is of the order of 15km^3. The water use by thermal and nuclear power plants with installed capacities of 40,000MW and 1500MW, respectively, is estimated to be about 19km^3. If the present rate of water uses continues, the water requirement for industries in 2050 would be 103km^3; this is likely to be nearly 81km^3 if water saving technologies are adopted on a large scale (Levy and Sidel, 2011).

9.6.5 Aquaculture

As you know, that aquaculture is the cultivation of aquatic animals specially fishes for food. Aquaculture is also known as aqua-farming. Aquaculture is farming of fish, crustaceans, molluscs, aquatic plants, algae, etc. Therefore, aquaculture required water resources such as ponds, rivers and lakes. In India, annual aquaculture production is about 9.6 million tones. In the production of aquaculture, India is second in position after China. As you know India is blessed with huge water resources, therefore, aquaculture is common practiced in India. Fisheries, prawn culture, integrated fish farming, mariculture, pearl culture, mussel culture, seaweed culture, etc. are entirely based on water resources.

9.6.6 Recreational

Recreational is an essential and growing activity at global level. It is an activity that the people do for enjoyment, generally fresh the body and mind. Various studies showed that water based activities such a river rafting, bathing and swimming are among the most popular activities. Certain land area around water bodies are open for recreational uses such as hiking, hunting, snow skiing, etc. Water resources are also used for water skiing, swimming and fishing. Recreational uses of water resources may be categorized as:

I. Primary body contact

(i) Skiing
(ii) Swimming
(iii) Tubing
(iv) Wind surfing

II. Secondary body contact

(i) Aesthetic values
(ii) Boating
(iii) Canoeing
(iv) Hunting

9.6.7 Navigation

Water bodies are also used as transportation by human beings since time immemorial. Various aquatic bodies such as Ganga River, Hoogly, Brada and Vistula are also used for navigation.

Summary

In this unit, we have discussed various aspects of water resources, their characteristics and utilization of water resources. So far you have learnt that:

- Water is one of the most important natural resource among all the natural resources.
- About 97.5% water on land is salt water and 2.5% water is fresh water. Salt water is found in seas, oceans and other wetlands. On the other hand, freshwater is found in

glaciers, ice caps, snow, rivers, streams, lakes, reservoirs, ponds, ground water, etc.

- Oceania continent has maximum water availability (70000 cubic meter per person per year), on the other hand Asia continent has minimum (3400 cubic meter per person per year).
- About 263 major international river basins are found in the world.
- In India, there is various water resources are found in different forms. Major rivers of India include Ganga, Yamuna, Brahmaputra, Krishna, Cauvery, Godavari, Indus and Mahanadi.
- Four states and two UTs of India have glaciers and these are Jammu & Kashmir and Ladakah, Arunachal Pradesh, Uttarakhand, Himachal Pradesh and Sikkim.
- There are various lakes namely, Hussain Sagar Lake, Kolleru Lake, Cumbum lake, Haflong Lake, Sivasagar Lake, Jaoysagar Lake, Gaurisagar Lake, Chandubi lake, Rudrasagar, Kanwar Lake Bird Sanctuary, Sukhna Lake, Dal Lake, Anchar Lake, Wular lake (Largest freshwater lake in India), Satsar Lake, Anshupa Lake, Chilka Lake (Largest Saltwater lake in India), Kanjia Lake, Pushkar Lake, Gurudongmar lake, Cholamau Lake (Highest lake of India), Samiti Lake, Kaliveli Lake, Kodaikanal Lake, OOty Lake, Perumal Eri, Bhimtal Lake, Naini Lake, Naukuchiya Tal, Sattal and Jhilmil jheel found in India.
- There water resources are utilized for Irrigation, domestic purposes, hydro-power generation, aquaculture, industrial processes, recreational purposes and navigation, etc.

Terminal Questions

1(a) Fill in the blank spaces with appropriate words.

Freshwater resources are unevenly distributed, with much of the water located far away from human beings. Most of the larger river basins of World run through thinly populated areas. There is an estimated …….. major international river basins in the world, covering …………..or 45.3% of the Earth's land surface area (excluding Antarctica). Groundwater represents about 90% of the available freshwater resources and some …………people depend upon groundwater for their drinking water. Agricultural water use accounts for about …………… of total global consumption, mainly through crop irrigation, industrial use accounts for about …….. and ………is used for domestic purposes and remaining 5% used for other purposes.

2 (a) Discuss the types of water resources.

(b) Differentiate between Ground water and Surface water.

3 (a) Describe the different rivers of India.

(b) Write the note on lakes of India.

4 (a) Define water resource. Write about causes water resources at global level.

5 (a) Differentiate between salt water and freshwater.

(b) Give the status of ground water resource in India.

(c) What are the surface water resources in India?

6 (a) Fill the blank spaces with appropriate words.

As you know that aquaculture is the cultivation of ……… specially ……. for food. Aquaculture is also known as ……… Aquaculture is farming of fish, crustaceans, molluscs, aquatic plants, algae, etc. Therefore, aquaculture required water resources such as ponds, rivers and lakes. In India, annual aquaculture production is about……... In the production of aquaculture, India is second in position after ……… As you know, India is blessed with huge water resources; therefore, aquaculture is common practiced in India. According to S. Ayappan, Inland water resource in India as ……….. of rivers, 0.3 million hectare of estuaries, 0.19 million hectare of brackish water and lagoons, 3.15 million hectare of reservoir, 0.2 million hectare of food plain, wetland and 0.72 million hectare upland lakes. Fisheries, prawn culture, integrated fish farming, mariculture, pearl culture, mussel culture and seaweed culture, etc. are entirely based on …………..

(b) Total salt water at global level is about 97.5% (Yes/No)

(c) Largest freshwater lake of India is (Chilka Lake/Wular Lake)

(d) Pushkar lake is located in (Rajasthan/Madhya Pradesh/Jammu & Kashmir/H.P.)

(e) Freshwater resources is about ……at global level (2.5%/6.2%)

(f) Give the per capita water availability in different continent.

7 (a) Describe the Characteristics of rivers and lakes.

(b) Describe the utilizations of water resources.

References

1. Balasubramaniam, A. (2007). RIVER SYSTEMS OF INDIA Technical Report · February 2007. https://www.researchgate.net/publication/314216345
2. Boswinkel JA (2000) Information Note, International Groundwater Resources Assessment Centre (IGRAC), Netherlands Institute of Applied Geoscience,

Netherlands. In: UNEP (2002) Vital water graphics–an overview of the state of the world's fresh and marine waters. UNEP, Nairobi, Kenya

3. Central Ground Water Board (CGWB). Ministry of Jal Shakti, Department of Water Resources, River Development and Ganga Rejuvenation
4. Integrated Water Resource Management. (2020). National Commission on Integrated Water Resources Development (NCIWRD) (1999) http://nwm.gov.in/?q=integrated-water-resource-management.
5. Khosla, A.N. (1949) Appraisal of Water Resources (Analysis and Utilization of Data). Proceedings of UNESCO Conference on the Conservation and Utilization of Resources, Lake Success, New York, 17 August-6 September 1949.
6. Levy, B.S. and Sidel, B.W. (2011). Water Rights and Water Fights: Preventing and Resolving Conflicts Before They Boil Over. American journal public health. 778-780.
7. National Commission on Agriculture. https://www.worldcat.org/title/report-of-the-national-commission-on-agriculture-1976/oclc/4491358
8. Sharma, P.D. (13th edition): A text book on Ecology and Environment. ISBN: 935078122.
9. Shiklomanov, L.A. (1999). World Freshwater Resources. In: Gleick, P.H., Ed., Water in Crisis: A Guide to World's Freshwater Resources, Oxford University Press, New York, 13-24.
10. United Nations Environment Programme https://www.unep.org/explore-topics/water/about-water
11. Water Resource information System India. https://indiawris.gov.in/wris/#/
12. Wilson, R.L., Reely, B.T. and Cox, M. (1997). The Water Resource Management System (WREMS): Linking data management and operational optimization. Annals of operations research. 72, pages105–124 (1997).

Unit 10 Water Resource Development - Dams The Necessary Evil

Unit Structure

10.0 Learning Objectives

After studying this unit you will be able to explain:

- What is Water resource development?
- the meaning of Dams and Hydropower Projects
- dams of International level
- dams at National level
- what are positive impacts of Dams
- what are negative Impacts of Dams
- Why Dams are necessary evil?

10.1 Introduction

As you have learnt about the water resources in the Unit-9 of this course, in which we have described the utilization of water resources. Water resource is the best resource of the world. But unfortunately, this resource is not equally distributed and most of the water occurs in seas and oceans as salt water. As you know 2.5% freshwater is available in the world, out of 2.5%, most of the water locked in glaciers and ice caps (Sharma, 2018). Therefore, human being depends on surface water and groundwater. Undoubtedly river basins have played and will play very important role. Man uses water resources in various ways and developed the water resources accordingly. Water resources development may be understood as being the endeavourer actions intended at improving the beneficial use of water for human society. All possible uses of water may be categorized as consumptive (water supply, irrigation) or non-consumptive (Hydro-power, navigation). Water development may be interesting for the environmentalists who seek sustainable development, habitat deterioration, pollution, deforestation, destruction of wetland, for lawyers who observed water rights, legislation, and for the economists who emphasize on economic growth, mitigation of poverty, etc. Engineering works for development of water, they modified water as dams, canals, hydropower stations, etc., intended to develop a precise water potential. Man used water resources for different purposes since time immemorial. As we have discussed about utilization of water in unit-9 of this course and have emphasized the various utilizations of water such as, domestic utilization, irrigation, aquaculture, hydro-power generation, etc. Human being modified the water resources in various ways and dams are the perfect example of development of water resources. If we want sustainable and appropriate use of water, we should develop the water in sustainable ways. In this unit, you will learn about water development, concept of dam, dams at International and National levels, positive and negative impacts of dams and why dams are regarded as necessary evil.

10.2 Water Resource Development

Water resource development has been regarded as a method of economical and social development in different parts of the world. Water development receives the attentions from ecologists, environmentalist, hydrologists, sociologists and economists. Water resource development may involve irrigation techniques, development of dams, recreational methods, etc.

Water Development or water resource development may be defined as, “the set of activities of planning, developing, distributing and managing the best utilization of water resources”. Preferably, water resource development planning has regard to all the demands for water and seeks to assign water on an equitable basis to fulfill all utilizations and demands of human beings.

As you know, India is an ancient rural and agricultural based country which is rapidly urbanizing. The Country receives a good share of its annual precipitation in monsoon season, with high inter-annual variations. In many parts of the country, there is a need to store a large proportion of its annual runoff in reservoirs for different uses in non-monsoon months. In the country, per capita reservoir storage is comparably small, and water use efficiency also remains low. Water required for growing crops in a scientific manner in areas even with deficit rainfall. Navigation possibility in rivers may be enhanced by increasing the flow, increasing the depth of water required to allow larger vessels to move. India has long history of water development; however, water development at large scale was started in 19th Century. Initially, a large number of "run of the river" types of diversion project for irrigation got built at the foot hills of Himalaya. After 1975, a very large ground water development took place. As per the data of Central Water Commission, India, a live storage of about 220Km^3 has been built in various places exclusion minor, small and medium storages. At local level we can develop water resources through various methods. Human being modified the water resources in various ways. Some of the indigenous methods of water resource development are given below and also summarized in Fig- 1.

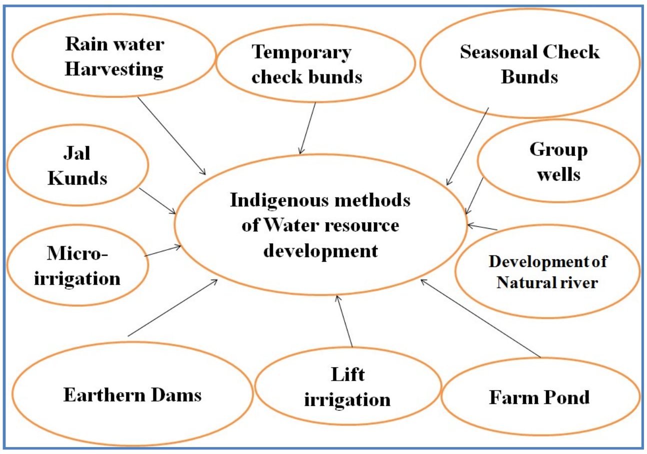

Fig-1. Indigenous methods of water resource development

Seasonal check bunds are good sources of water. Rivulets and gullies, which carry water for 4-6 months during and after the rainy season, are good sources of water. Development of checkbunds with soil or cement across rivulets is not generally advisable as the rivulets are prone to heavy flooding, and the catchment suffers heavy siltation. Instead, temporary checkbunds are constructed by placing sand bags across rivulets in the end of the rainy season. The water is used to cultivate rabi crops and irrigate fruit orchards. Temporary check bunds/dams can be built by local communities. In many villages, farmers have built bunds without finacial support. Water stored behind check bunds can be channelized by gravity to plots at lower elevations. In most cases, water is pumped and used by farmers. The structure is usually washed away in the monsoon season, and has to be rebuilt. *Earthen* dams can be constructed to plug gullies and use the catchment area as a percolation tank. A critical prerequisite is that beneficiary farmers should have ownership and control over the catchment area. Lift irrigation is used to distribute water collected in percolation tanks, behind check dams, as well as water flowing through rivers. Water is lifted and transported to farm ponds and tanks constructed by farmers. *Development of natural springs/Rivers is also very important method of water development. The main purpose of development of natural spring or rivers is to provide drinking water, irrigation etc.* In the areas where forest cover is high, natural springs are common. Special efforts are made to collect water from these springs, use for drinking purpose, irrigate agricultural land and nursery plants, and protect the catchment area from deforestation. Farm ponds developed in plots where percolation of rainwater is low, trapezoidal farm ponds of various sizes are dug to store rainwater. The water is used to irrigate fruit trees, food crops and vegetables. Pond size may vary from 5m x 5m to 10m x 10m.

Jalkunds are low-cost water tanks built in orchards. These are small rectangular ponds, with capacity to hold 2000-5000 liters of rainwater, are dug and all the sides are covered with a plastic sheet to prevent seepage. A jalkund with 4000 liters capacity can provide 10 liters of water every week to 10 trees of mango. Group wells are developed in area where ground water resources are *available, and there is no other water* source available, open wells are constructed. These methods are very useful specially in rural areas. The water from theses sources may be used for drinking, washing, cooking cleaning, irrigation and flood control. It is also observed that human being firstly modified or developed water resources by these methods. Human being developed “Gharat” in 7^{th} century to grind of grains wheat, rice and maize and also occasionally to extract oil. Gharats (Watermills) are generally developed near the river in which small amount of energy generated through the water current. However, these “Gharats” have been replaced by electric mills.

10.3 Dams at Global Level

Dam is just like a barrier that restricts the natural flow of water, specially in stream and river. Dams not only suppress flood, but also provide water for several activities such as irrigation, hydro-power generation, human consumption, industrial purposes, aquaculture, etc.

The first ever dam was built in 1890. In 1950 the world had 5,000 large dams. According to the World Commission on Dam Report (2000), there are 45,000 large dams in 140 countries in the world. Out of these, 22,000 are in China and in USA 6,390. India has about 4,291 dams (9% of the total of World), Japan has about 1,200 dams and Spain has about 100 dams. According to an estimate, 160-320 new large dams are built every year worldwide to trap runoff with dams and storage reservoirs so as to impound huge amount of rain water.

However, large dams can only be built in certain areas because these require space, water, money. Purposes of dam also vary according to country; some countries built dams for irrigation and some for generation of hydropower energy. For example: Europe has developed most of dams for HEP and Africa and Asia developed most dams for irrigation purpose. It is also important to know that very few dams help in flood control- only do flood control if dams at low level. There are various facts about dams at International level which are given below:

- Hydropower is the leading renewable source for electricity generation at global level. It is supplying 71% of all renewable electricity. It has 1,064 GW of installed capacity in 2016; it generated 16.4% of the world's electricity from all sources.
- Significant new development is concentrated in China, Latin America and Africa. Asia has the largest unutilized potential, estimated at 7,195 TWh/year, making it the likely leading market for future development. (PD Sharma, 2018)
- China accounted for 26% of the global installed capacity in 2015, on the other hand USA accounted for 8.4%, Brazil accounted for 7.6% and Canada for 6.5%. (Sharma, 2018)

Table-1: Showing largest dams at international level

Name of Dam	Generation Capacity	Name of River on which dam constructed	Name of Country
Three Gorges Dam	22.5GW	Yangtze River	China
Itai Pu Dam	14 GW	Parana River	Brazil
Xiluodu Dam	13860 MW	Jinsha River	China
Guri Dam	10235 MW	Caroni River	Venezuela
Tucurui Dam	8370 MW	Tocantins River	Brazil
Xingjiaba Dam	6400 MW	Jinsha River	China
Grand Colie Dam	6809 MW	Columbia River	United State
Long Tan Dam	6426 MW	Hongshui River	China
Krasnoyarsk Dam	6000 MW	Yenisei River	Russia
Robert Bourassa	5616 MW	La Grande River	Canada

- Significant advances in sustainable development practices in the sector through the Hydro-power Sustainability Assessment Protocol.
- As you know hydro-power has good synergies with all generation technologies, its role is expected to increase importance in the electricity systems of the future.

- There is an increasing trend towards building climate resilience and potential climate change impacts into decision-making processes for hydro-power owners and operators.
- Greater consideration of water management benefits offered by hydro-power facilities: flood control and water conservation during droughts or arid seasons.

Table-2: Showing number of Large Dams in India

NUMBER OF DAMS			
Time Period	**>15m high**	**10-15m High**	**Total**
Up to 1900	28	14	42
1901-1950	118	133	251
1951-1970	418	277	695
1971-1989	1187	1069	2256
1990 and beyond	56	60	116
Details are not available	74	162	236
Under Construction	461	234	695
Total	**2342**	**1949**	**4291**

(Source Central Water Commission)

- Significant new development is concentrated in the markets of Asia (particularly China), Latin America and Africa. In these regions, hydro-power offers an opportunity to supply electricity to under-served populations and a growing industrial base, while at the same time providing a range of other benefits related with multi-dimensional projects.

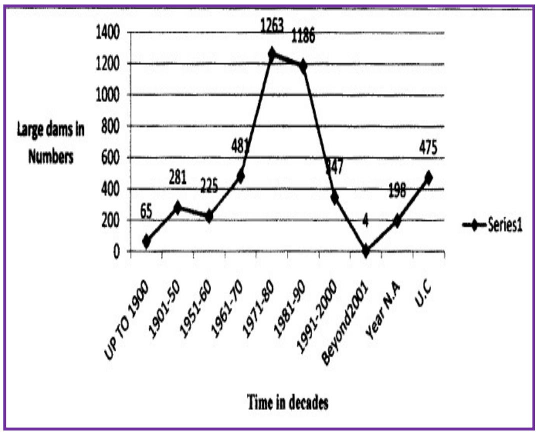

Fig-2: Growth of Large dams in India over the

10.4 Dams at National Level

As you have learnt in Unit-9, India is fully endowed with various natural resources and several rivers flowing across the country. Various rivers such as Godavari, Krishna, Damodar, Ganga, Yamuna, Tapti, Indus, etc. are flowing within the country. National water Policy in India was adopted in 1987 by National Water Resource Council. This policy is emphasized on holistic and integrated basin oriented approach to water development and promoting use of water. The Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR,RD&GR), Government of India, is responsible for conservation, management and development of water as a national resource. It is also responsible for overall national perspective of water planning, general policy, technical assistance, training, research and development, multi-purpose projects, flood management including flood-proofing, water logging, sea erosion and dam safety.

The Ministry of Water Resource (Now Ministry of Jal Shakti) has also been allocated the subject of regulation and development of Inter-State Rivers, implementation of Tribunals, water quality assessment, bilateral and external assistance and co-operation programmes for water resources and matters relating to rivers common to India and neighbouring countries.

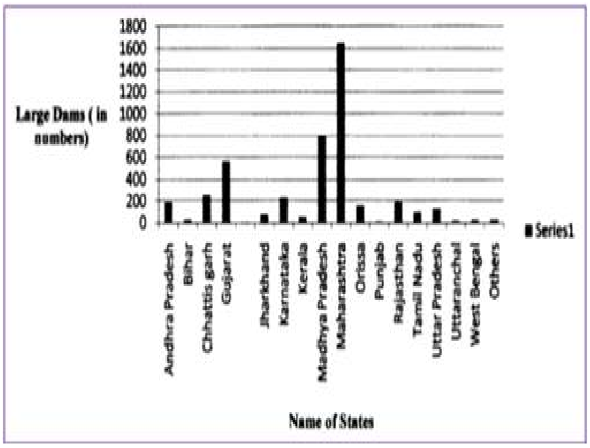

Fig-3: Distribution of Large dams in Different states of

Dam Rehabilitation and Improvement Project (DRIP) focus at rehabilitation and

Table-3: Showing some important dams of India, their location and capacity (Sharma, 2018)

Name of Dam	River	State	Installed Capacity (MW)	Height	Length
Nagarjuna Sagar dam	Krishna	Andhra Pradesh	816	124 m	1,450 m
Maithon dam	Barakar	Jharkhand	60	165 ft	15,712 ft
Tilaiya dam	Barakar	Bihar			
Sardar Sarovar dam	Narmada	Gujarat	1,450	163 m	1,210 m
Bhakra Nagal dam	Satluj	Himachal Pradesh	1325	226 m	520 m
Tungabhadra dam	Tungabhadra	Karnataka	72	49.38 m	2441 m
Krishnarajasagar dam	Main Cauvery	Karnataka	200	125 ft	3500 m
Cherothoni dam	Cheruthoni	Kerala	32	450 ft	2300 ft
Indira Sagar Dam	Narmada	Madhya Pradesh	1,000	92m	653 m
Koyana dam	Koyna	Maharastra	1,920	339 ft	2,648 ft
Hirakud dam (longest dam of India)	Mahanadi	Odisha	307.5	60.96 m	25800 m
Bisalpur Dam	Banas River	Rajasthan	172	130 ft	1883 ft
Bhavani Sagar dam	Bhavani	Tamil Nadu	32	105 ft	1700 m
Maitur Dam	Kaveri River	Tamil Nadu	120	120 ft.	1700 m
Tehri dam (highest dam of India)	Bhagirathi	Uttarakhand	1,000	260 m	575 m
Rihand dam	Rihand	Uttar Pradesh	300	299 ft	3064 ft

improvement of about 223 large dams in four States (Madhya Pradesh-50, Odisha-38, Kerala-31 and Tamil Nadu-104) through World Bank funding. The total cost of this project is about Rs.2,100 crore and has become effective from 18th April, 2012. There are various methods have implemented for water development in India.

10.5 Positive Impacts of Dam

Water is precious resource that is become increasingly scarce commodity worldwide. To assuage scarcity, there is growing pressure to harness and utilize surface water sources. The potential use could be for irrigation, aquaculture, hydroelectricity, water transport to deficit areas, etc. This is not a new trend, and people have been moving water around for many years. Some of the great ancient civilizations were based on large scale irrigation systems that brought river water to farm fields. Romans and Native Americans developed canals 2000 years ago to transport water from distant rivers to where it was needed. However, those early water engineers probably never even dreamed of moving water on a scale that is being proposed and in some cases, being accomplished now. Dams play very important role in the economy of any nations all across the globe. Various dams have been constructed for specific purposes such as flood control, water supply, irrigation, generate electricity, navigation, aquaculture, etc. Hydro-power is major source of electricity at global level, on the other hand agriculture required adequate amount of water which also provided by the dams. Therefore, dams play a vital role in overall development of the country. In ancient time, dams were constructed for single purpose, it either constructed for irrigation or either for flood control. But, at present time dams are multifunctional and have various utilities. There are various positive impacts of Dams which are summarized in Fig-4. The positive impacts of Dams are as follows:

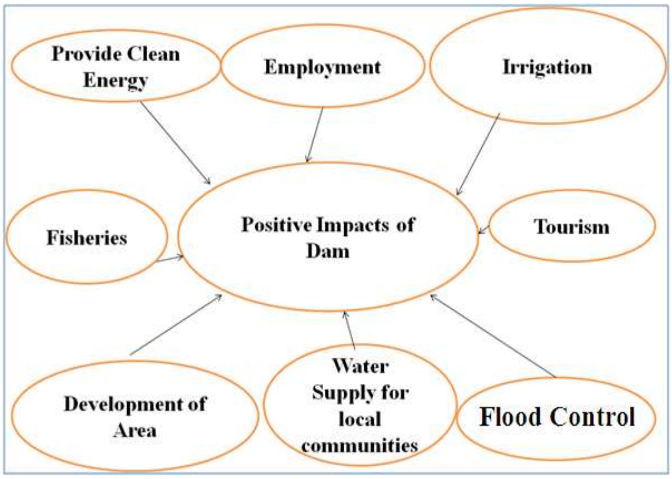

Fig-4: Positive impacts of Dams

1. **Provide Clean Energy:** Dams are very important to produce electricity by using the energy of moving water. In this process, kinetic energy of the river turns the wheel and converted into mechanical energy. The largest dam of world is Three Gorges dam which is constructed over Yangtze River in China. The dam is 2.3 kilometers wide and 185 meters high. The biggest hydro-plant in the United States is located at the Grand Coulee Dam on the Columbia River. More than 70 percent of the electricity made in Washington State is produced by hydro-electric facilities. In the present time, hydro-power is the cheapest way to produce electricity. Because once a dam has been built and the equipment installed, the energy source flowing water is free. It's a clean fuel source that is renewable.
2. **Irrigation:** This is one of the most important positive impacts of the dams. Most of the rivers of India flow in more than one state and hence irrigation is a controversial aspect in India. But, irrigation in India has been dominated by construction of major and medium projects. In the present time, water scarcity is common problem for farmers of all around globe. Dams provide adequate amount of water for irrigation. This water is generally used during the drier period. As you know, dams store large amount of water, then in the summer or drier period, it may be released from dam and distributed in agricultural land through different channels/canals. As you know about 70% of water resources have been used for irrigation purpose. Several irrigation projects such as Bargi project (Madhya Pradesh), Beas Project (Haryana, Punjab, and Rajasthan) and Bhadra Project (Karnataka) have been implemented in India (India water portal, 2017)
3. **Aquaculture:** Aquaculture is the cultivation of aquatic organisms specially fishes. Since, dams provide sufficient amount of water (stagnant), high plankton diversity, sufficient water depth and other suitable conditions to the fishes. Therefore dams also provide aquaculture opportunities to the communities. Aquaculture has proven to be a viable operation in multi-used irrigation many studies found the fitness-for-use of these dams for both net cage cultures of fish. (Central water commission) However, practicing intensive fish farming in existing open water bodies can increase the nutrient levels of the water through organic loading, originating from uneaten feeds and fish metabolic wastes.
4. **Navigation:** Population explosion certainly leads in to high pressure on roads, therefore many Governments of World looking for their alternative. As you known,

the conditions of rivers are very dangerous, due to erosion, sedimentation, etc. The rivers that have been developing with dams provide suitable condition for navigation. Dams provide stable water system of river transportation.

5. **Recreation:** Dams also provide prime recreational facilities throughout the world. Boating, skiing, camping, boat launch facilities are all supported by dams. There are various dams which are also used as recreational purpose, such dams are Nagarjuna Sagar Dam, Iddukki Dam, Tehri Dam, Hirakund Dam, Bhakra Nagal Dam, Sardar Sarovar Dam, etc.
6. **Flood control:** Dam is also helpful in flood control, since the dams can be effectively used to regulate level of river and prevent flood in downstream. Flood control is a main purpose for many of the existing dams.
7. **Water Supply:** Scarcity of water is common problem for whole world. Dams provide adequate amount of water supply to local communities. Dams store water for irrigation in summer seasons and dry months. Many desert areas can now farm due to dams and canals that supply water. Dams also provide drinking water to local stakeholders to compensate the hydrological cycle/water cycle, dams are needed to store water and then provide to communities during shortage of water.
8. **Land Improvement:** Dams are helpful in land improvement. Land improvement benefits; are the extra benefits that will occur after an increase in the soil productivity because of drainage and land improvement precautions.
9. **Economy and Employment:** Dams provide economy top states and countries. Dams also provide employment to engineers, workers, farmers, fishermens, etc. While the initial cost of dam construction is high, they are very inexpensive to operate. Electricity generated by hydro-electric power plants is the cheapest electricity generated.

10.6 Negative Impacts of Dams

Though dams have been useful over the centuries, but in recent years tapping of rivers through big dams has created lot of environmental, social and cultural issues. In many cases, they reduce water availability and destroy both natural and human values. Besides, the positive impacts, dams have various negative impacts especially on environment. The negative impacts of dams are summarized in Fig-5. The negative impacts are described as follows:

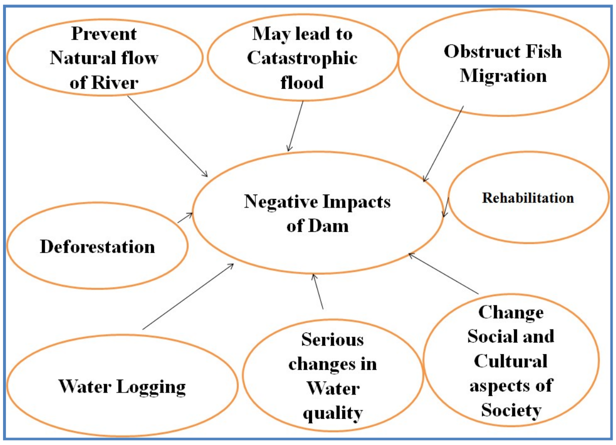

Fig - 5: Showing the negative impacts of dams

1. **Obstruct/Prevent Ecological flow of River:** Dams obstruct the natural ecological flow of the river. As you know that, natural ecological flow of river is responsible for sustainability of the river. Due to obstruction in ecological flow many biodiversity elements of the river are going to be threatened or are at the verge extinction. Ecological flow maintains the biodiversity and water of riverine ecosystem. Development of dams on river can change the species composition and water quality of the river.
2. **Enhance the chances of catastrophic flood:** The enormous weight of water behind the dam could trigger seismic activity that might damage the dam and can lead to catastrophic floods. As you know that catastrophic flood are more dangerous as compared to alluvial flood, coastal flood and other forms of flood. Catastrophic flood can submerge the cities within a few hours.
3. **Prevent fish migration:** As a result of dam construction and holding of sediments in reservoirs, sediment feeding of downstream channel or shore beaches is prevented. As the transfer of sediments is avoided by this way, the egg laying zone of the fishes living in the riverine ecosystem is eroded, too. Normal passing ways of territorial animals are hindered since the dam acts as a barrier. The fishes can be damaged while passing through the floodgates, turbines and pumps of the high bodied dams. There will be serious changes in the water quality as a result of drainage water returning from irrigation that was done based on the irrigation projects. The species may change parallel to the erosion caused by the human activities or the permanent increase in the water turbidity as an outcome of the dam construction. Migration is typical character of some migratory fishes in which fish moves from one place to another place for

different purposes (food, reproduction, etc.) especially for breeding purpose. Due to construction of dams many Diadromous fishes (fish which moves from fresh water to sea water or vice versa) cannot migrate. Due to construction of dam, the fish movement may be stopped or delayed. The Dam prevents migration of fishes between feeding and breeding zones. This type of prevention can lead to extinction of species. For example, *Hilsa ilisha* a fish of Ganga River ecosystem, as abundantly found in the regions of Patna, Bhagalpur, Varanasi, but after the construction of Farrakka barrage this fish can't migrate to these places and now restricted to some regions of West Bengal.

4. **Climate Change:** Climate of the regions may also affect due to construction and development of dams. Microclimate and even local climate changes may be observed due to construction of dams.
5. **Change in Water Quality:** Some dams loose so much water through evaporation and seepage into porous rock beds that they waste more water than they make available. Salt left behind by evaporation increase the salinity of the river and make its water unusable when it reaches the downstream. Accumulating sediments in the storage reservoir not only makes dams useless but also represents a loss of valuable nutrients to the downstream agricultural lands. Growth of snail populations in shallow permanent canals that distribute water to fields may lead to an epidemic of schistosomiasis. A number of water related diseases have been casually lined with creation of reservoir and the resettlement of population when dams are built. The greatest concern has been significant increase in the transmission of schistosomiasis and malaria, specially where water impoundments provide breeding-sites for the vectors. The spread of onchocerciasis in population living near dam spillways and downstream has also been reported. According to International River Network, 2001; Canadian Dam Association, 2001, temperature of water, salt and oxygen distribution may change vertically as a consequence of dam formation. This may cause the generation of new undesirable species.
6. **Water logging:** Water logging is the saturation of soil with water. Soil may water logged due to high water level. Water logging can reduce air in soil and increase in soil salinity, loss of useful biological community, etc. According to

Indian Institute of Science, about 40% of command area of Sardar Sarovar Dam will be water logged.

7. **Social and Cultural impacts:** Dams also affect the social and cultural aspects of the concern region considerably, specially forcing people, whose settlement areas and lands remain under water to migrate. Dams affect their psychology negatively. It is estimated that 400- 800 million people have been affected by dams at global level. For example, in Africa 3,50,000 people were displaced due to construction of dams during 1970s. Three Gorges Dams in China has displaced 1.4 million people. Dams also affect the society and culture of local community. As per World Commission on Dams, The Churchill Dams, have with cost benefit analysis and have great impact on social value of local people. However, Tehri Dam rehabilitated more than 135 villages. According to Administrative Staff College, Hyderabad the rehabilitation expenses of Tehri was Rs. 33,20,800 per family while in Narmada project the rehabilitated cost was Rs. 1,43,660, however, these figure are disputed and many families are still going to offices to retail the expenses. Sh. Sunder Lal Bahuguna made hunger strike to minimize the social impacts of Tehri Dam. About 135 villages were affected due to Tehri Dam construction. The dam generally displaces the tribal people who are uneducated and poor. Therefore, they cannot compete with other people in displaced areas, which consequently change the society of the communities. In Narmada valley project, were about one million people and 126 villages submerged in Maharastra, M.P. and Gujarat.

Table-4: Details of Family and Villages affected by Tehri Dam

	Completely submerged	**Partially submerged**	**Completely Evacuated**	**Total**
Number of villages and town	38	87	01	125 village and 1 Town
Number of families affected	5,012	4,278	5,291	14,581
Number of families paid compensation allotted land/flat, etc.	2,469 (564 Opted for cash)	Nil	5,057	7,526
Actually resettled in new sites	1,090	Nil	3,067	4,157

(Source: THDC, 1998)

10.7 Dams- the Necessary Evil

Dams help us retain our limited supply of fresh water whenever needed. Without dams, we cannot compete with other countries of the globe. Therefore, need for dams is undeniable. But, why the dams are necessary evil? Pt. Jawaharlal Nehru regarded dams as “Temple of India”. But as you know, dams have costs as well as benefits. Dams have played a vital role in the history of urban growth and were a vital part of infrastructure at the time.

Big dams even cause earthquakes due to high weight of reservoir, release greenhouse gases (because of the rotting of flooded vegetation), destroy marine fisheries (because they disrupt river-borne flows of freshwater and nutrients into oceans) and lead to coastal erosion (because the sediments that eventually fill reservoirs would previously have flowed out through estuaries and then been washed back by waves to protect the shoreline). The most noticed disaster related to dam was observed in China in which about 2, 30,000 people were died due to damage of dam. The World Commission on Dams estimated that 40 to 80 million people have been displaced by dams. As per the data, about 80% of lengths of the large river systems of world are at least moderately or severely eroded by dams.

On the other hand in Alwar and neighboring districts of Rajasthan state alone, around 7,00,000 people benefited from the improved access to groundwater for household use, farm animals and crops. Not a single family has been displaced in order to achieve this. Rainwater harvesting also works in urban areas, where rain can be caught on rooftops and channeled into tanks.

As we know dams are important but, there are many alternatives to hydro-electricity. The first is just to use electricity more efficiently. Why too many dams have been developed/constructed on the world’s rivers? There has never been a fair playing field when dams have been compared with their alternatives. If assessments of options for water and energy needs

Table 5. On the basis of Positive and negative impacts: Dams are necessary evil

Positive impacts on Dams	Negative Impacts of Dams
Provide energy/electricity	Prevent Natural flow of River
Aquaculture	Prevent Fish migration
Irrigation	Catastrophic flood
Employment	Water Logging
Recreational and Tourism	Change Water Quality Social and Cultural impacts Climate Change Loss biodiversity

were made comprehensive, transparent and participatory, very few large dams would make the grade. It also shows that a better water world is possible.

Various other impacts can be added to this list. The most important point is that we should distinguish the temporary benefits and the long term harms clearly. It must be compulsory that the groups engineers, hydrologists, social scientists and other profession groups attend the environmental impact assessment and that the alternatives do their duty in the estimation of environmental effects.

Dams, which contribute to the national economy from many aspects like irrigation, drinking water supply, flood control, electricity generation, fishing and tourism, are also important. Meanwhile, the new environment created by the dams also supports the arrival of different species to the area. Dams are not only important in economical growth, but also in overall economical and moral development. In many developed countries, dams have performed a key role in the development of the underdeveloped regions.

We need electricity, we need aquaculture we need agriculture, we need recreation and we need to control flood, but on the cost of environmental (Habitat destruction, water change quality, water logging, deforestation) and social impacts (poverty, rehabilitation), the dams are called as necessary evil at the present scenario. We should focus on economy, but on the other hand, we must think about the negative impacts of Dam. Large Dams are certain harmful to human being as compared to their benefits. Therefore, we should develop small dams which may as good and cause minimum damage.

Summary

In this unit, we have discussed various aspects of water resources development, dams and their positive and negative impacts. So far you have learnt that:

- Water development is the set of activities for planning, developing, distributing and managing the best use of water resources.
- Seasonal check bunds, Temporary check bunds/dams, Earthen dams, Lift irrigation, Farm ponds, Jalkunds and Group wells are common methods of water resource development
- Hydro-power is the leading renewable source for electricity generation at global level. It is supplying 71% of all renewable electricity. It has 1,064 GW of

installed capacity in 2016, it generated 16.4% of the world's electricity from all sources.

- China accounted for 26% of the global installed capacity in 2015, on the other hand USA accounted for 8.4%, Brazil for 7.6% and Canada for 6.5%.
- Largest dams of world are Three Gorges Dam, Itai Pu Dam, Xiluodu Dam, Guri Dam, Tucurui, Dam, Xingjiaba Dam, Grand Colie Dam, Long Tan Dam, Krasnoyarsk Dam and Robert Bourassa.
- Over 4,000 large dams are also constructed over the Indian rivers, examples of dams are Nagarjuna Sagar dam, Maithon dam, Tilaiya dam, Sardar Sarovar dam, Bhakra Nagal dam, Tungabhadra dam, Krishnarajasagar dam, Cherothoni dam, Indira Sagar Dam, Koyana dam, Hirakud dam, (longest dam of India), Bisalpur Dam, Bhavani Sagar dam, Maitur Dam, Tehri dam (highest dam of India) and Rihand dam.
- There are various positive impacts of dams such as: cleans energy, irrigation, aquaculture, navigation, recreation, flood control, water supply, land improvement, economy and Employment.
- Besides the positive impacts, dams have some negative impacts such as prevent ecological flow of the River, enhance the chances of catastrophic flood, prevent fish migration, climate change, change in water quality, water logging, social and cultural impacts.

Terminal Questions

1. (a) Fill the blank spaces with appropriate words.

Dam is just like a ………..that restricts the …..of water, specially in stream and river. Dams not only suppress flood, but also provide water for several activities such as irrigation, …………., human consumption, industrial purposes, aquaculture, etc. The first ever dam was built in 1890 and in 1950 the world had ……….. According to the World Commission on Dam Report-2000 there are …….. large dams in 140 countries in world. Out of these, 22,000 are in……., in USA…….., India has about 4,291 dams (……. of the total of World), Japan has about ……..dams, Spain has about 100 dams. According to an estimate, 160-320 new large dams are built …………worldwide to trap runoff with dams and storage reservoirs so as to impound huge amount of rain water. However, large dams can only be built in certain areas because these require space, water and money. Purpose of dam also vary according to the country; some countries built dams for ………..and some for ………. For example: Europe developed most of the dams for HEP and Africa and Asia developed most dams for irrigation purpose. It is also important to know that very few dams help in flood control- only do flood control if dams at…………

2 (a) Discuss the indigenous methods of water resources development.

(b) Describe the dams at global level.

3 (a) Describe the dams at national level.

(b) Give the list of important dams in India.

4 (a) Write about positive impacts of dams.

5 (a) What are the negative impacts of dams.

(b) Describe the social and cultural impacts of dams.

(c) Why dam is called necessary evil? Explain.

6 (a) Fill the blank spaces with appropriate words.

Pt. Jawaharlal Nehru regarded dams as "……………". But, as you know, dams have costs as well as benefits. "Dams have played a vital role in the history of urban growth and were a vital part of infrastructure at the time," Big dams even cause ………due to high weight of reservoir, release ……………(because of the rotting of flooded vegetation), destroy …………..(because they disrupt river-borne flows of freshwater and nutrients into oceans) and lead to coastal erosion (because the sediments that eventually fill reservoirs would previously have flowed out through estuaries and then been washed back by waves to protect the shoreline). The most noticed disaster related to dam was observed in China in which about …………people were died due to damage of dam. The World Commission on Dams estimated that ………..people have been displaced by dams. As per the data, about 80% of lengths of the large river systems of world are at least moderately or severely eroded by dams.

(b) Three Gorges dam constructed over (Yangtze river/Parana River/Jinsha River/Ganga River)

(c) Longest dam of India is (Hirakund Dam/Tehri dam/Sardar Sarovar Dam/Nagarjuna Sagar Dam)

(d) Rihand dam is located in (Rajasthan/Uttar Pradesh/Jammu & Kashmir/Himachal Pradesh)

(e) Tehri dam is constructed over (Alaknanda /Bhagirathi /Song /Yamuna Rivers)

(f) What is the impact of dams on fish?

7 (a) Give the graph of distribution of large dams in different states on India.

Answers to Terminal Questions

1 (a) Barrier, natural flow, hydropower generation, 5000 large dams, 45000, China, 6390, 9%, 1200, every year, irrigation, generation of hydropower energy, low level

2 (a) (section-10.2 and fig-1), (b) See the section 10.3

3(a) See the section 10.4, (b) See the section 10.4 (Table-3)

4 (a) See the section 10.5;

5(a) See the section 10.6, (b) See the section 10.6 (Social & cultural impacts), (c) See section 10.7

6 (a) Temple of India, earthquakes, greenhouse gases, marine fisheries, 2, 30,000, 40 to 80 million.

(b) Yangtze River, (c) Hirakund Dam, (d) Uttar Pradesh (e) Bhagirathi River

(f) See the section 10.6 (Prevent fish migration)

7 (a) See the section 10.4 (Fig-3).

References

1. American Rivers.2001 a.10 ways dams damage rivers. American RiversWebsite. URL:http://www.amrivers.org/damremoval/tenreasons.htm.
2. Central water commission report (2018). Ministry of Jal Shakti, Department of water resources, River Delopment and Ganga rejuvenation.
3. http://cwc.gov.in/national-register-large-dams
4. Sharma, P.D. (13th edition): A text book on Ecology and Environment. ISBN: 935078122.
5. World Commission on Dams (WCD) Report (2000). American University International Law Review. Asmal, Kader. "Introduction: World Commission on Dams Report, Dams and Development." American University International Law Review.16(6): 1411-1433.

Unit 11: Water Resource Conservation Watershed Management, Rain Water Harvesting, Micro-Irrigation: A Case Study- The Pani Panchayat

Unit Structure

11.0 Learning Objectives

After studying this unit you will be able to explain:

- What is water resource management
- What is Watershed management
- What is rain water harvesting?
- Advantages and disadvantages of rain water harvesting
- What is micro-irrigation?
- Methods of micro-irrigation
- Importance of micro-irrigation
- About case study of Pani Panchayat

11.1 Introduction

Conserving our natural resources is critical issue at international level. As you know, water is most valuable resource on earth and vital component to sustain life. We all are well acquainted with importance of water resources, its utilization and water resource development. First of all, it is a responsibility of the humanity to save water resources for the future generations. Besides, it helps to reduce the level of used energy because water management consumes a huge amount of electricity. In conclusion, water is a habitat for the different wildlife. Therefore, the world community tries to prevent water resources from their complete disappearing. As you have learned about water resources, importance of water resources and water resource development in unit-9 and unit-10, in these units we have discussed various aspects of water resources. Water resources are depleting rapidly than usual. Demand of water also increases with population explosion. Various anthropogenic activities such as deforestation, dumping of solid waste, excessive use of agrochemicals, urbanization, industrialization, mining, etc. are responsible for water resources depletion. The water quality data of different rivers of word showed that the man made activities certainly responsible for water resources depletion. Even our ocean are depleting due to dumping of solid waste. Industries releasing their effluents directly in to the water bodies which is responsible for severe water pollution. Domestic sewage is one of the greatest sources of water pollution in India. According to World Health Organization (WHO), 3,119 towns of India, only 209 have partial sewage treatment systems and only 8 town and cities have full sewage treatment facilities.

The human activities make the water unfit for utilization. Water is not only useful to human being but it is home to millions of species. Many aquatic species have become extinct or at the verge of extinction due to water resources depletion. Therefore, it is our duty to conserve this precious resource at all possible level. Conserving water resources can help save water for upcoming generations. As population rises, more demand will be placed on water supplies to provide water for human being, food and fodder production, manufacturing and recreational activities. To conserve water resources, we should remember that water is most valuable and limited resource. In this unit, you will learn about various techniques of water resources conservation such as watershed management, Rain Water Harvesting, micro-irrigation and concept of Pani Panchayat.

11.2 Water Resource Conservation

Water is an integral part of land/soil productivity base. There are various methods of water conservation and water management like watershed management, rain water harvesting, micro-irrigation, etc. As you know, that water is not only essential to sustain life, but to support ecosystems, economic development, community well-being and cultural values. Therefore, it is necessary to conserve water resources for upcoming generation. As you know, freshwater is limited and unevenly distributed around world. The water available for use in any place is not equal, but varies widely overtime due to both natural and anthropogenic activities.

Using the measure, any increase in population will lead to a decrease in per capita water availability, which has usually being assumed implicitly to be bad. A better definition of sustainable water use is the maintenance of a desired flow of benefits to a particular group, undiminished overtime. According to World Commission on Environment and Development, (987), humanity has the ability to make development sustainable to ensure that it meets the need of the present without compromising the availability of future generations to meet their needs. The desired sets of benefits provided by water does not have to be, and is unlikely to be, the same across different user of periods of time. Indeed, such benefits vary widely given political, religious, cultural and technological differences. But in any realistic discussion of sustainability, the benefits to be provided must be explicitly evaluated. Using the definition, water use is unsustainable provided by water resources and desired by the society diminish over time. Equity requirement would also required that a reduction of services over time to one user group be declared “unsustainable” even if other users are able to maintain the desired services.

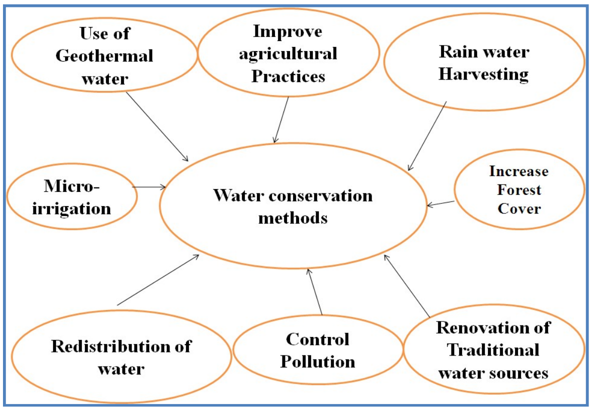

Fig-1: Various water conservation methods

There are various conservational strategies for conserving water resources and such strategies may include rainwater harvesting, improve agricultural practices, use of geothermal water, increase forest cover, renovation and traditional water resources, micro-irrigation, etc. Conservation of water is now become very important challenge across the world, because scarcity of water is increasing day by day. There are various conservational strategies for conserving water resources and such strategies are rain water harvesting, improved agricultural practices, use of geothermal water, increase forest cover, renovation of traditional water resources, micro-irrigation, watershed management, etc. Conservation of water resource is one of the most important challenges at global level, due to high demand of water. We can conserve water resource at our personal level. Because a large percentage of water is used in our daily needs. Excessive amount of water used in our bathrooms, toilets, kitchen, etc. There are various eco-friendly devices such as toilet dams, water saving showers, faucets aerators etc. to reduce water consumption at our houses. Our life style is also responsible for extra water consumption; therefore, we should change our daily life style to reduce the water use. Through these small activities, we can conserve large amount of water resources at local level.

There are two ways in which unsustainable water use can be developed:

- Through alteration in the stocks and flow of water that change its availability in space or time
- Through alteration in demand for the benefits provided by a resource, because of changing standard of living, technology, population levels, or societal modes.

Conservation of water resources is based on sustainability. There are certain criteria of sustainability of water. There criteria and goals are the result of considerable dialogue and analysis with academic, governmental, and non-governmental interests working on regional, national, and international water problems they are not, by themselves, recommendations for action rather they are and points of policies-they lay out of specific societal goals that could, or should be attended. In particular, these criteria can provide the basis for alternative "viscous" for further water management and conservation. Following are the different sustainability criteria.

- A minimum water requirement will be guaranteed to all human to maintenance human health.
- Sufficient water will be granted to restore and maintain the health of ecosystems. Specific amounts will vary depending on climate and other conditions. Setting these amounts will require flexible and dynamic management.
- Water quality will be maintained to meet certain minimum standards. These standards will vary depending on location and water use.

- Human actions will not impair the long-term renewability of freshwater stocks and flows.
- Data of water resources availability, use, and quality will be collected and made accessible to all parties.
- Institutional mechanisms will be set up to prevent and resolve conflicts over water.
- Water plan and decision making will be democratic, ensuring representation of all participations of affected interests.

11.3 Watershed Management

Literally, watershed means Boundary. All the aquatic bodies have a watershed. The watershed is the area of land that drains water in to water bodies (i.e. lakes, river, streams, ponds, etc.). The term "watershed" was introduced in 1920 and was used for boundaries. A watershed is an area of earth bounded by drainage. The watershed management technology is generally used in areas where rainfall is high. Watershed management is term to describe the process of implementing water use method to protect/preserve/conserve water resources.

Objectives/aims of watershed management: There are various objectives/aims of watershed management which are summarized in Fig-2.

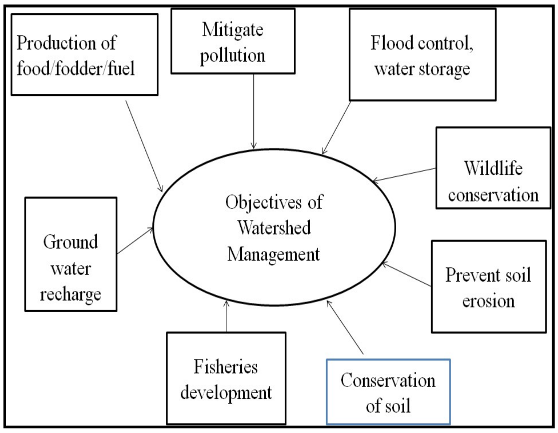

Fig-2: Objectives of Watershed Management

Types of watershed management: On the basis of size, shape, drainage and land use pattern, watershed may be as following.

- Macro watershed – 1000-10,000 hectare
- Micro watershed- 100-1000 hectare
- Mini watershed-10-100 hectare
- Mille watershed-1-10 hectare

Importance of Watershed Management: As you know that runoff is the draining away of water. Various forms of runoff like runoff from rain, agricultural land, and glaciers can lead in to aquatic pollution in lakes, rivers, ponds and other aquatic bodies. Watershed management helps to control pollution in aquatic bodies. Watershed management identified the various activities such as gardening, water release from septic tanks, agricultural runoff that affect the water quality of watershed. Watershed management makes the recommendation to resolve adverse impacts of these activities on watershed, therefore adverse impacts or negative impacts of pollution can be minimized. Watershed management is also effective where water resources are limited. Watershed management can protect land, water and vegetation.

Steps in watershed management:_There are mainly four phases in watershed management namely, recognition phase, restoration phase, protection phase, and improvement phase. These four phases are described below:

1. Recognition phase: Recognition phase comprises in three important steps such as

i) Recognition of problems: In this phase problems of watershed are identified, these problems may include entry of pesticides from agricultural runoff or entry of pollutants from industries.

ii) Monitoring of course at problem and its impact: This phase is emphasized on monitoring of analysis of watershed. Through the monitoring, we can recognize the absence or presence of toxic chemicals in and around watershed.

iii) Implementation of alternative solution of problems: In this phase, remedial measures for the problem are implemented to resolve the adverse impacts of related problems.

2. Restoration phase: This phase involved two steps.

i) Select best soil for identification.

ii) Apply appropriate solution for the problem to land.

3. Protection phase: In this phase, we generally protect the health (water quality) of watershed and make sure that normal functioning of watershed. Normal functioning of watershed includes: water quality other abiotic factors, vegetation cover, etc.

4. Improvement phase: This phase emphasizes on overall improvement of watershed. In this phase, generally focus is at agriculture, forest land & protection. Socio-economic condition is also considered during this phase.

Program related to Watershed Management

1) **Drought prone areas programme**: It was launched by Central Government (Ministry of Rural Areas and Employment) in 1973-74 to tackle the special drought related problems. This program was launched for hot desert region of Rajasthan, Haryana, cold desert of Jammu & Kashmir including Ladakh, Himachal Pradesh and Gujarat. The main purpose of the program is ecological balance. This program also focused on appropriate use of water, land, livestock, and mitigate the effect of drought.

2) **National Watershed Development Program for Rainfed Agriculture:** This program was launched by Ministry of Rural Areas and Employment in the year 1986-87. The main purpose of this program is to enhance the productivity of land and production of fruits, food, fodder and fuel resources. The program also focuses on conservation and utilization of water resources on watershed basis.

11.4 Rain Water Harvesting

Rainwater harvesting is defined as collection of rainwater and to store it in different containers for different uses. As you know, rain water is primary source of surface and ground water. The rain may fall on the earth, but proper use of rain water is difficult due to its uncertainty.

Rain water harvesting (RWH) is a technique used for collecting and storing rainwater by using various means in different resources for different purposes (for livestock production, drinking, irrigation, etc.). Water of rain can be collected into artificial tanks. Rooftop harvesting is also a method to collect rainwater. RWH is useful to the communities living in the low rainfall areas. They can continue seasonal crop harvesting by using collected rain water in the scarcity of water supply.

Rainwater harvesting may also be refers to the collection and storage of rainwater, therefore that it can be utilized. As the rain falls, water is directed to a suitable collection point. Rain water harvesting is a practice that has been around for a long time. The difference is that now demand of water is so high therefore, rainwater harvesting ensures the supply of water especially in drier months. Modern technologies have established and are now making the process simplest and more efficient.

Methods: There are various methods for Rain water harvesting.

- Rain water can be stored in a reservoir or under the surface. This stored water is finally taken to places with the help of pipes.

- Rainwater can be collected in treated containers that can be used in emergency for different purposes.

There are several ways in which water can be harvested. These methods are very effective for commercial activities while some methods are only suitable for domestic use. There are the common methods of rainwater harvesting which are discussed below and also summarized in Fig-3.

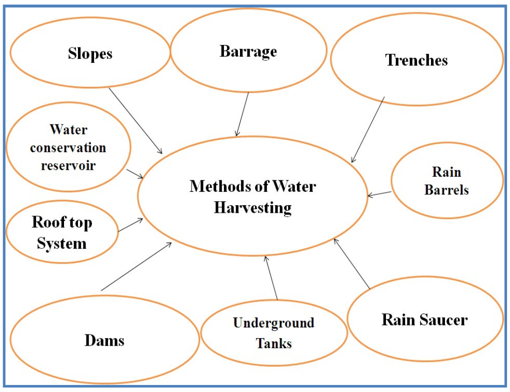

Fig-3: Different methods of rainwater harvesting

1) **Surface Water Collection Systems:** As you know, surface water is found above the earth surface. When rain falls on the surface, it generally flows down slopes as it moves towards a point of depression. Surface water collection systems allow the collection of rainwater before it flows to other areas. Examples of surface water collection systems include rivers, ponds, and wells. Pipes can be used to direct water into these systems. This water can be used for different purposes.

2) **Rooftop System:** This technique is very important because every house can collect the rain water by this method. Rooftop system method of rainwater harvesting is well accepted because the collected water is clean, pure and needs no treatment to make it fit for human consumption. In this method, a cemented tank developed on the roof of house, school and any buildings, the rain water collected in second tank with the help of pipes, the second tank should be developed under ground for sufficient storage of rain water.

3) **Dams:** As you know, dams are barriers that are designed to collect water. Rainwater can collect directly in these dams. Rainwater collected and stored in dams is mostly used for irrigation purposes and may be used for domestic use after treatment. Dams can also be used to harvest a lot of rain water because of the way in which they are constructed.

4) **Underground Tanks:** Underground tanks are also important and significant for accumulate and storing rainwater. These tanks are developed by digging into the ground and then cemented to reduce water infiltration. Top portion of tanks is also

sealed. This method is also valuable because rate of evaporation is too low, since these tanks are located below the surface where sunlight does not really penetrate.

5) **Rain Saucer:** These techniques are applicable where roof top is not suitable or applicable. The rain saucers look like umbrellas. These saucers generally attached to pipes, where rain water is collected. These rain saucers cover large area as compare to roof top methods.

6) **Water Collection Reservoirs:** This method is not really safe and rain water may get polluted. However, collected water through this method may be used for irrigation. In this method, rainwater is harvested from roads or footpaths.

7) **Barrage:** In this method, a dam that has many openings which can be closed or opened to control the water that passes through it. It is generally large and can be used to collect sufficient amount of water.

8) **Slopes:** In this method rainwater tends to collect at the base of slopes when it runs on the ground. When it rains heavily, water level can rise to the hill top. This method is the simple and natural way to rainwater harvesting.

9) **Trenches:** In this method, the rainwater is directed to the agricultural land through trenches. This is one of the best traditional methods of rainwater harvesting that is still very much use in present time.

10) **Rain Barrels:** Rain barrels are also used to harvest rainwater. They are specially designed for collecting water and can be purchased from stores. These rain barrels are used for rainwater which falls on rooftops.

Advantages of Rainwater Harvesting: As you know, rain water has minimum impurities; therefore rain water can be used for different purposes. There are various advantages of rainwater harvesting which are summarized in Fig-4 and also discussed below:

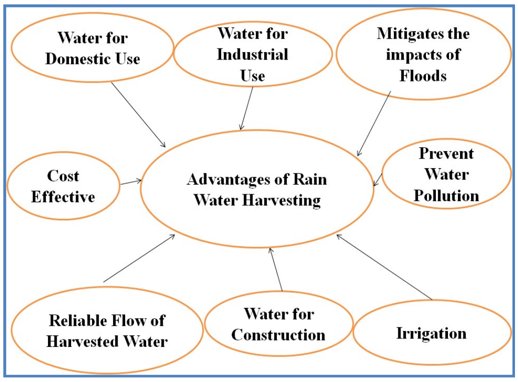

Fig-4: Advantages of Rain Water Harvesting

1) **Water for Domestic Use:** The RWH is beneficial because it provides a source of water for domestic

use. The collected and stored water can be used for cleaning purposes, washing and cooking food. After treatment, rainwater may also be used for drinking purpose. It is simplest way of getting water for use in the houses. Rain water can be used in toilets instead of clean water. The RWH saves drinkable/potable water which would be used for cooking and drinking only.

2) **Water for Industrial Use:** Various industries can also emphasize on rainwater harvesting for use in different industrial processes. Rainwater meant for industrial use is normally harvested in large scale. Such industries can develop their own dams or underground tanks to store rainwater. For the industrial purpose generally rain water harvesting should be done at large scales.

3) **Supplementary Water Source:** As you know that various regions have water shortages specially during dry period or summer period, because of improper rain and due to high rate of evaporation. It may be hard to get a source of water during dry periods. Water prices also increases with demand of water. Therefore, rainwater harvesting is seen as a way of preparing for the dry periods

4) **Irrigation:** As you know that agriculture of India entirely depend on rain water. Whenever rain falls generally low, it consequently leads in to low production of crops. Rainwater harvesting is very important to agriculture for farming. Once rain water is harvested, it can be utilized specifically during dry periods. Farmers can get good production rate due to rain water harvesting.

5) **Cost Effective:** Rain occurs in every part of the world. As you know, it is natural process and it is a gift of nature to earth. If we store enough water during the rainy season, we may never have to pay for water again because we will have enough water supplies throughout the summer. The RWH saves our money and expenditure on water.

6) **Reliable Flow of Harvested Water:** Although, rainwater harvesting depends on precipitation or rainfall, but once rain water stored, the supply of water is guaranteed. The RWH can provide a reliable flow of water from the place of storage as long as the amount harvested has not been finished.

7) **Mitigates/Reduces the Impacts of Floods:** Rainwater harvesting also plays an important role in mitigating or reducing the impacts of floods. Whenever rainwater is flooded to agricultural land through trenches, we can control its movement

through rain water harvesting technique. The RWH obstructs the flood in an area. As you know, the adverse impacts of floods are too dangerous, costly and enormous. Therefore, rainwater harvesting technique is an effective and appropriate way to reducing the impacts of flood in an area.

8) **Construction of Infrastructure:** The RWH can be used constructional activities. As you know constructional activities require a lot of water, rain water harvesting ensures the availability of water for these activities.

Precautions: Rain water harvesting is important technique to collect and store rain water for further use. However, we should take following precautions during rain water harvesting.

- Rain water should be pre-filtered to remove impurities/contamination would make rainwater safe.
- The rainwater may also be boiled to kill any pathogen before drinking it.
- Rainwater should be collected in containers. These containers should be free from any toxic substances or chemicals.
- Identify the collection points before it starts raining. Rain water harvesting generally performed during monsoon period, and this season is prone to several diseases. Therefore, don't use the fresh rain water for drinking purpose.

Disadvantages of Rainwater Harvesting: Besides the advantages of Rain water harvesting, there are various disadvantages, which are summarized in Fig-5 and also discussed below:

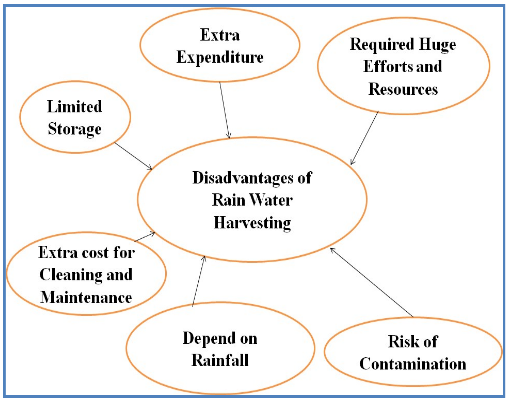

Fig-5: Disadvantages of Rain Water Harvesting

1) **Extra Expenditure:** For the rain water harvesting, we require extra expenditure. Treatment of rainwater also requires extra costs. This expenditure is not required when we use the water supplied by municipality. In rainwater harvesting method, there will be requirement of extra costs for cleaning and maintaining the reservoirs. Maintaining and Cleaning of underground water tank is not an easy task, even maintaining a

dam is very costly. Extra cost for cleaning and maintenance makes the thought of harvesting rainwater unattractive.

2) **Required Huge Efforts and Resources:** Building a dam and underground tank is not an easy task. When we begin harvesting rainwater, we will have to spend a significant amount of resources. Although there are also various cheap methods available, but these methods are not sufficient to store sufficient amount of rainwater.

3) **Depend on Rainfall:** As you know that rain water harvesting entirely depends on rain. Therefore, this method is unreliable and only possible during rain.

4) **Limited Storage:** In rain water harvesting, we can only store limited amount of water, even if it rains for three months, we cannot harvest all that water even if we wanted to, because there is limited storage capacity of reservoir.

5) **Risk of Contamination:** Rainwater may be contaminated, if not collected and stored with care. Contaminated water can cause various diseases especially the water is used without treatment. As you know treatment of water borne diseases is very costly. On the other hand, some rooftops of houses may have chemicals and contaminants that may mix with the rainwater, consuming this water can affect health. It is also observed that various industrial activities (generally due to emission of NO_2 and SO_2) are responsible for formation of acid rain. Collecting rainwater with low pH may cause several health problems in human being as well as in plants. By using acidic rainwater for irrigation, it can also cause the death of crops because it corrodes the soil and makes conditions unfavorable for plant growth.

6) **Lack of Water for Wildlife:** As you know wild animals drink water from natural sources such as rivers, streams, ponds etc. wild animals also use these water bodies for cooling in the hot and harsh weather. RWH reduces the amount of water in these aquatic bodies. Therefore, many wild animals may die due to shortage of water.

As you know, rainfall is an important weather phenomenon. It is a source of surface and ground water and is very important for the growth of crops, recharge of ground water, etc. The RWH is a practice that has been implementing on for a while. Many villages practiced this method to conserve and store the water. As you know that change in climatic conditions and human activities certainly lead to scarcity of water at global level. Rainwater harvesting method is an appropriate way of preparing for such period when the conventional water sources dry up, we can still use the stored water for many purposes. The best thing in rainwater harvesting is storage of water by this process. However, we should take some important precautions during rain water harvesting. When we apply innovation and technology, scientists/researchers can come up with better methods of rainwater harvesting and improve the conservational method.

11.5 Micro-Irrigation

As you know, most of the freshwater resources are used for irrigation purpose, if we can develop different techniques in agriculture sector to conserve the water, then we can preserve or conserve this natural resource. Micro-irrigation may be defined as the recurrent application of low volume of water directly above and below the soil; generally as discrete drops, continuous drops and small streams through emitters placed along a water delivery line.

Micro-irrigation also known as localized irrigation or low volume irrigation or low-flow irrigation, or trickle irrigation. This is an irrigation method with lesser pressure and flow than a traditional method. Micro-irrigation is used generally in agriculture for row crops, orchard, vineyards, etc. This technique is also used in horticulture, in nurseries, commercial, and private gardens, etc. It is the method of irrigation which saves the water and fertilizers. In this technique, water and fertilizers are applied in the root of plants gently. This technique involves network of pipes, controlling valves, drippers and tubes.

Sometimes, you see the land with full of water and sometime you observe the land is completely dry. This type of irregularity makes the agriculture very difficult. This uneven distribution of water causes great harm to crops. Therefore, there is urgent need of appropriate technique in which farmers can use the sustainable use of water for irrigation purpose.

Need of Micro-irrigation Technique

- To make agricultural land highly productive
- Eco-sensitive and capable of preserving the social basics of farmer communities

- Help produce more from the available land, water and labor resources without either ecological or social harmony
- To produce and generate higher farm income
- To provide on-farm and off-farm employment

Generally, two types of micro-irrigation techniques taken place, first is online micro-Irrigation system which is useful for orchard crops like mango, sweet orange, acid lime, sapota, etc. second is Inline micro-irrigation system for crops like vegetables, chilies, cotton, onion, banana, etc.

Steps in micro irrigation system

- Find out the availability of water from the source. This source may be bore wells and Tube wells.
- Topographical survey of field
- Note down the requirement of water in every months/periods
- Calculate the requirement of water to specific crops
- Each section should provide with a valve
- Make sure the power availability hours while making sections

Components used in micro-irrigation include

- Pressurized water source
- Water filters or filtration systems, sand separator, fertigation systems
- Backflow prevention device
- Pressure Control Valve
- Distribution lines (main larger diameter pipe, maybe secondary smaller, pipe fittings)
- Hand-operated, electronic, or hydraulic control valves and safety valves
- Smaller diameter polyethylene tube
- Poly fittings and accessories to make connections
- Emitter or dripper, micro spray head, inline dripper or inline drip tube

In micro-irrigation systems, pump and valves may be manually or automatically operated by a controller. Many large micro- irrigation systems utilize various types of filter to avoid clogging of the small emitter. Modern technologies are now being offered that prevent clogging. Some indigenous systems are installed without filters, because potable water doesn’t have many particles. Although manufacturers recommend that filters should be employed.

Micro-irrigation systems use treated municipal water. Rules and regulations recommended by government typically do not permit spraying water through the air that water not been fully treated. Farmers can use fertilizers with water and this process is called fertigation and chemigation. Fertigation may be used with the help of different injectors such as diaphragm pump, piston pumps, or aspirators. The chemicals may be added whenever the system is irrigating. Micro-irrigation may save about 90% of fertilizers as compare to traditional methods.

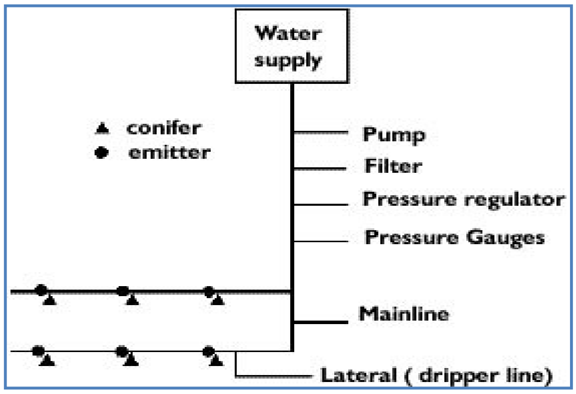

Fig:-6: Functioning of Micro-irrigation

Micro-irrigation may help achieve water conservation by reducing evaporation and deep drainage. Further, micro-irrigation can eliminate various diseases that are spread through water contact with the foliage. In the field where supply of water is limited, we can use micro-irrigation and increase the productivity of land.

In micro-irrigation technology, the water applies in roots of plants at ultra-low flow rates i.e., less than 1.0 liter/hour.

Advantages of micro-irrigation: There are various advantages of micro-irrigation which are summarized in Fig-7 and also discussed below:

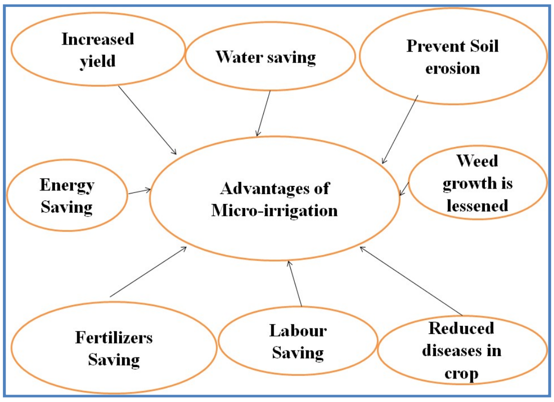

Fig-7: Advantages of micro-irrigation

- Fertilizer and nutrient loss is minimized due to localized application and reduced leaching
- Increased productivity
- No need of field leveling
- Save 95% water
- Moisture within the rhizosphere (area of root) can be maintained

- Prevent soil erosion
- Prevent weed growth
- Low labour cost
- Fertigation can be done with minimal waste of fertilizers
- Foliage remains dry which reduces the chances of diseases in crops
- Increased Fertilizer efficiency and Save fertilizers
- Energy saving

Disadvantages of micro-irrigation: Besides the advantages of micro-irrigation methods, there are various disadvantages. Some of the disadvantages of micro-irrigation are given below and also summarized in Fig-8.

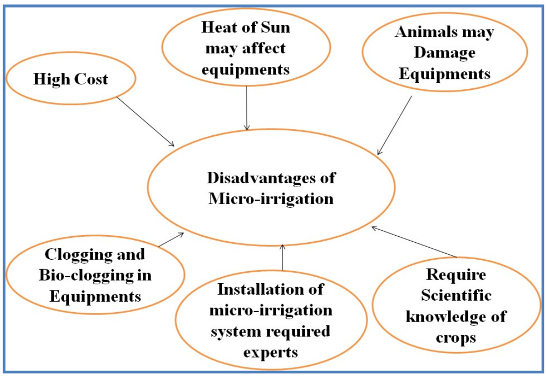

Fig-8: Disadvantages of micro-irrigation

- Initial cost of micro-irrigation is high
- Heat of Sun may affect the tubes used for micro- irrigation, which reduces the durability of equipment
- Clogging and bio-clogging may occur in equipments
- Micro- irrigation may unacceptable if herbicides need sprinkler irrigation for activation
- After harvesting, equipment like drip tape/micro tape takes more costs to cleanup
- If micro-irrigation not properly installed, it may leads to wastage of time, water, money etc. Micro-irrigation requires careful study about the topography, soil, water availability, crops etc.
- Many animals like mice, rats can damage the equipments (PVC pipes etc.), which ultimately increase the expenses of farmers.

11.6 Case Study -The Pani Panchayat

The Pani Panchayat movement was started in the drought prone region in Purandhar Taluk, Pune district of Maharashtra in the year 1974. This movement was started by

Sh. Vilasrao Salunke. Sh. Vilasrao Salunke Pani Baba was born on 18 February 1937in Sangali district of Maharashtra. His movement was focused on simple concept of equitable distribution of water. He promoted education and mass awareness among one and all about the importance of water and equity of water resource. He was deeply concerned about natural resource management issues in rural areas. He visited many drought affected villages during severe drought in 1972-73, in Maharashtra. After monitoring the situation, he suggested the Government of Maharashtra to implement the water resource development activities.

Gram Gaurav Pratishthan: Gram Gaurav Pratishthan (GGP) is a Charitable Trust and it was established, at village Naigaon, which lies in the severely drought-prone in Maharashtra, where Vilasrao Salunkhe had begun the work.

Sh. Vilasrao Salunkhe had experimented the equitable water distribution with active involvement and participation of local communities. Through this voluntary organization, the movement of equitable water rights was popularly termed as “Pani Panchayat”, spread all over Maharashtra.

Revolutionary concept of Vilasrao Salunkhe of Pani Panchayat worked on one very simple and important principle i.e., water is a common property resource and must, therefore, be accessible to all. Movement of the Pani Panchayat completely transformed the village where once there were barren lands, there now stands a prosperous and plentiful resources.

Principles of Pani Panchayat: Equity is one of the most important principles of Pani Panchayat. Pani Panchayat also seeks the demand management, community participation, rights of landless and sustainability of the resource. Pani Panchayat believes that every family member should be allowed water for cultivation. There are various principles of Pani Panchayat, which are summarized below:

- Water should be shared by the members on the basis of family size and not on the basis of land holding.
- Crops which have more demand of water should not be grown.
- Mutual consultation of the group decided the agricultural pattern.
- Rights of water are not attached to rights of land.
- Land for which the water is obtained under this project cannot be sold without the permission of the "Pani Panchayat".

- Irrigation schemes are built by joint efforts of farmers for common benefit.
- Taxes for water taxes must be paid in two installments in each year within stipulated time fixed by Pani Panchayat.
- All equipments required during this project should be kept with the "Pani Panchayat". "Pani Panchayat" paid all the claims related to project.
- The "Pani Panchayat" has the right to appoint workers. Salary/honorarium to the workers also fixed by Pani Panchayat.
- Two meetings in a month conducted by Pani Panchayat. In the meeting of Pani Panchayat, all the problems of farmers noted down for further action.
- The membership of a member who causes a grave problem in the working of the project and disobeys the "Pani Panchayat" be cancelled.
- The construction and management of the project and distribution of water and monitoring of crops is the joint responsibility of the members.

It ensures equable distribution of water to its entire village through sustainable development. Pani Panchayat conducts various trainings, campaigning and active participation in sustainable production activities.

Mission of Pani Panchayat: The mission of Pani Panchayat is to develop holistic farming system through the use of organic farming based on scientific techniques. As you know, world is facing lot of economic and ecological problems created by anthropogenic activities specially in agriculture sector. These activities may include excessive use of fertilizers, pesticides, etc. Pani Panchayat also assured water for Population who are depending on Land for livelihood. Another mission of Pani Panchayat is to protect and conserve, natural resource protection especially water resources. Pani Panchayat also charges water rights for weaker people of the society. They also focus on safeguarding agricultural income and provide alternate livelihood support to the people. Pani Panchayat also focuses on organic farming for sustainable development.

Vision of Pani Panchayat: The vision of Pani Panchayat is to promote harmony among the people and the environment. Pani Panchayat also vision to develop a watershed model. This model will be based on water equity.This watershed model will transfer philosophy and technology at national and international levels in the field of agricultural and resource conservation

Summary

In this unit, we have discussed various aspects of water resource conservation, watershed management, rain water harvesting, micro-irrigation and about the Pani Panchayat, so far you have learnt that:

- There are two ways in which unsustainable water use can be developed, first, through alteration in the stocks and flow of water that change its availability in space or time; and second is through alteration in the demand for the benefits provided by a resource, because of changing standard of living, technology, population levels, or societal modes.
- The term “watershed” introduced in 1920 and was used for boundaries. A watershed is an area of earth bounded by drainage, watershed management technology generally used in rainy areas.
- On the basis of size, shape, drainage and land use pattern, watershed may be decided as Macro watershed – 1,000-10,000 hectare, Micro watershed- 100-1,000 hectare, Mini watershed-10-100 hectare and Mille watershed-1-10 hectare.
- There are various objectives of watershed management, which are production of food/fodder/fuel, mitigate pollution, flood control, water storage, wildlife conservation, prevent soil erosion, conservation of soil, fisheries development and ground water recharge.
- There are main four steps in watershed management i.e., recognition phase, restoration phase, protection phase and Improvement phase.
- Rain water harvesting (RWH) is a technique used for collecting and storing rainwater by using various means in different resources for the different purposes (for livestock production, drinking, irrigation, etc,). Water of rain can be collected into artificial tanks. Rooftop harvesting is also a method to collect rain water.
- There are several ways in which water can be harvested. These methods are Surface Water Collection Systems, Rooftop System, Dams, Underground Tanks, Rain Saucer, Water Collection Reservoirs, Barrage, Slopes, Trenches and Rain Barrels.

- There are various advantages of rain water harvesting such as Water for Domestic Use, Water for Industrial Use, Supplementary Water Source, Irrigation, Cost Effective, Reliable Flow of Harvested Water, Mitigates/Reduces the Impacts of Floods and construction of Infrastructure.
- There are various disadvantages of rain water harvesting such as Extra Expenditure, Required Huge Efforts and Resources, Depend on Rainfall, Limited Storage, Risk of Contamination, Extra cost for Cleaning and Maintenance and Lack of Water for Wildlife
- Micro-irrigation is also known as localized irrigation or low volume irrigation or low-flow irrigation, or trickle irrigation.
- Components used in micro-irrigation include: pressurized water source, water filters or filtration systems: sand separator, fertigation systems (Venturi injector) and chemigation equipment, backflow prevention device, pressure control valve, main larger diameter pipe, may be secondary smaller, pipe fittings, smaller diameter polyethylene tube, poly fittings and accessories to make connections etc.
- There are various advantages of micro-irrigation. Fertilizer and nutrient loss is minimized due to localized application and reduced leaching, increased productivity, no need of field leveling, prevent soil erosion, prevent weed growth, low labour cost, fertigation can be done with minimal waste of fertilizers, foliage remains dry which reduces the chances of diseases in crops, increased fertilizer efficiency and Save fertilizers, energy saving, etc.
- Some of the disadvantages of micro-irrigation are; initial cost of micro-irrigation is high, heat of Sun may affect the tubes used for micro- irrigation, which reduces the durability of equipments, clogging and bio-clogging may occur in equipments, micro- irrigation may be unacceptable if herbicides need sprinkler irrigation for activation, micro tape takes more costs to cleanup and like mice, rats can damage the equipments.
- Pani Panchayat movement was started in the drought prone region in Purandhar Taluk, Pune district of Maharashtra in the year 1974.
- There are various principles of Pani Panchayat, which are: water should be shared by members on the basis of family size and not on the basis of land

holding, crops which have more demand of water should not be grown, mutual consultation of the group decided the agricultural pattern, rights of water are not attached to rights of land, land for which the water is obtained under this project cannot be sold without the permission of the "Pani Panchayat".

Terminal Questions

1 (a) Fill in the blank spaces with appropriate words.

Pani Panchayat movement was started in the drought prone region in ………district of Maharashtra in the year………. This movement was started by Sh. Vilasrao Salunke. Sh. Vilasrao Salunke popularly known as ………was born on …………in Sangali district of……….. He was focused on simple concept of equitable distribution of…….. He promoted education and mass awareness among one and all about the importance of water and equity of water resource. He was deeply concerned about natural resource management issues in……….. He visited many drought affected villages during severe drought in 1972-73, in Maharashtra. After monitoring the situation, he suggested the Government of Maharashtra to implement the …………developmental activities.

2 (a) Why water conservation is important? Explain.

(b) What is watershed management?

3 (a) Describe the Objectives of watershed management.

(b) Give the steps of watershed management.

4 a) Define rain water harvesting? Write about common methods of rain water harvesting?

5 (a) Discuss the advantages and disadvantages of rain water harvesting.

(b) Describe the advantages of micro-irrigation.

(c) What are the disadvantages of micro-irrigation?

6 (a) Fill the blank spaces with appropriate words.

As you know, most of the freshwater resources are used for …………purpose, if we can develop different ………in agriculture sector to conserve the……….., then we can preserve or conserve this natural resource. Micro-irrigation may be defined as the frequent application of …………of water directly above and below the soil; generally as…………, ………and small streams through emitters placed along a water delivery line. Micro-irrigation also known as ……….or low volume irrigation or low-flow irrigation, or trickle irrigation. This is an irrigation method with lesser pressure and flow than a ……………. Micro- irrigation is used generally in agriculture for row crops, orchards, vineyards, etc. This technique is also used in horticulture, in nurseries, commercial, and private gardens, etc. It is the method of irrigation which saves the …………and……….

(b) Macro-watershed should have an area about 1,000-10,000 (Yes/No)

(c) Fertigation is advantage of (Micro-irrigation/Rain water harvesting)

(d) Vilasrao Salunke who is popularly known as Pani baba associated with (Pani Panchayat/Watershed Management/Chipko Movement/Appikko Movement)

7 (a) Write about components used in micro-irrigation

(b) Write about principles, mission and vision of Pani Panchayat.

Answers to Terminal Questions

1 (a) Puran dhar Taluk, 1974, Pani Baba , 18 February 1937, Maharashtra, water, rural areas, water resource

2 (a) See the section 11. And 11.2, (b) See the section 11.3

3 (a) See the section 11.3 (Fig-2), (b) See section 11.3 (Steps in watershed management)

4 (a) See section 11.4,

5(a) See the section 11.4 and Fig-4 and Fig-5 (Advantages and disadvantages of rain water harvesting), (b) See section 11.5 (Advantages of micro-irrigation)(c) See section 11.5 (Disadvantages of micro-irrigation)

6 (a) Irrigation, techniques, water, low amount, discrete drops, continuous drops, localized irrigation, localized irrigation, water, fertilizers(b) Yes, (c) Micro-irrigation(d) Pani Panchayat

7(a) See the section 11.5 (components used in micro-irrigation), (b) See the section 11.6 (Case study of Pani Panchayat)

References

1. Gurjar, G.N., Meena, N. K., Swami,S. , Telkar, S. G. Lyngdoh, E. A. S. (2017): Concept of Watershed Management and its Components. Biomolecule Reports ISSN:2456-8759.
2. https://www.indiawaterportal.org/articles/pani-panchayat-model-groundwater-management-presentation-acwadam.
3. https://panipanchayat.org/

Unit 12: Biological Diversity

Unit Structure

12.0 Learning Objectives

After studying this unit you will be able to explain:

- Introduction of biodiversity and its type
- Importance of the biodiversity
- Values of biodiversity
- Ecosystem components, structure, and functions
- Biodiversity assessment

12.1 Introduction

Biodiversity originates from Greek word *Bios* means life and Latin word *Diversitas* means form or variety. It refers to different forms of life (plants, animals, fungi and microbes) on planet Earth. The term 'biological diversity' was coined by Thomas

Lovejoy in 1980 and the term 'biodiversity' was coined by Walter G. Rosen in 1986 at National Forum on Biodiversity held in Washington (Sarkar, 2019). Biodiversity or biological diversity can range from smallest known life forms *Nanobes* with diameter 20-150 nm, smallest known bacteria (Unwins, 1999) to blue whale having length up to 110 feet and from extreme cold to extreme hot. Different form of life exists at any extreme conditions with which one can depict the range of diversity on the Earth. Biological diversity has no particular/standardized definitions. Different definitions were given from time to time to explain biodiversity. Biodiversity or biological diversity defined as the variation among different genetic, species and ecosystem levels in the biological system (Bartkowski *et al*., 2015).

"Biological diversity is defined as the variability among all the sources including, inter alia, land (terrestrial), marine and aquatic ecosystems and the ecological complexes of which they are part it includes diversity within species, between species and of the ecosystems": Convention on Biological Diversity, 1992 (signed by United Nation Earth Summit held in Rio de Janeiro).

According to Noss (1990), "Biodiversity is not only the variability among genetic, species and ecosystem level in a defined area but it should also include the various inter-specific interactions, biogeochemical cycles and natural disturbances. It should include the range of diversity indices and quantitative factors along with quantitative factors should be considered as an indicator for biological disruption". Biodiversity is defined as the abundance, number, composition, interactions, spatial distribution, population, species, communities and their functions, genotypic and phenotypic traits, landscape units in a biological system (Díaz et al., 2009). It is the interaction between different types of diversities like genetic, species and ecosystem diversity.

12.2 Types of biodiversity

Generally, the biological diversity has three types, these includes genetic diversity, species diversity and ecosystem diversity (Fig. 1). The detailed description of genetic diversity, species diversity and ecosystem diversity are as follows:

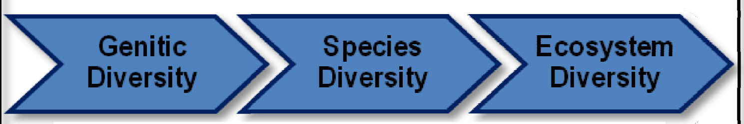

Fig 1. Types of biological diversity

12.2.1 Genetic diversity

It refers to the variation in the genetic constitution within a species or within a population. Every organism in this world is different from another in their genetic material. For example, in humans even twins are not exactly similar in their genetic makeup and shows lots of diversity from one another. Likewise, genetic diversity of rice, barley, maize etc. shows variation in the same species. The same species shows difference in their genetic makeup, color, size aroma, shape and nutrient content. Due to the genetic diversity species are able to show adaptation and respond to the environmental changes. It is also helpful in evolution and speciation (Carvalho *et al*., 2019).

12.2.2 Species diversity

It is the biological diversity at the most basic level. Species exists in large groups with different physical and biological characters. These species function individually or in a group in the food web. Species interact with each other through different interactions (competition, mutualism etc.) which collectively play an important role in ecosystem dynamics. Species diversity is measured by species richness and relative abundance (White *et al*., 2018).

12.2.3 Ecosystem diversity

As you know that an ecosystem consists of both living and non- living components and their interactions with each other. Ecosystem diversity is defined as the diversity among different ecosystems in a region. For example, ecosystems like mountains, desert, grasslands, and mangroves show diversity. This type of ecological diversity is more stable and productive as they are capable to tolerate unfavorable environmental conditions (Brierley *et al*., 2016; Kumar *et al*., 2019).

❖ **Diversity at the level of community and ecosystem exists along 3 levels**

- It could be within-community diversity (alpha diversity),
- Between-communities diversity (beta diversity) or
- Diversity of the habitats over the total landscape or geographical area (gamma diversity).

❖ **Alpha, Beta, and Gamma Diversity**

Whittaker (1972) described three terms for measuring biodiversity over spatial scales: alpha, beta, and gamma diversity.

- **Alpha Diversity:** It refers to the diversity within a particular area or ecosystem, and is usually expressed by the number of species (i.e., species richness) in that ecosystem.
- **Beta diversity:** A comparison of diversity between ecosystems, usually measured as the amount of species change between the ecosystems.
- **Gamma diversity:** A measure of the overall diversity within a large region. Geographic-scale species diversity according to Hunter (2002).

12.3 Importance of Biodiversity

As you know, that loss of biodiversity may have reverberating consequences on ecosystems because of the complex interrelations among species. For example, the extinction of one species may cause the extinction of another. Biodiversity is important to the survival and welfare of human populations because it has impacts on our health and our ability to feed ourselves through agriculture and harvesting populations of wild animals.

12.3.1 Human Health

Many medications are derived from natural chemicals made by a diverse group of organisms. For example, many plants produce compounds meant to protect the plant from insects and other animals that eat them. Some of these compounds also work as human medicines. Contemporary societies that live close to the land often have a broad knowledge of the medicinal uses of plants growing in their area. For centuries in Europe, older knowledge about the medical uses of plants was compiled in herbals—books that identified the plants and their uses. Humans are not the only animals to use plants for medicinal reasons. The other great apes, orangutans, chimpanzees, bonobos, and gorillas have all been observed self-medicating with plants.

Modern pharmaceutical science also recognizes the importance of these plant compounds. Examples of significant medicines derived from plant compounds include aspirin, codeine, digoxin, atropine, and vincristine. Many medications were once derived from plant extracts but are now synthesized. It is estimated that, at one time, 25 percent of modern drugs contained at least one plant extract. That number has probably decreased to about 10 percent as natural plant ingredients are replaced by synthetic versions of the plant compounds. Antibiotics, which are responsible for extraordinary improvements in health and lifespans in developed countries, are compounds largely derived from fungi and bacteria.

In recent years, animal venoms and poisons have excited intense research for their medicinal potential. By 2007, the FDA had approved five drugs based on animal toxins to treat diseases such as hypertension, chronic pain, and diabetes. Another five drugs are undergoing clinical trials and at least six drugs are being used in other countries. Other toxins under investigation come from mammals, snakes, lizards, various amphibians, fish, snails, octopuses, and scorpions.

Aside from representing billions of dollars in profits, these medications improve people's lives. Pharmaceutical companies are actively looking for new natural compounds that can function as medicines. It is estimated that one third of pharmaceutical research and development is spent on natural compounds and that about 35 percent of new drugs brought to market between 1981 and 2002 were from natural compounds.

Finally, it has been argued that humans benefit psychologically from living in a biodiverse world. The chief proponent of this idea is famed entomologist E. O. Wilson. He argues that human evolutionary history has adapted us to living in a natural environment and that built environments generate stresses that affect human health and well-being. There is considerable research into the psychologically regenerative benefits of natural landscapes that suggest the hypothesis may hold some truth.

12.3.2 Agricultural

Since the beginning of human agriculture more than 10,000 years ago, human groups have been breeding and selecting crop varieties. This crop diversity matched the cultural diversity of highly subdivided populations of humans. For example, potatoes were domesticated beginning around 7,000 years ago in the central Andes of Peru and Bolivia. The people in this region traditionally lived in relatively isolated settlements separated by mountains. The potatoes grown in that region belong to seven species and the number of varieties likely is in the thousands. Each variety has been bred to thrive at particular elevations and soil and climate conditions. The diversity is driven by the diverse demands of the dramatic elevation changes, the limited movement of people, and the demands created by crop rotation for different varieties that will do well in different fields.

Potatoes are only one example of agricultural diversity. Every plant, animal, and fungus that has been cultivated by humans has been bred from original wild ancestor species into diverse varieties arising from the demands for food value, adaptation to growing conditions, and resistance to pests. The potato demonstrates a well-known example of the risks of low crop diversity: during the tragic Irish potato famine (1845–1852 AD), the single potato variety grown in Ireland became susceptible to a potato blight—wiping out the crop. The loss of the crop led to famine, death, and mass emigration. Resistance to disease is a chief benefit to maintaining crop biodiversity and lack of diversity in contemporary crop species carries similar risks. Seed companies, which are the source of most crop varieties in developed countries, must continually breed new varieties to keep up with evolving pest organisms. These same seed companies, however, have participated in the decline of the number of varieties available as they focus on selling fewer varieties in more areas of the world replacing traditional local varieties.

The ability to create new crop varieties relies on the diversity of varieties available and the availability of wild forms related to the crop plant. These wild forms are often the source of new gene variants that can be bred with existing varieties to create varieties with new attributes. Loss of wild species related to a crop will mean the loss of potential in crop improvement. Maintaining the genetic diversity of wild species related to domesticated species ensures our continued supply of food.

Since the 1920s, government agriculture departments have maintained seed banks of crop varieties as a way to maintain crop diversity. This system has flaws because over time seed varieties are lost through accidents and there is no way to replace them. In 2008, the Svalbard Global Seed Vault, located on Spitsbergen island, Norway, began storing seeds from around the world as a backup system to the regional seed banks. If a regional seed bank stores varieties in Svalbard, losses can be replaced from Svalbard should something happen to the regional seeds. The Svalbard seed vault is deep into the rock of the arctic island. Conditions within the vault are maintained at ideal temperature and humidity for seed survival, but the deep underground location of the vault in the arctic means that failure of the vault's systems will not compromise the climatic conditions inside the vault.

Although crops are largely under our control, our ability to grow them is dependent on the biodiversity of the ecosystems in which they are grown. Crops are grown in soil and although some agricultural soils are rendered sterile using controversial pesticide treatments, most contain a huge diversity of organisms that maintain nutrient cycles—breaking down organic matter into nutrient compounds that crops need for growth. These organisms also maintain soil texture that affects water and oxygen dynamics in the soil that are necessary for plant growth. Replacing the work of these organisms is not practically possible. These kinds of processes are called ecosystem services. They occur within ecosystems, such as soil ecosystems, as a result of the diverse metabolic activities of the organisms living there, but they provide benefits to human food production, drinking water availability, and breathable air.

Other key ecosystem services related to food production are plant pollination and crop pest control. It is estimated that honeybee pollination within the United States brings in $1.6 billion per year; other pollinators contribute up to $6.7 billion. Over 150 crops in the United States require pollination to produce. Many honeybee populations are managed by beekeepers who rent out their hives' services to farmers. Honeybee populations in North America have been suffering large losses caused by a syndrome known as colony collapse disorder, a new phenomenon with an unclear cause. Other pollinators include a diverse array of other bee species and various insects and birds. Loss of these species would make growing crops requiring pollination impossible, increasing dependence on other crops.

Finally, humans compete for their food with crop pests, most of which are insects. Pesticides control these competitors, but these are costly and lose their effectiveness over time as pest populations adapt. They also lead to collateral damage by killing non-pest species as well as beneficial insects like honeybees, and risking the health of agricultural workers and consumers. Moreover, these pesticides may migrate from the fields where they are applied and do damage to other ecosystems like streams, lakes, and even the ocean. Ecologists believe that the bulk of the work in removing pests is actually done by predators and parasites of those pests, but the impact has not been well studied. A review article found that in 74 percent of studies that looked for an effect of landscape complexity (forests and fallow fields near to crop fields) on natural enemies of pests, the greater the complexity, the greater the effect of pest-suppressing organisms. Another experimental study found that introducing multiple enemies of pea aphids (an important alfalfa pest) increased the yield of alfalfa significantly. This study shows that a diversity of enemies is more effective at control than one single enemy.

Loss of diversity in pest enemies will inevitably make it more difficult and costly to grow food. The world's growing human population faces significant challenges in the increasing costs and other difficulties associated with producing food.

12.3.3 Wild Food Sources

In addition to growing crops and raising food animals, humans obtain food resources from wild populations, primarily wild fish populations. For about one billion people, aquatic resources provide the main source of animal protein. But since 1990, production from global fisheries has declined. Despite considerable effort, few fisheries on Earth are managed sustainability. Fishery extinctions rarely lead to complete extinction of the harvested species, but rather to a radical restructuring of the marine ecosystem in which a dominant species is so over-harvested that it becomes a minor player, ecologically. In addition to humans losing the food source, these alterations affect many other species in ways that are difficult or impossible to predict. The collapse of fisheries has dramatic and long-lasting effects on local human populations that work in the fishery. In addition, the loss of an inexpensive protein source to populations that cannot afford to replace it will increase the cost of living and limit societies in other ways. In general, the fish taken from fisheries have shifted to smaller species and the larger species are overfished. The ultimate outcome could clearly be the loss of aquatic systems as food sources.

12.4 Biodiversity of India and the world

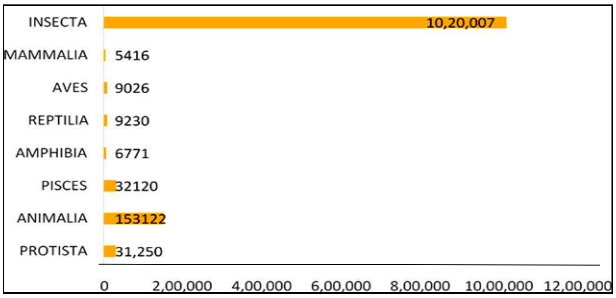

Fig. 2. Taxonomic group species of the world (Source: Zoological Survey of India, ZSI, 2014)

India consists of 10 major bio-geographic zones and 27 bio-geographical provinces based on their distinctive biota. One biotic province or bio-geographical province is different from another in their flora and fauna composition (Table 1). There are over 8.74 million species of eukaryotes on world's land and about 2.21 million species of eukaryotes in ocean water while approximately 10,000 species of prokaryotes on land and out of which 1300 are marine prokaryotes predicted on Earth. There are about 7.7 million species of animals and over 300,000 species of plants (Mora *et al.,* 2011). In this world there are about 1,399,189 species which belongs to kingdom Animalia and in India over 92,873 species belong to this kingdom which constitute 6.64% (ZSI, 2014). There are about 317,950 plants species present in this world. In India there are over 29,015 plant species with 9.13 percent (BSI, 2013). Total number of Insecta, Mammalia, Aves, Reptilia, Pisces, Animalia, Protista in India and the world is given in Fig. 2 and 3. There are about 7200 species of Algae, 2500 species of Bryophytes, 1269 species of Pteridophytes, 75 species of Gymnosperms and over 18,000 species of Angiosperms. About 9.13 percent floral diversity is found in India and Angiosperms contributes to over 27% (Fig. 4)

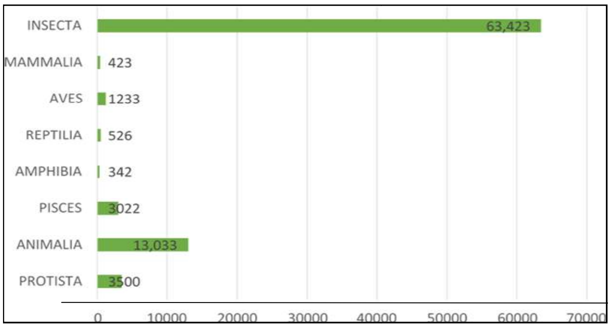

Fig. 3. Taxonomic group species of India (Zoological Survey of India, ZSI, 2014)

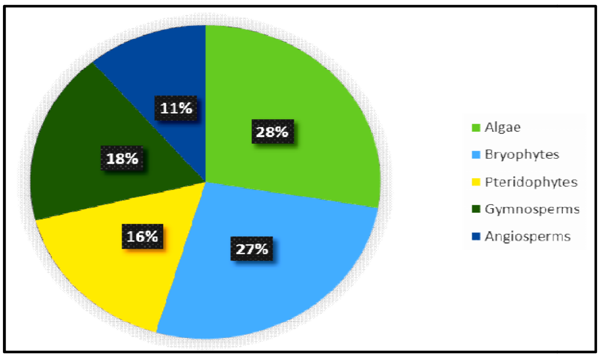

Fig. 4. Percentage of floral diversity in India (Source: Botanical Survey of India, BSI, 2013).

Table 1. Distribution of bio-geographic zones in India

Bio-geographic zone	Bio-geographic province
Trans-Himalayas	Ladakh mountains Tibetan Plateau Trans-Himalayan: Sikkim
Himalaya	North-Western Himalaya Western Himalaya Central Himalaya Eastern Himalaya
Indian desert	Kutch Thar Desert
Semi-arid	Punjab plains (semi-arid) Gujrat, Rajputana
Western ghats	Malabar Plains Mountains of Western Ghats

Deccan peninsula	Central Highlands Chotta Nagpur Eastern Highlands Central Plateau Deccan South
The Gangetic Plains	Lower Gangetic plains Upper Gangetic Plains
The Coasts	West Coast East Coast Lakshdweep
North-east India	Assam plains Shillong Plateau
Islands	Andamans - Nicobars

(Source: MoEF, 2009; Singh and Chaturvedi, 2017)

12.5 Values of biological diversity

Biological diversity plays a very crucial role for the survival of human beings on earth. The humans directly or indirectly depend upon biological diversity for fulfilling almost every need in their life such as food, energy, medicine, housing etc. Biological diversity helps to maintain the ecological balance (Dietsch *et al.*, 2016). It provides various ecological services and vital for maintaining, preserving and restoration of various ecological process. Biological diversity is helpful in maintaining biogeochemical cycles, maintaining the flow of water bodies like river and streams all-round the year, soil formation, control in floods, prevention from soil erosion, circulation of air globally and its cleansing, nutrient recycling and life support of all the species. Following are the direct and indirect values of biological diversity (Seddon *et al.*, 2016).

12.5.1 Direct values of biological diversity

(i) ***Consumptive use value:*** The consumptive use of values includes the direct consumption of resources without passing through the market. Biological diversity provides direct food, shelter, medicines, proteins, enzymes, fats, macro and micro nutrients, beverages, specimens for educational and scientific purposes, tourism and raw material for various commercial purposes (Thapa *et al.*, 2020). For example, Aloe Vera is directly consumed for its medicinal properties, timber is used for fire and animals are consumed directly after hunting.

(ii) ***Productive use value:*** Productive use value is the value which put on marketable products. The different professionals from various fields studied biological diversity for its productive values. The agricultural scientist uses biological diversity for improving the yield and quality of crops. The biotechnologist studies different genetic properties of plants, animals and microbes. The best traits can be selected from the organism with which new improved (disease resistant and high yield) variety of crops can be produced. It also helps to develop better livestock (high nutrient value and fast growth) (Jactel *et al*., 2018). Pharmacist use biological diversity as a raw material for the production of various plants based and animals-based drugs.

12.5.2 Indirect values of biological diversity

(i) ***Social values:*** From the ancient time people used to protect biodiversity for their needs. Ancient people used to value biological diversity specially in India, people worship various plants, animals, water bodies, stones and mountains as they are helpful for their survival and have high esteem. Earlier needs were few as less population so most of biological diversity is conserved (Griffiths *et al*., 2019). Still many tribal people directly depend on forests for their daily needs. Many indigenous people are helpful for conserving biological diversity as they used to cut only old tree branches for wood and only the leaves of young trees are used only for livestock. Modern people are least concerned about the conservation of biological diversity. They only care about their own usage and try to grab it as much as one can at once and exploit it which sometimes leads to irreversible loss (Evers *et al*., 2018).

(ii) ***Ethical and moral values:*** It is the moral duty of human beings to conserve biological diversity. Planet earth belongs to every species in this world and humans have no right to harm any species if it is of no use to them. Ethical values are related to conservation of biological diversity from animal trafficking, smuggling, illegal activities like cloning, inhuman treatment with animals, biopiracy, unauthorized animal testing, poaching, desertification and uncontrolled deforestation (Antonelli and Perrigo, 2018). To meet the high demand of resources due to population explosion benefits are given more importance rather than ethics and moral values

(iii) ***Aesthetic values:*** Biological diversity is secret for the beauty of our planet. The different kinds of plants, animals, flowers and birds provide great aesthetic value. Various recreational activities are linked to it like bird watching, butterfly parks, river rafting, national parks, aquarium and botanical gardens (Collins *et al*., 2017).

(iv) ***Economic values:*** Biological diversity has a great economic value; food is the basic necessity which is the product of it. The agricultural sector, various industries depend upon biodiversity products. The revenue generated from biodiversity products is essential for the growth of any country (Hanley *et al*., 2015).

(v) ***Scientific values:*** Various research work has been done on many species of plants, animals, insects etc. and many has to be done to attain knowledge. This scientific knowledge can be utilized for the things which of great value to human beings (Titley *et al*., 2017). During the COVID-19 pandemic we have learned various lessons for conservation of biodiversity. An enzyme used in COVID-19 testing is extracted from a bacterium, *Thermus aquaticus* which was discovered in a geyser in Yellowstone National Park, US (Buchanan, 2021).

12.6 Biodiversity and ecosystem functioning

The way we study, the external and internal morphology and physiology for understanding the structure and functioning of an organism and its life processes, similarly we can understand the ecosystem by studying the structural and functional attributes of all its living (biotic) and non-living (abiotic) components. Closely-linked structural and functional attributes are critical for the continued operation of an ecosystem and their integrated understanding provides a complete conceptualization of the ecosystem dynamics. An ecosystem has a function; each component plays a specific function while summed up functions of all components defines ecosystem function on a whole. Importantly, function means showing activity, and does not imply that organisms perform purposeful roles in ecosystem-level processes. Ecosystem functioning reflects the collective life activities of plants, animals, and microbes and the effects these activities (feeding, growing, moving, excreting waste, etc.) have on the physical and chemical conditions of their environment. A functioning ecosystem exhibits biological and chemical activities characteristic for its type. For instance, a functioning forest ecosystem exhibits rates of plant production, carbon storage, and nutrient cycling that are characteristic of most forests. If the forest is modified to an agroecosystem, its functioning changes. The concept of “ecosystem function” is based on a perspective that focuses on the whole system and the functional roles played by each component within it. However, the normative concept of ecosystem functioning also extends towards societal interests. Giller et al. (2004) characterize ecosystem functioning by three categories of ecosystem functions, namely, ecosystem processes, ecosystem properties, and ecosystem values (composed of ecosystem goods and services). To exemplify, ecosystem function of a lake ecosystem refers to processes and the causal relations that give rise to an ecological system, the role of organisms within it, the interactions between organisms of different species, overall processes that sustain it, long-term dynamics of different populations, overall biomass of the system, flow of energy and nutrients within it, and finally to the services it provides to human beings or other organisms.

12.6.1 Energy flow

In an ecosystem, there is a continuous interaction between plants, animals, and their environment to produce and exchange materials. The energy needed for this cycling of materials comes from the sun. Green plants, or producers, or autotrophs fix the solar energy into chemical energy. In this stored form, other organisms take the energy and pass it on further to other organisms. During this process, a reasonable proportion of energy is lost out of the living system. The whole process is called flow of energy. An ecosystem may be comprehended of any dimension, where the living and non-living systems are involved in a continuous flow of energy. The functional processes in an ecosystem are closely related to its structure and vice-versa. For instance, the flow of energy is based on trophic or food and feed structure of the ecosystem (producers- plants; consumers herbivores, carnivores, and omnivores; decomposers- microbes). Energy flows from sun to primary producers, to herbivores and then to different levels of carnivores are generally termed as trophic levels/trophic structure of the ecosystem. The flow of energy is unidirectional and non-cyclic (Fig. 5).

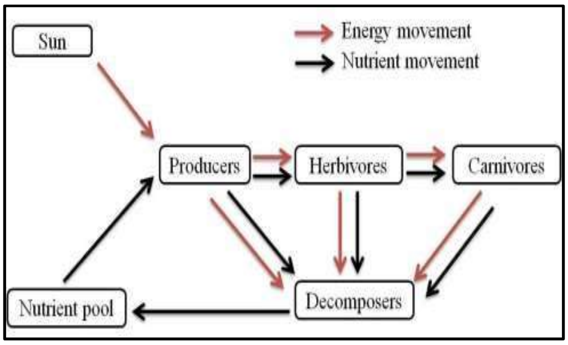

Fig. 5. A schematic representation of energy and nutrient movement in ecosystems. Energy flow is unidirectional and non-cyclic, whereas nutrient movement is cyclic

An energy flow model or energy flow diagram is a representation of trophic levels linked with each other showing the inputs and losses of energy incurred during energy transfer at each trophic level (Fig. 6). Lindeman firstly proposed such a model in 1942 assuming that plants and animals can be arranged into trophic levels; and laws of thermodynamics hold for energy transfer from one trophic level to the other.

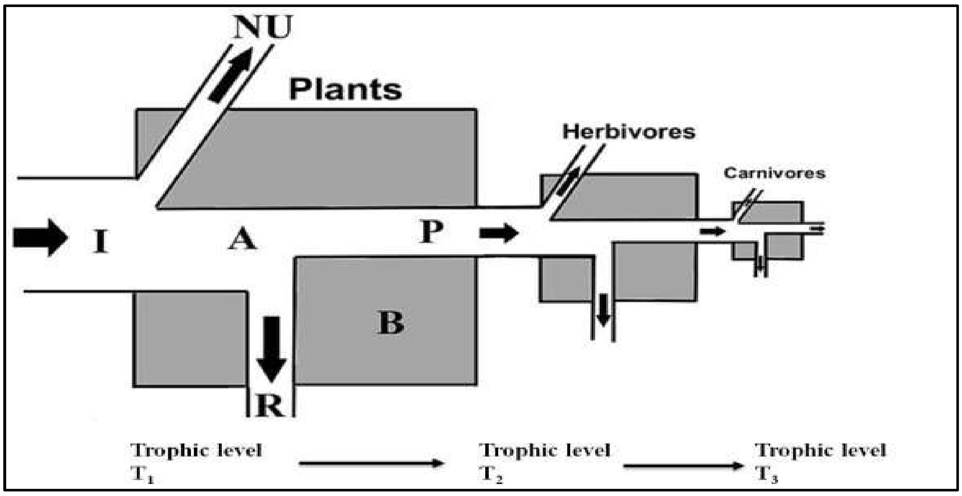

Fig. 6. An expanded three link energy food chain (1. Plants, 2. Herbivores, and 3. Carnivores) illustrating the relationship between food flow diagrams and energy transfer. The transfer of energy becomes degraded, dispersed, and diminished as the energy within a food chain flows from one trophic level to the other. Abbreviations: I=input, A=assimilation, R=respiration, NU=not utilized, P=production, B=biomass (Source:https://upload.wikimedia.org/wikipedia/commons/c/c5/EnergyFlowTransformity.jpg)

According to Raymond Lindeman (1942) "ten percent law"- during the transfer of energy from one trophic level/structure to another trophic level, only about ten percent of the energy is utilized. The remaining energy is lost during transfer, broken down in respiration, or lost to incomplete digestion by higher trophic levels. In a "universal" model of energy partitioning in the individual or species population, living structure or biomass is represented as a box (Fig. 7). Usable part of the ingested energy, I (light in case of autotrophs and food in case of heterotrophs) is assimilated, A while unusable part is ejected, NU. A large portion of assimilated energy must be respired, R to provide

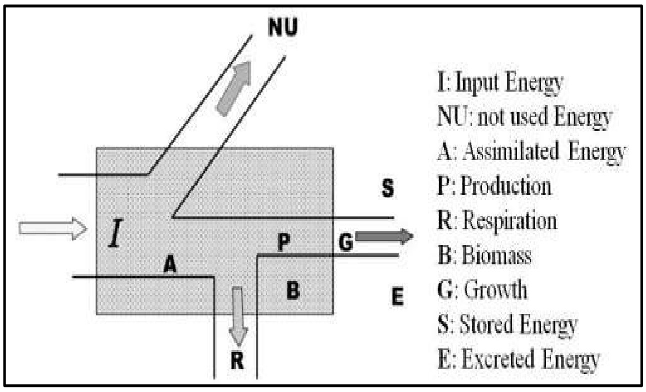

Fig. 7. A "universal" model of energy flow in a generalized ecosystem (based on Odum 1963). I = input or ingested energy; NU = not utilized energy; A = assimilated energy; P = production; R = respiration; B = biomass; G = growth; S = stored energy; E = excreted energy

existence energy to keep the body functioning and repaired. A part of energy can be used for growth and reproduction, P, while a part can be stored, S to accept further inputs of energy. Energy partitioning between P and R is of vital importance to the individual and species.

Primary producers convert the energy derived from sun into chemical energy in the form of food. This creates two major kinds of energy pools, the living organic matter (plant biomass) and the nonliving organic matter (plant detritus). These pools form the base of two major pathways of energy transfers (Fig. 8). The biophagic or grazing pathway comprises the ingestion of living organic matter by herbivores, while in the detritus or saprophagic pathway, detritus is consumed by the detritivores or saprovores. Organisms following the biophagic pathway constitute biophagic subsystem, and those that follow saprophagic pathway comprise the decomposition subsystem in an ecosystem. All heterotrophic organisms depending on food produced by autotrophs (primary producers) are called secondary producers and the organic matter synthesized by them constitutes secondary production.

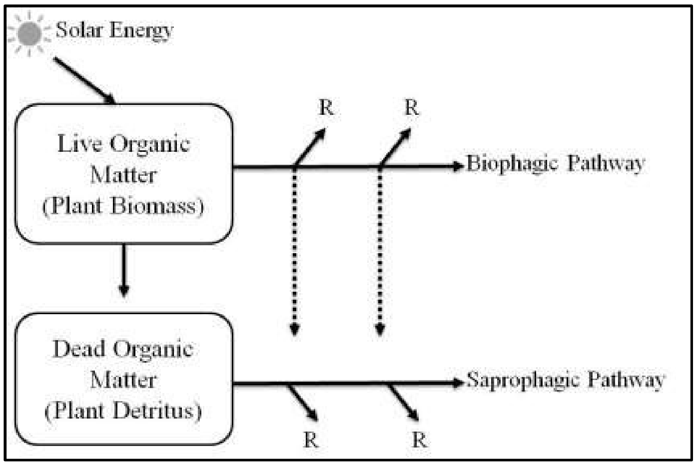

Fig. 8. Energy pools and associated pathways of energy transfer

12.6.2 Food chain and food web

A large number of microscopic phytoplanktons and other macrophytes perform the primary job of energy fixation. They, the primary producers are eaten by herbivores, which are further eaten by carnivores or predators in different ecosystems. The transfer of energy fixed by plants through a series of organisms eating one and being eaten

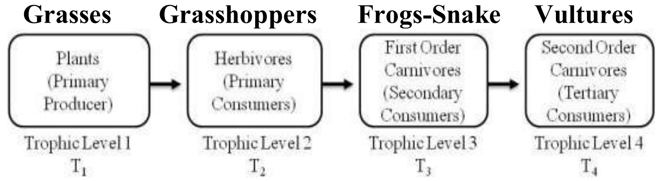

Fig. 9. Flow of energy in a generalized grazing food chain

by other is called food chain. A typical example of a food chain can be traced in a grassland ecosystem as shown in Fig.9.

However, the food relations are not so simple; rather they are complex. The trophic relationship between organisms of any ecosystem is not always in a simple chain-like fashion but forms a complicated network. This net-like trophic inter-relationship is called a food web. Since several species may occur in each of the trophic levels, the organisms that feed on a common set of organisms and are fed on by another common set of organisms are referred to as trophic species (Briand and Cohen 1984). The analysis of food webs is important to understand ecosystem dynamics in terms of limited euryphagy and euryphagous primary and secondary consumers (Fig. 10). According to Paine (1980), three types of food webs can be depicted, namely, connectedness webs- based on the concept of 'who eats whom', emphasizing the feeding relationships, energy flow food webs- where energy flow through the food web is estimated and quantified by the flux of energy between a resource and its consumer, and functional food webs- developed the idea of functional food webs on the basis of impact of species on the structure of community. The food webs have also been described as source webs- refer to one or more kinds of organisms that eat them, their predators, and so on, sink webs- refer to one or more kinds of organisms, the organisms they eat, their other prey, and so on (descending trophic levels), and community webs- represents a group of species within a defined area of habitat.

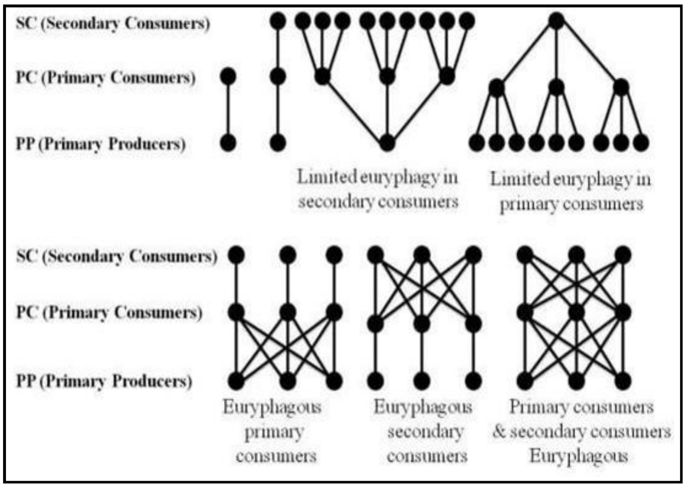

Fig. 10. Inter-linked network of food chains and food webs in an ecosystem

12.6.3 Ecological pyramids

There exists a relationship between the numbers, biomass, and energy contents of the primary producers, first and second order consumers, and so on to the top carnivores in any ecosystem. Such relationships represented in diagrammatic ways are referred to as ecological pyramids. Ecological pyramids are of three categories, namely, of numbers, of biomass, and of energy or productivity. Ecological pyramid of numbers and biomass may be upright pyramidal, inverted pyramidal or of any other shape, but the pyramid of energy is always upright pyramidal or triangle-shaped. Pyramid of numbers is the one in which individuals at each of the successive trophic levels are counted per unit area and their numbers are plotted (Fig. 11), pyramid of biomass, in which the total biomass existing at each of the successive trophic levels is measured in terms of dry weight or caloric value, per unit area and plotted (Fig. 12 & 13), while pyramid of energy or productivity, in which the energy flow per unit time at each of the successive trophic levels is measured and plotted (Fig. 14). The pyramid of energy flow is considered the one of fundamental significance as it illustrates the actual functional relationships between the trophic levels. Being governed by the second law of thermodynamics, energy flow declines from the producer level to successive trophic levels. Consequently, the pyramid of energy necessarily undertakes a typical upright pyramidal shape, reflecting a stepwise decrease in energy or productivity towards increasing trophic level. However, the shape of the pyramid of energy is not affected by size or rate of metabolism of organisms, while the other two pyramids are affected.

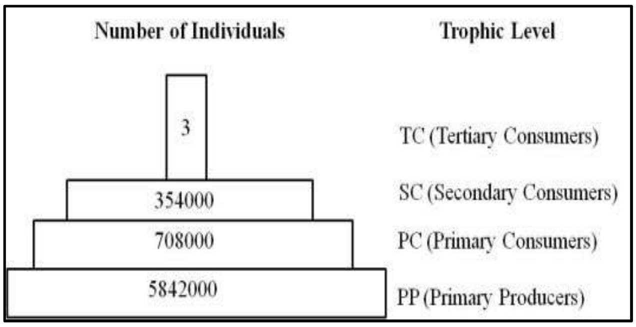

Fig. 11. Pyramid of numbers in a grassland ecosystem

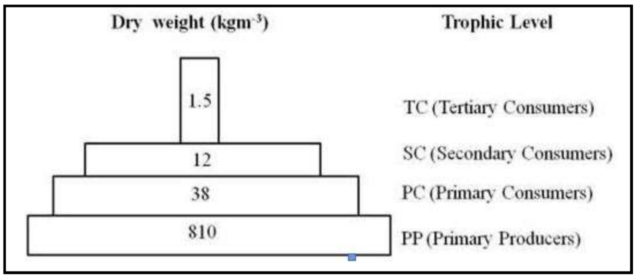

Fig. 8 12. Pyramid of biomass in a grassland ecosystem

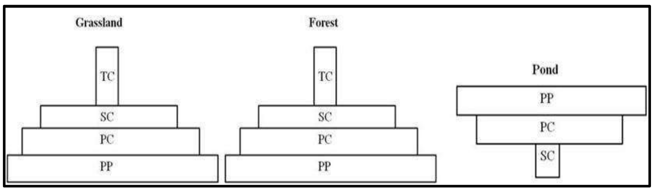

Fig. 9 13. Pyramid of biomass for various ecosystems

Animals may have larger biomass per unit area than plants, but their production per unit time per unit area would be much smaller than that of plants. An energy pyramid is a presentation of the trophic levels in an ecosystem. Energy from the sun is transferred through the ecosystem by passing through various trophic levels. Roughly 10% of the energy is transferred from one trophic level to the next, thus preventing transfer to a large number of trophic levels (see Fig. 14). There must be higher amounts of biomass at the bottom of the pyramid to support the energy and biomass requirements of the higher trophic levels (see Fig. 15).

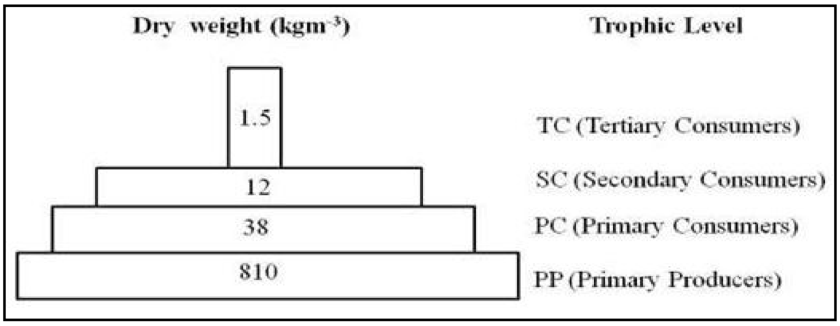

Fig. 14. Pyramid of energy in a grassland ecosystem

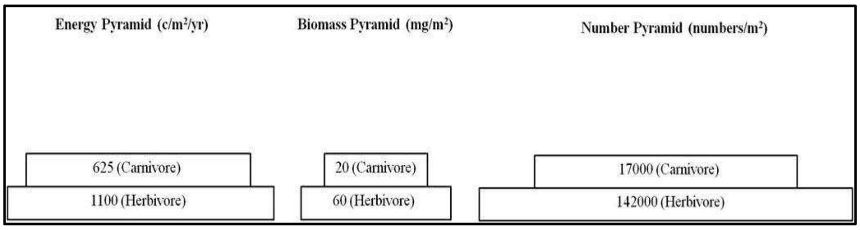

Fig. 15. Comparison of pyramid of energy, biomass and number in an old field in Michigan (modified from Odum 1971)

12.6.4 Nutrient cycling

The two processes proceed concurrently in ecosystems, the unidirectional flow of energy and the cycling of nutrient elements. Life sustenance is not only dependent on energy but also on the availability of key elements important for different life processes. Importantly, flow of energy is unidirectional and non-cyclic, whereas the movement of nutrient elements is cyclic. The conversion of radiant energy into chemical energy during photosynthesis, various inorganic elements and compounds are incorporated into the protoplasm of producers. The notable ones include the direct components of photosynthetic reaction, carbon dioxide, water, and those that are critical for protoplasmic synthesis viz. nitrogen, phosphorus, sulfur, magnesium (macronutrients), and other essential nutrients needed in small quantities (micronutrients). In the process of consumption of green plant, not only stored chemical energy in the form of carbohydrates, fats, and proteins is transferred to the herbivores, but nutrients are also transferred. Similarly, both, energy and nutrients are transferred from herbivores to carnivores and from the preceding trophic levels to the decomposers. Thus, the flow of energy and nutrients goes hand-in-hand in an ecosystem in a broadly similar pattern.

Although, there is a progressive decrease of energy in a food chain, the nutrients are not diminished. Eventually, nutrient-containing protoplasm is subjected to decomposition that releases nutrients in the environment and makes them available for reuse and recycling. The nature of the nutrient cycling process is closely inter-twined with the interaction of physical, chemical, and biotic factors in an ecosystem. Ecosystems, being open systems participate in various biogeochemical processes through a system of inputs and outputs. Broadly, there are two inter-related nutrient budget systems in an ecosystem, namely intra-system cycling of nutrients and extra-system nutrient transfers (Fig. 16). The intra-system cycling is concerned with the circulation of nutrients through the biotic and abiotic compartments of an ecosystem. It involves the input and output along the different trophic levels and the exchanges between reservoirs and sediments of an ecosystem. However, the extra-system transfers pertain to the intake and output of the entire ecosystem in relation to other ecosystems.

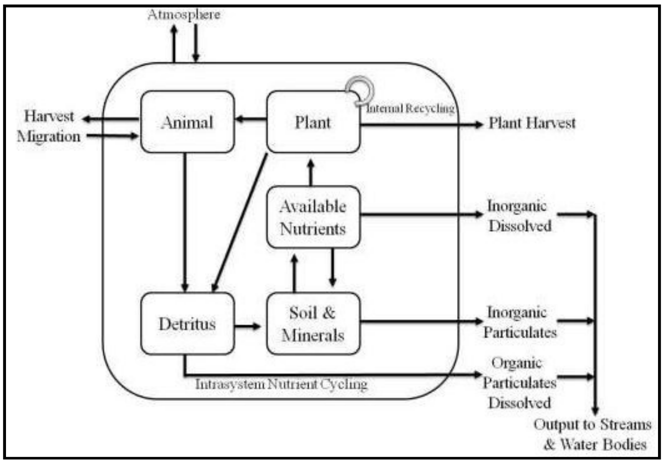

Fig. 12. A generalized model of intra-system nutrient cycling and extra-system nutrient transfer

12.6.5 Productivity

The pyramid of energy introduces a very important factor, i.e. the rate. The rate of energy fixation by green plants regulates the rate of production of organic material from simple inorganic substances in a given area over a given period of time. This rate of energy fixation and consequent increase in produced organic biomass is called primary productivity. Hence, the primary productivity can be defined as the primary fixation of radiant energy by plants in the form of organic substances and subsequent use of the fixed energy by herbivores, carnivores, and detritivores. Broadly, total amount of energy that is fixed by plants in a unit area in a given period of time is referred as gross primary productivity. A significant part of this energy is released during plant respiration for use in metabolic activities. Hence, net primary productivity is smaller because it is adjusted for energy losses required to support plant respiration and defined as the rate of storage of energy (or organic matter) in plant tissues when loss due to respiratory utilization by the plants is deducted out of the gross production rate. From producers, a portion of fixed energy gets transferred to heterotrophs that ingest living matter, while the remaining is converted to detritus pool to support those heterotrophs that feed on non-living organic matter. Within food webs, a pyramid-shaped structure characterizes ecological productivity. Plants typically account for more than 90% of the total productivity of the food web, herbivores most of the rest, and carnivores less than 1%.

Various factors influence the rate and amount of energy fixation during photosynthesis viz. the availability of basic chemical components of photosynthesis (moisture, nutrients, dissolved substances, etc.), diurnal and seasonal changes in physical and biological factors, species diversity in an ecosystem, etc. Because of differences in the availabilities of different factors, the world's ecosystems differ greatly in the amount of productivity that they sustain. Sustainable ecosystem relies on balance between the resource consumption and production. Unsustainable use of resources feeds back on itself and the ecosystem loses productivity in the long term.

12.7 Biodiversity Assessment

Measures of biodiversity at the level of species or populations are directed towards the attainment of an index of the number of species and their relative abundances within a given landscape. In this section we examine measures of biodiversity at each of the three levels of biological organization: within species/gene- tic, species and ecosystem. As with most categorizations, there will be overlap among measuring techniques at the various levets of biodiversiy.

12.7.1 Factors of Measuring biodiversity

Biodiversity can be measured in different ways. Two main factors taken into account when measuring diversity are **richness** and **evenness.**

(A) Measuring Diversity means

- **(i)** Scales
- **(ii)** Richness

(iii) Evenness

(iv) Diversity

(i) Scale

(a) Alpha Diversity: Diversity within a particular area, community or ecosystem.

(b) Beta Diversity: Expression of diversity between habitats.

(c) Gamma Diversity: it is a measurement of the overall diversity for different ecosystems within a region.

(ii) Species richness

- Is the number of different species in a habitat
- The more species the richer the habitat

(iii) Species evenness

(a) Species evenness refers to how close in numbers each species in an environment is.

(b) The uniformity of abundance between species in a community.

(c) Measurement of equitability among species in the community

The greater the species richness and species evenness in an area, the higher the biodiversity

(iv) Diversity indices

A diversity index is a mathematical measure of species diversity in a community. Diversity indices provide important information about the rarity, commonness, relative abundance and community composition simply species richness.

(a) Shannon-Wiener diversity Index: Species diversity is a function of the number of species present in a given area and the distribution of individuals among the species. The Shannon-Weiner index is also widely used index for the calculation of a species diversity. It is represented as:

$$H = -\Sigma\ (Ni / N) \log_2 (Ni / N)$$

Σ = Sum of species, Ni = number of individuals of i^{th} species
N = Total number of individuals of all species

(b) Simpson's index: This takes into account:

- the species richness
- the species evenness

To calculate Simpson's Index (D) for a particular area, the area must first be **sampled randomly (random sampling).**

The D is always a value from 0 to 1, where: High scores (close to 1) indicate high diversity. Low scores (close to 0) indicate low diversity.

A higher value means a more diverse habitat. For example, if one has an SDI of 0.5 and another has an SDI of 0.35, then the set with the SDI of 0.5 is more diverse

$$D= 1-[\Sigma (n/N)^2]$$

n= no. of individuals of a particular species
N= total no. of individuals of all species
Σ means 'sum of'

12.7.2 Importance of Biodiversity Assessment

- Determining key areas for conservation and establishing conservation priorities. Ranking of an area according to specified values such as rarity, diversity, fragmentation, habitat condition, resilience, threats and ecosystem processes.
- If biodiversity levels are right, it can strengthen the ecosystem to better resist stresses like climate change and invasive species.
- To detect changes over time has challenged mankind for centuries.
- Assessing the status and trends of biodiversity is essential for sustainable development strategies.
- Biodiversity is crucial for the wellbeing of people and the Earth. Ecological communities maintain the ecological and evolutionary processes that sustain life. These are necessary to help maintain the
- planet's chemical balance
- moderate climate
- renew soil
- conserve species diversity
- Plant, animal and other species have intrinsic worth.

- The more critical role an area or system plays for ecosystems, the more value it has in positively influencing biodiversity.

Summary

Biological diversity/biodiversity is the variety of life forms present on the planet. It is of immense importance for mankind. It provides various ecological services needed by human beings. Also, biodiversity provides us with various things of moral and economical importance. The overexploitations as well as change in the climatic conditions have contributed in the threatening of biodiversity. Moreover, the inappropriate utilization of biodiversity for its commercial value is heading towards its depletion in much faster way. Many ecologically important organisms/plants have become extinct because of their overutilization/overexploitation such as Dodo (*Raphus cucullatus)* and Woolly Mammoth *(Mammuthus primigenius).* Nowadays, many conservation methods like in-situ and ex-situ conservation are being adopted to save the available species especially which are at the verge of extinction. Therefore, this book chapter deals with the values, threats and Ecosystem structure and function and biodiversity assessment for the biodiversity in an elaborative manner.

Reference

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Alhajeri, B. H. and Fourcade, Y. (2019). High correlation between species-level environmental data estimates extracted from IUCN expert range maps and from GBIF occurrence data, *Journal of Biogeography*, 46(7): 1329-1341, https:// doi.org/10.1111/jbi.13619

Antonelli, A. and Perrigo, A. (2018). The science and ethics of extinction. *Nature ecology & evolution*, 2(4), 581-581, https:// doi.org/10.1038/s41559-018-0500-z

Baber, Z. (2016). The plants of empire: Botanic gardens, colonial power and botanical knowledge. *Journal of Contemporary Asia*, 46(4): 659-679, https://doi.org/10.1080/00472336.2016.1185796

Bailey, S.A. (2015). An overview of thirty years of research on ballast water as a vector for aquatic invasive species to freshwa- ter and marine environments. *Aquatic Ecosystem Health & Management*, 18(3): 261-268, https:// doi.org/10.1080/14634988.2015.1027129

Bartkowski, B., Lienhoop, N. and Hansjürgens, B. (2015). Capturing the complexity of biodiversity: A critical review of eco- nomic valuation studies of biological diversity. *Ecological Economics*, 113: 1-14, https://doi.org/10.1016/ j.ecolecon.2015.02.023

Basumatary, S.K., Tripathi, S., Bera, S.K., Nautiyal, C.M., Devi, N. and Sarma, G.C. (2015). Late Pleistocene palaeoclimate based on vegetation of the Eastern Himalayan foothills in the Indo-Burma Range, India. *Palynology*, 39(2): 220-233, https://doi.org/10.1080/01916122.2014.945665

Brei, M., Pérez-Barahona, A. and Strobl, E. (2016). Environmental pollution and biodiversity: Light pollution and sea turtles in the Caribbean. *Journal of Environmental Economics and Management*, 77: 95-116.

Bremner, J., Paramor, O.A.L., Frid, C.L.J. 2006. Developing a methodology for incorporating ecological structure and functioning into designation of Special Areas of Conservation (SAC) in the 0-12 nautical mile zone. School of Biological Sciences, University of Liverpool. (2006) 158pp.

Brierley, G.J., Li, X., Cullum, C. and Gao, J. (2016). Introduction: landscape and ecosystem diversity in the Yellow River Source Zone. In Landscape and ecosystem diversity, dynamics and management in the Yellow River Source Zone (pp. 1-34). Springer, Cham.

BSI (2014). Botanical Survey of India, Annual report 2014-15. Retrieved from https://bsi.gov.in/uploads/documents/reports/annualReportBsi/english/Annual%20Report%202014-15_.pdf

Buchanan, M. (2021). Nature fights back. *Nature Physics,* 17, 758.

Carvalho, Y.G., Vitorino, L.C., de Souza, U. J. and Bessa, L.A. (2019). Recent trends in research on the genetic diversity of plants: Implications for conservation. *Diversity*, 11(4): 62, https://doi.org/10.3390/d11040062

Collins, R., Schaafsma, M. and Hudson, M.D. (2017). The value of green walls to urban biodiversity. Land Use Policy, 64, 114- 123.

Cracknell, D., White, M.P., Pahl, S., Nichols, W.J. and Depledge, M.H. (2016). Marine biota and psychological well-being: a preliminary examination of dose–response effects in an aquarium setting. *Environment and Behavior*, 48(10): 1242-1269, https://doi.org/10.1177/0013916515597512

Desouza, A.C. and Prevedello, J.A. (2020). The importance of protected areas for overexploited plants: Evidence from a biodi- versity hotspot. *Biological Conservation*, 243: 108482, https://doi.org/10.1016/j.biocon.2020.108482

Díaz, Sandra, Andy, H. and Wardle, D.A. (2009). Biodiversity in forest carbon sequestration initiatives: Not just a side bene- fit. *Current Opinion in Environmental Sustainability*, 1(1): 55–60, https://doi.org/10.1016/j.cosust.2009.08.001

Dietsch, A.M., Teel, T.L. and Manfredo, M.J. (2016). Social values and biodiversity conservation in a dynamic world. *Conserva- tion Biology*, 30(6): 1212-1221, https://doi.org/10.1111/cobi.12742

Evers, C.R., Wardropper, C.B., Branoff, B., Granek, E.F., Hirsch, S.L., Link, T.E. and Wilson, C. (2018). The ecosystem services and biodiversity of novel ecosystems: A literature review. *Global Ecology and Conservation*, 13: e00362, https:// doi.org/10.1016/j.gecco.2017.e00362

Fortelius, M. and Kappelman, J. (1993). The largest land mammal ever imagined. *Zoological Journal of the Linnean Society*. 108: 85–101, https://doi.org/10.1111/j.1096-3642.1993.tb02560.x.

Gaston, Kevin J., Spicer and John, I. (2004). Biodiversity: An Introduction. Wiley. ISBN 978-1-4051-1857-6.

Giller, P. S., Hillebrand, H., Berninger, U.-G. et al. 2004. Biodiversity effects on ecosystem functioning: emerging issues and their experimental test in aquatic environments. Oikos 104: 423-436.

Gonzalez, A., Cardinale, B.J., Allington, G.R., Byrnes, J., Arthur Endsley, K., Brown, D.G. and Loreau, M. (2016). Estimating local biodiversity change: a critique of papers claiming no net loss of local diversity. *Ecology*, 97(8): 1949-1960, https:// doi.org/10.1890/15-1759.1

Griffiths, V.F., Bull, J.W., Baker, J. and Milner-Gulland, E.J. (2019). No net loss for people and biodiversity. *Conservation Biology*, 33(1): 76-87, https://doi.org/10.1111/cobi.13184

Gupta, N., Tiwari, V., Everard, M., Savage, M., Hussain, S.A., Chadwick, M.A. and Belwal, V.K. (2020). Assessing the distribution pattern of otters in four rivers of the Indian Himalayan biodiversity hotspot. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 30(3): 601-610.

Hanley, N., Breeze, T.D., Ellis, C. and Goulson, D. (2015). Measuring the economic value of pollination services: Principles, evidence and knowledge gaps. *Ecosystem Services*, 14: 124-132, https://doi.org/10.1016/j.ecoser.2014.09.013

Hiromoto, S., Inoue, M., Taguchi, T., Yamane, M. and Ohtsu, N. (2015). In vitro and in vivo biocompatibility and corrosion behaviour of a bioabsorbable magnesium alloy coated with octacalcium phosphate and hydroxyapatite. *Acta biomateri- alia*, 11: 520-530, https://doi.org/10.1016/j.actbio.2014.09.026

Hoban, S., Callicrate, T., Clark, J., Deans, S., Dosmann, M., Fant, J. and Griffith, M.P. (2020). Taxonomic similarity does not predict necessary sample size for ex situ conservation: A comparison among five genera. *Proceedings of the Royal Society B*, 287(1926): 20200102, https://doi.org/10.1098/rspb.2020.0102

Hu, X., Huang, B., Verones, F., Cavalett, O. and Cherubini, F. (2021). Overview of recent land-cover changes in biodiversity hotspots. *Frontiers in Ecology and the Environment*, 19(2): 91-97, https://doi.org/10.1002/fee.2276

Huang, D., Goldberg, E.E., Chou, L. M. and Roy, K. (2018). The origin and evolution of coral species richness in a marine biodiversity hotspot. *Evolution*, 72(2): 288-302, https://doi.org/10.1111/evo.13402

Importance of Biodiversity by OpenStax is licensed under CC BY 4.0. Modified from the original by Matthew R. Fisher. https://openoregon.pressbooks.Pub/ envirobiology/chapter/123/

Jactel, H., Gritti, E.S., Drössler, L., Forrester, D.I., Mason, W.L., Morin, X. and Castagneyrol, B. (2018). Positive biodiversity– productivity relationships in forests: climate matters. *Biology Letters*, 14(4): 20170747.

Johnson, K.G., Hasibuan, F., Mueller, W. and Todd, J.A. (2015). Biotic and environmental origins of the southeast Asian ma- rine biodiversity hotspot: The throughflow project. *Palaios*, 30(1): 1-6.

Kamal, S. Bawa, Da, A. and Krishnaswamy, J. (2007), Western Ghats & Sri Lankan Biodiversity Hotspot. Critical Ecosystem Partnership Fund Conservation International 2011 Crystal Drive Suite 500 Arlington, VA 22202, USA.

Kano, Y., Dudgeon, D., Nam, S., Samejima, H., Watanabe, K., Grudpan, C. and Utsugi, K. (2016). Impacts of dams and global warming on fish biodiversity in the Indo-Burma hotspot. *PloS one*, 11(8): e0160151.

Kiran, M., Caboň, M., Senko, D., Khalid, A.N. and Adamčík, S. (2021). Description of the Fifth New Species of Russula subsect. Maculatinae from Pakistan Indicates Local Diversity Hotspot of Ectomycorrhizal Fungi in Southwestern Hima- layas. *Life*, 11(7): 662.

Kumar, A. and Verma, A.K. (2017). Biodiversity loss and its ecological impact in India. *International Journal on Biological Sciences*, 8(2): 156-160.

Kumar, V. and Chopra, A.K. (2009). Impact of climate change on biodiversity of India with special reference to Himalayan region-An overview. *Journal of Applied and Natural Science,* 1(1): 118-122, https://doi.org/10.31018/jans.v1i1.48

Kumar, V., Kumar, P. and Singh, J. (2019). An introduction to contaminants in agriculture and environment. In: Contaminants in Agriculture and Environment: Health Risks and Remediation, 1: 1-8.

Mora, C., Tittensor, D.P., Adl, S., Simpson, A.G.B. and Worm, B. (2011). How many species are there on earth and in the ocean? *PLoS., Biology* 9(8): e1001127. https://doi.org/10.1371/journal.pbio.1001127

Muller, F. 1997. State-of-the-art in ecosystem theory. Ecol. Model. 100:135-161. Myster, R.W. 2001. What is Ecosystem Structure?. Caribb. J. Sci. 37: 132-134.

Myers, N., Mittermeier R.A., Mittermeier, C.G., Da Fonseca, G.A.B. and Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature,* 403: 853-858, https://doi.org/10.1038/35002501

NOSS, R.F. (1990). Indicators for Monitoring Biodiversity: A Hierarchical Approach. *Conservation Biology,* 4(4): 355–364. https://doi.org/10.1111/j.1523-1739.1990.tb00309.x

Odum, E. P. 1953. Fundamentals of Ecology. Saunders, Philadelphia. First edition, 384 pp.

Odum, E.P., Barrett, G.W. 2005. Fundamentals of Ecology (5th ed.). Thomson, Brooks/Cole: Australia.

Oliver, T.H. and Morecroft, M.D. (2014). Interactions between climate change and land use change on biodiversity: attribution problems, risks, and opportunities. *Wiley Interdisciplinary Reviews: Climate Change*, 5(3): 317-335, https:// doi.org/10.1002/wcc.271

Peres, S. (2016). Saving the gene pool for the future: Seed banks as archives. Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences, 55, 96-104.

Perrino, E.V. and Wagensommer, R.P. (2021). Crop wild relatives (CWR) priority in Italy: Distribution, ecology, in situ and ex situ conservation and expected actions. *Sustainability*, 13(4): 1682, https://doi.org/10.3390/su13041682

Puri, M., Karanth, K.K. and Thapa, B. (2019). Trends and pathways for ecotourism research in India. *Journal of Ecotourism*, 18 (2), 122-141: https://doi.org/10.1080/14724049.2018.1474885

Rana, S.K., Luo, D., Rana, H.K., O'Neill, A.R. and Sun, H. (2021). Geoclimatic factors influence the population genetic connec- tivity of Incarvillea arguta (Bignoniaceae) in the Himalaya–Hengduan Mountains biodiversity hotspot. *Journal of System- atics and Evolution*, 59(1): 151-168.

Rani, S., Kumari, S., Kumar, P. and Kumar, V. (2021). Biological diversity: Introduction, values, threats and conservation measures. In: Biological Diversity: Current Status and Conservation Policies, Volume 1, Eds. Kumar., V., Kumar, S., Kamboj, N., Payum, T., Kumar, P. and Kumari, S. pp. 1-23, https://doi.org/10.26832/aesa2021-bdcp-01

Sahoo, M. and Pradhan, J. (2021). Adaptation and Acculturation: Resettling displaced tribal communities from wildlife sanc- tuaries in India. *Migration Letters*, 18(3): 237-259, https://doi.org/10.33182/ml.v18i3.877

Sarkar, S. (2019). What Should "Biodiversity" Be?. In: Casetta E., Marques da Silva J., Vecchi D. (eds) From Assessing to Conserving Biodiversity. History, Philosophy and Theory of the Life Sciences, vol 24. Springer, Cham. https://doi.org/10.1007/978-3-030-10991-2_18

Sayer, J., Margules, C. and McNeely, J.A. (2021). People and biodiversity in the 21st Century. Ambio, 50(5), 970-975, https:// doi.org/10.1007/s13280-020-01476-9

Seddon, N., Mace, G.M., Naeem, S., Tobias, J.A., Pigot, A.L., Cavanagh, R. and Walpole, M. (2016). Biodiversity in the Anthro- pocene: prospects and policy. *Proceedings of the Royal Society B: Biological Sciences*, 283(1844): 20162094, https:// doi.org/10.1098/rspb.2016.2094

Sholihah, A. (2020). Diversification of Sundaland aquatic biotas: build-up of freshwater fishes' diversity and distribution in a biodiversity hotspot (Doctoral dissertation, Université Montpellier).

Singh, J.S. and Chaturvedi, R.K. (2017). Diversity of ecosystem types in India: a review. *Proceeding of Indian National Science Academy,* 83: 569–594.

Sivaperuman, C., Venkataraman, K. and Kumar, A. (2018). Endemic, Endangered and Threatened Vertebrates in the Indian Hotspots. In Indian Hotspots (pp. 29-56). Springer, Singapore.

Stephan, A., Suresh, R. and Livingstone, C. (2015). Indian Biodiversity: Past, Present and Future. *International Journal of Envi- ronment and Natural Sciences,* 7: 13-28.

Stoll-Kleemann, S. and Schmidt, U.J. (2017). Reducing meat consumption in developed and transition countries to counter climate change and biodiversity loss: a review of influence factors. *Regional Environmental Change*, 17(5): 1261-1277, https://doi.org/10.1007/s10113-016-1057-5

Tansley, A. G. 1935. The use and abuse of vegetational concepts and terms. Ecology 16: 284-307. Waide, R.B. 1999. The Relationship between Productivity and Species Richness. Annu. Rev. Ecol. Syst. 30: 257-300.

Thapa, S., Wang, L., Koirala, A., Shrestha, S., Bhattarai, S. and Aye, W.N. (2020). Valuation of ecosystem services from an important wetland of Nepal: A Study from Begnas watershed system. *Wetlands*, 40(5): 1071-1083, https:// doi.org/10.1007/s13157-020-01303-7

Titley, M.A., Snaddon, J.L. and Turner, E.C. (2017). Scientific research on animal biodiversity is systematically biased towards vertebrates and temperate regions. *PloS one*, 12(12): e0189577, https://doi.org/10.1371/journal.pone.0189577

Unwins, P.J.R., Webb, R.I. and Taylor, A.P. (1999). Novel Nano-organisms from Australian Sandstones. *American Mineralo- gist*, 83: 1541.

Venkataraman, K. and Sivaperuman, C. (2018). Biodiversity Hotspots in India: Vertebrate Faunal Diversity, Conservation and Management. Volume 2, Singapore: Springer

Verma, M., Symes, W.S., Watson, J.E., Jones, K.R., Allan, J.R., Venter, O. and Carrasco, L.R. (2020). Severe human pressures in the Sundaland biodiversity hotspot. *Conservation Science and Practice*, 2(3): e169, https://doi.org/10.1111/csp2.169

White, A., Fant, J.B., Havens, K., Skinner, M. and Kramer, A.T. (2018). Restoring species diversity: assessing capacity in the US native plant industry. *Restoration Ecology*, 26(4): 605-611, https://doi.org/10.1111/rec.12705

Wilcox, B.A. (1984). In situ conservation of genetic resources: determinants of minimum area requirements. In National Parks, Conservation and Development, Proceedings of the World Congress on National Parks, J.A. McNeely and K.R. Miller, Smithsonian Institution Press, pp. 18–30.

Yakovlev, R.V. and Zolotuhin, V.V. (2021). Revision of the family Metarbelidae (Lepidoptera) of the Oriental Region. II. Two monotypic genera–Ghatarbela gen. nov. and Micrarbela gen. nov. from the Western Ghats and Sri Lanka biodiversity hotspot. *Ecologica Montenegrina*, 42: 103-108.

ZSI (2014). Zoological Survey of India, Prani Vigan Bhawan, M-Block, News Alipore Kolkata-700053, Retrieved from www.http;//www.zsi.gov.in/App/Index.aspx.

Unit 13: Global Biodiversity

Unit Structure

13.0 Learning Objectives

After studying this unit you are able to answer following questions:

- To understand the concept biodiversity Hot spots
- Biodiversity Hot spots in India
- Protecting and maintaining biodiversity hotspots
- Rate of extinction is a crucial determinant of global biodiversity at any point in time
- To know principal causes of natural background extinctions
- IUCN categories of threatened species.
- What is Red Data Book?
- The Categories Enlisted in Red Data Book
- List of Threatened Flora And Fauna In India

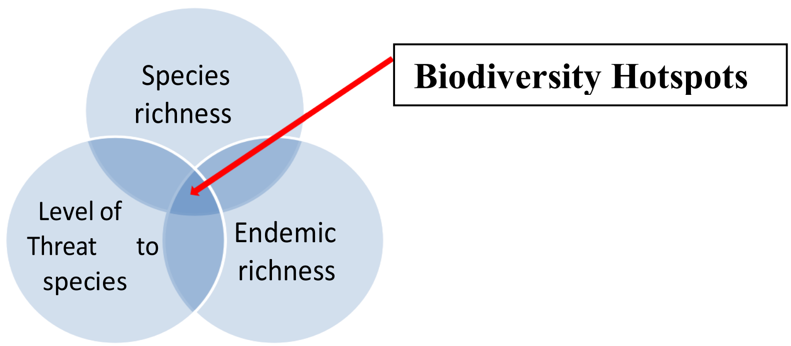
13.1. Introduction

Biodiversity hotspots are areas that support natural ecosystems that are largely intact and where native species and communities associated with these ecosystems are well represented. They are also areas with a high diversity of locally endemic species, which are species that are not found or are rarely found outside the hotspot.

- The concept of biodiversity hotspots was given by Norman Myers in two articles ''The Environmentalist'' (1988 & 1990). In 1988 he first identified ten tropical forest ''hotspots'' characterized both by exceptional levels of plant endemism and by serious levels of habitat loss.
- In 1990, Myers added a further eight hotspots, including four Mediterranean type ecosystems.
- Conservation International (CI) adopted Myers' hotspots as its institutional blueprint in 1989, and in 1996, the organization made the decision to undertake a reassessment of the hotspots concept. Three years later an extensive global review was undertaken, which introduced quantitative thresholds for the designation of biodiversity hotspots.

In 1999, CI identified 25 biodiversity hotspots in the book "Hotspots: Earth's biologically Richest and Most Endangered Terrestrial Eco regions". Collectively, these areas held as endemics about 44% of the world's plants and 35% of terrestrial vertebrates in an area that formerly covered only 11.8% of the planet's land surface. The habitat extent of this land area had been reduced by 87.8% of its original extent, such that this wealth of biodiversity was restricted to only 1.4% of Earth's land surface. In 2005 CI published an updated titled "Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Eco regions".

13.2. Hotspots of Biodiversity



13.2.1. Global Biodiversity Hotspots: World

Currently, there are 35 Biodiversity Hotspots. Overall, these hotspots once covered 15.7 percent of the Earth's land surface. In all, 86 percent of the hotspots' habitat has already been destroyed, such that the intact remnants of the hotspots now cover only 2.3 percent of the Earth's land surface. The biodiversity hotspots hold especially high numbers of endemic species. Each hotspot faces extreme threats and has already lost at least 70% of its original natural vegetation. Over 50% of the world's plant species and 42% of all terrestrial vertebratespecies are endemic to the 35 biodiversity hotspots.

I. Africa

A total of 08 Hotspots in African continent hold a diversity of plant and animal life, many of which are found nowhere else on Earth.

1. Cape Floristic Region
2. Coastal Forests of Eastern Africa
3. Eastern Afromontane
4. Guinean Forests of West Africa
5. Horn of Africa
6. Madagascar and the Indian Ocean Islands
7. Maputaland-Pondoland-Albany
8. Succulent Karoo

II. Asia-Pacific

Composed of large land areas as well as islands dotting the Pacific seas, these 14 Hotspots represent important biodiversity.

1. East Melanesian Islands
2. Himalaya
3. Indo-Burma
4. Japan
5. Mountains of Southwest China
6. New Caledonia
7. New Zealand
8. Philippines
9. Polynesia-Micronesia
10. Southwest Australia
11. Forests of Eastern Australia (new)
12. Sundaland
13. Wallacea
14. Western Ghats and Sri Lanka

III. Europe and Central Asia

From the Mediterranean Basin to the Mountains of Central Asia, these four Hotspots are unique in their diversity.

1. Caucasus
2. Irano-Anatolian
3. Mediterranean Basin
4. Mountains of Central Asia

IV. North and Central America

North and Central America play host to thousands of acres of important habitat.

1. California Floristic Province
2. Caribbean Islands
3. Madrean Pine-Oak Woodlands
4. Mesoamerica

V. South America

From Brazil's Cerrado to the Tropical Andes, South America has some of the richest and most diverse life on Earth.

1. Atlantic Forest
2. Cerrado
3. Chilean Winter Rainfall-Valdivian Forests
4. Tumbes-Chocó-Magdalena
5. Tropical Andes

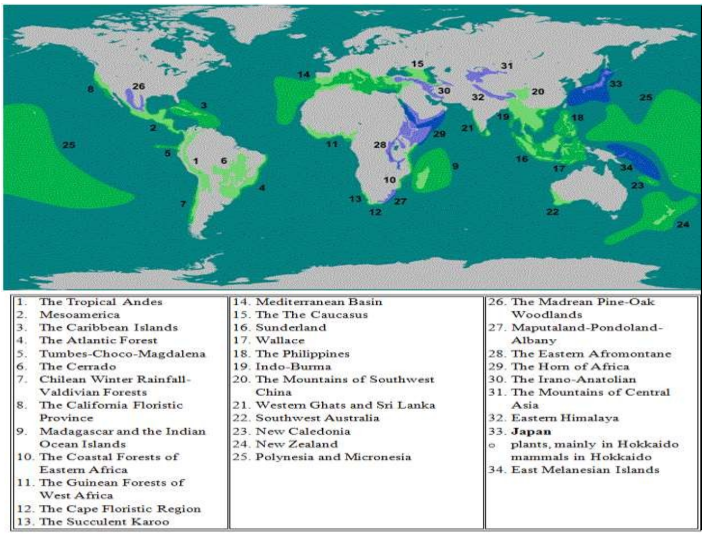
Hottest hotspots

Some hot spots are much richer than others in terms of their numbers of endemics. The analysis so far has considered five key factors: numbers of endemics and endemic species/area ratios for both plants and vertebrates, and habitat loss. These factors do not carry equal weight, so they cannot be combined into a single quantitative ranking. For comparative purposes in qualitative fashion, Hear is a list of eight 'hottest hotspots', which appear at least three times in the top ten listings for each factor.

1. Madagascar
2. Philippines
3. Sundaland

4. Brazil's Atlantic forests
5. Caribbean island
6. Indo – Burma region
7. Western Ghats & Sri lanka
8. Eastern arc & coastal forests of Tanzania/Kenya

The leaders are Madagascar, the Philippines and Sunderland, appearing for all five factors, followed by Brazil's Atlantic Forest and the Caribbean, appearing for four. Three of these hotspots, Madagascar, the Philippines and the Caribbean, have small areas, which further highlights their importance.



The map shows 34 biodiversity hotspots. These are the areas which are suffering from loss of biodiversity where attention is needed. Norman Myers gave the twenty five biodiversity hotspots (green coded as 1-25) and later nine hotspots (blue (26-34)) added by Mittermeier

http://www.drishtiias.com/upsc-exam-gs-resources- .

BIODIVERSITY HOTSPOT

Mega-diverse countries

The concept of mega-diversity is based on the total number of species in a country and the degree of endemism at the species level and at higher taxonomic levels. The World Conservation Monitoring Centre recognized 17 mega-diverse countries in July 2000 including:

1. Australia	6. India	11. Brazil	16. United States
2. The Congo	7. Indonesia	12. Colombia	17. Venezuela
3. Madagascar	8. Malaysia	13. Ecuador	
4. South Africa	9. Papua New Guinea	14. Mexico	
5. China	10. Philippines	15. Peru	

This group of countries has less than 10% of the global surface, but support more than 70% of the biological diversity on earth.

The concept was first developed by Russell Mittermeier in 1988, as a way to prioritize conservation action. Based on an analysis of primate conservation priorities, he found that four countries accounted for two-thirds of all primate species. The analysis was then expanded to include other mammals, birds, reptiles, amphibians, plants and selected groups of insects.

This countries representing majority of tropical rainforests, coral reefs and other priority systems. The results of the assessment were published in the Megadiversity: Earth's biologically wealthiest nations (Mittermeier, Gil and Mittermeier eds. 1997. Cemex, Mexico).

13.2.2. Global Biodiversity Hotspots: Asia-Pacific

1. East Melanesian Islands

Once largely intact, the 1,600 East Melanesian Islands are now a hotspot due, sadly, to accelerating levels of habitat loss.

2. Himalaya

The Himalaya Hotspot is home to the world’s highest mountains, including Mt. Everest.

3. Indo-Burma

Encompassing more than 2 million km² of tropical Asia, Indo-Burma is still revealing its biological treasures.

4.Japan

The islands that make up the Japanese Archipelago stretch from the humid subtropics in the south to the boreal zone in the north, resulting in a wide variety of climates and ecosystems.

5. Mountains of Southwest China

With dramatic variations in climate and topography, the Mountains of Southwest China support a wide array of habitats including the most endemic-rich temperate flora in the world.

6. **New Caledonia**

An island the size of New Jersey in the South Pacific Ocean, New Caledonia is the home of no less than five endemic plant families.

7. **New Zealand**

A mountainous archipelago once dominated by temperate rainforests, New Zealand harbors extraordinary levels of endemic species.

8. **Philippines**

More than 7,100 islands fall within the borders of the Philippines hotspot, identified as one of the world's biologically richest countries.

9. Polynesia-Micronesia

Comprising 4,500 islands stretched across the southern Pacific Ocean, the Polynesia-Micronesia hotspot is the epicenter of the current global extinction crisis.

10. Southwest Australia

The forest, woodlands, shrublands, and heath of Southwest Australia are characterized by high endemism among plants and reptiles.

11. Forests of Eastern Australia

Forests of East Australia Hotspot consists of a discontinuous coastal stretch along the Australian states of Queensland and New South Wales, extending inland and further west, although it includes the New England Tablelands and the Great Dividing Range. This region contains more than 1500 endemic vascular plants.

12. Sundaland

The spectacular flora and fauna of the Sundaland Hotspot are succumbing to the explosive growth of industrial forestry in these islands.

13. Wallacea

The flora and fauna of Wallacea are so varied that every island in this hotspot needs secure protected areas to preserve the region's biodiversity.

14. Western Ghats and Sri Lanka

Faced with tremendous population pressure, the forests of the Western Ghats and Sri Lanka have been dramatically impacted by the demands for timber and agricultural land.

Protecting and maintaining biodiversity hotspots

Hotspots are not formally recognized or governed areas. However, the identification of an area as a biodiversity hotspot increases the likelihood of conservation investment. In addition, other designations for biodiversity conservation are likely to be present within these broad areas which may have more formal management structures. For example, the average protected area coverage of hotspots, based on IUCN Protected Area Management Categories I-VI, is 12% of their original extent.

13.2.3. Hotspot conservation initiatives

Only a small percentage of the total land area within bio-diversity hotspots is now protected. Several international organizations are working in many ways to conserve bio-diversity hotspots.

The Critical Ecosystem Partnership Fund (CEPF) is an alliance among seven non-governmental and private-sector organizations (including Conservation International). It is a global program provides grants to organizations around the world that are working to help protect biodiversity hotspots. Biodiversity hotspots are also used by major foundations and the Global Environment Facility (GEF) to target investments in global conservation.

The World Wide Fund for Nature has derived a system called the "Global 200 Ecoregions", the aim of which is to select priority Ecoregions for conservation within each of 14 terrestrial, 3 freshwater, and 4 marine habitat types. They are chosen for their species richness, endemism, taxonomic uniqueness, unusual ecological or evolutionary phenomena, and global rarity. All biodiversity hotspots contain at least one Global 200 Eco region.

Birdlife International has identified 218 “Endemic Bird Areas”(EBAs)each of which hold two or more bird species found nowhere else. Birdlife International has identified more than 11,000 Important Bird Areas all over the world.

Plant life International coordinates several the world aiming to identify Important Plant Areas.

Alliance for Zero Extinction is an initiative of a large number of scientific organizations and conservation groups who co-operate to focus on the most threatened endemic species of the world. They have identified 595 sites, including a large number of Birdlife's Important Bird Areas.

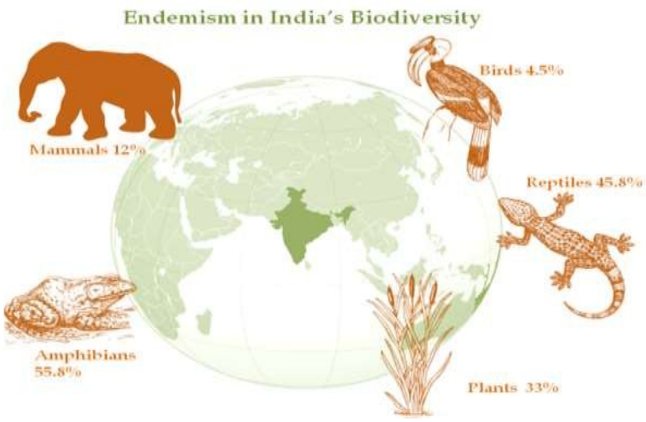
The National Geographic Society has prepared a world map of the hotspots and ArcView shape-file and metadata for the Biodiversity Hotspots including details of the individual endangered fauna in each hotspot, which is available from Conservation International.

13.2.4. Biodiversity Hotspots of India

Just 17 of the world's 200 or so countries contain 70% of its biodiversity, earning them the title "megadiverse." India is one of these megadiverse countries with only 2.4% of world land area & 4% of fresh water, yet accounts for 7.3% of recorded species making it 3rd most mega diverse country (after Brazil & Costa Rica) with highest concentration of species in Agasthymalai Hills in Western Ghats.

Group	Number	% of world species
Mammals	350	7.6%
Birds	1224	12.6%
Amphibians	197	4.4%
Reptiles	408	6.2%
Fishes	2546	11.7%
Flowering plants	15000	6%

http://conceptedu.blogspot.in/2013/03/biodiversityhotspots-in-india-india.html



http://thewesternghats.indiabiodiversity.org/biodiversity_in_india

13.2.4.1. Major hotspots of endemic and genetic diversity of India.

S.No.	Hotspots	Bio-geographic Zone
1.	Karakoram and Ladakh	Trans Himalaya
2.	Kumaon and Garhwal Himalaya	Western Himalayas
3.	Siwaliks	Himalaya
4.	Sikkim Himalaya	Eastern Himalaya
5.	Arunanchal Pradesh	Eastern Himalaya
6.	Lushai Hills	North-eastern India
7.	Tura-Khasi Hills	Meghalaya
8.	Aravallis	Semi-arid zone
9.	Bundelkhand	Central India Plateau
10.	Chota-Nagpur Plateau	Deccan Plateau
11.	Panchmarhi-Satpura ranges	Deccan Plateau
12.	Simlipal and Jeypore Hills of Orissa	Deccan (Eastern Ghats)
13.	Bastar and Koraput Hills	Deccan Plateau
14.	Vishakhapatnam Hills and Araku	Eastern Ghats
15.	Tirupati- Cuddappa Hills	Eastern Ghats
16.	Marathwada Hills	Deccan Plateau
17.	Saurashtra Kutch	Deccan Plateau
18.	Mahabaleshwar- Khandala ranges	Wastern Ghats
19.	Agumbe- Phonda ranges	Wastern Ghats
20.	Ratnagiri and Kolaba ranges	Wastern Ghats
21.	Nilgiris	Wastern Ghats
22.	Silent valley and Wynaad	Wastern Ghats
23.	Annamalai	Wastern Ghats
24.	Idduki- Sabarigiri	Wastern Ghats
25.	Kalakad and Agastyamalai Hills	Wastern Ghats
26.	Andaman and Nicobar	Islands

http://www.biologydiscussion.com/biodiversity/hotspots-of-biodiversity-in-india/7142

There are 4 major biodiversity hot spots present in India. They are:

1. **Himalaya:** Includes the entire Indian Himalayan region (and that falling in Pakistan, Tibet,Nepal, Bhutan, China and Myanmar)

2. **Indo-Burma:** Includes entire North-eastern India, except Assam and Andaman group ofIslands (and Myanmar, Thailand, Vietnam, Laos, Cambodia and southern China)

3. **Sundalands:** Includes Nicobar group of Islands (and Indonesia, Malaysia, Singapore,Brunei, Philippines)

4. **Western Ghats and Sri Lanka:** Includes entire Western Ghats (and Sri Lanka)

1. Himalaya

http://bsienvis.nic.in/files/Biodiversity%20Hotspots%20in%20India.pdf

Species diversity and endemism

Taxonomic	Species	Endemic	Endemism
Plants	10,000	3,160	31.6
Mammals	300	12	4.0
Birds	977	15	1.5
Reptiles	176	48	27.3
Amphibians	105	42	40.0
Freshwater	269	33	12.3

http://bsienvis.nic.in/files/Biodiversity%20Hotspots%20in%20India.pdf

- This region encompassing Bhutan, north eastern India, and southern, central, and eastern Nepal.
- The abrupt rise of the Himalayan Mountains from less than 500 meters to more than 8,000 meters results in a diversity of ecosystems that range from alluvial grasslands and subtropical broad leaf forests along the foothills to temperate broad leaf forests in the mid hills, mixed conifer and conifer forests in the higher hills, and alpine meadows above the tree line.

Biodiversity

- The Himalayan hotspot has nearly 163 globally threatened species (both flora and fauna) including the One-horned Rhinoceros [Vulnerable], the Wild Asian Water buffalo [Endangered].

- There are an estimated 10,000 species of plants in the Himalayas, of which one-third are endemic and found nowhere else in the world.
- The area has long been recognized as a rich centre of primitive flowering plants and is popularly known as the 'Çradle of Speciation'.
- The area is also rich in wild relatives of plants of economic significance e.g. rice, banana, citrus, ginger, chilli, jute and sugarcane.
- It is also regarded as the centre of origin and diversification of five palms of commercial importance, namely coconut, arecanut, palmyra palm, sugar palm and wild date palm. Tea (*Thea sinensis*) has been cultivated in this region for the last 4,000 years. Many wild and allied species of tea, the leaves of which are used as a substitute for tea, are found in the North East, in their natural habitats.
- The Taxol plant (*Taxus wallichiana*) is sparsely distributed in the region and is listed under the red data category due to its overexploitation for extraction of a drug effectively used against cancer.
- A few threatened endemic bird species such as the Himalayan Quail, Western tragopan are found here, along with some of Asia's largest and most endangered birds such as the Himalayan vulture and White-bellied heron.
- Mammals like the Golden langur, The Himalayan tahr, the pygmy hog, Lang-urs, Asiatic wild dogs, sloth bears, Gaurs, Muntjac, Sambar, Snow leopard, Black bear, Blue sheep, Takin, the Gangetic dolphin, wild water buffalo, swamp deer call the Himalayan ranged their home.

2. Indo-Burma

http://bsienvis.nic.in/files/Biodiversity%20Hotspots%20in%20India.pdf

Species diversity and endemism

Taxonomic Group	Species	Endemic Species	Endemism (%)
Plants	13,500	7,000	51.9
Mammals	433	73	16.9
Birds	1,266	64	5.1
Reptiles	522	204	39.1
Amphibians	286	154	53.8
Freshwater Fishes	1,262	553	43.8

http://bsienvis.nic.in/files/Biodiversity%20Hotspots%20in%20India.pdf

- The Indo-Burma region encompasses several countries. It is spread out from Eastern Bangladesh to Malaysia and includes North-Eastern India south of Brahmaputra river, Myanmar, the southern part of China's Yunnan province, Lao People's Democratic Republic, Cambodia, Vietnam and Thailand.
- The Indo-Burma region is spread over 2 million sq. km of tropical Asia.Since this hotspot is spread over such a large area and across several major landforms, there is a wide diversity of climate and habitat patterns in this region.

Biodiversity

- Much of this region has been deteriorating rapidly in the past few decades.
- This region is home to several primate species such as monkeys, langurs and gibbonswith populations numbering only in the hundreds.
- Many of the species, especially some freshwater turtle species, are endemic.
- Almost 1,300 bird species exist in this region including the threatened white-eared night-heron [Endangered], the grey-crowned crocias [Endangered], and the orange-necked partridge [Near Threatened].
- It is estimated that there are about 13,500 plant species in this hotspot, with over half of them endemic. A wide array of orchid and ginger species (there are more than1,000 orchid species in Thailand alone) and many tropical hardwood trees, includingcommercially valuable dipterocarp species and teak (*Tectona grandis*).

3. Western Ghats and Sri Lanka

- Western Ghats, also known as the "Sahyadri Hills" encompasses the mountain forests in the southwestern parts of India and highlands of southwestern Sri Lanka.
- These regions have moist deciduous forest and rain forest. The region shows high species diversity as well as high levels of endemism.
- Sri Lanka, which lies to the south of India, is also a country rich in species diversity.It has been connected with http://bsienvis.nic.in/files/Biodiversity%20Hotspots%20in%20India.pdf
- India through several past glaciations events by a land bridge almost 140kn wide
- The entire extent of hotspot was originally about 1,82,500 square kms, but due to tremendous population pressure, now only 12,445 square Km or 6.8% is in pristine condition.

Species diversity and endemism

Taxonomic Group	Species	Endemic Species	Endemism (%)
Plants	5,916	3,049	51.5
Mammals	140	18	12.9
Birds	458	35	7.6
Reptiles	267	174	65.2
Amphibians	178	130	73.0
Freshwater Fishes	191	139	72.8

Biodiversity

- The wide variation of rainfall patterns in the Western Ghats, coupled with the region's complex geography, produces a great variety of vegetation types.
- Some prominent genera and families are represented by large numbers of endemic species, such as Impatiens with 76 of 86 species endemic, Dipterocarpus with 12 of 13 species endemic, and Calamus with 23 of 25 species endemic. Of the 490 tree species recorded from low- and midelevation forests, 308 species are endemic. The only gymnosperm tree, *Podocarpus* (= Nageia) *wallichianus*, is also endemic. Of the 267 species of orchids, 130 are endemic.

- There are over 6000 vascular plants belonging to over 2500 genera in this hotspot, of which over 3000 are endemic. Much of the world's spices such as black pepper and cardamom have their origins in the Western Ghats. Nearly 235 species of endemic flowering plants are considered endangered.
- Similarly, plant diversity and endemism in Sri Lanka are quite high, with 3,210 flowering plant species in 1,052 genera, of which 916 species and 18 genera are endemic. Amazingly, all but one of the island’s more than 55 dipterocarp species is found nowhere else in the world. In addition, the island’s ferns (although not recently assessed) are estimated to number about 350 species. Approximately 433 plant. species, and at least five genera, are confined to Sri Lanka and the Western Ghats combined.
- Rare fauna of the region include –Asian elephant, Niligiri tahr, Nilgiri langur, Flying squirrel, Indian tigers, lion tailed macaque [All Endangered], Indian Giant squirrel [Least Concern], etc
- The highest concentration of species in the Western Ghats is believed to be the Agasthyamalai Hills in the extreme south. The region also harbors over 450 bird species, about 140 mammalian species, 260 reptiles and 175 amphibians. Over 60% of the reptiles and amphibians are completely endemic to the hotspot.
- Remarkable as this diversity is, it is severely threatened today. The vegetation in this hotspot originally extended over 190,000 square kms. Today, its been reduced to just 43,000 sq. km. In Sri Lanka, only 1.5% of the original forest cover still remains

4. **Sundaland**

http://bsienvis.nic.in/files/Biodiversity%20Hotspots%20in%20India.pdf

Species diversity and endemism

Taxonomic Group	Species	Endemic Species	Endemism (%)
Plants	25,000	15,000	60.0
Mammals	380	172	45.3
Birds	769	142	18.5
Reptiles	452	243	53.8
Amphibians	244	196	80.3
Freshwater Fishes	950	350	36.8

http://bsienvis.nic.in/files/Biodiversity%20Hotspots%20in%20India.pdf

- Sundaland is one of the biologically richest hotspots on Earth. The United Nations declared the islands a World BiosphereReserve in 2013.
- It is a region in South-East Asia that covers the western part of the Indo-Malayan archipelago. It includes Thailand, Malaysia, Singapore, Brunei and Indonesia. India is represented by the Nicobar Islands.
- The islands have a rich terrestrial and marine ecosystem that includes mangroves, coral reefs and sea grass beds.
- It has about 25,000 species of vascular plants, 15,000 (60%) of which are found nowhere else. One plant family, the Scyphostegiaceae, is confined to the hotspot andis represented by a single tree species, *Scyphostegia borneensis* from Borneo.
- Notable plants in the hotspot include members of the genus Rafflesia, represented by 16 species with very large flowers. One of these*, Rafflesia arnoldii*, has the largest flowers in the world, measuring up to one meter in diameter.
- The marine biodiversity includes several species such as whales, dolphis, dugong, turtles, crocodiles, fishes, prawns, lobsters, corals and sea shells.
- The primary threat to this biodiversity comes from over exploitation of marine resources. In addition, the forests on the island also need to be protected

Hope spots

- A hope spot is an area of ocean that merits special protection because of its wildlife and significant underwater habitats.
- Andaman and Nicobar & Lakshadweep Islands have been named as the new “hope

spots" by IUCN & oceanographer Sylvia Earle of Mission Blue, an organization involved in the study of oceans.

➢ Andamans & Nicobar Island has some of world's unique species of birds and plants. In the case of Lakshadweep, the coral reefs are quite sensitive to the ocean environment and that needs protection.

13.3. Biodiversity importance of hotspots

The biodiversity importance of hotspots is due to the high vulnerability of habitats and high irreplaceability of species found within large geographic regions. This means that these areas and the species present within them are both under high levels of threat and of significant global value based on their uniqueness. Therefore, operations that occur within global biodiversity hotspots should follow rigorous biodiversity assessments to prevent further biodiversity loss within these areas. This is a global scale approach based on coarse scale ecoregions that therefore, has limited use for site-scale assessment and decision making. Biodiversity hotspots will include areas of high biodiversity importance as well as degraded land and urban areas and therefore more detailed assessments are needed to locate the actual distribution of biodiversity within these areas.

13.4. Social-cultural values of hotspots

Given the richness of hotspot ecosystems, hotspots are often areas which offer essential ecosystem services. It is estimated that biodiversity hotspots, despite comprising 2.3% of the Earth's surface, account for 35% of the global ecosystem services. Furthermore, hotspots are home to 2.08 billion people which add significance to the ecosystem services that they provide. Biodiversity hotspots can include a variety of human land-uses, rural and urban, as well as protected areas under a range of possible governance types therefore many social and/or cultural values are likely to be present in some parts. This however is irrespective of the identification of the area as a biodiversity hotspot.

13.5. Reasons for biodiversity loss in hotspots

There are four main reasons why species are being threatened in these biodiversity hotspots

1. **Habitat destruction:** As recently as 30 years ago, most of the regions in these biodiversity hotspots were inaccessible and remote. Now, due to better infrastructure, contact of these areas with humans has increased. Activities such as logging of wood, increased agriculture, increased human habitation has led to destruction of forests and pollution of rivers. These factors are causing species ranges to reduce and habitats to become choppy. The government planned to establish habitat corridors, but these plans have not yet materialized in most areas. Activities such as mining, construction of large dams, highway construction has also caused significant destruction of habitats.
2. **Resource mismanagement:** Increased tourism without proper regulation has led to pollution and environmental degradation. Prime example are pilgrimage destinations like Rishikesh and hill stations like Dehradoon. These spots, once nestled in the pristine ranges of the Himalayas, are now dirty commercial destinations. Places like Dehradoon are even experiencing a construction boom so large that illegal immigrants from Bangladesh are also flocking there. Religious destinations in the Himalayas, where devotees flock in millions now, are also hot destinations for medicinal plant trade, which has threatened plant life in the area.
3. **Poaching:** Large mammals such as the tiger, rhinoceros and the elephant once faced the distinct possibility of complete extinction due to rampant hunting and poaching. However, efforts by conservationists since the 1970s has helped stabilize and grow these populations. Still, the trade in tiger hide, elephant tusks, tiger teeth, rhinoceros horn remains profitable and rampant.
4. **Climate change:** Although dire IPCC predictions of Himalayan glaciers melting by 2035 have been retracted, there is no doubt that several Himalayan glaciers are melting. In the Western Ghats, studies have shown that the deciduous and the evergreen forests of Karnataka are the most at risk. Climate change may significantly affect the temperatures, rainfalls and water tables in the Western Ghats, according to an assessment by the

Government of India.

13.6. Extinction of Species

Extinction, or more specifically ‘species extinction,’ refers the death of the last member of a species. As the definition is centered about the species, all the ambiguities and problems of species concept discussed in speciation module also affects the term extinction. Consider the common ancestor of human (Homo) and chimp (Pan) lineages that lived on planet earth approximately 12 million years ago. Homogenous population of this species might have split into two because of vicariance (the exact cause remain unknown), and each of these two populations evolved to construe common ancestors of either of these two lineages. For example, after this population split into two, the population that evolved into lineage consisting of human beings served as the common ancestor of Homo lineage, not shared with Pan Lineage, and vice versa with the other population. An intuitive analogy for this allopatric speciation is the phenomenon of binary fission (reproduction) that occurs in bacteria. In binary fission, a mother cell split into two daughter cells. Each of these daughter cells grow in size, and split into two again. During this split, can we affirm that the mother cell had died? Even if the mother cell prior to binary fission have become non-existent in the form it used to be, the daughter cells are in part made up of the mother cell. Similarly, when a population of one species split into two and each evolve to different lineages or different species, it is incorrect to call the original species as ‘extinct’ sensu stricto. This phenomenon is sometimes referred as pseudo-extinction or cladogenesis. A rigorous delineation between these pseudo-extinct species and extinct species is nearly impossible to achieve through paleontological studies. For example, if we study the fossils of this common ancestor of Homo and Pan, we would conclude that this species once existed on planet earth (perhaps for a span between 1 million and 10 million) had gone extinct around 12 million years ago. If we reconstruct the evolutionary legacy of these lineages using molecular phylogenetics, of course we would be able to know that this ‘extinct’ species is in fact a pseudo-extinct species.

An extinct species is often denoted with a dagger symbol (†) in species lists and phylogenetic trees. Many species, including African elephants, are now on the verge of extinction. IUCN (International Union for the Conservation of Nature) Red List often uses the terms threatened and endangered to denote species on the verge of extinction. A number of species that are extinct in the wild already are now conserved through ex-situ mode in zoos and botanical gardens; these species are denoted extinct in wild.

13.6.1. Causes of natural extinction

Almost the whole of extinctions ever happened in the earth were due to natural causes in contrast to anthropogenic causes. This is partially due to the fact that the humanity came into existence only very recently (3, 00, 000 years ago) in the deep geological history of life on earth spanning 4 billion years. Rate of extinction is an important determinant of biodiversity at any given point of time (along with rate of speciation). Most of these extinctions are 'natural, background extinctions'; extinction is an eventuality of any species, like death in the case of individuals. Causes of these natural extinctions are multifaceted and often unknown; often there are contrasting hypotheses for the same extinction events.

A major cause of natural extinctions is between-species competition for similar resources. This phenomenon is analogous to natural selection; while natural selection acts on individuals of population, interspecific competition occurs at the level of communities. For example, consider a marine pelagic habitat where the only primary producer are phytoplanktons. There could be competitions between different zooplankton species for this limiting food resource. In this interspecific competition, better-adapted fit species outcompetes the unfit species, and ultimately the fit species drives the unfit to extinction. Species can also lose its competitive advantage over other species when the habitat it occupies changes in response to various and biotic factors. For example, desertification of vegetation leads to dramatic changes in ecological niche; a number of previously well-adapted, fit species would become less adapted to desert ecosystem and ultimately go extinct. However, note that such extinctions are local in nature; same species might be living at some other locations of planet earth.

Many global-scale species extinctions were caused by tremendous catastrophes such as asteroid impact or global glaciation. These massive geological events wipes out all the individuals of species, and thus species goes extinct. Species extinction is an irrevocable event, a loss that can never be reverted. Asteroid impact usually act at a specific location on planet earth, but could have global scale repercussions; for instance, it could spread massive amount of fine dust into the atmosphere such that the whole planet would become covered in thick dust layer and sunlight would become a limiting factor. Without enough sunlight reaching the earth surface, earth would cool down dramatically; plants die out, driving the rest of the trophic levels into extinction.

Extinctions could also be caused by climate changes at the global or local level. Local-level environmental stress conditions would affect endemic species; for instance drying up of a lake housing many endemic species of fishes. As these endemic species are found nowhere else on this planet, even the local level environmental conditions would result in global-level species extinction. Therefore, small speciose habitats housing a substantial endemic species are the most labile ecosystems for the extinctions. For this reason, conservation programmes often prioritize these 'hotspots'. Biodiversity hotspots are regions with extraordinary level of endemism for vascular plants (1500 species of endemic plants), and it need to have lost at least 70 percentage of its original habitat. Whil e the hotspot criterion is based on endemism and loss of habitat, it is skewed towards vascular plants; it does not account other major plant lineages such as algae or mosses, or other living beings such as animals, fungi, protozoa or bacteria. Global-level climate change would have huge ramifications and drive several species in the world towards extinction, as in the case of Permian mass extinction. During each glacial periods-the last of such events happened around 20,000 years ago, several species at high latitudes would go extinct, as temperate and subpolar regions would become glaciated for a long period.

13.7. IUCN Red list categories

13.7.1. Introduction

The International Union for conservation of Nature (IUCN) is an international organization working in the field of nature conservation and sustainable use of natural resources. It is the leading International environmental organization. Its headquarter is at Gland, Switzerland.

History

The IUCN was founded on 18 October, 1948 at Fontainebleau, France. It is the world's most comprehensive inventory of the global conservation status of species. The organization is funded by governments, member organizations bilateral and multilateral agencies, etc. It is theworld's main authority on the conservation status of species. It is headquartered in Gland, Switzerland. India became a state member of IUCN in 1969. The office of IUCN in India is located in New Delhi established in 2007.

Logo of IUCN

IUCN has produced several key international environmental agreements namely:

a. the Convention on Biological Diversity (CBD),
b. the Convention on International Trade in Endangered Species (CITES),
c. the World Heritage Convention, and
d. the Ramsar Convention on wetlands.

Functions of IUCN

The organization is best known for compiling and publishing the IUCN Red List of threatened species, which assesses the conservation status of species worldwide. The mission of IUCN isto persuade, promote and help societies to preserve the diversity of nature. Its aim is to protect nature and promotes its sustainable utilization of natural resources. It also integrates matter ofpoverty alleviation, climate change, and biodiversity and gender equality.

Activities of IUCN

IUCN works over a wide range of themes related to conservation, environmental and ecological issues.Some of them are given below Source: IUCN; https://www.iucn.org/theme):

a) **Business and Biodiversity:** aims to transform business values, manages and invests in nature, highlighting the opportunities and benefits of a more sustainable approach.

b) **Climate Change:** assessing the risks of climate change; practical nature-based solutions centred on better conservation, management and restoration of natural ecosystems.

c) **Ecosystem Management:** IUCN works to have healthy ecosystems to provide goods (foodand water,) and services (climate regulation and protection from natural hazards).

Forest conservation

a) Protection of Marine and Polar environments

b) IUCN Global Species Programme is to save species for people and nature.

c) Water Conservation and Management

d) Natural World Heritage sites

13.7.2. IUCN Global Protected Areas Programme

IUCN has generated several resources. Such as

a) Conservation Tools
b) IUCN Red List of Threatened Species
c) IUCN Red List of Ecosystems
d) Key Biodiversity Areas

The details of some of them are given below:

Conservation tools

The key objective of IUCN is to share the knowledge. IUCN's knowledge products consist of conservation databases and tools. The major

The List of Conservation databases developed by IUCN is given below:

- The IUCN Red List of Threatened Species
- The IUCN Red List of Ecosystems assesses
- The World Database on Key Biodiversity Areas
- Protected Planet assesses
- ECOLEX : a gateway to environmental law

13.8. IUCN Red List of Threatened Species

The IUCN Red list of threatened species was created in 1964. This is the world's most inclusive record of worldwide conservation status of biological species. It is one of the most well-known objective assessment systems for classifying the status of plants, animals, and other organisms threatened with extinction.

The International Union for Conservation of Nature

(IUCN) unveiled this assessment system in 1994. It contains explicit criteria and categories to classify the conservation status of individual species on the basis of their probability of extinction. The species are categorized into nine groups by IUCN Red List as shown in the Figure 1.

Criteria for classification

The IUCN system uses a set of five quantitative criteria to assess the threat or extinction riskof a given species. These are the followings:

1) The rate of population decline of a given species.
2) The geographic range.
3) Population size
4) Species size or its habitat area
5) Whether these above quantitative properties indicate a high probability of extinction of species in the wild.

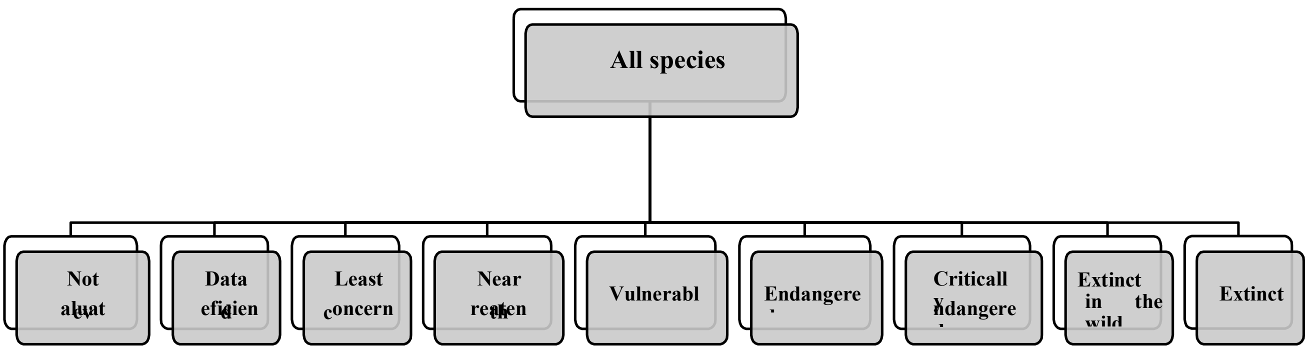


Figure 1: Showing IUCN Red list various categories

Table 1 : Representing various categories under Red List

IUCN Category	Description
Extinct (EX)	A taxon is E when there is no reasonable doubt that the last individual has died. For example : Dodo
Extinct in the wild (EW)	A taxon is EW when it is known only to survive in cultivation,in captivity or as a naturalized population (or populations) well outside the past range. For example: Alagoas curassow
Critically endangered (CR)	A taxon is CR when it is considered to be facing an extremely high risk of extinction in the wild in immediate future. Forexample: Gharial.

Endangered (EN)	A taxon is EN when the best available evidence indicates that itis facing a risk of extinction and is become less in number. For example: Tiger.
Vulnerable (VU)	A taxon is Vulnerable when it is not CR or EN but it facing a high risk of extinction in the wild in the medium term future.For example: Polar bear.
Near threatened (NT)	A taxon is NT when it has been evaluated against the criteria butdoes not qualify for CR, EN or VU now, but is close to qualifying for or is likely to qualify for a threatened category in the near future. For example: Blue-billed duck.
Least concern (LC)	A taxon is LC when it has been evaluated against the criteriaand does not qualify for CR, EN, VU or NT. Widespread and abundant taxa are included in this category.
Data deficient (DD)	A taxon is DD, when there is inadequate information to make adirect, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat.
Not Evaluated (NE)	A taxon is NE, when it is has not yet been evaluated against the criteria.

13.9: Red data book; list of threatened flora and fauna in India

13.9.1. What is Red Data Book?

The book which has been created to record the rare and endangered species of plants, animals,fungi and some local sub-species which is present within the region of the state or country. It is also called as **IUCN Red List.** It is a type of public document which help us to provide information about research, monitoring and conservation strategies, studies related to the rare and endangered species. Many species have been extinct long before without any information about them to present day. Therefore, International Union for Conservation of Nature (IUCN),which was established in 1964, started maintaining the record of all rare and endangered species in red data book. This document is also called as Russian Red Data Book, as this is from Russian Federation. This book contains color-coded information sheets arranged according to the threats to the existence of various species of flora and fauna.

The different colored sheets representing the various categories of threatened species is givenbelow:

S.NO	Color of the Sheet	Category of the Threatened Species
1.	Black	Species which are extinct
2.	Red	Species that are at greater risk of extinction
3.	Amber	Species which are getting attacked by other species
4.	white	Rare species
5.	Green	Non-dangerous species
6.	Grey	Species that are indicated to be endangered, vulnerable or rare

13.9.2. Goals of Red Data Book

IUCN (1996) has given the following goals of Red data book

(1) to provide scientifically based information on the status of species and sub-species at aglobal level,
(2) to draw attention to the magnitude and importance of threatened biodiversity,
(3) to influence national and international policy and decision-making, and
(4) to provide information to guide actions to conserve biological diversity.

Advantages of Red Data Book

1. It maintains the record of rare and endangered species, hence, one could easily identifythe risk of extinction of that species.
2. It maintains the record of all the categories of flora and fauna i.e., plants, animals and other sub-species.
3. The information provided in this book can be useful to evaluate the taxa globally.
4. Various strategies could be developed in advance to lower the risk of extinction of the taxa.

Disadvantages of Red Data Book

- Complete list of the extinct and present day species is not maintained.
- Information about the various rare and endangered species of micro-organisms is notavailable in this book.

13.10: The Categories Enlisted In Red Data Book

A representation of the relationships between the categories is shown in Figure 1.

EXTINCT (EX)

A taxon is Extinct when there is no reasonable doubt that the last individual has died from bothits wild and cultivation range.

EXTINCT IN THE WILD (EW)

A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in its known and/or expected habitat have been failed to record an individual at appropriate times (diurnal, seasonal, annual) and throughout its historic range.

CRITICALLY ENDANGERED (CR)

A taxon is Critically Endangered when it is facing an extremely high risk of extinction in thewild in the immediate future.

A. Range reduction of 80% over 3 generations or 10 years;
C. Less than 250 plants and decline;
D. Less than 50 mature plants;
E. Probability of extinction of 50% in 10 years or 3 generations.

ENDANGERED (EN)

A taxon is Endangered when it is not Critically Endangered but is facing a very high risk ofextinction in the wild in the near future.

A. Range reduction of 50% over 3 generations or 10 years;
B. Occurrence of less than 5000sq km or occupancy of less than 500sq km and decline inpopulations;
C. Less than 2500 plants and decline;
D. Less than 250 mature plants;
E. Probability of extinction of 20% in 20 years or 5 generations.

VULNERABLE (VU)

A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a highrisk of extinction in the wild in the medium-term future.

A. Range reduction of 20% over 3 generations or 10 years;
C. Less than 10000 plants and decline;
D. Less than 1000 mature plants, or low occupancy (<100km^2), or less than 5 locations;
E. Probability of extinction of 10% in 100 years.

LOWER RISK (LR)

A taxon is Lower Risk when it has been evaluated and does not fall into the categories CriticallyEndangered, Endangered or Vulnerable. There are three subcategories:

Conservation Dependent (cd). Taxa which are the focus of a continuing conservation programme, and which would become threatened if such actions stopped.

Near Threatened (nt). Taxa which do not qualify for Conservation Dependent, but which areclose to qualifying for Vulnerable.

Least Concern (lc). Taxa which do not qualify for Conservation Dependent or Near Threatened.

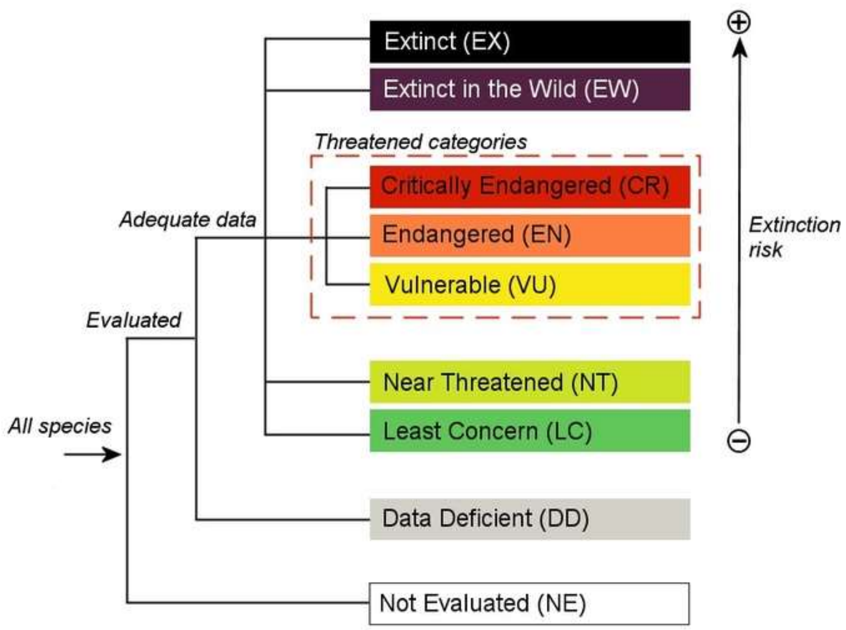
DATA DEFICIENT (DD)

A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking.

NOT EVALUATED (NE)

A taxon is Not Evaluated when it has not yet been assessed against the criteria of extinction.

Figure 1. *Structure of the categories. (source: IUCN Red List)*



13.11. List of Threatened Flora and Fauna in India

ENDANGERED PLANTS IN INDIA

Plant	Also Known As	Region (Status)
Polygala irregularis	Milkwort	Gujarat (rare)
Lotus corniculatus	Bird's foot	Gujarat (rare)
Amentotaxus assamica	Assam catkin yew	Arunachal Pradesh (threatened)
Psilotum nudum	Moa, skeleton, fork fern, and whisk fern	Karnataka (rare)
Diospyros celibica	Ebony tree	Karnataka (threatened)
Actinodaphne lawsonii		Kerala (threatened)
Acacia planifrons	Umbrella tree, kudaivel (Tamil)	Tamil Nadu (rare)
Abutilon indicum	Indian mallow, thuthi (Tamil) and athibalaa (Sanskrit)	Tamil Nadu (rare)
Chlorophytum tuberosum	Musli	Tamil Nadu
Chlorophytum malabaricum	Malabar lily	Tamil Nadu (threatened)
Nymphaea tetragona		Jammu (endangered), Kashmir (threatened)
Belosynapsis vivipara	Spider wort	Madhya Pradesh (rare and endangered)
Colchicum luteum		Himachal Pradesh (rare and threatened)
Pterospermum reticulatum	Malayuram, Malavuram	Kerala (rare), Tamil Nadu (threatened)
Ceropegia odorata	Jeemikanda (Gujarat)	Gujarat, Melghat Tiger, Rajasthan, and Salsette Island, (endangered)

Endangered animals of India

CATEGORY	SPECIES NAME	ALSO KNOWN AS
	BIRDS	
	Ardea insignis	White-bellied Heron
	Ardeotis nigriceps	Great Indian Bustard
	Eurynorhynchus pygmeus	Spoon-billed Sandpiper
	Grusleuco geranus	Siberian Crane
	Gyps bengalensis	White-rumped Vulture
	Gyps indicus	Indian Vulture
	Gyps tenuirostris	Slender-billed Vulture
	Ophrysia superciliosa	Himalayan Quail
	Rhodonessa caryophyllacea	Pink-headed Duck
	Sarcogyps calvus	Red-headed Vulture
	Vanellus gregarius	Sociable Lapwing
	Rhyticeros narcondami	Narcondam Hornbill
	FISHES	
	Carcharhinus hemiodon	Pondicherry shark
	Glyphis gangeticus	Ganges shark
	Labeo potail	Deccan labeo
	Pristis zijsron	Longcomb sawfish
	REPTILES AND AMPHIBIANS	
	Batagu rkachuga	Red-crowned roofed turtle
	Dermochelys coriacea	Leatherback sea turtle
	Eretmochelys imbricata	Hawksbill sea turtle
	Gavialis gangeticus	Gharial
	Indirana gundia	Gundia Indian frog
	Indirana phrynoderma	Toad-skinned frog
	Ingerana charlesdarwini	Charles Darwin's frog
	Raorchestes munnarensis	Munnar bush frog
	Raorchestes ponmudi	Ponmudi bush frog
	Raorchestes sanctisilvaticus	Sacred Grove bush frog
	Raorchestes shillongensis	Shillong bubble-nest frog
	Rhacophorus pseudomalabaricus	Anaimalai flying frog

MAMMALS		
	Biswamoyopterus biswasi	Namdapha flying squirrel
	Canis himalayensis	Himalayan wolf
	Cervus Canadensis hanglu	Kashmir stag
	Crocidura andamanensis	Andaman shrew
	Dicerorhinus sumatrensis	Sumatran rhinoceros
	Millardia kondana	Kondana soft-furred rat
	Porcula salvania	Pygmy hog
	Viverra civettina	Malabar large-spotted civet
	Ailurus fulgens	Red panda
	Balaenoptera musculus	Blue whale
	Balaenoptera physalus	Fin whale
	Bos grunniens	Yak
	Bubalus arnee	Wild water buffalo
	Capra aegagrus	Wild goat
	Caprolagus hispidus	Hispid hare
	Elephas maximus	Asian elephant
	Eupetaurus cinereus	Woolly flying squirrel
	Lutrogale perspicillata	Smooth-coated otter
	Macaca arctoides	Stump-tailed macaque
	Macaca silenus	Lion-tailed macaque
	Martes gwatkinsii	Nilgiri marten
	Neofelis nebulosa	Clouded leopard
	Nilgiri tragus hylocrius	Nilgiritahr
	Panthera tigri stigris	Bengal tiger
	Pantholops hodgsonii	Tibetan antelope
	Platanista gangetica gangetica	Ganges River dolphin
	Pteropus faunulus	Nicobar flying fox
	Rattus palmarum	Palm rat
	Rucervus duvaucelii	Barasingha
	Tetracerus quadricornis	Four-horned antelope
	Trachypithecus johnii	Nilgirilangur
	Uncia uncia	Snow leopard
	Ursus thibetanus	Asian black bear

References

Adapted from E-PGPathshala

- Paper No: 03 Hot spots of biodiversity Module: 15
- Paper No: 03 Causes of species extinction: Module: 20
- Paper No. 03 International Union for conservation of Nature (IUCN) categories of threatened species: Module: 28
- Paper No. 03 RED DATA BOOK; LIST OF THREATENED FLORA AND FAUNA: Module: 39
- IUCN (2013) IUCN Red List of Threatened Species. IUCN Species Survival Commission, Gland, Switzerland (http://www.iucnredlist.org/about/summary-statistics).
- Textbook of Environmental Studies for Undergraduate Courses By Erach Bharucha
- Chitale VS, Behera MD, Roy PS. 2015. Global biodiversity hotspots in India: significant yet under studied. Curr Sci. 108: 149–150.
- Myers N, Mittermeier RA, Mittermeier CG, Da Fonseca GA, Kent J. 2000. Biodiversity hotspots for conservation priorities. Nature. 403: 853-858.
- http://www.iucnredlist.org
- https://competitiondigest.com/endangered-species-of-plants-and-animals-of-india-edit
- https://owlcation.com/stem/Rare-and-Endangered-plants-of-India
- http://www.nationalredlist.org/red-listed-plants-of-india-2015
- Red List of threatened species – as an indicator of biodiversity trend
- http://www.iucnredlist.org/about/overview
- https://www.britannica.com/topic/IUCN-Red-List-of-Threatened-Species
- http://byjus.com/free-ias-prep/iucn-red-list-india-2016-upsc-ias-exam
- http://www.iucnworldconservationcongress.org/.
- https://en.wikipedia.org/wiki/Biodiversity_hotspot
- http://www.biologydiscussion.com/biodiversity/hotspots-of-biodiversity-in- india/7142
- http://thewesternghats.indiabiodiversity.org/biodiversity_in_india
- https://iasmania.com/biodiversity-and-biodiversity-hotspots/
- http://www.biodiversityofindia.org/index.php?title=Biodiversity_hotspots_in_India
- http://www.bsienvis.nic.in/Database/Biodiversity-Hotspots-in-India_20500.aspx
- http://www.currentscience.ac.in/Volumes/108/02/0149.pdf
- http://iasgs.com/resources/env/hotspots2.pdf
- https://www.pmfias.com/biodiversity-hot-spots-india-world/

Unit 14: Biodiversity Conservation

Unit Structure

14.0 Learning Objectives

In this unit you will be able to understand the following Biodiversity Conservation Methods:

- In-situ conservation
- Ex-situ conservation
- In-vitro techniques of conservation
- International Framework For Biodiversity Conservation
- National Framework For Biodiversity Conservation
- Role of Indigenous traditional knowledge for the conservation of biodiversity

14.1. Introduction

The 1992 United Nations Conference on Environment and Development, held in Rio de Janeiro, brought the topic of biodiversity conservation into the living rooms of the world and helped place this critical issue on the agendas of world leaders. While the ranks of those concerned with biodiversity seem to have diversified and increased, a basic understanding of what it is, what it means to mankind, and how it can be protected is still lacking.

In an effort to solve these problems, the World Conservation Union has attempted to clarify the definition and show the value of "biodiversity." Going beyond "genetic makeup," the IUCN interprets biodiversity to encompass all species of plants, animals, and microorganisms and the ecosystems (including ecosystem processes) to which they belong. Usually considered at three different levels--genetic diversity, species diversity, and ecosystem diversity--it is the complicated mosaic of living organisms that interact with abiotic substances and gradients to sustain life at all hierarchical levels (McNeely, 1990). Furthermore, each of these levels extends enormous, often immeasurable, economic and social benefits to mankind. Although it is recognized that a very high percentage of the total biodiversity exists in a small number of tropical countries, significant diversity also occurs in temperate zones and in aquatic ecosystems as well.

Biodiversity conservation is accomplished in a number of ways. *Ex-situ* methods focus on species conservation in botanic gardens, zoos, gene banks, and captive breeding programs. *In-situ* methods use conservation areas as "warehouses" of biological information. Many scientists and conservationists feel that until methods are available to discern easily which of the millions of species and varieties will have economic value, *in-situ* conservation through the protection of natural areas should be the primary means for the maintenance of these resources. However, a rigid preservation approach is virtually impossible to implement and even less likely to be maintained over time. Considering trends in population growth and the urgency of economic development--especially in the developing countries--a more appropriate response would be to pursue proactive alternatives to high-impact development activities, and to implement carefully formulated strategies for *in-situ* methods that would include protected areas in the development mix.

Unfortunately, the formulation of that development mix is not easy, because moral, as well as technical and economic, choices are involved. According to Wilson (1984):

To choose what is best for the near future is easy. To choose what is best for the distant future is easy. To choose what is best for both the near and distant futures is a hard task, often internally contradictory, and requiring ethical codes yet to be formulated.

Although integrated regional development planning makes no claim to moral superiority, it does provide a framework for making such very difficult choices. That biodiversity conservation must be a part of development planning efforts is clear.

14.1.1. Strategies for Biodiversity Conservation

Biological diversity is the key foundation of a healthy, livable and sustainable planet but the increasing exploitation coupled with natural calamities has led to the rapid dwindling of important species. Large numbers of organisms are facing loss or extinction due to natural and anthropogenic reasons. It is estimated that 60,000 to 1,00,000 species with diverse economic uses are under threat of extinction and needs to be protected. This necessitates urgent measures to conserve the biodiversity at ecosystem, species and gene pool levels, and to enable sustained use for present and future generations. Conservation refers to the protection, preservation, management and restoration of the landscapes, ecosystems and species.

An organism can be conserved in a natural/ artificial habitat or in the form of a germplasm (bacterial cultures, animal tissues, seeds *etc.*) by employing various methods. A number of efforts have been put forward by various governmental and non-governmental organizations aiming for the conservation of biodiversity. It includes certain *in-situ* and *ex-situ* approaches. Emergence of *in-vitro* technology as an adjunct to *ex-situ* conservation is being viewed with great expectations for conservation of threatened species. The need of hour is to amalgamate the traditional as well as emerging technologies towards conservation of biodiversity and genetic resources for sustainable development.

The first and foremost step required in the direction of biodiversity conservation is about gathering knowledge on the existing biodiversity. It has been stated that the earth inhabits millions of plants and animal species, only a few of which have been identified so far. The taxonomists are required to identify and quantify more and more species so that closer estimates could be build up while measuring the biodiversity loss. Thereafter, appropriate plansand policies should be designed, depending on the habitats, species and conservation priorities.The last step requires the strong implementation of these conservation strategies by enforcing the laws in order to achieve the objective. Also, promoting awareness among the general public about the ongoing overexploitation and its future implications are required. It is also important for all the developed and developing countries to work in coordination, share as muchinformation as they have about the biodiversity in their region and help each other for the realization of this goal.

14.2. Biodiversity Conservation Methods

14.2.1. In-situ conservation

In-situ or "on-site" conservation is the protection of organism in its natural habitat where evolutionary progression continues. The *in-situ* approach includes protection of a group of typical ecosystems or the regions with high biodiversity through a network of protected areas. These are the terrestrial or marine areas, exclusively meant to protect biological diversity and its allied resources. This is the most appropriate method as the species are being conserved in their natural habitats. It includes National Parks, Wildlife Sanctuaries, Sacred groves, and Biosphere Reserves.

i) National Parks

National Parks are protected areas under government, secluded from any kind of human interference. These are the small reserves meant for the protection of wild life and their natural habitats. Activities like grazing, forestry *etc.* are not permitted in these areas.

Some Major National Parks in India

1. Gir National Park, Gujrat
2. Jim Corbett National Park, Uttrakhand
3. Kaziranga National Park, Assam
4. Bandipur National park, Karnataka
5. Tudula national Park, Maharashtra
6. Kanha National Park, Madhya Pradesh
7. Manas National Park, Assam
8. Reibul Lamjao National Park, Manipur

ii) Wildlife Sanctuaries

The Wildlife Sanctuaries are bounded to conserve the wild flora and fauna. Similar to National Parks, these are also government owned areas, but limited human activities such as harvesting of timbers, collection of forest products, cultivation of lands *etc.* are allowed in wildlife sanctuaries as long as these do not interfere with the wild environment.

Some Wildlife Sanctuaries in India

1. Bandipur Wildlife Sanctuary, Karnataka
2. Bhitarkanika Wildlife Sanctuary, Orissa
3. Gibbbon Wildlife Sanctuary, Assam
4. Dachigam Wildlife Sanctuary, Jammu and Kashmir
5. Sunderbans Wildlife Sanctuary, West Bengal
6. Keoladeo Bird sanctuary, Rajasthan (Now converted to National Park)
7. Periyar Wildlife Samctuary, Kerela
8. Mundanthurai Wildlife Sanctuary, Tamil Nadu

iii) Sacred Groves

Sacred groves are the forest fragments of varying sizes, which are communally protected and usually have a significant religious importance. Economic activities like hunting, timber production *etc.* are strictly prohibited in these areas. Sacred groves do not enjoy protection *via* federal legislation in India but are protected by locals and associated NGO's. For example Scrub Forest in Thar Desert of Rajasthan maintained by Bishnois community and Sacred HinduGrove near Chandod on the banks of Nerbudda worshiped by local communities. Largest sacred grove in India is Hariyali, near Ganchar in Chamoli district in Uttrakhand. According to an estimate there are nearly 14000 to 1, 00,000 sacred groves all over India.

Figure 1. Sacred Groove

iv) Biosphere Reserves

Biosphere Reserves, on the other hand are a special category of protected areas of land, wherepeople are an integral component of the system. A biosphere reserve consists of a core, bufferand transition zones. The natural or core zone represents an undisturbed or least disturbed area

of representative ecosystem. The buffer zone surrounds the core zone, and is managed for research, education and training activities. The transition zone is an area of active cooperationbetween reserve management and the local people. Its goal is to facilitate the conservation of biodiversity, foster sustainable economic and human development and to provide support for research, monitoring, education and information. Nine of the 18 Biosphere Reserves in India are included in UNESCO Man and the Biosphere Program list.

List of Biosphere Reserves in India

1. Nilgiri, Western Ghats (1986)
2. Nandadevi, Uttrakhand (1988)
3. Nokrek, Meghalaya (1988)
4. Gulf of Mannar, Tamil Nadu (1989)
5. Sunderbans, West Bengal (1989)

6. Manas, Assam (1989)
7. Great Nicobar, Andaman and Nikobar Islands (1989)
8. Simlipal, Odisha (1994)
9. Dibru-Saikhowa, Assam (1997)
10. Dehang-Dibang, Arunachal Pradesh (1998)
11. Panchmarhi, Madhya Pradesh (1999)
12. Khangchendzonga, Sikkim (2000)
13. Agasthyamalai, Western Ghats (2001)
14. Achanakamar-Amarkantak, Madhya Pradesh (2005)
15. Kuchchh, Gujrat (2008)
16. Cold desert, Himachal Pradesh (2009)
17. Seshachalam, Andhra Pradesh (2010)
18. Panna, Madhya Pradesh (2011)

Protected area network in India

Protected area	Status
National parks	103
Wildlife sanctuaries	543
Biosphere reserves	18
Community reserves	45
Conservation reserves	73

Total protected area: 1, 62,024.69 km² (4.93% of total geographical area)(Source: www.wiienvis.nic.in [July, 2017])

14.2.2. Ex- situ Conservation

Ex-situ or “off site” conservation refers to the protection of elements of biodiversity outside their natural habitats. In this case, there is a cessation of evolutionary progression, but the desired genes would be preserved. This conservation strategy plays an important role in recovering the endangered species. It is particularly useful in the field of agriculture as the domesticated plants which cannot survive in nature unaided, can be preserved using various *ex-situ* techniques.It includes

1. **Zoological gardens** where the animals are confined in enclosures, displayed to public for educational and recreational motives and may even bred for conservation purposes.
2. **Botanical gardens** has a collection of wide range of plants grown outside natural habitat in some artificially provided conditions and are meant for conservation, research and education.
3. **Arboreta** are the botanical gardens specialized in trees.
4. **Nurseries** are a place where plants are propagated to a usable size, usually up to the seedling stage, generally meant for ornamental purposes.
5. **Field gene banks** are useful for conserving plant genotypes (generally vegetative propagated) as live plants that undergo continuous growth and require continuous maintenance. These provide an easy access to plant genetic resources but are expensiveto maintain, require more labor, inputs and space and have higher levels of risk from natural disasters and attacks from pests and pathogens. 42,000 varieties of rice are conserved in Central Rice Research Institute in Orissa.
6. **Captive breeding** of animals with possible reintroduction into the wild.
7. Artificial propagation of plants
8. ***In-vitro* techniques** include the laboratory practices used for the conservation of plant/ animal and microbial diversity through its storage in germplasm banks, propagation *via* tissue culture methods, preservation using the technique of cryopreservation, conversion into artificial seeds, maintenance as slow growth cultures, and long term perpetuation as DNA clones.

14.2.3. In-vitro techniques

i) Germplasm banks

Germ plasm banks or bio-banks provide controlled storage facilities of temperature, humidity *etc.* for the material to be conserved. These are variously called as seed banks, gene banks, DNA banks *etc.* depending on the material that is conserved in them. They are generally usedfor the storage of seeds, sperm and ova. The germ plasm banks save large variety of plants & animals in a very small space and at the same time ensure the authenticity of scientific identity of the conserved material. It also insures the responsible use of the material, equitable benefit sharing by all parties, and international networking with other *in-vitro* banks, thereby facilitating the exchange of knowledge/ material.

Material conserved in germplasm banks are of 3 types:

- Base collection: Samples which is kept for long term and is not to be used as a routinedistribution source.
- Active collection: Samples maintained for medium term viability (about 30 years)which are available when required.
- Working collection: Samples which are easily accessible to be used by breeders orresearchers for various experiments and crop improvement programmes.

ii) Seed banks

In case of plant species, seeds are a convenient means of long term storage of genetic diversity, as the samples are small in size, easy to handle, require low maintenance and frequently remainviable for long periods. In seed banks, material in the form of seeds are stored at nearly -10 to -20°C, often using silica gel in the seed containers to reduce humidity. In general, conditions of low temperature and desiccation allow seeds to maintain viability, in many cases indefinitely. Further, the method provides ease of storage, economy of space, low labor demands, maintenance of large samples and cost related advantages. Thus, storage of materialin the form of seeds is one of the most widespread and valuable *ex-situ* approaches to conservation.

However, they are found to be ineffective for recalcitrant seeds (seeds which get killed or become unviable over a period of time when exposed to drying and freezing conditions), plantswhich reproduce by vegetative means and materials modified by genetic engineering which aregenerally unstable.

Famous Seed Bank projects

Millennium Seed Bank Project, associated with royal botanical garden, Kew. In October, 2009 it has reached its 10% goal of banking the entire world's wild plant species. Its 47 plant organizations in 17 countries intend to store 25% of world's plant species by 2020.

10 international agricultural research institutions, coordinated by Consultative Group on International Agricultural Research (CGIAR), Washington, focused on crops and have extensive seed collection.

Svalbard Global Seed Vault opened on February 26, 2008 near Norway, 600 miles from North Pole. It is designed to hold 4.5 billion batches of seeds of world's main crops. On March, 2013the number of samples has increased to 7, 70,000.

National Bureau of Plant Genetic Resources (NBPGR), New Delhi, India has over 3.43 lakh samples of 2.47 lakh varieties of various species which include around 28,000 accessions of wild relatives of various crops.

iii) Tissue culture

Tissue culture is an *in-vitro* technique, based on the concept of "totipotency" of plant cells. Cellular totipotency is the capability of a cell to give rise to a whole new plant. Mature cells undergo dedifferentiation to become meristematic and then undergo redifferentiation to form a whole new organism. Tissue culture methods are increasingly being employed for storing valuable threatened species. This is because it offers the unique opportunities of storing severalvaluable species in a comparatively small space under secure and pathogen free environment, with relative ease of multiplication. Germplasm available in the form of microbial cultures, cells or organs in case of animal species and seeds, cuttings or vegetative propagules in case ofplants is used for micropropagation.

However, this proves to be uneconomical in terms of labor and physical resources and time consuming as well. Also, it may have constraints such as somaclonal variations or loss of morphogenetic potential in some cases.

Plants conserved by tissue culture

Mature trees of *Ulmus americana*, which survived the epidemics of Dutch elm disease and arepotential sources of disease resistance, are conserved using mature leaf as an explant by tissueculture techniques (Shukla *et al.*, 2012).

Leptadenia reticulata (Jeewanti), a medicinally important endangered woody climber, is preserved using leaf as explant (Patel *et al.* Jan, 2014a).

Caralluma edulis, an endangered and endemic edible plant species of the Thar Desert, is tissuecultured using nodal segments as explant (Patel *et al.,* 2014b).

Orchis lanata, native to South Europe and endangered in Kashmir and Kumaon regions ofIndia is conserved by callus formation (Shreshta and Joshi, 1992).

Gentiana kurroo, a medicinally important plant, endemic to Kashmir and Himalayas is culturedusing axillary shoots in order to conserve it *in-vitro* (Sharma *et al.,* 1993).

iv) Cryopreservation

Cryopreservation or freeze preservation is a technique of preservation of germplasm at ultra low temperature of -196°C *i.e.* the temperature of liquid nitrogen. The principle underlying cryopreservation involves bringing the culture to a state of non-dividing and zero metabolism, so that any biological activity, is effectively stopped. Cryopreservation also helps in storing tissues of animal origin such as cultured animal cells, spermatozoa, ovarian or embryonic tissues and whole embryos for livestock breeding programmes. Freeze preservation of microbes, algae, insects and other organisms can also be done which can possibly be used in future for biotechnological researches.

v) Artificial seeds

Somatic embryos are cultured in vitro through embryogenesis and can be preserved as artificialor synthetic seeds by coating with gels like sodium alginate, calcium alginate, and polyacralamide gel *etc.* which prevent them from desiccating. These somatic embryos are thendehydrated to a suitable level and subjected to slow growth or cryopreservation in a manner similar to zygotic seeds. Production of sodium alginate beads by encapsulation of shoot tips and nodal segments of medicinally important plant *Mentha arvensis* helps in its *in-vitro* regeneration and conservation (Islam and Bari, 2014).

vi) DNA clones

DNA, the basic unit of heredity of a cell, can effectively be used for conservation of threatenedplant species. Germplasm can be stored in the form of DNA segments cloned into a suitable vector such as cosmids, plasmids and bacteriophage. With the recent progress in the field of molecular biology such as polymerase chain reaction (PCR), combined with gene cloning, small amounts of tissues can provide substantial collections of all the DNA of a plant genome.

This is particularly useful in the case of threatened species where the material is available in limited numbers. Additionally, DNA can be isolated from dead tissues (herbarium specimens), providing information that would be otherwise lost if living tissues are dead. However, this option can only be considered for those species where no other strategy is workable as the technique is highly sophisticated, technically demanding and expensive.

Currently extracted or preserved DNA cannot be used to regenerate whole organism, but any chosen gene can be isolated for use in genetic engineering. Its preservation can be used for conservation of valuable genes or DNA segments from threatened species.

14.3. International Framework for Biodiversity Conservation

a) The World Heritage Convention

Since its beginning in 1972, this convention has been responsible for the preservation of cultural properties with 190 parties under it. It enhances public knowledge, awareness and appreciation for the heritage sites.

b) The International Union for Conservation of Nature and Natural Resources (IUCN) (now called as World Conservation Union (WCU)

It was founded in 1948 in order to bring governmental/ non-governmental agencies around the world together to conserve biodiversity and natural resources and promote their sustainable useat local, national and international levels. 81 countries all over the world are its members and the headquarters of the organization are located in Gland, Switzerland.

c) The Convention on International Trade in Endangered Species (CITES)

The Convention was signed in Washington DC in March, 1973, basically to put ban on the overexploitation and international trade of wild fauna and flora. Currently 178 parties are thereunder CITES and nearly 30,000 species are protected by this convention

d) Convention on Biological Diversity (CBD)

The convention came into force on 29 December, 1993 with objective of conserving the biodiversity, sustainable use of biodiversity and fair and equitable share of benefits arising bythe use of natural resources. 193 countries have adopted this convention including India

e) International Treaty for Plant Genetic Resources for Food and Agriculture (ITPGRFA)

International Treaty for Plant Genetic Resources, popularly known as International Seed Treaty is a comprehensive international agreement in harmony with the Convention on Biological Diversity, which aims at guaranteeing food security through the conservation, exchange and sustainable use of the world's plant genetic resources for food and agriculture, as well as the fair and equitable benefit sharing arising from its use.

f) Ramsar Convention on wetlands of International Importance

It is an international collaboration of 168 parties covering 21431 wetlands of international importance. It was initiated in 1971 for the conservation of wetlands, mangrove and coral reefs.

g) The Convention on Migratory Species (CMS)

Also known as Bonn Convention, it is an international treaty aiming to conserve terrestrial, aquatic and avian migratory species.

14.4. National Framework for Biodiversity Conservation

State and Union government of India has developed a number of Wildlife Acts for the enforcement of conservation strategies

1. Madras Wild Elephant Preservation Act, 1873
2. All India Elephant Preservation Act, 1879
3. The Wild Birds and Animals Protection act, 1912
4. Bengal Rhinoceros Preservation Act, 1932
5. Assam Rhinoceros Preservation Act, 1954
6. Wildlife (Protection) Act, 1972 (amended in 1983, 1986 and 1991)

7. Forest Conservation Act, 1980 (amended in1988)
8. The Environment (Protection) Act, 1986
9. The Biodiversity Act, 2002 (implemented in 2004)
10. The National Environmental Policy, 2006

Apart from that, Individual projects for the conservation of endangered species. For example Project Tiger was launched in 1973 and tiger reserves were formed to promote their conservation. Similar projects on crocodiles (1954), lion (1952) and elephants (1991-1992) have also been undertaken.

The Indian Board of Wildlife (IBWL) is the main advisory body of Govt. of India, constituted in 1952 (reconstituted in 1991 under the chairmanship of Prime Minister) and it ensures the conservation of species diversity in the country, establishment of protected areas, sustainable use of ecological services, and control of unethical activities that could harm the biodiversity.

Other non-governmental organizations such as World Wide Fund for Nature, Wildlife Preservation Society of India, Dehradun and Bombay Natural History Society *etc.* also help inmanagement and conservation of natural flora and fauna.

14.5. Role of ICT for Biodiversity Conservation

INFORMATION AND COMMUNICATIONS TECHNOLOGY (ICT)

There are various ecosystems on the Earth such as forests, marshes, rivers and oceans. An enormous number of creatures living on the Earth including hu- mans is supported by these ecosystems. Thinking only of the known ones, there are about 1.75 million species of creatures in the world. Including those that are yet to be found, it is estimated that there are more than 30 million species. However according to the Red List reported by the International Union for Conservation of Nature and Natural Resources (IUCN) in 2012, about 20% of the vertebrates and about 60% of the plants, in total about 30% of all organisms are in danger of going extinct.

To arrest this loss of biodiversity, Aichi Biodiversity Targets adopted in the tenth meeting of the Conference of the Parties (COP10) of the Convention on Biological Diversity, held in 2010 in Nagoya, act as a series of strategic initiatives including: Mainstreaming biodiversity across government and society; promoting sustainable use; and enhancing implementation through participatory planning, knowledge management and capacity building.

14.5.1. Possibility of biodiversity preservation using ICT

By using ICT, it is possible to collect, analyze and evaluate a large amount of information efficiently, and it is also possible to optimize human behaviors, working processes and social systems by making positive use of the data obtained from the aforementioned information. In recent years, these data have come to be used in a wide range of applications to make our life more rational by carrying out composite analysis of diverse information as big data based on the combined knowledge of people, with the aim of creating new values. Also in the field of biodiversity, efficient collection and appropriate use of the complex and diverse information may contribute to the avoidance and decrease of biodiversity loss, promotion of sustainable use and maintenance/extension of biodiversity (Figure 2).

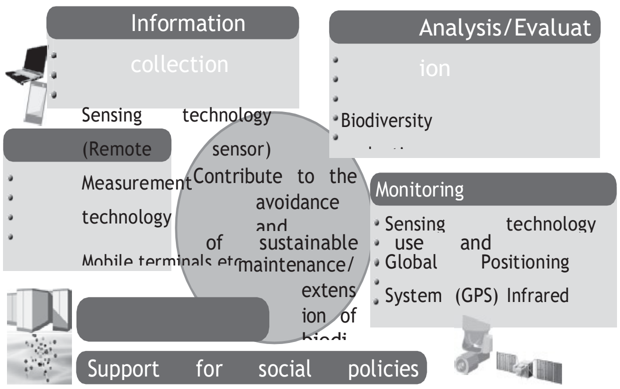


Figure 2. Biodiversity preservation using ICT

14.5.1.1. Key areas where ICT can help in bio-diversity conservation

The key areas where IT can help in bio diversity conservation are:

- ***Knowledge:*** Provide basic knowledge and under-standing of the environment, the biodiversity and their interrelationship with humans. Remote sensing of organisms, temperature and humidity; identification of species by image analysis of organisms, collection of organism information and environment information by using mobile terminals

- ***Awareness :*** Promote awareness and a sensibility in individual and communities about the environment, the biodiversity and its importance.

- ***Attitude:*** Encourage individuals and communitiesto value the environment and consider it important in order to inspire participation in the process of improving and protecting the environment for the betterment of their own livelihoods.
- ***Skills:*** Provide people with skills to identify, predict, prevent and solve environmental problems and to make them capable of utilizing limited resources in a sustainable way and of coping with unexpected vulnerabilities.
- ***Participation:*** Provide individuals and communities with the opportunities to actively participate in solving environmental problems and to make educated decisions about biodiversity conservation
- **Analysis/evaluation:** Evaluation of impacts on organisms, ecosystems and habitats.
- **Information management:** Organism information (species, population, habitats etc.), database for genetic information etc.
- **Monitoring:** Monitoring and observation of environment changes and organism behaviors Education, propagation and enlightenment Propagation of information and enlightenment of entire society through network communication technologies and image distribution technologies.

Further, it is possible to contribute to biodiversity preservation by supporting economic activities, environmental considerations and productivity enhancement in the primary industries (agriculture, fishery, forestry, etc.), which directly involve the supply services that constitute the ecosystem services1) (various benefits generated by biodiversity).

Some ways ICT can help spread the word:

1. **Access to variety of learning resources**

IT may help in the conservation of biodiversity by making the sophisticated databases on biodiversity available to each and everyone who have access to the internet. These resources can be accessed by all from students to professionals to grass root level organizations/NGOs working on Biodiversity conservation to high level policy makers. There is no dearth of resources on the internet to study biodiversity, be it Ecosystem, Genetic or species, which can help us understand the value of biodiversity in our eco system, our dependence on it and thereby create awareness in terms of its conservation.

2. Teaching and Training

Schools, NGOs, and others are now using the Internet to expand their distance learning programs. Some offer formal courses with mandatory assignments that offer academic credits; others are less formal. Teachers and administrators may use computers and IT to improve their roles in education process. e.g. Convenient sharing of expertise, increasing professional development activities by taking distance education courses, accessing education research and classroom materials such as lesson plans, provide in- house training for their staff etc.

Hence, Biodiversity conservation education and communication aims to bring about changes in the attitude and behavior of youth, concerned people, societies and leaders through various awareness programs, so that they become catalysts in efforts to raise voices supporting conservation.

Conservation and the sustainable use of resources begin at home. Thus, knowing about conservation and sustainable use of resources is important for everyone as it increases the level of awareness on conservation and access to livelihood resources and its sustainable use.

Informational Technology through its various ways of communication may induce a subset of relevant population to desist from natural resource exploitation. Children may become much environment conscious and proactive, identify and choose better livelihood opportunities as they grow up, while making their environment a better place to live. Trustme if that happens it’s a big achievement!

After this I assume all those enlightened people may have both good information and an experiential base, and some existing awareness, on which to build additional public awareness activities and to do their bit for our ecosystem. As they say small efforts make big difference!

3. **Mobile photo system/cloud services**

For preservation of biodiversity and its sustainable use, it is critical to run a PDCA (plan-do-check-act) cycle. At first, it is necessary to understand accurately how many wild animals and plants live and grow in which location inside the targeted area ("check"). Then, it is essential to carry out analysis and evaluation based on this study and monitoring data and to under- stand the current status and the time-related changes ("act"). Thereafter, based on the analysis/evaluation results, it is requested to develop preservation and utilization plans to stipulate how the targeted area should be preserved and used, and who takes what action in which timeframe ("plan"). Following this stage, actions should be taken for preservation activities and sustain- able use based on these preservation and utilization plans ("do"). Finally, the results are used as feedback for the next implementation plan. The mobile photo system2) is a tool that can be used in a series of phases (research/monitoring [check] and analysis/evaluation [act]) for biodiversity preservation and utilization.

14.6. Role of ITK for Biodiversity Conservation

14.6.1. Indigenous Traditional Knowledge (ITK)

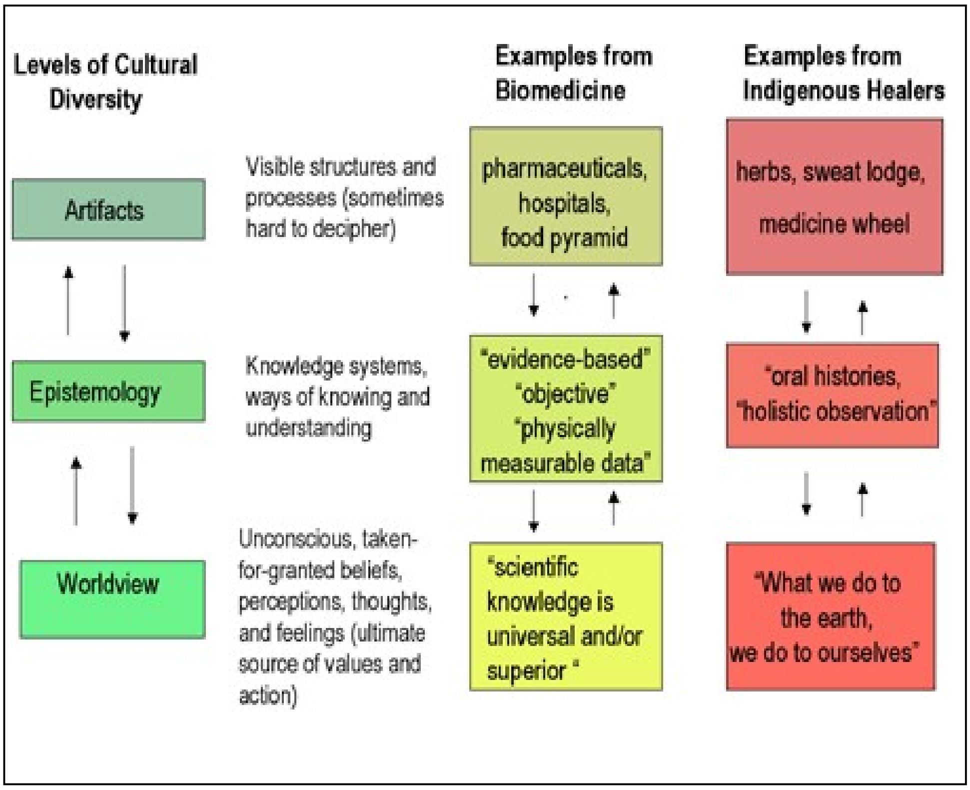
Indigenous knowledge is traditional knowledge, which is existing in our local communities and societies from the time immemorial (Sharma, Bajracharya & Sitaula, 2009). Knowledge which is used by the people (we call them first settlers) who were living there for long time back and very close to nature (river, land and forest). On the other view, their lives depend upon proximity of nature and have very unique system of life i.e. self created or without burrowing from others can be said as Indigenous Knowledge. Indigenous knowledge is the local knowledge which is exclusive to a given cultures or societies. In other words, local knowledge held by indigenous people, or local knowledge unique to a given culture or society (Berkes 1999, as cited in ICIMOD, 2007). It is different from the knowledge generated by national and international research institute. It is the basis for local-level decision making in agricultures, health care, food preparations, education, natural-resource managements, and a host of other activities in rural communities (Warren 1991). Warren tried to highlight that indigenous people decide on their own how to use the resources that is derived from the nature for their survival without the help from others. Indigenous knowledge is the information that people in a given communities, based on experiences and adaptation to local cultures and environments have developed over time, and continued to improvise and develop (Shrestha, Shrestha, Rai, Sadha & Shrestha, 2008). Thus we can say indigenous knowledge has its base on unique sense of life or unique systems of articulation of the culture which is not burrowed from others.

14.6.2. Importance of Indigenous knowledge

Indigenous knowledge has been used by the local rural people in various sectors of their life. From maintaining the soil fertility in the agricultural fields by using mulching method to use of water for grinding and milling food grains through watermills or using ash in agriculture to get rid of pest to selective burning method in forest to foster nutrition are many methods used by the indigenous people for their survival. IK are farmer"s friendly, economic and environmental friendly, socially accepted and suited to specific local and environmental conditions (Sharma, Bajracharya & Sitaula, 2009). It includes practices and technologies, such as seed treatments, storage methods and tools used for planting and harvesting (Shrestha et. al, 2008). Though there may have been different weakness with the IK system but rural people developed skills to fight in the very harsh conditions brought about by the nature. At present, we are crying to mitigate and minimize the effect brought by the climate change in agriculture and different other sectors, thus those knowledge used by the indigenous people in the past to cope with extreme climatic events can be important knowledge base to use for minimizing the devastating effect brought by climate change and many other environmental problems. Highlighting the importance of Indigenous Knowledge, Limbu (2008) says, "Limbu people one of the indigenous tribe of Nepal and were found to carry out subsistence farming (based on integration of livestock and agriculture activities) in a very sustainable manner (conservation tillage, mini dike construction, crop rotation, relay cropping, farmyard- and green manuring, and integrated pest management". Furthermore "Limbu people of the study sites cope with natural calamities (landslides and flashflood, fire, etc.) by traditional methods; they also use prophylactic measures utilizing local resources and indigenous ideas. They do not know much about the link between environment and biodiversity but are contributing their bit to it in their own ways (e.g., by establishing „devithan‟, and „raniban‟ to protect segments of forests) (Limbu, 2008, p.1).

14.6.3. Linkages of Biodiversity with Indigenous Knowledge

Indigenous people are living in close proximity with the nature and always dependent upon the natural resources and biodiversities. Biodiversity and IK have mutual relationship with each other. IK helps in the conservation of biodiversity and biodiversity in turn is helping the survival of Indigenous people living nearby these biological resources. Thus they can always in line with the conservation of those resources for their survival. If they are conserved they can utilize it, if not they will be in problem and may affect their livelihood. Indigenous people and their socio-cultural relationships with biological systems have largely been contributing to sustainable conservation of biodiversity, especially in in-situ conservation (conservation of the resources in their natural state or natural habitat) (Shrestha et.al, 2008). Indigenous people can be used to describe any ethnic group who have historically belonged to a particular region or country, and may have different—cultural, linguistic, traditional, and other characteristics to those of the dominant culture of that region. The Indigenous people interact with the available natural resources and maintain them in pristine condition (ibid.). People who have unique culture within the society have to depend upon the resources brought from the nature hence they do not only think for themselves but also conserve the natural habitats and individual species for their future generations. Indigenous Limbu people have been using hundreds of plants for the treatment of diseases (Subba, 2006, as cited in Limbu, 2008), ranging anything from diarrhea, constipation, to fracture. Socio-cultural practices in a particular area can help for protect local biodiversities; a good example is the local religious belief in Dolpa of not allowing the killing of leopards, which is the sole contributor for the protection of snow leopards in the region (ibid.). This strongly shows that, indigenous people are always thriving to achieve sustainable development i.e. indigenous and place-based knowledge always works for sustainable development (Irwin 1995, as cited in, Semali, Grim & Maretzki, 2006).



Source: http://www.joe.org/joe/2005december/images/a1-fig1.gif

The above chart shows how the indigenous knowledge system supports the biomedicines and hospitals through the creation of different important medicines and that knowledge are transferring through oral history and observation.

14.6.4. Traditional Knowledge on Biodiversity Conservation

In order to be effective, efforts on biodiversity conservation can learn from the context-specific local knowledge and institutional mechanisms such as cooperation and collective action; intergenerational transmission of knowledge, skills and strategies; concern for well-being of future generations; reliance on local resources; restraint in resource exploitation; an attitude of gratitude and respect for nature; management, conservation and sustainable use of biodiversity outside formal protected areas; and, transfer of useful species among the households, villages and larger landscape. These are some of the useful attribute of local knowledge systems (Pandey, 2002a). Traditional knowledge on biodiversity conservation in India is as diverse as 2753 communities (Joshi *et al.* 1993) and their geographical distribution, farming strategies, food habits, subsistence strategies, and cultural traditions.

14.6.4.1. Local Vegetation Management

Over thousands of years local people have developed a variety of vegetation management practices that continue to exist in tropical Asia (Pandey, 1998), South America (Atran *et al.*, 1999; Gomez-Pompa and Kaus, 1999), Africa (Getz *et al.*, 1999; Infield, 2001), and other parts of the world (Brosius, 1997; Berkes, 1999). People also follow ethics that often help them regulate interactions with their natural environment (Callicott, 2001). Such systems are often integrated with traditional rainwater harvesting that promotes landscape heterogeneity through augmented growth of trees and other vegetation, which in turn support a variety of fauna (Pandey, 2002a).

In India these systems can be classified in several ways:

- Religious traditions: temple forests, monastery forests, sanctified and deified trees
- Traditional tribal traditions: sacred forests, sacred groves and sacred trees
- Royal traditions: royal hunting preserves, elephant forests, royal gardens etc.
- Livelihood traditions: forests and groves serving as cultural and social space and source of livelihood products and services

The traditions are also reflected in a variety of practices regarding the use and management of trees, forests and water. These include:

- Collection and management of wood and non-wood forest products
- Traditional ethics, norms and practices for restraint use of forests, water and other natural resources
- Traditional practices on protection, production and regeneration of forests.
- Cultivation of useful trees in cultural landscapes and agroforestry systems
- Creation and maintenance of traditional water harvesting systems such as tanks along with plantation of the tree groves in the proximity

These systems support biodiversity, which is although less than natural ecosystems but it helps reduce the harvest pressure. For instance, there are 15 types of resource management practices that result in biodiversity conservation and contribute to landscape heterogeneity in arid ecosystems of Rajasthan. Environmental ethics of Bisnoi community suggest compassion to wildlife, and forbid felling of *Prosopis cineraria* trees found in the region. Bisnoi teachings proclaim: "If one has to lose head (life) for saving a tree, know that the bargain is inexpensive" (Pandey, 2002a).

In India, local practices of vegetation management perhaps emanate from the basic ecological concepts of local communities reflected in "ecosystem-like concepts in traditional societies" (Berkes *et al.* 1998). Two key characteristics of these systems are that the unit of nature is often defined in terms of a geographical boundary; and abiotic components, plants, animals, and humans within this unit are considered to be interlinked. Many local knowledge systems are similar in temperament to the emerging scientific view of ecosystems as unpredictable and uncontrollable, and of ecosystem processes as nonlinear, multiequilibrium, and full of surprises (Berkes *et al.* 1998).

14.6.4.2. 1Biodiversity in Sacred Cliffs

Cliffs are completely forgotten cultural landscape elements that support a variety of species of plants and animals in India. As humans have special fascinations to such areas often cliffs across the country are considered sacred. Cliffs elsewhere have been found to support undisturbed ancient woodland, dominated by tiny, slow-growing and widely spaced trees. Vertical cliffs often support populations of widely spaced trees that are exceptionally old, deformed and slow growing. Some of the most ancient and least-disturbed wooded habitats on Earth are found on cliffs, even if such sites are close to intensive agricultural and industrial development. The age of the trees on cliffs may indicate the age and growth rates of the entire plant communities on the cliffs. Cliffs across the world may support ancient, slow-growing, open woodland communities that have escaped major human disturbance, even when they are situated close to agricultural and industrial activity, which has destroyed or altered most other natural habitats (Larson *et al.*, 1999, 2000a & b; Peterken, 1996). Examples of such habitat in India abound. Cliffs in Udaipur and Kota districts of Rajasthan were surveyed (7 cliff with ancient vegetation). Cliffs were found to have more than 25 species of trees, several species of shrubs and herbs. Areas close to Bhopal have more than 50 cliffs in central India in a radius of about 100 kms. All the 7 cliffs surveyed in Rajasthan are sacred. They are often part of the sacred corridors along the riverbank escarpment with several meters of precipitous fall. Attempts have been made to regenerate the Gaipernath Cliff with the traditional species occurring in the area (*Lannea coromandelica*, *Boswellia serrata*, *Sterculia urens* etc. about 25 species). The result was very poor initially. But local ethnoforestry techniques of tucking the branch cuttings of coppicing species in whatever little crevices area may have were successful. Also, depositing the seeds (same species that occur) in crevices with the ball of moist earth has been found promising.

14.6.4.3. Farm Biodiversity

Throughout the Indian farms and field one finds strips of vegetation containing several species of plants and small animals. These strips are beneficial in several ways. Such strips on tropical lands have been found to accelerate natural successional processes by attracting seed-dispersing animals and increasing the seed rain of forest plants. Effects of these strips resemble the windbreaks on seed deposition patterns (Harvey, 2000). Isolated trees provide seed in the area for natural regeneration. The strips enhance seed rain, and connectivity. Because such strips trap large number of seeds of several species they help in further tree growth. Compared to open fields, farm boundaries with vegetation receive seed in greater densities and species-richness than open farms and pastures. All forms of seed dispersal help in the process but animal-dispersed (birds, bats, mammals etc.) seeds often occur in greater densities and species numbers. Presence of isolated trees and shrubs or remnant trees helps. Farm boundaries maintained throughout the country are often self regenerating and require only management as these barriers considerably increase the deposition of tree and shrub seeds within the cultural landscape. Indeed considerable biodiversity is found within these strips. This is a practice that needs to be maintained as it has several socio-economic benefits as well.

Value of traditional agroecosystems in supporting the plant and animal diversity (see for example, Kunte *et al.* 1998) is immense. Tree diversity in farms and agroecosystems is often the product of interaction of local and formal knowledge. A recent study by Shastri et al. (2002) provides interesting insights on the tree-growing practices and associated biodiversity in Karnataka. Shastri *et al*. (2002) found trees belonging to 93 species in a sampled area of 1.7 ha of Sirsimakki agro-ecosystem. Additional 44 species were noted on non-agricultural lands in the village ecosystem, which included *soppina betta*, minor forest and reserve forest. The overall agroecosystem had 556 trees/ha, while the non-agroecosystem had only 354 trees/ha. The overall, tree density of 418.8 per ha was present in the village. There were 144 species in the village ecosystem with 2238 individuals in the sampled area of 5.34 ha. The total number of species in non-agro ecosystem was 104 with 1286 individuals. Home-gardens are notable with 93 tree species in just about 1.7 ha. The number of tree species varies between 20 and 40 in home-gardens, indicating that home-gardens in Karnataka villages are highly biodiverse in comparison to those in Mexico and Brazil (Shastri *et al.* 2002).

Farms themselves have domesticated biodiversity essential for survival and subsistence. One such example is by Kimata *et al.* (2000) form South India on the cultivation and process of domestication of *Brachiaria ramosa* cultivated in pure stands. Its grains are used in nine traditional food preparations in South India. Another crop *Setaria glauca* is cultivated in mixed stands along with little millet (*Panicum sumatrense*). In Orissa state and in Southern India the grains are used to make at least six traditional supplementary foods. The weedy forms of these species were found by the researchers growing with upland rice and some millets in diverse agro-ecological niches. The domestication process is supposed to have gone through three phases: first growing in association with weed and with upland rice and other millets; a secondary crop mixed with *kodo* millet; and finally as an independent crop.

14.6.4.4. Cultivation of Medicinal plants

There are numerous examples of medicinal plant cultivation by local people in India. Socio-culturally valued species find place in home gardens and courtyards. For example, Around the Nanda Devi Biosphere Reserve in the western Himalaya, the Bhotiya community, whose livelihood is depends on local natural resources, practices seasonal and altitudinal migration and stay inside the buffer zone for only 6 months (May-October). A survey in 5 villages in Pithoragarh District, found that Bhotiya people cultivate medicinal plants on their agriculture fields. Of a total of 71 families, 90% cultivated medicinal plants on 78% of the total reported cultivated area (15.29 ha). Around 12 species of medicinal plants were under cultivation. Survey also found that a family earned about Rs.2423 +/- 376.95 per season from the sale of medicinal plants in 1996 (Rs.38 = US$1 in 1996). Thus, supporting medicinal plant cultivation at high altitudes in the Himalayas may help to generate additional support to people as well as conserve the species in the wild (Silori and Badola, 2000, see also, Maikhuri *et al.* 1998). Another study (Satyal *et al.* 2002) on traditional knowledge of Kumaun Higher Himalaya found that Bhotia tribes use 34 species of medicinal plants native to the region. Among these, *Angelica glauca* and *Allium stracheyi* are narrow range endemic and *Allium stracheyi*, *Picrorhiza kurrooa* and *Nardostachys grandiflora* have been recorded in the Red Data Book of Indian Plants. Interestingly, the annual production of medicinal plants has been found to be comparable with the annual production of traditional crops. Thus, cultivation, and harvesting can help in livelihood security and *in situ* conservation of these species.

Similarly, juang and Munda tribes of the Keonjhar district of eastern India use 215 plants, belonging to 150 genera and 82 families (Mahapatra and Panda 2002). This suggests a wealth of traditional knowledge on biodiversity and herbal health care in tribes of eastern India. Tribes in the region are dependent on forests for other species as species of mushrooms, wild berries, tubers, and flowers that are included in their diet including cooking oil. Understanding of traditional knowledge on biodiversity of the region will be most helpful in planning for sustainable forest management.

14.6.4.5. Traditional Ethos

Similarly, in spite of the modernization, traditional ecological ethos continues to survive in many other local societies, although often in reduced forms. Investigations into the traditional resource use norms and associated cultural institutions prevailing in rural Bengal societies (Deb and Malhotra, 2001) demonstrate that a large number of elements of local biodiversity, regardless of their use value, are protected by the local cultural practices. Some of these may not have known conservation effect, yet may symbolically reflect a collective appreciation of the intrinsic or existence value of life forms, and the love and respect for nature. Traditional conservation ethics are still capable of protecting much of the country's decimating biodiversity, as long as the local communities have even a stake in the management of natural resources.

Traditional ethos is reflected in a variety of practices including sacred groves and sacred landscapes. One example from northeast India is particularly notable (see, Tiwari *et al.* 1998). The tribal communities of Meghalaya – Khasis, Garos, and Jaintias – have a tradition of environmental conservation based on various religious beliefs. As elsewhere in India, particular patches of forests are designated as sacred groves under customary law and are protected from any product extraction by the community. Such forests are very rich in biological diversity and harbor many endangered plant species including rare herbs and medicinal plants. Tiwari *et al.* (1998) identified 79 sacred groves and their floristic survey revealed that these sacred groves are home to at least 514 species representing 340 genera and 131 families. The status of sacred groves was ascertained through canopy cover estimate. About 1.3% of total sacred grove area was undisturbed, 42.1% had relatively dense forest, 26.3% had sparse canopy cover, and 30.3% had open forest. Notably, the species diversity indices were higher for the sacred grove than for the disturbed forest.

14.6.4.6. Traditional Knowledge, Water, and Biodiversity

Simple local technology and an ethic that exhorts "capture rain where it rains" have given rise to 1.5 million traditional village tanks, ponds and earthen embankments that harvest substantial rainwater in 660,000 villages in India (Pandey, 2001a), and encourage growth of vegetation in commons and agroecosystems. If India were to simply build these tanks today it would take at least US $ 125 billion (Pandey, 2002*a*).

Humans have virtually appropriated fresh water. Humanity now uses 26 percent of total terrestrial evapo transpiration and 54 percent of runoff that is geographically and temporally accessible. New dam construction could increase accessible runoff by about 10 percent over the next 30 years, whereas population is projected to increase by more than 45 percent during that period (Postel *et al.*, 1996).

Over thousands of years societies have developed a diversity of local water harvesting and management regimes that still continue to survive, for example, in South Asia, Africa, and other parts of the world (Agarwal and Narain, 1997). Such systems are often integrated with agro-forestry (Wagachchi and Wiersum, 1997) and ethnoforestry practices (Pandey, 1998). Recently it has been suggested that market mechanisms for sustainable water management such as taxing users to pay commensurate costs of supply and distribution and of integrated watershed management and charging polluters for effluent treatment can solve the problem (Johnson *et al.*, 2001). Such measures are essential although, but they are insufficient and would need to draw on the local knowledge on rainwater harvesting across different cultures (Pandey, 2001).

Rainwater harvesting in South Asia is different from other parts of the world in that it has a continued history of practice for at least over 5000 years. Similarly, Balinese water temple networks as complex adaptive systems are also very useful systems (Falvo 2000). Although hydraulic earthworks are known to have occurred in ancient landscapes in many regions, they are no longer an operational systems among the masses in the same proportion as in South Asia. For instance, remains of earthworks and water storage adaptations are found in Mayan lowlands in South America (Mann, 2000). Such systems had been used for prehistoric agriculture in Mayan lowlands (Turner, 1974; Coe, 1979), and for fish culture in Bolivian Amazon (Erickson, 2000).

Rainwater harvesting have been found to be scientific and useful for rainfed areas (Li *et al.*, 2000). For instance, a validation comes from the Negev. Ancient stone mounds and water conduits are found on hillslopes over large areas of the Negev desert. Field and laboratory studies suggest that ancient farmers were very efficient in harvesting water. A comparison of the volume of stones in the mounds to the volume of surface stones from the surrounding areas indicates that the ancient farmers removed only stones that had rested on the soil surface and left the embedded stones untouched. According to results of simulated rainfall experiments, this selective removal increased the volume of runoff generated over one square meter by almost 250% for small rainfall events compared to natural untreated soil surfaces (Lavee *et al.*, 1997).

One of the principle tree genus growing in association with tanks and ponds in India is *Ficus* which is culturally valued throughout the country. It is a keystone genus and supports a variety of other species. Records of frugivory from over 75 countries for 260 *Ficus* species (approximately 30% of described species) suggest that in addition to a small number of reptiles and fishes, 1274 bird and mammal species in 523 genera and 92 families are known to eat figs (Shanahan *et al.* 2001).

14.6.4.7. Incorporating Traditional Knowledge in Practice

Any attempt, endeavouring to integrate traditional knowledge for biodiversity conservation and sustainability of natural resources should be based on the principle that traditional knowledge often cannot be dissociated from its cultural and institutional setting. Regarding the cultural and institutional the following suggestions may be useful:

1. Each programme aiming at the promotion of traditional knowledge should be based on the recognition that natural resource rights and tenurial security of local communities forms the fundamental basis of respecting traditional knowledge.
2. More attention is needed on protection of intellectual property rights of traditional people.

3. Innovative projects may need to be developed that aim at the enhancement of the capacity of local communities to use, express and develop their traditional knowledge on the basis of their own cultural and institutional norms.

In spite of the value of traditional knowledge for biodiversity conservation and natural resource management there still is a need to further the cause. The following consideration may be useful in this respect:

1. Encouraging the documentation of indigenous knowledge and its use in natural resource management. Such documentation should be carried out in participation with the communities that hold the knowledge. Due attention should be given to document the emic perspectives regarding IK rather than only the perspectives of professional outsiders. The documentation should not only consist of descriptions of knowledge systems and its use, but also information on the threats to its survival. People's biodiversity registers are a case in point (Gadgil 1994 & 1996, Gadgil *et al.* 2000). The program of People's Biodiversity Registers promotes folk ecological knowledge and wisdom by devising a formal means for their maintenance, and by creating new contexts for their continued practice. PBRs document traditional ecological knowledge and practices on use of natural resources, with the help of local educational institutions, teachers, students and NGOs working in collaboration with local, institutions. Such a process and the resulting documents, could serve a significant role in "promoting more sustainable, flexible, participatory systems of management and in ensuring a better flow of benefits from economic use of the living resources to the local communities" (Gadgil *et al.* 2000).
2. Facilitating the translation of available and new documents describing Indic traditions such as ancient texts on medicinal plants, into local languages and dissemination of these documents amongst local people. Such a translation is indeed required because texts are often available in languages (e.g. Sanskrit) not understood by many in contemporary India. On the other hand, translation of local knowledge into formal scientific terminology will provide space to external researchers, policy makers, and practitioners to comprehend and support people's knowledge systems and initiatives.
3. Facilitating the exchange of information amongst practitioners of local knowledge.
4. Developing clear and concise educational material on traditional knowledge systems to be used in communication programmes to impart information regarding the merits and threats to indigenous knowledge systems to both policy makers and the general public.

Scientific institutions have an important role to play in supporting the knowledge systems. As has been pointed out earlier, it is now recognized that a dichotomy between local and formal systems of knowledge is not real, and that any knowledge is based on a set of basic values and beliefs and paradigms. Therefore, there is a definite need to further develop systematic insight into the nature and scope of traditional knowledge. The following activities may be useful in this regard:

1. Developing curricula and methods for providing formal training and education in traditional knowledge systems to agencies, researchers and practitioners who work in collaboration with communities. In this context, the Indian Himalayan Region, which represents a unique biogeographic entity, new initiatives by G.B. Pant Institute of Himalayan Environment and Development have yielded positive results (see Dhar *et al.* 2002).
2. Developing research projects aimed at assessing the possibilities and constraints of using traditional knowledge under specific conditions. Such research projects should move beyond the first generation research projects, which aimed at demonstrating the value of local knowledge systems by focusing on successful cases of application. Second generation research projects shall focus on comparing application of knowledge systems across a range of circumstances and across disciplines to craft the traditional sustainability science.
3. Developing new methods for incorporating local knowledge systems in natural resource management regimes through action research.

14.7. Summary

Biodiversity conservation is accomplished in a number of ways. Ex-situ methods focus on species conservation in botanic gardens, zoos, gene banks, and captive breeding programs. In-situ methods use conservation areas as "warehouses" of biological information. Many scientists and conservationists feel that until methods are available to discern easily which of the millions of species and varieties will have economic value, in-situ conservation through the protection of natural areas should be the primary means for the maintenance of these resources.

It is often said that whether it is possible or not to sustain our relatively stable environmental conditions that have supported the lives of human beings for the past ten thousand years depends on our behaviors in the coming ten to twenty years. We are currently at a pivotal point where it will be determined whether we can prevent biodiversity loss or not. At such a critical point, we consider "information" and its "positive use" to be essential keys for moving in the right direction by understanding complicated natural environments globally and also understanding

them on regional and species levels. To address this international environmental initiative, the Fujitsu Group is committed to continuing with approaches for biodiversity preservation and its sustainable use based on positive use of ICT.

Terminal Questions:

A. Choose the correct option:

1. . In which approach do we protect and conserve the whole ecosystem to protect the endangered species?
   a) Ex-situ conservation b) Off-site conservation
   c) No conservation d) In-situ conservation
2. In which approach do we protect and conserve the animals that need urgent measures to save it from extinction?
   a) In-situ conservation b) On-site conservation
   c) Ex-situ conservation d) No conservation

3. What is the number of biosphere reserves present throughout the world?
a) 24 b) 44
c) 14 d) 04

4. What is the number of national parks India consisting of?
   a) 19 b) 90
   c) 29 d) 120
5. . By which of the following technique the gametes of threatened species are preserved in viable and fertile conditions for long periods?
   a) Botanical gardens b) Cryopreservation techniques
   c) Zoological parks d) Wildlife safari parks
6. Which of the following is an odd one?
a) Botanical gardens b) Zoological parks
c) Wildlife safari parks d) National parks

B. Answer the following questions:

1. Explain different methods of Biodiversity conservation.
2. Discuss In-situ conservation?
3. Discuss Ex-siu conservation?
4. Explain the role of Indigenous Traditional knowledge for the conservation of biodiversity.

References

Adapted from E-PGPathshala

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Islam, M. S., & Bari, M. A. (2014). *In vitro* regeneration protocol for artificial seed production in an important medicinal plant *Mentha arvensis* L. *Journal of Bio-Science*, *20*, 99-108.

Patel, A. K., Agarwal, T., Phulwaria, M., Kataria, V., & Shekhawat, N. S. (2014a). An efficient *in vitro* plant regeneration system from leaf of mature plant of *Leptadenia reticulata* (Jeewanti):a life giving endangered woody climber. *Industrial crops and products*, *52*, 499-505.

Patel, A. K., Phulwaria, M., Rai, M. K., Gupta, A. K., Shekhawat, S., & Shekhawat, N. S. (2014b). *In vitro* propagation and *ex vitro* rooting of *Caralluma edulis* (Edgew.) Benth. & Hook. f.: an endemic and endangered edible plant species of the Thar Desert. *Scientia Horticulturae*, *165*, 175-180.

Sharma, N., Chandel, K. P. S., & Paul, A. (1993). *In vitro* propagation of *Gentiana kurroo*—an indigenous threatened plant of medicinal importance. *Plant cell, tissue and organ culture*, *34*, 307-309.

Shrestha, J. N., & Joshi, S. D. (1992). Tissue culture techniques for medicinal important herbs
Orchis incarnata and *Swertia chirata*. *Banko Janakari*, *3*, 24-26.

Shukla, M. R., Jones, A. M. P., Sullivan, J. A., Liu, C., Gosling, S., & Saxena, P. K. (2012). *In vitro* conservation of American elm (*Ulmus americana*): potential role of auxin metabolism in sustained plant proliferation. *Canadian Journal of Forest Research*, *42*(4), 686-697.

Agarwal, A., and Narain, S. eds. (1997). *Dying Wisdom: Rise, Fall and Potential of India's Traditional Water Harvesting Systems*. Centre For Science and Environment, New Delhi.

Agrawal, A. (1995a). Dismantling the Divide between Indigenous and Scientific Knowledge. *Development and Change* 26: 413-39.

Agrawal, A. (1995b). Indigenous and Scientific Knowledge: Some Critical Comments. *Indigenous Knowledge and Development Monitor* 3(3): 3-6.

Agrawal, D.P. (1997). Traditional knowledge systems and western Science. *Current Science* 73: 731-733.

Ahmed, M.R., and Laarman, J.G. (2000). Gender equity in social forestry programs in Bangladesh. *Human Ecology* 28: 433-450.

Anderson, P.N. (2001). Community-based conservation and social change amongst South Indian honey-hunters: an anthropological perspective. *Oryx* 35: 81-83.

Arnold, J. E. M., and Dewees, P. Eds. (1997). *Farms, Trees and Farmers: Response to Agricultural Intensification*. Earthscan Publ. London, UK.

Arunachalam, A., Khan, M. L. and Arunachalam, K. 2002. Balancing traditional jhum cultivation with modern agroforestry in eastern Himalaya – A biodiversity hot spot. *Current Science* 83: 117-118.

Arunachalam, V. 2001. The science behind tradition. *Current Science* 80: 1272-1275.

Atran, S. *et al.*, (1999). Folkecology and commons management in the Maya Lowlands. *Proceedings of the National Academy of Sciences USA* 96: 7598-7603.

Ayensu, E. *et al.*, (1999). International ecosystem assessment. *Science* 286: 685-686.

Balvanera, P. et al., (2001). Conserving biodiversity and ecosystem services. *Science* 291: 2047.

Bates, D.G. (2000). *Human Adaptive Strategies: Ecology, Culture, and Politics*. Allyn & Bacon, pp 238. 2nd ed.

Bawa, K. S., and Dayanandan, S. (1997). Socioeconomic factors and tropical deforestation. *Nature* 386: 562-563.

Berkes, F. (1999). *Sacred Ecology: Traditional Ecological Knowledge and Resource Management.* Taylor and Francis, Philadelphia.

Berkes, F., Colding, J., and Folke, C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications* 10: 1251-1262

.

Berkes, F., Feeny, D., McCay, B. J., and Acheson, J. M. (1989). The benefit of the commons. *Nature* 340: 91-93.

Berkes, F., Kislalioglu, M., Folke, C., and Gadgil, M. 1998. Exploring the basic ecological unit: Ecosystem-like concepts in traditional societies. *Ecosystems* 1: 409-415.

Bews, J.W. (1935). *Human Ecology*. Oxford University Press, London, pp. 312.

Boers, T. M., and Ben-Asher, J. (1982). A review of rainwater harvesting. Agric. *Water Management* 5: 145-158.

Brechin, S. R., Wilshusen, P. R., Fortwangler, C. L., and West, P. C. (2002). Beyond the square wheel: Toward a more comprehensive understanding of biodiversity conservation as social and political process. *Society and Natural Resources* 15: 41-64.

Briers, R. A. (2002). Incorporating connectivity into reserve selection procedures. *Biological Conservation* 103: 77-83.

Brodt, S.B. (2001). A systems perspective on the conservation and erosion of indigenous agricultural knowledge in central India. *Human Ecology* 29: 99-120.

Brosius, P.J. (1997). Endangered forest, endangered people: environmentalist representations of indigenous knowledge. *Human Ecology* 25: 47-69.

Brush, S. B. & Stabinsky, D. (eds.)1996. *Valuing Local Knowledge: Indigenous People and Intellectual Property Rights* (Island Press, Washington DC).

Unit 15: Conservation and Sustainable Use of Biodiversity: National and international initiative

Unit Structure

15.0 Learning objective

After completing this unit you will be able to:

- list the areas requiring the sustainable use of biodiversity
- Explain the various initiatives taken at international level for sustainable use of biodiversity
- Explain the various initiatives taken at national level for sustainable use of biodiversity

15.1 Introduction

The biodiversity that we observe around us today has not evolved all of a sudden, but has taken billions of billions years. It is integral part of ecosystems and humans are one of such species. Together all the life forms in an ecosystem are interrelated and forms the web of life. It is through this diversity of life that we derive various useful things. Different species in an ecosystem live as population or aggregates of different populations that are known as communities. They interact with one another and with abiotic components such as soil, air and water around us. This diversity of life and their interactions with each other and with the rest of the environment has resulted into a system that provides a variety of goods and services which are important for sustaining life of human beings, their domesticated animals and other biotic components. According to the United Nations Food and Agriculture Organization, 40% of the world's economy is based directly and indirectly on the use of biological resources. It is, therefore, that the sustainable use of biological diversity is one of the three objectives set out in the first article of the Convention on Biological Diversity (CBD).

Conservation and sustainable use of biodiversity has been in practice in Indian culture and traditions since very long time which is evident from our ancient religious scriptures and traditions of community conserved areas and our respect for various religious trees such as papal tree, banyan tree and tulsi etc. and also respect for nature and natural resources such as mountains, rivers, forests, plants and animals. Formal laws, policies and programs for conservation and sustainable use of biodiversity date back to several decades. Further, over the years, India has also developed a robust institutional structure and a strong legal and policy framework for the conservation of biodiversity. Keeping in view the needs and national priorities and in conformity with the commitments to the CBD, India is making significant progress towards achieving goals of CBD.

When the Convention on Biodiversity (CBD) came into force in 1992, one of its main objectives was the promotion of sustainable use of biodiversity. Article 2 of the CBD defines

Sustainable use as the “use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations” . This became a subject of debate because not all concerned were clear as to what ‘sustainable use’ is and how it can be achieved.

With the continuous increase in human population, the social and economic needs also grow. Most of these needs were fulfilled either by direct use of biodiversity or by biodiversity based derived products. This has, in turn, resulted into tremendous pressure on the biodiversity. It is also true that the exploitation of biodiversity resources is mainly done by industrialized nations for their wellbeing, however, the negative impacts of over-exploitation are observed very widely and whole humankind is facing these negative impacts or consequences. The degradation of biodiversity is mainly the result of greed and aspirations of urban communities of rich industrialized nations to satisfy the needs of modern life whereas traditional practices of rural and indigenous communities often conserve and result in sustainable use of bio-resources, thus, ensuring its availability and continuous flow to future generations.

15.2 International Initiatives on sustainable use of biodiversity

15.2.1 Stockholm Declaration on Human Environment, 1972

The Conference on the Human Environment was held at Stockholm, capital of Sweden from 5-16 June 1972 where more than 107 states participated. It is one of the most successful International Conference. In a two week period it adopted not only a basic declaration and a detailed resolution on Institutional and Financial arrangements but also 109 recommendations comprising an ambitious action plan relating to natural resources, human settlement, human health, territorial ecosystem, environment and development etc. Also at the end of the conference the participating States agreed and declared 26 Principles which are known as the Magna Carta on Human Environment. The Stockholm Declaration was the first holistic approach to deal with the problems of environment.

The Stockholm era, spans 2 decades from 1968 to 1987. It encompasses the 1972, Stockholm Conference, including the extensive array of precautionary meetings in the years preceding it, as well as the implementation of its recommendations over the following decade. The success of the Stockholm Conference was based on a complex preparatory process during which agreement was reached among the major group of countries on many issues so that a limited number of questions had to be resolved at the conference itself. The preparation for the conference was primarily in the hands of Conference Secretariat headed by Maurice F. Strong, former president of the Canadian International Development Agency.

The declaration on the human environment is divided in two parts – first part proclaims seven truths about man in relation to his environment and contains general observations such as men is both creature and molder of his environment which gives him physical substance and affords him the opportunity for intellectual, moral, social and spiritual growth; the protection and improvement of the human environment is a major issue which affects the well-being of people and economic development throughout the world. It is the urgent desire of the peoples of the whole world and the duty of all governments in the developing countries.

The part II of the Declaration on the human environment enunciates 26 principles. These principles provide the basis of an international policy for the protection and improvement of the environment. The object of the Stockholm declaration was to pass our mother earth to the coming generations in clean and healthy conditions.

Principles of Stockholm Declaration

Human Centric: (Principles 1 and 15)

Principle 1 states that Man has the fundamental right to freedom, equality and adequate conditions of life, in environment of that permits a life of dignity and well-being, and he bears a solemn responsibility to protect and improve the environment for present and future generations. In this respect policies promoting or perpetuating apartheid, racial segregation, Discrimination, colonial and other forms of oppression and foreign domination stand condemned and must be eliminated.

Principle 15 talks about Precautionary actions and states that planning must be applied to human settlement and urbanization to avoid adverse effects on the environment and obtaining maximum social, economic and environmental benefits for all.

Sustainable Development (Principles 2,3,4,5, 13 and 14)

Principal 2: The natural resources of the earth including the air, water, land, flora and fauna and especially representative samples of natural ecosystems must be safeguarded for the present and future generations through careful planning or management as appropriate.

Principle 3: The capacity of the earth to produce vital renewable resources must be maintained and wherever practicable restored or improved.

Principle 4: Man has a special responsibility to safeguard and wisely manage the heritage of wildlife and its habitat, which are now gravely imperiled by a combination of factors. Nature conservation, including wildlife, must therefore receive importance in planning for economic development.

Principle 5: The non-renewable resources of the earth must be employed in such a way so as to safeguard against the danger of their future exhaustion and to ensure that the benefits from all emoluments are shared by all mankind.

Principle 13: States should adopt an integrated and coordinated approach to their development planning so as to ensure that the development is compatible with the need to protect and improve environment for the benefit of their population.

Principle 14: The need for rational planning by the States to reconcile the conflict between development and environment.

Reflection of Customary International Law position (Principle 21)

Principle 21: Prevention of Environmental Harm Further developments in the area of legal control of activities and exploitation of the natural resources within their jurisdiction to prevent any damage to the environment.

Preventative Actions (Principles 6, 7 15 18 and 24)

Principle 6: The discharge of toxic substances or of other substances and the release of heat, in such quantities or concentrations as to exceed the capacity of the environment to render them harmless, must be halted in order to ensure that serious or irreversible damage is not inflicted upon ecosystems. The just struggle of the people of all against pollution should be supported.

Principle 7: States shall take all possible steps to prevent pollution of the seas by substances which are liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea.

Principle 15 talks about Precautionary actions and states that planning must be applied to human settlement and urbanization to avoid adverse effects on the environment and obtaining maximum social, economic and environmental benefits for all.

Principle 18: Science and Technology must be applied to identification, avoidance and control of environment risks and the solution of environment problems for the common good of mankind, thus, incorporating the "Precautionary Principle" in essence.

Principle 24: Cooperation through multilateral and bilateral agreements or other appropriate means for effective control to eliminate the adverse environmental effects resulting from activities conducted in all spheres.

Compensation to Victims (Principle 22)

Principle 22: States to cooperate and develop further the international law regarding liability and compensation of victims of pollution and other environmental damage caused by activities within the jurisdiction or control of such states to areas beyond their jurisdiction.

Cooperation (Principles 24 and 25)

Principle 24: Cooperation through multilateral and bilateral agreements or other appropriate means for effective control to eliminate the adverse environmental effects resulting from activities conducted in all spheres.

Principle 25: States shall ensure that the international organizations play a coordinated and dynamic role for the protection and improvement of the environment.

enlightened opinion and responsible conduct by individuals, enterprises and communities in protecting and improving the environment in its full

Aftermath of Stockholm Declaration

As a result of the Stockholm Declaration, some other Global Conventions on the preservation of Environment were convened such as:-

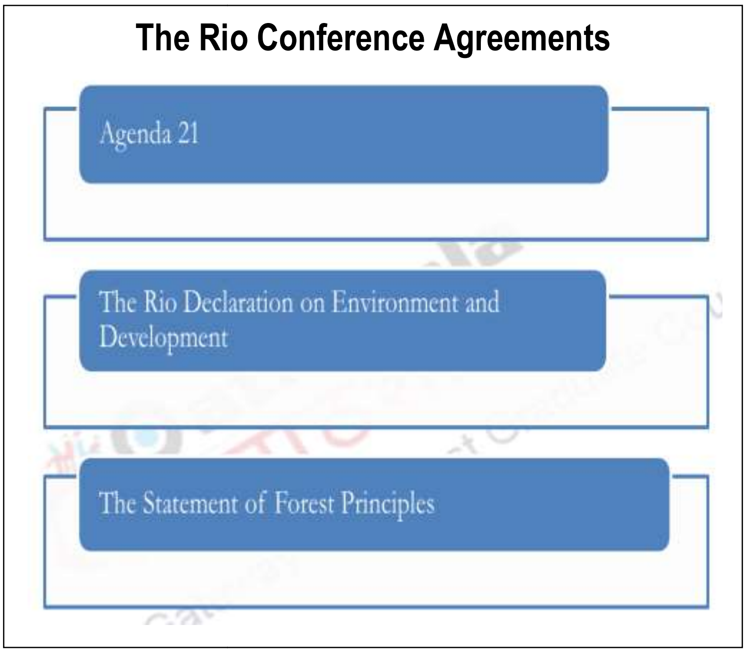
- The Convention on International Trade in endangered species of Wild Fauna and Flora, 1973.
- The Convention for the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972.
- The Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircrafts, 1973.

15.2.2 The Convention on Biological Diversity (CBD)

The Earth Summit in Rio de Janeiro was unprecedented for a UN conference, in terms of both its size and the scope of its concerns. Twenty years after the first global environment conference, the UN sought to help Governments rethink economic development and find ways to halt the destruction of irreplaceable natural resources and pollution of the planet. Hundreds of thousands of people from all walks of life were drawn into the Rio process. They persuaded their leaders to go to Rio and join other nations in making the difficult decisions needed to ensure a healthy planet for generations to come. The Summit's message — that nothing less than a transformation of our attitudes and behavior would bring about the necessary changes — was transmitted by almost 10,000 on-site journalists and heard by millions around the world. The message reflected the complexity of the problems facing us: that poverty as well as excessive consumption by affluent populations place damaging stress on the environment. Governments recognized the need to redirect international and national plans and policies to ensure that all economic decisions fully took into account any environmental impact and the message has produced results, making eco-efficiency a guiding principle for business and governments alike.

The two-week Earth Summit was the climax of a process, which began in December 1989, of planning, education and negotiations among all Member States of the United Nations, leading to the adoption of Agenda 21, a wide-ranging blueprint for action to achieve sustainable development worldwide. At its close, Maurice Strong, the Conference Secretary-General, called the Summit a "historic moment for humanity". Although Agenda 21 had been weakened by compromise and negotiation, he said, it was still the most comprehensive and, if implemented, effective Programme of action ever sanctioned by the international community. Today, efforts to ensure its proper implementation continue, and they will be reviewed by the UN General Assembly at a special session to be held in June 1997.

The Earth Summit influenced all subsequent UN conferences, which have examined the relationship between human rights, population, social development, women and human settlements — and the need for environmentally sustainable development. The World Conference on Human Rights, held in Vienna in 1993, for example, underscored the right of people to a healthy environment and the right to development, controversial demands that had met with resistance from some Member States until Rio.



The Principles at Rio Conference

Principle 1: Human beings are at the center of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature

Principle 2: States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

Principle 3: The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.

Principle 4: In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.

Principle 5: All States and all people shall cooperate in the essential task of eradicating poverty as an indispensable requirement for sustainable development, in order to decrease the disparities in standards of living and better meet the needs of the majority of the people of the world.

Principle 6: The special situation and needs of developing countries, particularly the least developed and those most environmentally vulnerable, shall be given special priority. International actions in the field of environment and development should also address the interests and needs of all countries.

Principle 7: States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit to sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.

Principle 8: To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies.

Principle 9: States should cooperate to strengthen endogenous capacity-building for sustainable development by improving scientific understanding through exchanges of scientific and technological knowledge, and by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies.

Principle 10: Environmental issues are best handled with participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.

Principle 11: States shall enact effective environmental legislation. Environmental standards, management objectives and priorities should reflect the environmental and development context to which they apply. Standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries. Sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.

Principle 12: States should cooperate to promote a supportive and open international economic system that would lead to economic growth and sustainable development in all countries, to better address the problems of environmental degradation. Trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade. Unilateral actions to deal with environmental challenges outside the jurisdiction of the importing country should be avoided. Environmental measures addressing transboundary or global environmental problems should, as far as possible, be based on an international consensus.

Principle 13: States shall develop national law regarding liability and compensation for the victims of pollution and other environmental damage. States shall also cooperate in an expeditious and more determined manner to develop further international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control to areas beyond their jurisdiction.

Principle 14: States should effectively cooperate to discourage or prevent the relocation and transfer to other States of any activities and substances that cause severe environmental degradation or are found to be harmful to human health.

Principle 15: In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Principle 16: National authorities should endeavor to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment.

Principle 17: Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.

Principle 18: States shall immediately notify other States of any natural disasters or other emergencies that are likely to produce sudden harmful effects on the environment of those States. Every effort shall be made by the international community to help States so afflicted.

Principle 19: States shall provide prior and timely notification and relevant information to potentially affected States on activities that may have a significant adverse transboundary environmental effect and shall consult with those States at an early stage and in good faith.

Principle 20: Women have a vital role in environmental management and development. Their full participation is therefore essential to achieve sustainable development.

Principle 21: The creativity, ideals and courage of the youth of the world should be mobilized to forge a global partnership in order to achieve sustainable development and ensure a better future for all.

Principle 22: Indigenous people and their communities and other local communities have a vital role in environmental management and development because of their knowledge and traditional practices. States should recognize and duly support their identity, culture and interests and enable their effective participation in the achievement of sustainable development.

Principle 23: The environment and natural resources of people under oppression, domination and occupation shall be protected.

Principle 24: Warfare is inherently destructive of sustainable development. States shall therefore respect international law providing protection for the environment in times of armed conflict and cooperate in its further development, as necessary.

Principle 25: Peace, development and environmental protection are interdependent and indivisible.

Principle 26: States shall resolve all their environmental disputes peacefully and by appropriate means in accordance with the Charter of the United Nations.

Principle 27: States and people shall cooperate in good faith and in a spirit of partnership in the fulfillment of the principles embodied in this Declaration and in the further development of international law in the field of sustainable development.

The Outcomes of Rio Conference

The Earth Summit succeeded in presenting new perspectives on economic progress. It was lauded as the beginning of a new era and its success would be measured by the implementation — locally, nationally and internationally — of its agreements. Those attending the Summit understood that making the necessary changes would not be easy: it would be a multi-phased process; it would take place at different rates in different parts of the world; and it would require the expenditure of funds now in order to prevent much larger financial and environmental costs in the future.The main outcomes of the summit are as follows:

- **UN Commission on Sustainable Development:** The Earth Summit called on the General Assembly to establish the Commission under the Economic and Social Council as a means of supporting and encouraging action by Governments, business, industry and other non-governmental groups to bring about the social and economic changes needed for sustainable development. Each year, the Commission reviews implementation of the Earth Summit agreements, provides policy guidance to Governments and major groups involved in sustainable development and strengthens Agenda 21 by devising additional strategies where necessary. It also promotes dialogue and builds partnerships between Governments and the major groups which are seen as key to achieving sustainable development worldwide. The work of the Commission was supported by numerous inter-sessional meetings and activities initiated by Governments, international organizations and major groups. In June 1997, the General Assembly held a special session to review overall progress following the Earth Summit.

  Under a multi-year thematic work programme, the Commission has monitored the early implementation of Agenda 21 in stages. Each sectoral issue — health, human settlements,

  Freshwater, toxic chemicals and hazardous waste, land, agriculture, desertification, mountains, forests, biodiversity, atmosphere, oceans and seas — was reviewed between 1994 and 1996.

  Developments in most “cross-sectoral” issues are considered each year. These issues, which must be addressed if action in sectorial areas is to be effective, are clustered as follows: critical elements of sustainability (trade and environment, patterns of production and consumption, combating poverty, demographic dynamics); financial resources and mechanisms; education science, transfer of environmentally sound technologies, technical cooperation and capacitybuilding; decision-making; and activities of the major groups, such as business and labour.

In 1995, the Commission established under its auspices the Intergovernmental Panel on Forests with a broad mandate covering the entire spectrum of forest-related issues and dealing with conservation, sustainable development and management of all types of forests. Reports submitted annually by Governments are the main basis for monitoring progress and identifying problems faced by countries. By mid-1996, some 100 Governments had established national sustainable development councils or other coordinating bodies. More than 2,000 municipal and town governments had each formulated a local Agenda 21 of its own. Many countries were seeking legislative approval for sustainable development plans, and the level of NGO involvement remained high.

- **Setting of Standards**: Achieving sustainable development worldwide depends largely on changing patterns of production and consumption — what we produce, how it is produced and how much we consume, particularly in the developed countries. CSD's work programme in this area focuses on projected trends in consumption and production; impacts on developing countries, including trade opportunities; assessment of the effectiveness of policy instruments, including new and innovative instruments; progress by countries through their time bound voluntary commitments; and extension and revision of UN guidelines for consumer protection.In 1995, the Commission also adopted a work programme on the transfer of environmentally sound technology, cooperation and capacity building. The programme places an emphasis on three interrelated priority areas: access to and dissemination of information, capacity building for managing technological change and financial and partnership arrangements. The Commission is working with the World Trade Organization, the UN Conference on Trade and Development and the United Nations Environment Programme (UNEP) to ensure that trade, environment and sustainable development issues are mutually reinforcing.
- **Financing Sustainable Development:** At Rio, it was agreed that most financing for Agenda 21 would come from within a country's own public and

private sectors. However, new and additional external funds were considered necessary if developing countries were to adopt sustainable development practices. Of the estimated \$600 billion required annually by developing countries to implement Agenda 21, most — \$475 billion — was to be transferred from economic activities in those countries.A further \$125 billion would be needed in new and additional funds from external sources, some \$70 billion more than current levels of official development assistance (ODA). According to the Organization for Economic Co-operation and Development (OECD), between 1992 and 1995, levels of ODA fell from about \$60.8 billion to \$59.2 billion, despite a call at Rio for donor countries to increase their official assistance by more than double.Other monies are available for implementation of Agenda 21. The Global Environment Facility (GEF) was set up in 1991. It is implemented by the World Bank, the United Nations Development Programme and the United Nations Environment Programme. The GEF provides funding for activities aimed at achieving global environmental benefits in four areas: climate change, loss of biodiversity, pollution of international waters and the depletion of the ozone layer. At Rio, the Facility became the funding mechanism for activities under the United Nations Framework Convention on Climate Change and the Convention on Biological Diversity. In 1994, the scope of the GEF's funding was broadened to include land degradation, primarily desertification and deforestation, where this is linked to the four focal areas above. Since 1992, some \$2 billion has been pledged for activities supported by the GEF. In the years since the Earth Summit, the level of funding channelised to many of the developing countries as direct private investment has increased significantly and now far outstrips official flows. In 1995, this reportedly amounted to some \$95 billion. Efforts are being made to ensure that activities supported by these funds are also environmentally sustainable.

Other outcomes of the summit were:

- The 1992 UN Conference on Environment and Development or, as it is better known, the "Rio Earth Summit," is symbolic of the international solidarity that the world showed in the face of deteriorating environmental conditions, when the nature was crying out for sustainable development.

- The Summit resulted in a plethora of crucial decisions Agenda 21, the Rio Declaration on Environment and Development, the Statement of Forest Principles, the United Nations Framework Convention on Climate Change and the United Nations Convention on Biological Diversity.
- The two major core themes decided at the Rio+20 were “a green economy in the context of sustainable development and poverty eradication” and “institutional framework for sustainable development”, when seen in the context of the official language adopted at the Conference.
- India has always been advocating for a non-binding legal commitment being a developing country, for effective sustainable development, effective mobilization of appropriate resources is also required to effectively carry out the aim of sustainable development.
- Agenda 21, adopted by the United Nations Conference on Environment and Development on 14 June 1992.
- In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.
- In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities.
- Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority

15.2.2 The International Treaty on Plant Genetic Resources for Food and Agriculture

Popularly known as the International Seed Treaty, this is important in the fight against hunger and poverty. It is an international agreement that covers many aspects. It was made on the principle that genetic resources belong to all of humanity. It came into force in 2004. India is a signatory to this Treaty.

This treaty aims to:

- Guarantee food security through the conservation, exchange and sustainable use of the world's plant genetic resources for food and agriculture
- Ensure that the people use and share the benefits of plant genetic resources in a fair and equitable manner
- Recognize farmers' rights in the following areas: to be able to have free access to genetic resources without being restricted by intellectual property rights; to be
- involved in policy discussions and decision making related to biodiversity; and to use, save, sell and exchange seeds, subject to national laws
- Undertake capacity building, technology transfer and exchange of information activities in the area of traditional knowledge.

The Treaty has implemented a Multilateral System (MLS) through which countries that ratify the treaty can use and share the benefits of 64 of the most important food crops essential for food security and interdependence. Under the terms of this Treaty, it is compulsory that benefits made from commercial utilization of plant genetic resources for food and agriculture covered by the MLS must be shared. We may say that the Treaty is an example of responsible global governance to ensure that plant genetic resources essential for present and future food security are kept within the reach of all farmers and in the public domain.

15.2.3 The Global Strategy for the Management of Farm Animal Genetic Resources

The development of a Global Strategy for the Management of Farm Animal Genetic Resources was started by FAO in 1993 in recognition of the important contribution of animal genetic resources to global food security and community identity, and in view of the fact that these resources were rapidly declining and poorly managed.

The FAO Global Strategy stresses the need to ensure an effective global response to increase awareness of the roles and values of animal genetic resources. It provides a framework for local, national, regional and global efforts to better use, develop, and conserve these resources through policies, strategies and actions. It also helps to mobilize necessary financial support for the development and implementation of the

Strategy. In addition, it coordinates activities of different independent organizations working for sustainable agricultural and rural development.

The Global Strategy for the Management of Farm Animal Genetic Resources aims to

- Identify and understand those unique genetic resources that make up the global gene pools for each of the important domestic animal species used for food and agriculture.
- Develop and properly utilize the associated diversity to increase production and productivity, achieve sustainable agricultural systems and meet demands for specific product types.
- Monitor all genetic resources, particularly those that are currently represented by small animal populations or that are otherwise being displaced by one breed replacement strategy or another.
- Preserve the unique resources for which there is not enough current demand. Train and involve people in the management of these resources, including their best use and development, and in the maintenance of diversity.
- Communicate to the world's community the importance of its domestic animal genetic resources and of the associated diversity, their current exposure to loss and that they cannot be replaced.
- Survey and describe genetic resources.
- Establish the importance of existing animal genetic diversity and reliable rates of loss.
- Once genetic resources have been identified and characterized, two basic conservation activities follow, namely in situ and ex situ.

15.2.4 CITES

CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is an international agreement between governments that came into force on 01 July 1975. It aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival.

It is fairly common knowledge today that many prominent species, such as the tiger and elephants, are endangered, making the need for such a convention seem obvious. But in the 1960s, when the ideas for CITES first emerged, international discussion of the regulation of wildlife trade for conservation purposes was something quite new. In a year, international wildlife trade is worth approximately billions of dollars and includes hundreds of millions of plant and animal specimens. The trade ranges from live animals and plants to many different wildlife products derived from them, e.g. food products, exotic leather goods, wooden musical instruments, timber, tourist curios and medicines.

Some animal and plant species are highly exploited and the trade in them, together with other factors, such as habitat loss, can easily reduce their populations to the extent that they come close to extinction. Many wildlife species in trade are not endangered, but the existence of an agreement to ensure the sustainability of the trade is important if we wish to safeguard these resources for the future.

Because the trade in wild animals and plants is across borders between countries, the effort to regulate it requires international cooperation. CITES was conceived in the spirit of such cooperation. Today, CITES protects more than 30,000 species of animals and plants whether they are traded as live specimens, fur coats or dried herbs. CITES is an international agreement to which States (countries) adhere voluntarily. States that have agreed to be bound by the Convention ('joined' CITES) are known as Parties.

Although CITES is legally binding on the Parties – which means that they have to implement the Convention – it does not take the place of national laws. Instead, it provides a framework to be respected by each Party, which has to adopt its own domestic legislation to ensure that CITES is implemented at the national level.

15.2.5 The Ramsar Convention on Wetlands

The Convention on Wetlands of International Importance, called the Ramsar Convention, was adopted in the Iranian city of Ramsar in 1971 and came into force in 1975. It is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. It is the only global environmental treaty that deals with a particular ecosystem, and the Convention's member countries cover most of the planet.

15.2.6 The Kyoto Declaration (1995)

The Kyoto Declaration is the result of the International Conference on the Sustainable Contribution of Fisheries to Food Security, held in Kyoto (Japan) in 1995.

This Declaration lays emphasis on the following issues:

- States (countries) should conserve and sustainably use biological diversity and its components in the aquatic environment
- Prevent practices leading to irreversible changes, e.g. extinction of genes and species, destruction of habitats
- Policies, strategies and resource management and utilization for sustainable development in the fisheries sector should be based on the maintenance of ecological systems and the use of the best scientific evidence available
- Promoting the use of sustainable and environmentally sound aquaculture and ranching in coastal, marine and inland waters.

15.3 National Initiatives on sustainable use of biodiversity

15.3.1 Indian Forest Act, 1927

Object and Scope of the Act

The object of the Indian forest Act [hereinafter referred to as 'the Act'] was to consolidate and reshape the law relating to forests in India. This was the first step towards codification of the various practices and activities of the forest officials. The Act further aimed towards regulating the rights of various groups of people over forest lands and the resources. Different classifications of forests were made and the scope of the provisions was elaborated to extend control of State over forests and resources. Unlike the 1878 Act, this Act did not refer to the community's right over the forest and people were expected to put in their claims over forest lands. Further, the act tried to govern the transit of forest produce and duties to be levied on forest products. Thus, the Act depicted the revenue yielding aspects of forests, in the mind of colonial rulers.

Salient features of the Act

- The Act contains 86 sections and deals in four categories of forest which includes (i) Reserve Forest (ii) Village Forest (iii) Protected Forest (iv) Non-government Forest.

- Regulatory measures were introduced to prohibit/control quarrying of stones, burning of lime or charcoal, the collection of any manufacturing process, or removal of any forest produce in any such forest and the breaking up or clearing for cultivation, for building and for herding cattle
- Inspectors were conferred with the power to arrest without warrant in cases of disobeying or violation of the provisions of this Act.
- Unlike the 1878 Act, the 1927 Act did not refer to rights of various communities over forests, rather the communities/individuals were expected to claim their right over the particular forest land before the Forest Settlement Officer. The officer may conduct appropriate enquiry against such claim.
- Special provisions have been included to control the shifting cultivation. The practice of shifting cultivation is subject to satisfaction of the Forest Settlement Officer who upon recording the claims, informed the State Government regarding the permissibility of the same.

15.3.2 Wildlife (Protection) Act, 1972

Conservation of living natural resources – plants, animals, and microorganisms and the nonliving elements of the environment on which they depend is crucial for development and progress. Wildliferesources constitute a vital link in the survival of the human species, because every one of us depends on plants and animals for all vital components of our welfare. The whole environment runs in the formof a food chain and survival and dependence of all the species is vital and interdependent. Hon'ble Markandey Katju J, has also stated that "***Preservation of wildlife is important for maintaining the ecological balance in the environment and sustaining the ecological chain. It must be understood that there is interlinking in nature In the present society, the challenge that the world faces is not the idea of conservation but can conservation be implemented in national interest and within the means available to each country.***

The general impression about the term "wildlife" is that it includes ferocious, terrestrial or aquatic animals living in jungle such as lions, tigers etc. But actually the term includes all living organisms i.e. all plants, animals and micro-organisms living in their natural habitat in wild state other than the cultivated plants and domesticated animals.

The Conservation of wildlife is of immense importance to mankind, the extinction of wildlife would ultimately lead to the extinction of the human species itself. The ecological balance of the nature is disrupted if any harm is caused to the wildlife.

Legislative History of wildlife laws in India

- The earliest concern for wildlife could be traced to 3rd Century BC when King Ashoka enacted the law of preservation of wildlife and environment.
- Under the Indian Penal Code, 1860 the term "animal" is defined and it declares maiming and killing of animals as an offence punishable under various sections.
- The British Government passed the Elephants Preservation Act, 1879 which prohibited killing, injuring, capturing or any attempt of the same to elephants.
- The first direct codified law for wildlife protection was enacted by the British Government –The Wild Birds Protection Act, 1887 which prohibited possession or sale of any kind of specified wild birds.
- In 1912, the Wild Birds and Animal Protection Act was passed to fulfill the inadequacies of the Wild Birds Protection Act 1887.
- The Indian Forest Act, 1927, thereafter consolidated the law relating to forests and the transit of forest produce.
- The Forest (Conservation) Act, 1980 was enacted to further check deforestation.
- The Cruelty to Animals Act, 1960 and The Wildlife Protection act, 1972 were passed to protect, preserve and improve Wild Life.

The Wildlife (Protection) Act, 1972 was passed by the Parliament under Article 252 of the Constitution at the request of eleven states and was intended to provide a comprehensive National framework for wildlife protection and to adopt a conservation strategy for specified endangered species and provide for protection of all species in specified areas.

The Preamble of the Act Lays down, "An Act to provide for the protection of wild animals, birds and plants and for matters connected therewith or ancillary or incidental thereto with a view to ensuring the ecological and environmental security of the country."

The Act serves the Constitutional purpose mentioned under Article 48 A and Article 51 A(g) as it prohibits hunting of wild animals except in certain limited circumstances. The court has declared that the provision of the wildlife Act are salutary and are necessary to be implemented to maintain ecological chain and balance.

The provisions of this Act include:

- Establishing schedules of protected plant and animal species;
- Putting ban on the hunting or harvesting of these species;
- Protecting wild animals, birds and plants;
- Establishing a network of ecologically-important protected areas;
- Central and State governments are empowered to declare any area a wildlife sanctuary(Section 18), national park (Section 35), conservation reserve (section 36 A), community reserve (Section 36 C), or closed area under Chapter IV of the Act.
- Restricting sanctuaries, national parks and closed areas
- Putting a blanket ban on carrying out any industrial activity inside these protected areas;
- Prohibiting hunting of animals except with permission of authorized officer when an animal has become dangerous to human life or property or as disabled or diseased as to be beyond recovery;
- This Act extends to the whole of India, except the State of Jammu and Kashmir, which has its own wildlife act.

Some other facts about wildlife protection are as follows:

- Wildlife resources constitute a vital link in the survival of the human species, because every one of us depends on plants and animals for all vital components of our welfare. The whole environment runs in the form of a food chain and survival and dependence of all the species is vital and interdependent.
- India is the seventh largest country in the world and Asia's second largest nation with an area of 3,287,263 km2, a national border of 15,200 km, and a coastline of 7516 km.

- The earliest concern for wildlife could be traced to 3rd Century BC when King Ashoka enacted the law in a matter of preservation of wildlife and environment.
- The first direct codified law for wildlife protection was enacted by the British Government –The Wild Birds Protection Act, 1887 which prohibited possession or sale of any kind of specified wild birds.
- The Project Tiger was launched in the country on 14.04.1973 for conserving the endangered tiger. Initially, 9 Tiger Reserves were covered under the Project which have now increased to 28 reserves falling in 17 states.

15.3.3 Forest (Conservation) Act, 1980

The Forest (Conservation) Act of 1980 was enacted to curb and control deforestation. The legislation thus enshrined various provisions which are applicable to all forests notwithstanding the classification. The power of State Government related to use of forest land and preservation of forest resources, has also been restricted by the Act. Section 2 provides that the State Government shall not make amendments except with the prior approval of the Central Government. The Act further directs cessation of all such non-forest activities within any forest which are ongoing without prior approval of the Central Government.

Furthermore, an advisory committee shall be constituted under the Act to advise the Government with regard to the grant of approved by the Central Government (Section 2) or any other matter connected with conservation of forests which may be referred to it by the Central Government (Section 3).

15.3.4 Forest (Conservation) Act and Forest Policies in India (1952, 1988)

The Forest Conservation Act was amended in 1988 to strengthen the legislative framework required for conservation of forests and its resources. The amended Act provides that the aim of the Act is to ensure environmental stability and maintenance of ecological balance. Thus, derivation of any economic benefit from the environment is ancillary in nature. The Act advocates Joint Forest Management by giving usufruct rights for protection of forests.

Contravention of the provisions of the Act is punishable by imprisonment which may extend to a period of 15 days as per Section 3A. The Act also enshrines offences by the authorities and Government departments (Section 3B).

Forests are the sinks of carbon dioxide and they provide us much needed oxygen which is essential for the survival of living beings on the planet earth. Forests have much economic value for a nation, apart from being the sinks of Carbon dioxide. Therefore, protection of forest cover and forest conservation is a very important subject for any welfare government and accordingly, each nation sets its policy objective keeping in view national goals and situations prevalent in country.

Conservation of forests formed an integral part of the Vedic tradition of India as early as 300 BC. Vedic tradition, there were 'Van' (forests) were worshipped for they provided us with timber for fuel,food and other resources for survival on this planet. The Maurya kingdom recognized the importance of forests. During the reign of Chandragupta Maurya, an officer was appointed to look after the forests (K.S. Shobajasmin, 2013). Therefore, conservation and sustainable use of forests used to be an important subject since ancient times in India.

Forest Policy is the set of principles and guidelines devised by each country keeping in view its economic, ecological, social and political factors for protection, conservation, development, use and exploitation of forest resources with the aim of sustainable development. Forest Policy sets the targets and paves the way for channelization of various executive, policy and legal measures for achievement of those objectives. The Policy is not a tangible document in the sense of a master plan, but a participatory process with defined outputs. It is a long-term process, composed of various elements, including the country policy and legal framework related to forests, the participation mechanisms, and the capacity-building initiatives. (Aditya Kumar Joshi et al, 2010). The forest policy is a complex balance between economic, social and political objectives in an environment where the forests and the institutions continuously change (Kant, 2003). Forest Policy encompasses not only development, protection and conservation of forests but also targets regarding use and exploitation of forest resources and accordingly subjects like timber needs, pricing, trade, developmental needs, property rights, forest dwellers rights, forest management etc are all included in the dynamic forest policy document.

Evolution of National Forest Policy in India

National Forest Policy (NFP) is a dynamic document and is liable to change over a period of time in consonance with socio-economic and political objective of the government. NFP of India has also undergone various changes over a period of time since its inception. In this section, an attempt will be made to trace the origin of NFP and objectives, goals and drawbacks of the same.

The origin of NFP can be traced back to 1854 when McClelland submitted a report to Government of India wherein he suggested restrictions on the exploitation of forests by private individuals. The report submitted by McClelland became a basis for the preparation of Charter of the Indian Forests by Lord Dalhousie in 1855 (L. Ravi Shankar, 2008). It contained outline for the forest conservation.

Thereafter, Indian Forests Act, 1865 was enacted which established State monopoly over Indian forests. Forest Department was established in 1864 and the organized forestry activities began in 1864.The then government took help of German Forester Dietrich Brandis, who was brought to look into the process of forest resource management in India (Mishra, 1999). Brandis emphasized the importance of forest on climate, rainfall, and irrigation sources as a strong tool for the imposition of state control over forests.

Forest Act of 1865 was succeeded by Forest Act of 1878. Act of 1878 classified forests into reserved forests, protected forests and village forests. It established State control over all wastelands. The Act took away the rights of local communities and forest dwellers regarding exploitation of forests particularly in case of protected forests. The Act also declared enacted penal provisions punishable with imprisonment and fines. Therefore, State control over forests was established like never before.

Forest Policy 1894

The report on Improvement of Indian Agriculture submitted in 1893 by J.A. Voelekar, Superintendent of Forests became the basis of Forest Policy, 1894. Accordingly, first Forest Policy of India was declared on 19th October 1894. Prior to 1894, forests were basically the property of Zamindars and Princes and there was no uniform management policy regarding forests. Policy of 1894 emphasized commercial exploitation of forests and promoted use of lands for agriculture. The policy treated forests as a commercial resource rather than the life-blood of human society which needed protection and conservation.

Forests were classified into four categories under the FP, 1894. The first category of forests needed protection as these were situated on hill slopes and were essential to protect the cultivated plains from landslides and they played a conservation role for the benefit of cultivated plains and assured revenue to the state. The second class of forests consisted of valuable timber trees like Devdar, Sal, Teak etc. Due to the precious timber value, regeneration was promoted for expanding commercial exploitation. Next category of forest were the forests producing minor produce and fuel-wood which was required by the local communities and forest dwellers. Fourth category consisted of grazing lands which were needed by the locals for grazing their cattle. (K.S. Shobajasmin, 2013).

The FP, 1894 was the first formal policy documents dealing with uniform management of forests under the control of Forests Department, yet the policy had various demerits. It did not apply to forests owned by government. The main aim of this policy was commercial exploitation of forests than preservation and conservation. Therefore, it promoted conversion of forest land into agricultural land and failed to restrict shifting cultivation. Hardly, any effort was made to protect wild life which is essential part of forests.

National Forest Policy 1952

Forest Policy, 1894 was formulated in the pre-independence period when India was under colonial rule. The main aim of that policy was commercial exploitation than conservation and protection. As such, the policy was bound to change after independence. Independence of India followed by enactment of the Constitution of India laid the foundation for a more comprehensive forest policy in conformity with the socio-economic welfare of the masses. Accordingly, new NFP was formulated on 12th May 1952 for making the policy consistent with the goals, targets and policies of independent India where the thrust was on conservation and protection coupled with sustainable use and exploitation of forest resources. NFP, 1952 set the target of having atleast 1/3rd of the total geographical area of the country to be under forest and tree cover. The policy laid stress on economic exploitation coupled with sustainable use of forests. The demand for forest produce was increasing with increased industrialization and the use of forest produce in defense, railways and industries and other national needs. Accordingly, the pressure on forests was ever increasing. In this backdrop, NFP 1952 was formulated with increased focus on conservation and having the forest cover upto 1/3rd of the geographical area and also meeting the use of forests to meet national needs. Policy also laid stress on control over denudation in mountainous regions, control over erosion of river banks and shifting sand dunes.

NFP, 1952 classified the forests as

- National Forests
- Protected Forests
- Village Forests

NFP, 1952 laid stress on preservation of protected forests since they are situated on hill slopes and thus play an important role in protecting soil erosion and plains from floods etc. National Forests constitute valuable timber and hence are vital for the development of the country and therefore, is sustainable management is required. Village forests are basically meant to meet the needs of the local community regarding fuel wood and minor forest produce. Later an year after, forests under Zamindars were nationalized.

However, the policy suffered from various drawbacks and was basically an extension of FP, 1894 with emphasis on maintaining 1/3rd of the area under forest cover. However, Imperial approach of treating forests as revenue resource continued. Hence, the immense pressure on forests and excessive use of forests led to depletion of forest cover thereby necessitating change in NFP.

National Forest Policy, 1988

NFP, 1952 was influenced by FP, 1894. Initially, there were no express provisions in the Constitution of India dealing with forests, forestry etc. However, Constitution (Forty Second Amendment) Act, 1976 inserted Article 48A which provided inter alia for protection of forests and wild life. This apart, legislative competence to enact laws on Forests and Protection of Wild animals and birds was also conferred concurrently on both the Union and State governments by inserting entries 17A and 17B respectively. Accordingly, both the layers of government can enact laws to protect, safeguard regulate and manage the forests. Union has enacted various forest legislations which will be discussed in the next section of this paper. However, 'forests' being in the concurrent domain, the implementation of the system has been devolved upon the States. These changes coupled with failure of NFP 1952 to

meet the changing situations, forced the adoption of new NFP in 1988.

NFP, 1988 was formulated on 7th December 1988 with the basic objective of maintenance of environmental stability and restoration of the ecological balance. NFP, 1988 has helped in the stabilization of forests in the country over around three decades despite huge pressure on the forests due to increasing population and rampant industrialization. The objectives of NEF 1988 were:

- Ensuring Environmental stability
- Promoting Conservation of forests
- Checking soil erosion and denudation in the catchment areas of rivers, lakes, reservoirs
- Checking the extension of sand-dunes in the desert areas of Rajasthan and along the coastal tracts.
- Increasing substantially the forest/tree cover in the country
- Meeting the requirements of fuel-wood, fodder, minor forest produce and small timber of the rural and tribal populations.
- Increasing the productivity of forests to meet essential national needs.
- Encouraging efficient utilization of forest produce and maximizing substitution of wood.
- Creating a massive people's movement with the involvement of women

The essentials of forest management under the NEF 1988 are summarized as under:

- Protection of Existing Forests
- Increasing forest and vegetal cover on hill slopes, catchment areas of rivers etc
- Discouraging diversion of good agricultural land to forestry
- Creating and strengthening network national parks, sanctuaries, biosphere reserves and other protected areas

- Making adequate provision for fodder, fuel, pasture etc. in forests adjoining areas
- Emphasis on Afforestation
- Enhancement of production of minor forest produce

NFP, 1988 has aimed at having at least 1/3rd of the total geographical area under forest and tree over. In case of hilly and mountainous area, the aim is to have minimum of 2/3rd area under forests and tree cover. More particularly in hilly slopes, the attempt is to prevent denudation so as to protect the plains from floods.

NFP has stressed upon undertaking afforestation programmes. In this context, following strategy is devised:

- To launch massive afforestation programmes
- Planting of trees alongside of roads, railway lines, rivers and streams and canals, and on other
- unutilized lands under State/corporate, institutional or private ownership
- To develop Green belts in urban/industrial areas
- Development of tree cover and fodder resources on Village community lands
- Regulation of felling of trees on private holdings

Management of State Forests

Management of State forests is an important component of forest policy. State forests have traditionally been used by forest dwelling communities. However, their rights were restricted by successive colonial interventions and post-colonial policies also. In this context, management of state forests in consonance with national objectives while at the same time recognizing the right of the forest dwellers and local communities is important. NFP has formulated following strategy regarding management of State forests

- Regulating and restricting development schemes having adverse impact on forest cover on hill slopes, catchment areas of rivers etc.
- Approval of management plans of forests
- Central Government to ensure implementation and monitoring

- Enhancement of forest cover and forest productivity
- To reduce the gap between demand and supply of fuel-wood

Rights and Concessions

As stated earlier, the state forests have traditionally been used by local communities for meeting their needs, accordingly strategy dealing with management of state forests has recognized limited rights of local communities. The rights and concessions are as under:

- Grazing rights to be commensurate with carrying capacity
- To encourage stall feeding of cattle
- Rights and Duties of communities living in and near the forests
- Making available to STs and forest dwellers fuel-wood, minor produce etc. at reasonable prices
- To encourage substitution of wood in industry
- To encourage substitution of Fuel-wood with alternate sources like bio-gas, LPG and solar energy

Diversion of Forest Lands for Non-Forest Purposes

Generally diversion of forest lands for non-forest purposes should be discouraged. In this context, following strategy has been adopted:

- Forest land should be treated as a national asset and therefore, its diversion for non-forest purposes is not preferred and it calls for strict regulation of diversion of forest land for non-forest purposes
- Development activities to be in harmony with the need for conservation of trees and forests
- Liability of mining/quarring agencies to re-vegetate the area
- Mine Management plan should be taken from the beneficiaries of mine and it should be in conformity with NFP

Tribal People and Forests

There has been an historical and traditional association of tribal people with forests. They have rights over the use of forest land since times immemorial and therefore, they have a greater stake in sustainable use of forests. Accordingly, NFP strategizes associating tribal people in forest management. In this regard, following steps are mulled:

- To associate tribal people in the protection, regeneration and development of forests
- Contractors should be replaced by tribal cooperatives, labour cooperatives, government corporations, etc.
- To ensure development of forest villages at par with revenue villages
- To launch Family oriented schemes for improving the status of the tribal beneficiaries
- To initiate integrated area development programmes to meet the needs of the tribal economy in and around the forest areas

Shifting Cultivation

Colonial regime promoted diversion of forest lands for agricultural purposes so as to generate more revenue. Forests were treated as revenue resource and were meant for exploitation. Increased emphasis on agriculture lead to shifting cultivation wherein the land after being put to agricultural use is left unused for some time so that it can gain productivity again the cultivation is shifted to another piece of land usually forest land. It had led to depletion of forests and their conversion into agricultural tracts. NFP has recognised the need to contain the problem of shifting cultivation and has provided the following strategy to deal with the situation

- Alternatives to shifting cultivation should be adopted and encouraged

Emphasis should be on rehabilitation of areas already damaged by cultivation through social forestry and energy plantations

Damage to Forests from Encroachment, Fires and Grazing

Over the years, encroachment on forest lands has become a serious concern and it has adversely affected forest management. NFP, 1988 recognized and accepted this as a fact and called for checking the increasing incidence of encroachments.

Further, the incidents of forest fires have also restricted and mitigated the efforts of the government regarding preservation and conservation of forest, flora and fauna and wildlife. In this context, NFP called for reducing and controlling forest fires to prevent damage to forests

Unrestricted and unregulated grazing in forests can cause loss to growing plants and is harmful in the long run, therefore, NFP made it imperative to control, regulate and restrict grazing in forests. Further, in India, it has been seen that people maintain large herds of non-essential livestock and the emphasis is rather on quantity than on quality. This puts pressure on forests accordingly, NFP aimed at discouraging people from maintaining large herds of non-essential livestock

Forest Based Industry

NFP 1988, promulgated the following strategy regarding forest based industry

- Forest based industry should develop self-sufficiency in Raw material by regenerating and vegetating the area
- Such industries should be subject to careful Scrutiny before they are allowed to operate
- To provide employment to local people in raising trees and raw-material
- Encouraging farmers to grow wood species on marginal/degraded lands
- Natural forests not to be made available to industries for undertaking plantation and for any other activities
- Encouraging industry to use alternative raw materials

Forest Extension

As stated earlier, NFP aimed at having atleast 1/3rd of the total geographical area under forest cover. Therefore, it is required to enhance the present coverage of area under forests. For this purpose, policy proposed the following strategy

- Training in silvicultural and agri-silvicultural techniques at Krishi Vigyan Kendras, Trainers' Training Centres
- Educating the farmers
- Forestry Education
- Sustainable forest management is not possible unless, forestry education is promoted and encouraged. In this context following steps are recommended by NFP
- Forestry as a scientific discipline and a profession
- Promotion of research in agricultural universities

- Higher Forestry education should be a qualification for Indian Forest Service and the State Forest Service

15.3.5 Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006

This Act under Section 4 has recognized the failure of earlier forest policies in recognizing the rights of forest dwellers, due to which discrimination has been meted out against them. Thus, the legislation endeavors to reverse the historical injustice done to the forest dwellers and tribal people. It was for the first time that through this Act the rights of the forest dwelling people got recognized in the Indian forest policy formation. Traditionally the forest dwellers held only the right to collect and use the forest produce. Howbeit, the Act of 2006 now recognizes the rights of Scheduled Tribes and Forest Dwellers including right to forest land in terms of living, holding, occupying the forest land under (Section 3).

Along with various rights, the Act also provides for certain duties of the forest dwellers to protect the wildlife and diversity of the forests and to promote sustainability in the ecological areas. Furthermore, Section 6 of the Act empowers the Gram Sabha for deciding upon the community rights and that of the individuals in the areas that has been marked as forest areas.

Hence, with the inclusion of forest communities in forest conservation policy, there is a radical shift in the governance and management of the forests.

15.3.6 Forest Rights Act, Amendment Rules, 2012

To ensure that the intended benefits of this welfare legislation flow to the eligible forest dwellers and to strengthen Forest Rights Act, the Ministry has notified the Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Amendment Rules, 2012 on 6.9.2012.

The quorum of the Gram Sabha shall be reduced from 2/3 to 1/2 of the members to ensure that at least fifty percent of the claimants are there. The resolution to pass any claims shall be held in the presence of these claimants so there was a majority present between those voting for these rights. Rejection or modifications are to be communicated to the claimants and reasonable time shall be given to the claimant in case he decides to file a petition against the decision. Further, a procedure shall be laid down for identification of the village forests and similar laws shall be made for bringing them in to the main stream. The Scheduled Tribes in the Forest Rights Committee shall be represented by 2/3 rather than 1/3 as was earlier represented.

Furthermore, there shall be modification of the transit permits when there is transportation of the minor forest produce. Such modifications shall be done only by Committee constituted by Gram Sabha or a person authorized by the Gram Sabha. The royalties and other MFP related revenue shall be collected by these committees. The idea behind this is to recognize the rights of the forest dwellers and ensure sustainable development through localization of the laws. The rights of forest dwellers shall be recognized by all the villages.

15.3.7 The Biological Diversity Act 2002

After an extensive and intensive consultation process involving the stakeholders, the Central Government has brought Biological Diversity Act which was enacted in the year 2002. The genesis of the law can be traced to the Convention on Biological Diversity (CBD), which was signed at the Rio Summit in 1992.The Act prescribed an institutional framework in order to implement the three Convention objectives of conservation, sustainable use, and equitable sharing of benefits arising out of the use of biological resources and related knowledge. Salient Features of the Act are as follows:

- To regulate access to biological resources of the country with the purpose of securing equitable share in benefits arising out of the use of biological resources; and associated knowledge relating to biological resources;
- To conserve and sustainably use biological diversity;
- To respect and protect knowledge of local communities related to biodiversity;
- To secure sharing of benefits with local people as conservers of biological resources and holders of knowledge and information relating to the use of biological resources;
- Conservation and development of areas of importance from the standpoint of biological diversity by declaring them as biological diversity heritage sites;
- Protection and rehabilitation of threatened species; and

- Involvement of institutions of state governments in the broad scheme of the implementation of the Biological Diversity Act through constitution of committees.

References

Adapted from E-PGPathshala

Paper No: 13 Environmental Law and Policies Module: 29 Agenda 21 and Rio +20

Paper No: 13 Environmental Law and Policies Module: 05 The Wild Life (Protection) Act, 1972

M03- 1512112878Module03Learnmore Indian Forest Act, 1927

M05- 1512112546module_05_etext The Wild Life (Protection) Act, 1972

M06- 1511784973Paper13_Module_06_Learnmore Scheduled Tribes and Other Traditional Forest Dwellers

M07- 1512113718module_7_etext The Biological Diversity Act, 2002

M08- 1513143078Module_8_e_text National Forest Policy, 1988

M12- 1512113087module_12_etext The Environmental (Protection) Act, 198