1

ECOLOGY: CONCEPTS AND APPLICATIONS

Unit Stucture :

After reading this chapter you will be able to understand the following:

1.1 OBJECTIVES

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

- Know the concept of ecology and its various components.
- Understand the cyclic process of circulation of nutrients viz., phosphorus, nitrogen and carbon.
- Learn the flow of energy, trophic levels and energy pyramids.
- Study life on land and in water through the example of a land-based and water-based ecosystem.

1.2 INTRODUCTION

Planet 'Earth' is indeed a very unique planet. This uniqueness is not just because of the fact that it is the only planet where life evolved some 3-4 billion years back, but also because of the diversity which exists among the living organisms in the form of microorganisms, vegetation, animals, birds, insects, etc. This diversity is extensive and distinctive too. This diversity evolved and has sustained because of the different non-living features which form the interior of the earth, lithosphere, hydrosphere and atmosphere. The interactions and the interdependence between the non-living and the living world are necessary for the evolution and sustenance of life on the earth's surface. Life underwent various stages of evolution and can be seen living and working on the planet in the form of different species and organisms. Human beings are the most dominant species present today on the planet in two ways – in the form of numbers (the total population of human beings as of today on earth is around 7 billion) and in the form of impact on the planet through the use of their intelligence, wisdom, knowledge and skills. Throughout the development of human civilisation on this planet, it is evident that human species has had a more profound impact on planet earth in terms of modifications and alterations done to the surroundings with the help of technology.

1.3 SUBJECT DISCUSSION

The surroundings or the environment which are present around any organism play an important role in the growth and development of that organism. There exists a give and take relationship between the organism and the environment. The environment provides food, water, shelter and other resources to the organism necessary for its survival. Similarly, the organism also influences the environment in various ways. For example, human species has maximum impact on environment because of use of technology and their skills for construction of settlements, industries, transport lines, etc. Ecology is a science that helps us to understand the relationship between the environment and various living organisms.

1.4 INTRODUCTION TO ECOLOGY AN OVERVIEW

Ecology as a science got its separate identity because of the efforts of German biologist, Ernst Haeckel in 1869 who coined the term '*oecology*'. It has its origin in two Greek words, '*Oikos*' which means 'a house or a dwelling as a habitat' and '*Logos*' which means 'the study of'. Thus, ecology means a study which understands the relationship between living organisms and their surroundings or environment. E. P. Odum later in 1960s proposed that with changing times there has been a need to widen the traditional definition of ecology. Odum said that ecology is the study of the structure and function of ecosystems. The definition focussed on the fact that ecology not only studies the inter-relationship between nature, the living and non-living components of the environment but also the individual functioning of these components in an orderly manner in the form of a system.

Initially the scope of ecology was focusing on the interactions between the biotic and abiotic components of the environment. But over a period of time the scope of ecology has undergone a drastic change. As human civilisation has made progress in terms of humans understanding about nature, use of skills, knowledge and technology by human beings to extract resources from the environment the scope of ecology has expanded. Human population has been increasing and this increasing population has been demanding various resources for their survival on the planet and also to modify their lifestyle. Thus, the relationship between humans and environment has undergone a drastic change. With this changing relationship new terms and concepts have been introduced in ecological studies and therefore ecology as a subject has been dynamic in nature. The aims, objectives, scope and approaches with reference to ecology can be divided into following four phases:

- Phase- I which am considered upto World War I. During this phase the studies were focussed on understanding the evolution and history of flora and fauna and the inter-dependent relationship between plants and animals with reference to their habitats, etc.
- Phase – II lies between World War I and World War II. During this period more emphasis was given on laboratory-based experiments and analysis like pollen analysis, etc. and use of statistical techniques in the field of ecological studies.
- Phase – III was from the end of World War II (approximately 1945) to 1960. This period saw the use of systems analysis in research related to ecology. The relationship between various organisms and their surrounding were studied through more practical experiments. Major processes related to ecological science were studied during this phase.
- Phase – IV started from 1960 onwards. This phase has been responsible for focusing more on the application of ecology in conservation of nature and management of environmental problems.

As a science, studies and research in ecology has been done since the beginning of 19^{th} century. Scientists from various fields of knowledge like Ernst Haeckel, Isodore Geoffrey, St. George Jackson Mivart, E. P. Odum and many more have contributed towards the development of various concepts in ecology. The conventional view point of the studies done in this subject was to understand the relationship between living organisms and the environment but gradually it has been extended to the following areas of research:

- Relationship between the living and the non-living components of environment.
- The relationship between the living, non-living components of the environment and their surroundings.
- Impact of humans on their environment.

- Changing relationship between humans and environment during various phases of human evolution and civilisation.
- Problems like increasing human population, depletion of natural resources, role of technology, accelerated economic development, change in life styles, etc. and degradations of environment.
- Application of technology to understand the ecological problems and suggest solutions to these problems.

Thus, over a period of time, this subject has undergone a drastic change and has extended research in the areas of plant and animal ecology, agricultural ecology, rural ecology, industrial ecology and so on.

Key concepts in ecology:

- Ecosystem is a basic unit of study which is a combination of the living organisms, non-living factorsand energy. It is a functional unit which is run by solar energy. This energy from the sun is taken up by the green plants thatprepare food by undergoing the process of photosynthesis and use other elements from the environment. This food energy is then circulated among the biological communities.
- Ecosystem functions at different spatial and temporal scales. Starting from a micro-level like a pond ecosystem towards the entire earth's surface functioning as an ecosystem. It also functions with reference to time. Thus, both spatially and temporally the ecosystem keeps on changing making it a dynamic entity.
- An ecosystem is an open system where there is exchange of energy and matter.
- Ecosystem tries to maintain stability and equilibrium but can be affected by certain disturbances.
- An ecosystem is a reservoir which provides the human civilisation with various natural resources like rocks, minerals, soils, energy resources etc.

1.5 NUTRIENT CYCLING : PHOSPHORUS, NITROGEN AND CARBON

An ecosystem being an open system, there exists an exchange and circulation of energy and nutrients from one component to another one. This cyclic movement consists of creation, maintenance and destruction of matter. It is a process which goes on and on. Hence inspite of the fact that some resources are available on a limited quantity on the earth's surface, these resources are made available because of their cyclic circulation in the environment.However due to misuse of technology by human beings many renewable resources today are becoming scarce and these resources are likely to vanish from the earth's surface.

This cyclic movement of biological, geological and chemical resources is termed as the biogeochemical cycle. There are several sub cycles that function on the earth's surface and circulate the nutrients and energy. These cycles are circulating elements from the abiotic components to the biotic world and then back to the abiotic components.

Among these elements water is a very significant resource because it helps in the circulation of various organic and inorganic components in the earth-atmosphere system and without water life would not have evolved and sustained on the earth's surface.

Phosphorus Cycle: The second most important element is phosphorus. Availability of phosphorus is mostly in the form of phosphate rocks (in solid form) and in a very small quantity in the gaseous form. But still, it is necessary for the growth of living organisms. Phosphorus cycle is very slow and most of the phosphorus is circulated from land to the oceans. Phosphorus is stored in sedimentary rocks and when these rocks undergo the process of weathering phosphorus is available in the soil. In the soil it mixes with calcium, magnesium, potassium and iron. As phosphorus does not easily dissolve in water only ten percent of phosphorus circulates in the cyclic path.

Inorganic phosphorus is available to plants from the soil through the process of absorption. It is converted into organic form by the plants. From the plants then phosphorus is circulated to the other trophic levels in the food chain. Phosphorus is returned back to the environment after the plants and other living organisms die through the processes of decomposition and mineralisation of organic forms of phosphate. Phosphorus is also made available to the crops and plants in the form of fertilisers.

Nitrogen Cycle: Nitrogen is another important element which is necessary for the development of living organisms and is available to the living world in the form of amino acids and proteins. It occupies about 78% of the gaseous composition of the atmosphere. Nitrogen is present in various forms of oxides and compounds on the earth's surface. Although it is present in abundance, living organisms cannot take it directly from the atmosphere. They have to depend on some other source for having access to nitrogen compounds.

Following are the steps involved in the nitrogen cycle:

- **Lightning :** Nitrogen and oxygen from the atmosphere combine due to lightning and form nitric oxide. Nitric oxide further oxidises to form nitrogen peroxide which reacts with water to form Nitric acid. This Nitric acid from the atmosphere combines with rain water and falls on the soil. These nitrogen compounds present in the soil are then used by plants for their growth and development.

- **Nitrogen fixation through biological activity :** This is also a natural process of fixing nitrogen. There are two types of organisms that fix nitrogen. The first group consists of free-living bacteria and algae and

the second group consists of some autotrophic blue green algae and bacteria which live in a symbiotic relationship with the green plants. Similarly on the root nodules of leguminous plants (like green peas, soya bean, gram, peanuts, etc.)the bacteria which are present help in the fixation of atmospheric nitrogen and supply the nitrogen compounds in the form of amino acids to the plants. Even in the oceanic surface, nitrogen fixation is done by blue green algae and bacteria.

- **Artificial fixation :** In this process chemical fertilisers containing nitrogen compounds like ammonium sulphate, nitrates, etc. are manufactured and used in agricultural operations in order to make the soil rich in nitrogen.

Organic nitrogen compounds are converted into inorganic form as ammonia or ammonium which is further converted into nitrites and/or nitrates. This process is called as nitrification. Plants take up nitrogen from the soil and use it for their own growth and development. Subsequently, this nitrogen which is in the form of proteins is transferred to different organisms present at different trophic levels in the food chain. The protein present in the organisms will disintegrate into amino acids, urea, etc.

Denitrification : It is the process opposite to nitrification. The body waste of various organisms and the dead remains of plants and other living organisms contain amino acids, urea, etc. these nitrogen compounds are released back to the environment by another set of bacteria called as the denitrifying bacteria. So,the balance of nitrogen on the earth's surface is the combined efforts of the two processes – nitrification and denitrification. Thus, the nitrogen cycle gets completed.

However, in the present times the natural functioning of the nitrogen cycle has been disturbed due to human intervention. This is because of excess application of nitrogen rich fertilisers to the soil; agricultural lands all over the world are heavily polluted. The excess fertiliser mixes with rainwater and gets leached into nearby water bodies. The nitrogen fertiliser present in the water body results into eutrophication. Eutrophication is a process by which due to the presence of excess chemical fertilisers the growth of water weeds like water hyacinth is enhanced which uses the dissolved oxygen present in the water bodies for decomposition of the dead organisms in the water bodies and this process makes the water body dead for living organisms.

Carbon Cycle : Carbon is present in three different forms on the earth's surface. In the gaseous form it is available as carbon monoxide, carbon dioxide etc. In the liquid form it is available as carbon dioxide dissolved in water and in the solid form it is available as fossil fuels, carbon stored in sediments and as organic matter.

Carbon cycle functions at different levels. It enters the biotic world through the process of photosynthesis. Wherein, plants take up carbon dioxide from the atmosphere and along with sunlight, water, chlorophyll

and other nutrients from the soil, they prepare food. This carbon is stored in the green plants as woody tissues and is present in a large quantity in the form of different types of forests present on the earth's surface. The carbohydrates generated by vegetation at trophic level one is passed on to the other organisms and consumed by them through the food chains.

Living organisms undergo the process of respiration through which carbon is released. Similarly, the process of decomposition of dead organic matter like fallen leaves, dead remains of plants and animals, body waste of animals, etc. also releases carbon dioxide back to the environment. The process of combustion or burning of fossil fuels like coal, petroleum, natural gas, etc. also releases carbon dioxide.

Some carbon is also stored in the form of sediments (like shells, bones, etc.) on the earth's surface. Similarly, the organic matter present in vegetation, animals, etc. is buried underground and remains there for a very long geological time. This energy present in the living organisms gives rise to the formation of fossils. Sedimentary carbon is released through the processes of weathering and erosion of rocksand also through volcanic eruptions.

A huge amount of carbon dioxide is absorbed by the marine plants that are present in seas, oceans and other marine ecosystems. Hence oceans are considered as carbon sinks. This carbon absorbed the planktons (aquatic vegetation) is used by them for photosynthesis and then the carbohydrates are passed on to the other organisms in the aquatic food chain. A huge amount of carbon sediments are also deposited and stored on the ocean floor giving rise to the formation of coral reefs, sedimentary rocks, hydro carbons, etc.

A huge amount of carbon is released due to heavy deforestation, increasing population, increasing industrialisation, urbanisation, transportation, etc. The disturbances caused in the natural functioning of the carbon cycle has resulted in Green House Effect – Global Warming and Climate Change resulting into melting of glaciers, rise in sea level, heat and cold waves and so on.

1.6 ENERGY FLOWS- TROPHIC LEVELS - ENERGY PYRAMIDS

Energy plays a very vital role in the functioning of the earth-atmosphere system. The major source of energy is the sun and some other sources of energy consist of the geo-thermal energy, cosmic radiation, energy from fossil fuels and so on.

The solar energy is absorbed by the green plants and then converted into food energy through the process of photosynthesis. Part of this energy is used by the plants themselves for their growth and development and remaining part of the energy is passed on to the other organisms. Hence it is said that the flow of energy on the earth-atmosphere system is unidirectional. This circulation of energy occurs through various trophic

levels giving rise to the formation of different food chains and food webs that function in a variety of ecosystems that are present on the earth's surface. The process of conversion of light energy into food or chemical energy resulting in the formation of biological matter or tissues in organisms is called as biosynthesis. The process by which biological matter degrades and decomposes and the energy stored in it is sent back to the environment is known as biodegradation.

The law related to energy that energy can neither be created nor be destroyed but it changes its formis applicable to the ecosystems too.

Food chain : A food chain refers to the sequential transfer of food energy from the autotrophs (green plants) to heterotrophs (herbivores, carnivores and omnivores) and the detritivores in an ecosystem. For example, grass is eaten by a grasshopper that is further eaten by a frog and frog can be eaten by a snake.

Food web : A complex combination of different food chains gives rise to a food web. In case of a food web various organisms can be a prey or a predator of other organisms. For example, a hen can be eaten by a snake, a fox or even by human beings. Similarly human beings can eat fish, meat and vegetables.

Trophic Levels : The term trophic level refers to the level of nutrition or nourishment in a food chain. In other words, it is the movement of food energy from one level of organisms to another level. This concept was put forward by R. L. Lindman (1942). The green plants are located at trophic level onebecause they initiate the process of energy conversion and transfer through the process of photosynthesis. Hence green plants are also called as autotrophs or self-nourishing organisms as they can prepare their own food. About 90% of energy is used by the plants for their respiration and development and only 10% of energy is passed on to the next level of organisms.The herbivores or the grass eating organisms (hens, grasshoppers, elephants, etc.) are located at trophic level two who consume green plants and thus obtain energy from them. This energy from the herbivores is passed on to the carnivores (frogs, snakes, tigers, etc.) or the flesh-eating animals that form trophic level three when they eat the herbivores. The omnivores for example, human beings are located at trophic level four who can feed on both the green plants as well as the flesh of organisms.

At different trophic levels some amount of energy is released in the form of waste (urine, dung, excreta, etc.) and when organisms die the process of releasing the energy locked up in the waste products and dead bodies of plants and animals is done by the decomposers or the detritivores who are responsible for the release of energy back to the environment.

Ecological Pyramids : An ecological pyramid can be defined as a pyramid in which there is decline in the total number of species, the total biomass and the available energy from lower trophic levels to higher ones.

Following are the three types of ecological pyramids:

1. **Number Pyramids :** This type of pyramid includes the total number of species of organisms at different trophic levels. It does not include the size of the organisms. A huge variety of species are found at trophic level one (among green plants) as compared to trophic levels three or four. For example, if a deer (a herbivore at trophic level 2) is eating grass (autotroph at trophic level 1) then large number of grasses should be available to feed the organisms at trophic level 2.

2. **Biomass Pyramid :** Biomass refers to the biological matter present on the earth's surface. The biomass pyramid represents the total biological matter present at each trophic level in an ecosystem.

3. **Energy Pyramids :** The energy pyramid represents the total amount of energy transferred from one trophic level to another. The energy pyramid helps in understanding the productivity of an ecosystem.

1.7 LIFE ON LAND AND WATER

It is a known fact that planet earth is the only known planet so far which consists of life supporting elements and because of which life has evolved on this planet and it sustains here. Lithosphere or the land area present on the planet occupies about 29% of the earth's surface whereas the Hydrosphere or the water bodies occupy about 71% of the area. Both land and water support life in various ways.

Land areas can be further divided into various physiographic features like mountains, plateau, plains, coastal plains, islands, etc. These are further made up of rocks, soil, minerals and other elements. Various types of plants, animals, birds, insects, human beings need the support of the land surface for living on this planet. Hence planet earth is characterised by various land-based ecosystems which are rich in diverse living organisms. For example, forest ecosystem, desert ecosystem, and so on. Forests cover about 30% of the land area on the earth's surface. They play a significant role in maintaining the oxygen-carbon balance, provision of food and various other ecological and economic services.

Due to the advancement made by human civilisation in the present times land is under heavy pressure because of various human activities like agriculture, industrialisation, urbanisation, etc. Land is also getting degraded because of pollution, dumping of waste, etc.

Water is necessary for life to sustain on the planet because it is the element through which various nutrients are circulated on the earth's surface and also it helps in the circulation of nutrients in the living organisms. Water surface differ in features in various parts of the earth's surface based on temperature conditions, salinity, density and so on. Like land surface, water surfaces also support different types of ecosystems like marine ecosystems, mangrove ecosystems and so on.

Because of human interference, water surfaces are also affected by pollution, climate change and other problems of environmental degradation.

Importance of Solar energy and Ocean water :

Solar energy : Sun is the centre of our galaxy (Milky Way) and also the closest star to the earth located at a distance of 150 million kilometres.The gravitational force exerted by the sun keeps the planets at their defined positions and this force is important in maintaining the balance in our planetary system. Being a star, sun emits radiation which is the principal source of heat and light. Solar energy is necessary for the living as well as the non-living world. It was because of the availability of solar energy that life evolved and has sustained on the earth's surface. Sunlight is necessary for plants to undergo the process of photosynthesis by which plants prepare food. This food is then circulated among the other living organisms in various ecosystems. Solar energy is also necessary for circulation of other elements in nature like the functioning of water cycle where water evaporates because of sun's heat followed by condensation and precipitation. Solar energy is necessary for cloud formation, circulation of winds and many such climatic phenomena which are directly or indirectly necessary for life on the earth's surface. Solar energy is also a source of light as today with advanced technology sunlight can be trapped and used in generation of electricity. Thus solar energy is significant in helping the development of agriculture, industry, transport, communication and other sectors of the economy.

Ocean water : 71 percent of the earth is covered by hydrosphere and about 97 percent of water is saline present in seas and oceans. Therefore ocean water like sunlight also plays a pivotal role in sustenance of life on planet earth. Ocean water provides moisture for cloud formation; it acts as a carbon sink, absorbs solar radiation forms ocean currents and maintains the heat balance on the earth; preserve a variety of organisms through the marine ecosystems, coral reefs and so on. Ocean water is also a source of numerous salts and minerals like chlorine, sodium, magnesium, etc.

Hot desert ecosystem (Terrestrial) : Geographically a desert can be defined as an area which experiences dry or arid type of climate with very negligible rainfall and a poor, immature soil profile. A desert area may receive rainfall which can be less than 50cms annually and experiences extreme temperature conditions that is very high temperature during the day (45-50 degrees Celsius) and very cold temperature during night (5-10 degrees Celsius). Deserts can be of two types: Hot desert and Cold desert. Because of very less precipitation and poor soil profile, the number of producers (vegetation) found in a desert is very limited but yet it supports various organisms in the higher trophic levels. The organisms found in the deserts have adapted to very extreme climatic conditions.

Hot and dry desert ecosystem exists in South Asia (Thar desert), North America, Africa (Sahara and Kalahari Desert), etc. Desert ecosystems are fragile in nature. But inspite of very extreme climatic conditions, the

desert ecosystems have an elaborate food chain where all the organisms have very well developed adaptation mechanism to the harsh environments. These different organisms found in a desert ecosystem are explained below:

Producers : Cacti and thorny plants (acacia variety) which are covered by thorns and can store water in the fleshy mass present on the plant body.

Herbivores : Camels, deer, antelopes, sheep and goats.

Carnivores : Wolves, jackals, scorpions, snakes, etc.

Decomposers : Millipedes, termites, earthworms, protozoa and bacteria.

Polar ecosystem (Aquatic) : These ecosystems are located between the Arctic and Antarctic circles and the poles. These ecosystems occupy about ten percent of the earth's surface and belong to the permafrost category.

The Arctic Region : The Arctic region experiences only two seasons: summer and winter. The average temperature ranges between -40 degrees Celsius in winter to 10 degrees Celsius in summer along with extreme winds. This region experiences six months of day and six months of night and hence is also known as the 'land of midnight sun'. The growing season is very short and hence most of the Arctic region is devoid of trees and only short plants grow.

Inspite of limited vegetation, this region is a very productive ecosystem with a huge variety of fishes and migratory birds.

Producers : The summer months in the Arctic region are from March to September when the sun is present in the skies throughout the summer. Constant availability of sunlight allows the growth of microscopic phytoplankton and ice algae. The food produced by these autotrophs supports an elaborate ecosystem.

Consumers : Jellies and shrimps form the primary consumers (herbivores). Blue whales, Bowhead whales, seals, walruses, sea lions etc. form the secondary consumers (carnivores).

Scavengers and Decomposers : Sharks, crabs, marine worms and some forms of algae complete this marine food chain by cleaning the organic waste (body waste and dead remains of plants and animals).

The Antarctic Region : Antarctica continent is present on the South Pole and is a continent without permanent human settlement. It is coldest, driest and windiest compared to other continents. A major part of the continent is covered with ice and lacks growth of any vegetation species. The temperature ranges between -10 degrees Celsius to -60 degrees Celsius. During the summer months the temperature can be 10 degrees Celsius along the coast. Summer prevails from October to March and winter from March to October. Most of the precipitation in this region is in the form of snow and ice. The Antarctic ecosystem is comparatively a simpler ecosystem but a productive one.

Producers : A few land plants and phytoplanktons (uni-cellular plants) which float on the sea surface and can also grow at a depth of 100 metres in the sea.

Consumers : Krills are small shrimp like creatures which are the primary consumers who feed on the phytoplanktons. One blue whale can consume around three to four tonnes of krill for one meal. Squids, penguins, leopard seals, elephant seals, baleen whales, etc. form the secondary consumers.

Scavengers and Decomposers : Lobsters, sea cucumbers, shrimps, crabs, prawns, sea slugs, worms, fungi and algae play the role as scavengers and decomposers.

1.8 SUMMARY

Various concepts in the subject Ecology are important to study because these concepts help in widening the understanding of a learner. Basic concepts like food chain, food web, trophic levels, biogeochemical cycles, etc. explain about how various elements present in the environment whether living or non-living are interdependent. Their functioning in the environment is responsible for making this system dynamic.

1.9 CHECK YOUR PROGRESS/EXERCISE

I. State whether the following statement is 'True' or 'False':

a) An ecosystem is a closed system.

b) Scavengers help in keeping the environment clean.

c) Food web refers to a complex combination of different food chains.

d) The concept of Ecology was put forward by Charles Darwin.

e) 71 percent of the earth's surface is covered by land masses.

II. Fill in the blanks:

a. An ecosystem is a _____ unit.
(functional, temporary, casual, mechanical)

b. _____ are primary consumers in the Antarctic ecosystem.
(Krills, Lobsters, Blue whales, Polar bears)

c. _____ are producers in a hot desert ecosystem.
(Cacti, Grasses, Trees, Mangroves)

d. The _____helps in understanding the productivity of an ecosystem.
(Energy pyramid, Pyramid of number, Biomass pyramid, Biogas pyramid)

e. The natural functioning of the nitrogen cycle is disturbed by _____.
(Eutrophication, Magnification, Calcification, Oxidation)

III. Multiple Choice Questions:

a) a.In the term 'ecology' what does the word 'oikos' mean?
(Dwelling, cave, shade, canopy)

b) Name the process by which plants prepare food?
(Photosynthesis, Eutrophication, Bio mass, Saturation)

c) Name the most abundant gas present in the atmosphere.
(Nitrogen, Oxygen, Phosphorus, Carbon dioxide)

d) Name the geographical region which experiences very high temperature with less or no rainfall.
(Desert, Rain Forest, Grassland, River valley)

e) Name the continent which does not have permanent human population.
(Antarctica, Australia, Patagonia, Arctic)

1.10 ANSWERS TO SELF-LEARNING QUESTIONS

I. State whether the following statement is 'True' or 'False':

a. False.

b. True.

c. True.

d. False.

e. False.

II. Fill in the blanks:

a. Functional.
b. Krills.
c. Cacti.
d. Energy pyramid.
e. Eutrophication.

III. Multiple Choice Questions:

a. Dwelling.

b. Photosynthesis.

c. Nitrogen.

d. Desert.

e. Antarctica.

1.11 TECHNICAL WORDS AND THEIR MEANING

Food Chain : A food chain refers to the sequential transfer of food energy from the autotrophs (green plants) to heterotrophs (herbivores, carnivores and omnivores) and the detritivores in an ecosystem.

Food Web : A complex combination of different food chains gives rise to a food web.

Trophic Levels : The term trophic level refers to the level of nutrition or nourishment in a food chain.

Biogeochemical Cycle : The cyclic movement of biological, geological and chemical resources on the earth's surface is termed as the biogeochemical cycle.

1.12 TASK

Plan a visit to a nearby Nature Park to study and understand the various components of the natural ecosystem present in the park.

1.13 REFERENCES FOR FURTHER STUDY

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- Arctic Ecosystem: Description, Food Chain, and Animals (earthreminder.com)
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- Desert Ecosystem: Definition, Types and Characteristics | Earth Reminder

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2

ENVIRONMENTAL DEGRADATION

Unit Structure :

After going through this chapter, you will be able to understand the following features

2.1 OBJECTIVES

At the end of this unit, you will be able to –

- Understand the factors responsible for nature-induced environmental degradation and its consequences.
- Know about the factors responsible for human-induced environmental degradation and its consequences.
- Get an overview of the significant environmental problems globally.
- Elucidate the local environmental problems with particular reference to Mumbai Metropolitan Region (MMR).

2.2 INTRODUCTION

Environmental degradation is an umbrella concept because it includes diverse issues like loss of biodiversity, pollution, deforestation, and many more. This concept reflects on the problems causing the deterioration of the natural environment and depletion of biological diversity. The worsening of the general health of the environment can be either natural, human-made, or both at the same time. This chapter will separately focus on how nature and humans are responsible for environmental degradation. It will further discuss the major global environmental problems. Lastly, the chapter will discuss some local environmental issues with particular reference to MMR.

2.3 SUBJECT DISCUSSION

Environmental degradation is a severe problem globally. It refers to the deterioration of the environment through depletion of resources which includes all the biotic and abiotic elements that form our surroundings, that is, air, water, soil, pant animals, and all other living and non-living element of the planet of the earth(Bourque et al., 2005; Malcolm and Pitelka, 2000). The degradation of the environment is also a result of the dynamic interplay amongst socioeconomic, institutional, and technological activities. The damage or reduction in quality of environmental features is influenced directly or indirectly by two significant factors – natural (flood, drought, earthquakes, typhoons, hurricanes, fires, etc.) and human (overpopulation, urbanization, industrialization, deforestation, etc.). Continued environmental degradation can destroy the various aspects of the environment - biodiversity, ecosystems, natural resources, and habitats. For instance, air pollution can lead to acid rain, reducing the quality of natural water systems by making them acidic.

There are mainly four types of environmental degradation –

- **Water degradation –** This includes the degradation of water due to illegal dumping, disposal of large amounts of industrial waste into nearby rivers or lakes, etc.
- **Land degradation** - Often known as soil degradation, this degrades soil quality because of poor farming practices, excessive use of fertilizers and pesticides, leakage from landfills, etc.
- **Atmospheric degradation** - This includes air particle pollution and the depletion of the ozone layer.

Thus, it is essential to understand this concept asit touches on major paramount topics, such as deforestation, biodiversity loss, desertification, global warming, animal extinction, pollution, and many more.

2.4 FACTORS RESPONSIBLE AND CONSEQUENCES NATURE INDUCED (ONE EXAMPLE FROM EACH RELATED TO TECTONIC/ATMOSPHERIC/ OCEANIC)

Physical factors such as earthquakes, hurricanes, floods, drought, volcanoes, etc., accelerate the decline in environmental resources.

Earthquakes are one of the most devastating geological processes with destructive effects on nature and humans. The effects caused by an earthquake on its surrounding environment are known asEarthquake environmental effects (EEE). EEE includes surface faulting, tectonic uplift and subsidence, tsunamis, soil liquefaction, ground resonance, landslides, and dust clouds. These effects can be directly connected to the earthquake (primary effects) or indirectly incited by theground shaking (secondary effects). EEEs can be observed near the earthquake's epicenter or, at times, far away from the center.

Direct impacts or primary effects will be felt immediately.It will directly cause damage toinfrastructures, and land, including ground failure and landslides. Observations from some after-effects of earthquakes suggest that the liquefaction of sand can trigger soil subsidence. Liquefaction is a phenomenon in which the stiffness and strength of soil reduce by ground shaking. In other words,liquefaction makes soil behave more like a liquid than a solid during an earthquake. The phenomenon occurs in saturated soils.In saturated soils,the space between individual particles is filled with water. The water is responsible for exerting pressure on the soil particles that press the particles tightly together. Before an earthquake, the water pressure is relatively low. However, the earthquake shaking rearranges the sand and silt grains in wet soil underground and squeezes the water between the grains by increasing the water pressure. Due to stress, the water is forced to the surface, causing cracks in the ground or concrete.Thus, when liquefaction occurs, the soil's strength decreases, and a soil deposit's ability to support foundations for buildings and bridges is reduced.

Worldwide,liquefaction has been responsible for tremendous amounts of damage in earthquakes.Especially liquefaction occurring beneath buildings and other structures can cause significant damage during earthquakes. For example, the 1964 Niigata earthquake caused widespread liquefaction in Niigata, Japan. Part of Niigata city was built on deltaic deposits from the two rivers. The shaking during the earthquake sourced liquefaction, causing subsidence of up to 140 cm, thus destroying thousands of buildings.

Volcanic eruptions often follow earthquakes. These explosions damage the environment due to the release of numerous toxic gases.Water vapour is the most abundant volcanic gas, followed by carbon dioxide and sulfur dioxide. Other principal gases are hydrogen chloride, hydrogen fluoride, and hydrogen sulfide. Gases like carbon dioxide promote global warming, while sulfur dioxide emission causes global cooling, ozone destruction,

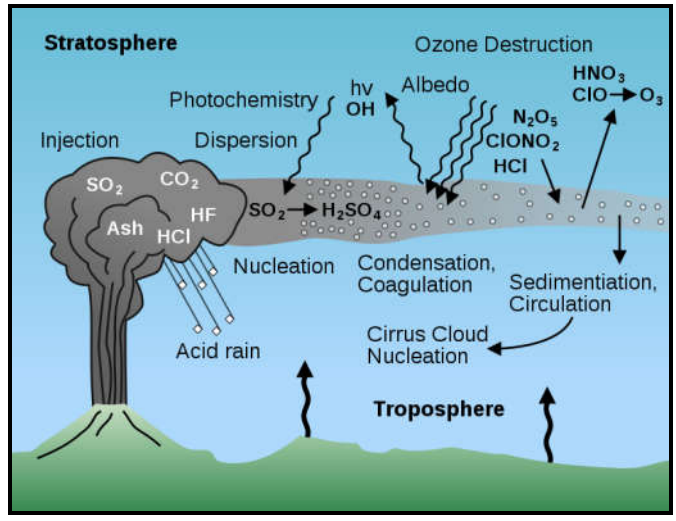
and polluted air, known as volcanic smog.Voluntary gas emissions aredirectly harmful to humans and the surrounding environment. Usually, the severity of hazards from volcanic gases is high in the areas immediately surrounding volcanoes. But these hazards canpersist for long distances also.

The volcanic ash fallout from large-scale explosive eruptions ismade of tiny fragments of jagged rock and minerals, iscomplex, abrasive, and does not dissolve in water.These rock fragments generally mix with the solidified lava in the air and create an ash cloud. Winds carry small volcanic ash particles to great distances because the smaller the particle, the further the wind carries it. When Mount St. Helens, in Washington, erupted in 1980, a column of ash from the volcano rose 19 km into the air.

Ashes have been found thousands of kilometers away from an eruption site. As eruptions produce features like pyroclastic flows, mudflows, etc.,they causesignificant loss of life and property. For example, the 2008 eruption of Chaitén in Chile produced an ash cloud that blew 1,000 kilometers across Patagonia to Argentina, reaching both the Pacific and Atlantic coasts.

Plumes of volcanic ash cause enormous clouds, often accompanied by lightning and thunder. The ash and gases can sometimes reach the stratosphere, reflecting incoming solar radiation and absorbing outgoing land radiation, leading to the Earth's temperature cooling. In extreme cases, thiscooling, known as "volcanic winters," can affect weather patterns across the globe. The Mount Tambora eruption in Indonesia in 1815 (one of the largest eruptions in history) ejected an estimated 150 cubic kilometers of debris into the air. The average global temperature cooled by 3° C, causing extreme weather worldwide for three years. As a result of its volcanic ash, North America and Europe experienced the "Year without a summer" in 1816. The same year was characterized by widespread famine, crop failure, and diseases.

Fig. 1. Volcanic injection



Source: https://en.wikipedia.org/wiki/File:Volcanic_injection.svg

Volcanic gases can severely damage human health, vegetation, and wildlife. Exposure to acid gases can damage the eyes and respiratory system and, under extreme conditions, can lead to death. For example, In October 1902, Santa Maria, a stratovolcano eruption in Guatemala,killed about 1,500 people. At least 350 people from one village died from deadly fumes.[1]In another instance, at least 1,200 people were killed and 300 hospitalized when an underwater volcanic explosion unleashed poisonous gases at Lake Nios in a remote area of northern Cameroon. [2]Direct and long-term exposure to volcanic gas is lethal to most types of foliage. Mammoth Mountain, a significant volcanic depression in eastern California, has been active for about 4 million years. Numerous 'persistent swarms of small earthquakes in the 1990s occurred beneath the volcano, making the U.S. Forest Service rangers first notice the areas of tree kill. When U.S. Geological Survey scientists investigated, they discovered that the trees were killed by high concentrations of carbon dioxide gas in the soil.From 1990 to 2000, areas of dying forest around Mammoth Mountain occupy more than 100 acres.[3]

Similarly, the release of sulphur dioxide gas cause acid rain when it gets converted to sulphuric acid in the stratosphere. Acid rains cause ecological imbalance, mostly in aquatic environments, such as streams, lakes, and marshes. These can be harmful to fish and other wildlife. While it flows through the soil, acid rainwater can leach aluminum from soil clay particles.Recently, Tonga'sHunga Tonga - HungaHa'apai massive underwater volcanic eruption in January 2022 is feared to deliver long-lasting damage to coral reefs, erode coastlines, and disrupt fisheries. One can be through acid rain, as the volcano has released sulfur dioxide and nitrogen oxide since its initial eruption. These two gases create acid rain when interacting with water and oxygen in the atmosphere. As acid rain causes widespread crop damage, thefearof Tongan staples like taro, bananas, corn, and garden vegetables getting ruined is gripping the population. The toxic volcanic ash discharge in ocean water can harm marine life more because Tonga has an exclusive economic zone of nearly 700,000 marine square kilometers, which is 1,000 times larger than its land area. And the majority of its population gets their food and livelihood from the ocean.Falling ash is also expectedto smother coral reefs, thus affecting Tonga's ability to cope with rising waters and storm surges. Rising wateris a concern for Tonga, as climate change is driving the sea level to rise by about 6 millimeters per year,double the global average.

Tsunami often follows earthquakes in coastal areas. In addition to destroying human construction, tsunamis destroy vegetation, resulting in landslides and coastal vegetation. The waves that enter inland fill fresh water sources with saltwater and cause contamination of soil. The salt inhibits plant growth and renderssoil fertility in coastal farmland for many years. The base of a tsunami wave can change the topography of the sea floor by eroding seafloor sediments.It devastates the sea bottom

ecosystems by transportingvast amounts of sand, which reshapes beaches and creates miles of underwater dunes. For example, the tsunami that struck Japan in March 2011 tore up the rocky seabed. Later, researchers found that large rocks had been overturned along the coast, destroying whole communities of some sea species thatwere vital as fishery resources.

The 2004 Indian Ocean tsunami was undoubtedly one of the worst the world has ever seen.An estimated 2,50,000 persons perished in the tsunami. Millions more were displaced or rendered homeless. Environmental assets such as water, land, forest, agricultural and fisheries areas, and coral reefs had been brutally damaged. The affected countries' most critical ecological problems were solid waste and disaster debris. They were combined with the issue of waste, hazardous materials, and toxic substances like asbestos, oil fuel, and other industrial raw materials and chemicals.Contamination of water and soil was the second critical environmental impact of the tsunami. This caused the salination of freshwater bodies from rivers to groundwater aquifers. It also affected the soil fertility of agricultural lands due to salination and debris contamination, which affected medium and long-term yields. Indonesia's Sumatra island lost around 20 percent of sea-grass beds, 30 percent of coral reefs, 25-35 percent of wetlands, and 50 percent of sandy beaches on the west coast due to the receding waters of the tsunami.The debris generated by the tsunami not only mixed different types of wastes, but the backwash carried these wastes and deposited them in the ocean. In Thailand, along the Andaman coast,about 15 to 20 percent of the coral reefs were affected by the tsunami - due to siltation and sand infiltration. In Sri Lanka, around 62,000 groundwater wells were contaminated by seawater, wastewater, and sewage, thus, rendering them useless.Tsunamis also endanger the local environment by releasing radiation from damaged nuclear facilities.In 2011, a tsunami and earthquake in Japan caused the Fukushima Daiichi nuclear disaster. The nuclear plant released radioactive material that required the contaminated water into the Pacific Ocean and evacuation of the nearby area. It was the largest nuclear disaster since Chernobyl because it caused many issues in the ecosystem and surrounding waters, spreading radioactive material through far-ranging ocean currents.

Even tropical cyclones often cause environmental changes far beyond where they make landfall. Fast winds rip trees from the ground, erode soil, and flatten buildings. It often results in the loss of animal habitats, interrupting and changing ecosystems.

Tsunamis, cyclones, or incessant rain, cause floods. Flooding leads to devastation at personal and regional scales. Loss of life and damage to property and infrastructure are the immediate effects of a flood. It also brings many long-term challenges, including environmental impacts, deterioration of human health in affected areas, and economic hardship. The 2013 North India flood, often labeled as a mega-disaster, became one of the worst disasters in living memory, causing widespread damage and destruction, besides heavy casualties.Uttarakhand was hit byheavy rains,

which resulted in flash floods in all the major river valleys in the State. Torrential rains triggered major landslides at numerous locations. The 2004 Indian Ocean tsunami resulted in an extensive surge in coastal areas and a few kilometers of inland areas.

Hurricane Harvey, one of the most devastating hurricanes in recent years, caused catastrophic flooding in Texas and Louisiana in 2017. Water quality, air quality, and energy supply were the three areas significantly impacted by the hurricane. Because flood waters carry enormous amounts of debris and sediments, tons of residues were dragged along and deposited downstream in water bodies and city streets, causing health concerns. Water from flooded refineries, industries, storage tanks, grounded vessels, and household garbage was swept up and spread with the flood waters leading to toxic releases. Millions of gallons of untreated sewage overflowed the region of hurricane landfall. The ecosystem also faced direct loss. The hurricane resulted in vast amounts of freshwater inflows the bay, consequently decreasing salinity levels to near zero.Even though freshwater inflows are an essential component of the bay system, such long-term decreases in salinity can kill oysters.It has been estimated that it might take more than two years for oysters torepopulate bay areas. Along with these,catastrophic floods also result in changes toand loss of nesting and feeding habitats for bird, reptile, and mammal species.

2.5 FACTORS RESPONSIBLE AND CONSEQUENCES - HUMAN-INDUCED RIMARY/ SECONDARY/ TERTIARY ACTIVITIES (ANY ONE EXAMPLE FROM EACH ACTIVITY)

Human beings have the most significant ecological footprint. The increasing human population is negatively affecting the environment due to human activities.

Primary activities mainly include farming, fishing, and mining. These activities directly depend on the environment as these refer to the utilization of the earth's natural resources.Agriculture uses "more inputs of natural resources per unit of value added than any other sector of the economy, including manufacturing, construction, and transportation."[4]Agriculture contributes to a larger number of environmental issues depending upon the farmers' practices and the scale of their practice. Farming cause environmental degradation such as -

- **Deforestation** - According to the Food and Agriculture Organization (FAO), "the expansion of agriculture caused nearly 80 percent of global deforestation, with the construction of infrastructures making up the remaining causes of deforestation."[5]Worldwide, more than half of forest loss is due to the conversion of forest into cropland for commercial or industrial agriculture.Livestock grazing is responsible for almost 40 percent of forest loss globally. From 2000 to 2018, most

deforestation occurred in tropical biomes. Conversion of forest land to cropland dominates in South America, Africa, and Asia.In South America, almost three-quarters of deforestation is due to livestock grazing.

- **Climate change** - Agriculture significantly contributes to anthropogenic global warming, generating 19–29 percent of total greenhouse gas (GHG) emissions. This happens for usingfossil fuels, also due to land clearing for grazing and cropping, methane emissions from livestock, rice cultivationand burning of manure and biomass, and nitrous oxide emissions to the atmosphere for using fertilizers. Without action, that percentage could rise substantially.

- **Biodiversity loss** - Biodiversity is "the number, variety, and variability of living organisms and howthese change from one location to another and over time." Agricultural biodiversity refers to "all ecosystems and life forms directly related tofarming." Farmed crops interact with various organisms in the natural ecosystems and depend on them for their output production. This vast chain of interdependence makes agriculture the largest contributor to biodiversity loss.

- **Genetic engineering** - "Genetically Modified Organisms (GMOs)" was introduced with promises of better and more food. Through genetic engineering[6], desirable[7] genes were moved from one plant or animal to another or from a plant to an animal or vice versa. Despite many advantages, the genetic engineering of plants and animals today looms as one of the present century's most significant and intractable environmental challenges. The movement of genes from GMO plants into conventional crops causes an indirect effect on food safety and food security. Generally, the pollen or seeds from genetically engineered (GE) crops contaminates traditional crops.Contamination of corn is the biggest concern as it is both used in human food and is also used to feed livestock. According to GMO critic Greenpeace International, there were 39 cases of crop contamination in 23 countries in 2007 and more than 200 in 57 countries over the next decade.

- **Irrigation problems** - Globally, agriculture accounts for around 70 percent of freshwater consumption. As per the experts, to feed the growing population, water extraction may increase by an additional 15 percent or more by 2050. This diversion of freshwater and depletion of aquifers through over-drafting is undoubtedly alarming for farmers and researchers.

- **Soil degradation** - According to recent reportsfrom the United Nations, almost one-third of the world's farmable land has disappeared in the last four decades due to soil degradation. It contributes to 36–75

billion tons of land depletion yearly, and freshwater shortages threaten the global food supply.Soil degradation is the loss of soil's intrinsic physical, chemical, and biological qualities by natural or anthropic processes, which result in the diminution or destruction of essential ecosystem functions. The main threats to its ecological functions are - erosion, organic matter decline, loss of biodiversity, compaction, sealing, point-source and diffused contamination, pollution, and salinization.

Terrestrial mining causes deforestation and releases toxic amounts of fly ash and smoke laden with greenhouse gases and chemicals like methane. The effects of mining coal persist for years after the coal is removed.Different types of mining destroy landscapes, forests, and wildlife habitats at the mine site, thus causing soil erosion and destruction of agricultural land. One of the worst ecological disasters caused by humans caused severe harm to the environment along the Ok Tedi River and the Fly River in the Western Province of Papua New Guinea between about 1984 and 2013. Since the mid-1980s, the large copper and gold mine has released millions of tons of untreated mining waste into the Ok Tedi tributary of the Fly River every year. This mining pollution, caused by the collapse of the Ok Tedi tailings dam system in 1984 and the consequent switch to riverine disposal for several decades, caused the death of fish, the disappearance of turtles, the destruction of food gardens, and killed thousands of trees.

Similarly, deep-sea mining affects ocean biodiversity and ecosystems. Deep-sea mining refers to retrieving mineral deposits from the deep seabed of the ocean below 200m. Depletion of terrestrial deposits and rising demand for metals initiated deep-sea mining. However, machines can alter or destroy marine habitats by digging and gauging the ocean floor. Also, pelagicspecies such as whales, tuna, and sharks could be affected by noise, vibrations, and light pollution caused by mining equipment and surface vessels, as well as potential leaks and spills of fuel and toxic products.

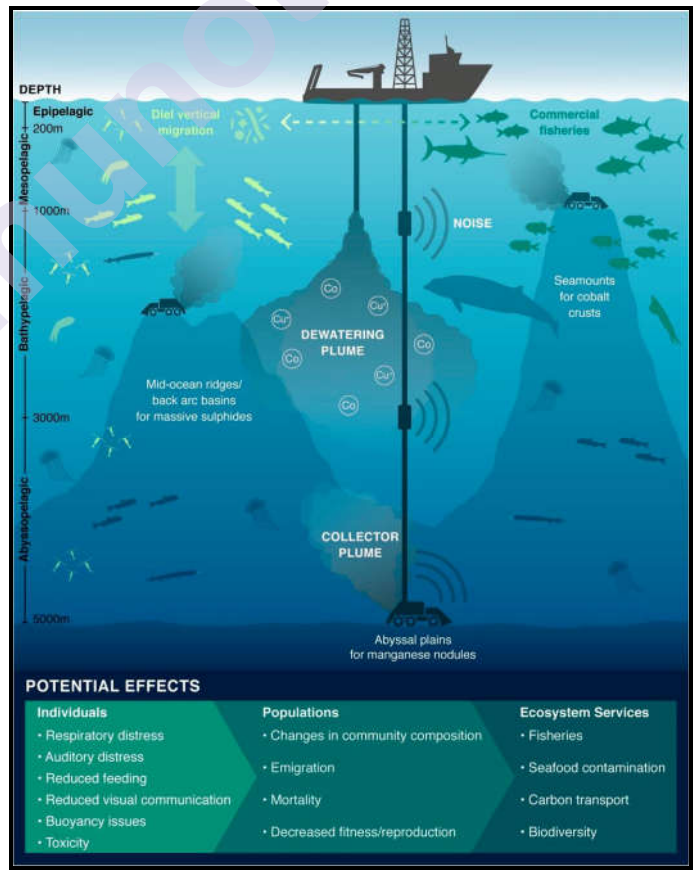
Fishing is one of the most significant drivers of declines in ocean wildlife populations. The fishing industry affects marine conservation issues, including fish populations, water pollution, and habitat degradation. According to the Food and Agriculture Organization of the United Nations, the number of overfished stocks globally has tripled in half a century. At present, one-third of the world's assessed fisheries are pushed beyond their biological limits. This is closely followed by bycatch, i.e.,the capture of unwanted sea life while fishing for a different species hasa severe marine threat that causes the needless loss of billions of fish and hundreds of thousands of other marine species.

Factories have majorly contributed to environmental damage—air pollution, toxic waste, and water contamination. Industrial factories are significant contributors to air pollution. Pollutants like gas, smoke, or particulate matter reduce air quality and lead to adverse living conditions for plants, animals, and humans. Carbon dioxide and methane emitted

from factories absorb radiation from the sun and, therefore, affect the planet's temperature directly. Industrial waste, pesticides, chemical fertilizers, and oil spills pollute the soil. This, in turn, affects the growth of crops and can damage natural environments.

Industrial accidents harm the environment. A serious contaminant that may be seen after an industrial accident is acid-rain.Water contamination was caused by the BP oil spill in the Gulf of Mexico, the largest marine oil spill in history. After an oil platform exploded, large amounts of oil spilled out into the ocean, ravaging the aquatic water life in the area and consequently impacting the local community and food chain.The Chernobyl disaster, an accident in 1986 at the Chernobyl nuclear power station in the Soviet Union, was the worst in the history of nuclear power generation.Belarus, Russia, and Ukraine were the most affected. Millions of forests, farmland and freshwater bodies were contaminated, and thousands of people were evacuated. In addition, in subsequent years, many livestock were born deformed, and among humans, several thousand radiation-induced illnesses and cancer deaths were expected in the long term.The impacts on wildlife in the vicinity of the Chernobyl plant are disputed.The Bhopal Gas tragedy in 1984 was one of the tragic disasters in India that resulted in thousands of deaths and continues to have serious ramifications decades later. Even the environmental disaster impact was huge.

Fig. 2. Potential impacts from deep-sea mining



[Source: Drazen, J. C., Smith, C. R., Gjerde, K. M., Haddock, S. H., Carter, G. S., Choy, C. A., ... & Yamamoto, H. (2020). Midwater ecosystems must be considered when evaluating environmental risks of deep-sea mining. Proceedings of the National Academy of Sciences, 117(30), 17455-17460.]

2.6 GLOBAL ENVIRONMENTAL PROBLEMS

Burning fossil fuels, expanding agriculture, and exploiting fresh water for irrigation and industrial waste disposal are major human activities interfering with the global ecosystem.Natural Environment Degradationrefers to "the destruction and loss of native species and natural processes such that only certain components of the original biodiversity and ecological functions persist, often with significantly altered natural communities." It is expected that by the end of this century, humans will have transformed almost every inhabitable stretch of the planet. The degradation of natural resources results from the cumulative activities of farmers, households, and industries. Thesignificant ways by which humans alter the natural environment are –

- **Deforestation** - Biodiversity is threatened by the degradation and destruction of forests resulting in the reduction or fragmentation of the natural ecosystem. Factors like timber production, cutting trees for firewood, clearing forests for agriculture, mining, cyclones, droughts, etc., causes deforestation. The remaining forests are threatened by – climate change, fire, increasing population, acidification, and diseases. Tropical forests are the most important surviving forest lands, which contain about two-thirds of all plant and animal species. At the present rate of deforestation, an estimated 15 percent of all forest species could disappear within the next two decades.

Deforestation expedites erosion and changes local hydrological cycles and precipitation patterns.This results in decreased land's ability to retain water during rainy periods, flash floods that destroy irrigation systems,and many more.The underlying forces behind deforestation are - poverty, population growth, economic growth, urbanization, and expansion of agricultural lands. In the past, the introduction of agriculture led to losses of forests in temperate zones (Europe, Asia, and North America). Recent years have witnessed the rapid disappearance of tropical forests (Latin America, Asia, and Africa).Between 1970 and 2002, forest cover decreased by 12 percent. Developing countries have a higher rate of deforestation. Around 16 percent of the world's forests are in the Asia/Pacific.

The mountain forests are vulnerable to severe losses because of logging operations, local farmers, and charcoal producers. The Himalayan watershed covering Nepal, Bangladesh, and Northern India, had lost 40 percent of its forest by 1980. Logging and clearing rainforests and mangroves are rapid in the Philippines and Indonesia to establish exotic plantations. The slash and burn agriculture, known as Jhum cultivation in India, is also responsible for deforestation in the practiced regions.

- **Desertification** - occurs when "the natural vegetation cover is reduced, and the topsoil becomes susceptible to erosion." Consequently, leading to increased surface runoff, stream discharge, reduction of water infiltration and groundwater recharge, and reduction in native plants. Climate change results in the gradual depletion of vegetation structure and cover, species diversity, mineral content, and soil structure. Thus eventually leading to the formation of deserts. Human actions like overgrazing, over-cultivation, deforestation, irrigation, and soil erosion produce desert and semi-desert conditions.

Mismanagement of agriculture and continuous population growth has resulted in desertification worldwide. Desertification is a significant threat to the world's arid, semiarid and dry sub-humid regions. In 2015, about 500 million people lived in areas that experienced desertification between the 1990s and 2000s. By 2050, an estimated 4 billion people will live in drylands. As two-thirds of Africa is arid or semi-arid, it is most seriously affected by desertification.

- **Land Degradation** - This umbrella term covers problems like - wind and water erosion and soil pollution by urban wastes. It disrupts five essential ecosystem functions - food production, water retention, fiber provision, microclimate regulation, and carbon storage. Degradation of land impacts includes loss of soil fertility, destruction of the habitat of species, soil erosion, and excessive nutrient runoff. It also causes malnutrition, diseases, forced migration, etc. According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), in 2018, "worsening land degradation caused by human activities is undermining the well-being of two-fifths of humanity, driving species extinctions and intensifying climate change. It also contributes significantly to mass human migration and increased conflict." The significant direct causes of land degradation are –

a. theconversion of native vegetation into crop and grazing lands and unsustainable land-management practices.

b. theeffects of climate change and loss of land to rapid urbanization, infrastructure, and mining.

The IPBES (2018) reports that 43% of the world's population lives in regions affected by land degradation. Sub-Saharan Africa, Asia, and South and Central America are witnessing rapid land degradation.

- **Erosion of Biological Diversity** - Human activity endangers habitats, species, and genepools. The loss of biodiversity is majorly driven by economic systems that fail to value the environment and its resources. Some species are under direct threat due to hunting and poaching. Changes in landuse followed by alteration, fragmentation, and destruction of habitats are the primary threats. Tropical forests are significant biodiversity stocks. These stocks are declining worldwide

as half of their original cover has vanished. For example, the Atlantic forest is home to 35 percent of South America's population. Atlantic forests are one of the world's most fragmented tropical/subtropical forests. This might happen in the future with other tropical forests worldwide.

- **Destruction of Natural Barriers and threat to coral reef ecosystem** - Destruction of natural barriers may result in ecological disasters. For example - The Gulf of Mannar in the Indian Ocean is bestowed with three distinct coastal ecosystems - coral reef, sea grass bed, and mangroves. It is considered an ecological paradise for its unique biological wealth. The Gulf is under severe threat due to over-harvesting of fishery resources, destruction of habitats, industrial pollution, destructionof breeding grounds of fish, trade-in of highly endangered marine organisms, dynamite fishing, and use of prohibited fishing gears by fisher folk.

- **Detrimental changes in ocean characteristics** - The constant complex processes in the sea can destroy sea life. Man-made events like nuclear explosions can trigger these processes. Lowering temperature due to climate change, lowering of salinity because of river discharge, and displacing ocean currents (El Nino) are some of the adverse effects.

Persistently rising temperatures of water cause coral bleaching, which in turn impacts coral reef ecosystems. Warmer waters also cause mass migration of marine species as they search for the right conditions for spawning and feeding. For example, Conservation International research revealed that increasing ocean water temperaturealters tuna habitats. The warming is causing them to move significantly to the east of the Pacific Islands. This mass exit could be catastrophic for the economies of many Pacific Island countries, such as Fiji and the Cook Islands.

- **Global Warming** - An increase in average global temperature leads to changes in rainfall patterns, rises in sea levels, melting of the ice caps, and widespread flooding. The IPCC has forecast that the level of carbon dioxide (CO2) in the atmosphere will double by 2050, and the global average temperatures will rise between 1.4 to 5.8^{o}C by 2100. According to researchers, Antarctica is shrinking underwater, as submerged ice is melting rapidly. The production of algae depends on the presence of sea ice. As sea ice diminishes, algae diminish too, causing a ripple effect on species like polar bears, seals, and whales.

The sea-level rise iscausing the melting of polar ice and glaciers from Greenland and Antarctica at a rapid rate. Per the 2019 UN report, the melting of polar ice is resulting in an unprecedented rise of sea levels that can displace more than 680 million people living across low-lying coastal communities.

Ocean currents play a significant role in maintaining Earth's climate. The warming of oceans alters currents. For example, The Gulf Stream, which maintains Europe's mild climate, is experiencing an unprecedented slowdown.These will have significant implications worldwide, including changes in rainfall patterns. To explain broadly, the deceleration of the current might lead to more rain in some areas and much less in others, along with fluctuating air temperatures. These changes have drastic implications for both species and humans.

Overpopulation, poverty, urbanization, rapid industrialization, and various other factors exert ever-increasing pressure on the carrying capacity of land and resources, causing environmental degradation.

2.7 LOCAL ENVIRONMENTAL PROBLEMS WITH SPECIAL REFERENCE TO MUMBAI METROPOLITAN REGION

Mumbai, the city of paradoxes, has pollution and a growing population as significant problems. As Mumbai was carved out of seven islands, the pressing environmental issues of the city emerged during its creation. The filling up of the river that ran through the city hasdepleted the areas of dissipation.

Mangroves form an integral part of the landscape of Mumbai and are disappearing fast because of encroachments, aquaculture ponds, and infrastructure development. Mangrove ecosystems serve as a buffer between land and sea; theyprevent soil erosion and protect shorelines against cyclones and ecological disasters.The mangrove swamps of greater Mumbai spread over various areas like Mahim, Madh, Versova, Gorai, Thane creek, and Ghodbunder. However, the city is losing stretches of mangroves to the reclamation of land for construction and developmental projects. For example, hundreds of acres of mangrove stretches weresanctioned to build the Essel World amusement park in the Gorai creek at Borivali.The loss of mangrove cover due to urbanization projects has increased the frequency of flooding. Similarly, the construction of sea links or bridges to ease traffic congestion posesan environmental danger tothe habitats of various species and is wiping out once-thriving wildlife breeding grounds.

Mumbai's marine population is declining due to pollution caused by the industrial waste discharge. Carbon monoxide levels and particulate matter emissions have risen owing to traffic congestion. Illegal construction, encroachment by slums, and quarryingthreaten the national park's green space.

Along with these, various other environmental issues are likely to threaten Mumbai. Even though the city has always had its share of dedicated NGOs and environmentalists who have fought tirelessly to secure the constant environmental suicide, it still has a long way to go.

2.8 SUMMARY

As Homo sapiens first walked the earth, there have been several modifications on the planet through the development of infrastructure, travel, and the incorporation of urbanization and other commercial networks. However, the change has been both positive and negative, physically or human-induced.

2.9 CHECK YOUR PROGRESS OR EXERCISE

1. True or False

a. As per IPCC, the global average temperatures will rise by between 1.4 to 5.8^{o}C by 2100.

b. Hurricane Harvey caused catastrophic flooding in Texas and Louisiana in 2017.

c. Niigata earthquake caused a volcanic eruption in Niigata.

d. Gulf Stream maintains Europe's mild climate.

e. Desertification refers to the conversion of native vegetation into crop and grazing lands

2. Fill in the blanks

a. The phenomenon in which the stiffness and strength of soil reduce by ground shaking is known as _____.

b. IPBES stands for _____.

c. _____ caused the collapse of Ok Tedi.

d. The capture of unwanted sea life while fishing for a different species is called _____.

e. _____ refers to retrieving mineral deposits from the deep seabed of the ocean below 200m.

3. Multiple Choice Questions

1. Ok Tedi river incident occurred in the _____ province of _____

   a. Eastern, Papua New Guinea

   b. Northern, West Indies

   c. Western, Philippines

   d. Western, Papua New Guinea

2. According to the Food and Agriculture Organization (FAO), the expansion of agriculture caused nearly _____ of global deforestation.

   a. 75 percent

   b. 80 percent

   c. 60 percent

   d. 85 percent

3. The Chernobyl disaster occurred in _____ at the Chernobyl nuclear power station in the _____

   a. 1986, South Korea

   b. 1986, Soviet Union

   c. 1987, Soviet Union

   d. 1987, Seoul

4. Mammoth Mountain incident took place in _____

   a. USA

   b. Canada

   c. Indonesia

   d. South Africa

5. North America and Europe experienced the "Year without a summer" in _____

   a. 1816

   b. 1820

   c. 1813

   d. 1821

4. Answer the following questions

a. How does volcanic activityaffect a community? How do they affect the natural environment? How does a volcanic eruption fit into the natural cycle of environmental changes?

b. Betweennature and humans, who has more impact on the environment? Why does one have more impact? What are both nature's and humans' negative and positive effects on the environment?

c. Discuss in detail the environmental problems faced by the Mumbai Metropolitan Region.

d. Explain the global environmental problems with examples.

e. Write about any five major recent time disasters in India and their impact on the environment.

2.10 ANSWERS TO THE SELF-LEARNING QUESTIONS

1.a. True

1.b. True

1.c. False

1.d. True

1.e. False

2.a.Liquefaction

2.b. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

2.c. Mining pollution

2.d. Bycatch

2.e. Deep-sea mining

3.1. d

3.2. b

3.3. b

3.4. a

3.5. a

2.11 TECHNICAL WORDS AND THEIR MEANING

- **Liquefaction** – It occurswhen loosely packed, water-logged sediments at or near the ground surface lose their strength in response to firm ground shaking.
- **Overdraft** - Overdraft occurs when, over the years, more water is pumped from a groundwater basin than is replaced from all sources – such as rainfall, irrigation water, streams fed by mountain runoff, and intentional recharge.
- **Pyroclastic Flow** – Along with shooting volcanic ash into the atmosphere, an explosive eruption can create an avalanche of ash, volcanic gases, and rock called a pyroclastic flow. These incredibly fast volcanic debris avalanches can be impossible for humans to outrun. Pyroclastic flows are capable of razing buildings and uprooting trees.
- **Soil degradation** - is the loss of land's production capacity in terms of loss of soil fertility, biodiversity, and degradation.Soil degradation causes include agricultural, industrial, and commercial pollution; loss of arable land due to urban expansion; overgrazing, unsustainable farming practices; and long-term climatic changes.
- **Subsidence** - The movement of the earth's surface from a higher to a lower position concerning a particular datum, such as the mean sea level, is known as subsidence of the earth's crust. It is measured in units of length.

2.12 TASK

Are there other large-scale natural occurrences that affect communities on such large scales than the ones you read in this chapter? What are they? What are the differences and similarities among these occurrences?

2.13 REFERENCES FOR FURTHER STUDY

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3

ENVIRONMENTAL CONSERVATION AND SUSTAINABILITY (CONTACT HOURS 15)

Unit Structure :

3.1 OBJECTIVES

By the end of this unit you will able to understand:

- The concept of ecological equilibriumenvironmental sustainability
- The Principles of environmental conservation
- Efforts taken towards environmental conservation at global level
- Role of Indian government towards Environmental conservation

3.2 INTRODUCTION

Ecology is scientific study of the interactions between organisms and their environments (Ernst Haeckel, 1866).All living things are interrelated, interlinked and interdependent upon each other for growth and survival. Transfer of energy and cycling of nutrients through various bio-geo-

chemical cycles of the environment are responsible for supporting life in different habitats. Depending upon the physical environment various terrestrial ecosystem (grassland, shrub-land, marshland, sparse forest, dense forest, hot-desert, cold desert, highland ecosystems) and aquatic ecosystem (marine ecosystem, lake ecosystem, fresh water ecosystem etc.) function through its diverse biotic and abiotic factors. However any disturbance in these factors has a cascading effect in the entire ecosystem functions and ultimately causes ecological disequilibrium and instability. These disturbances in present times occur largely due to irrational human interference in the natural processes threatening the entire life forms and ecosystem vitality. It is therefore essential to understand the fundamental principles of ecosystem, so that human activities are managed in a way that maintains ecological equilibrium by practicing environmental sustainability.

3.3 SUBJECT DISCUSSION

The various escalating environmental issues has brought serious debates about the development activities and associated socio-economic outcomes. The patterns of resource availability and its utilization has resulted in large scale environmental degradation leading to the countries all over the world to reckon the sustainability approach in the current times. To achieve a balance between environmental and socio-economic needs, the practice of conservation and management of natural resources has been seen as a key instrument and is therefore accepted as an integral part of global and national policies and governance. The present chapter explains these aspects at length and thus highlights the importance of environmental conservation and sustainability and the efforts taken at international and national level.

3.4 NEED FOR ECOLOGICAL EQUILIBRIUM, STABILITY AND ENVIRONMENTAL SUSTAINABILITY

Ecological equilibrium or ecosystem stability in simplest terms refers to the balance between the ecosystem functions of resource creation and our consumption of the resources i.e. demands from it. For ecosystem to remain in balance, the conditions of diversity and functional vibrancy need to be present through the ecosystem dynamics. The carrying capacity of ecosystems hence needs to be respected and maintained. Environmental sustainability as an approach focuses upon maintaining the restorative capacities of the nature which provide us with abundant resources for survival, livelihood and development. Environmental sustainability refers to the ability to maintain the qualities that are valued in the physical environment (Sutton, 2004). In simplest terms it refers to maintenance of natural capital so that the ecosystems remain diverse function and produce resources infinitely. The need for environmental sustainability arises as global demand for finite natural resources is increasing and is becoming beyond the natural capacity of our ecosystems to replenish the same. This population pressure has started to raise concerns over the future of entire

human civilization and its development, making it necessary to bring in line our activities in tandem with environmental conservation and resource management. This makes it clear that the only way forward is through understanding the fundamental principles on which our environmental systems function and incorporating the elements of sustainability to foster long term socio-economic development from local to global levels.

Various attempts from local to global efforts have been devised to bring in ecological stability by promoting and practicing sustainability. Sustainability focuses on balancing this fine line between competing needs driven by technological and economic advancement and the needs to protect our environments in which we and other organisms live (C.T Emejuru and Dike, 2019). Environmental sustainability as a practice thus is a means to improve human welfare by protecting the natural capital as a source of raw materials for human needs and ensuring that the wastes created are assimilated in the natural sinks.It entails the maintenance of natural capital by holding the scale of human economic subsystem within the biophysical limits of the overall ecosystem on which it depends. Environmental sustainability can be ensured through sustainable production and sustainable consumption. It thus needs the conservation efforts to maintain traditional value and measure of income to natural capital now that it is no longer a free good but instead a more and more limiting factor in development. Environmental sustainability thus adds consideration of physical inputs into production, emphasizing environmental life-support systems without which neither production nor humanity could exist. These systems include atmosphere, water, soil, biodiversity all of which need to be healthy meaning that their environmental service capacity must be maintained. (C.T Emejuru and Dike, 2019).

3.5 PRINCIPLES OF ENVIRONMENTAL CONSERVATION

The term conservation finds it origin in the Latin word ‘conservare’ meaning “to keep, preserve, guard” from. In its simplest notion environmental conservation includes all activities towards protection, preservation, enhancement of the state of natural resources. It thus refers to the management and judicious utilization of natural resources in a planned way so that the biodiversity is maintained and so is the ecological balance. It integrates the idea of sustainability as it seeks to safeguard the resources for present as well as future generations to meet their needs. The key concept of conservation thus lies in optimum utilization of resources without wastages. Thus the scope of environmental conservation includes resource management, pollution control, climate studies, disaster management, environmental engineering, ecosystem management, habitat protection etc. conservation is this involved with studying all kinds of damages, understanding the factors responsible, developing techniques to prevent losses and restoring the biodiversity (Encyclopedia of Britannica). The Principles of Environmental Conservation have been put forth in various ways. The Earth Charter's ethical vision proposes that environmental protection, human rights, equitable human development, and peace are interdependent and indivisible. The Earth

Charter which serves as an international declaration of fundamental values and principles to build a just, sustainable, and peaceful global society in the 21st century, puts forth the following principles which provide guidelines for environmental conservation, sustainability and development.[6]

I . RESPECT AND CARE FOR THE COMMUNITY OF LIFE :

1. Respect Earth and life in all its diversity.

a. Recognize that all beings are interdependent and every form of life has value regardless of its worth to human beings.

b. Affirm faith in the inherent dignity of all human beings and in the intellectual, artistic, ethical, and spiritual potential of humanity.

2. Care for the community of life with understanding, compassion, and love.

a. Accept that with the right to own, manage, and use natural resources comes the duty to prevent environmental harm and to protect the rights of people.

b. Affirm that with increased freedom, knowledge, and power comes increased responsibility to promote the common good.

3. Build democratic societies that are just, participatory, sustainable, and peaceful.

a. Ensure that communities at all levels guarantee human rights and fundamental freedoms and provide everyone an opportunity to realize his or her full potential.

b. Promote social and economic justice, enabling all to achieve a secure and meaningful livelihood that is ecologically responsible.

4. Secure Earth's bounty and beauty for present and future generations.

a. Recognize that the freedom of action of each generation is qualified by the needs of future generations.

b. Transmit to future generations values, traditions, and institutions that support the long-term flourishing of Earth's human and ecological communities.

In order to fulfill these four broad commitments, it is necessary to:

I I . ECOLOGICAL INTEGRITY

5. Protect and restore the integrity of Earth's ecological systems, with special concern for biological diversity and the natural processes that sustain life.

a. Adopt at all levels sustainable development plans and regulations that make environmental conservation and rehabilitation integral to all development initiatives.

b. Establish and safeguard viable nature and biosphere reserves, including wild lands and marine areas, to protect Earth's life support systems, maintain biodiversity, and preserve our natural heritage.

c. Promote the recovery of endangered species and ecosystems.

d. Control and eradicate non-native or genetically modified organisms harmful to native species and the environment, and prevent introduction of such harmful organisms.

e. Manage the use of renewable resources such as water, soil, forest products, and marine life in ways that do not exceed rates of regeneration and that protect the health of ecosystems.

f. Manage the extraction and use of non-renewable resources such as minerals and fossil fuels in ways that minimize depletion and cause no serious environmental damage.

6. Prevent harm as the best method of environmental protection and, when knowledge is limited, apply a precautionary approach.

a. Take action to avoid the possibility of serious or irreversible environmental harm even when scientific knowledge is incomplete or inconclusive.

b. Place the burden of proof on those who argue that a proposed activity will not cause significant harm, and make the responsible parties liable for environmental harm.

c. Ensure that decision making addresses the cumulative, long-term, indirect, long distance, and global consequences of human activities.

d. Prevent pollution of any part of the environment and allow no build-up of radioactive, toxic, or other hazardous substances.

e. Avoid military activities damaging to the environment.

7. Adopt patterns of production, consumption, and reproduction that safeguard Earth's regenerative capacities, human rights, and community well-being.

a. Reduce, reuse, and recycle the materials used in production and consumption systems, and ensure that residual waste can be assimilated by ecological systems.

b. Act with restraint and efficiency when using energy, and rely increasingly on renewable energy sources such as solar and wind.

c. Promote the development, adoption, and equitable transfer of environmentally sound technologies.

d. Internalize the full environmental and social costs of goods and services in the selling price, and enable consumers to identify products that meet the highest social and environmental standards.

e. Ensure universal access to health care that fosters reproductive health and responsible reproduction.

f. Adopt lifestyles that emphasize the quality of life and material sufficiency in a finite world.

8. Advance the study of ecological sustainability and promote the open exchange and wide application of the knowledge acquired.

a. Support international scientific and technical cooperation on sustainability, with special attention to the needs of developing nations.

b. Recognize and preserve the traditional knowledge and spiritual wisdom in all cultures that contribute to environmental protection and human well-being.

c. Ensure that information of vital importance to human health and environmental protection, including genetic information, remains available in the public domain.

I I I . SOCIAL AND ECONOMIC JUSTICE

9. Eradicate poverty as an ethical, social, and environmental imperative.

a. Guarantee the right to potable water, clean air, food security, uncontaminated soil, shelter, and safe sanitation, allocating the national and international resources required.

b. Empower every human being with the education and resources to secure a sustainable livelihood, and provide social security and safety nets for those who are unable to support themselves.

c. Recognize the ignored, protect the vulnerable, serve those who suffer, and enable them to develop their capacities and to pursue their aspirations.

10. Ensure that economic activities and institutions at all levels promote human development in an equitable and sustainable manner.

a. Promote the equitable distribution of wealth within nations and among nations.

b. Enhance the intellectual, financial, technical, and social resources of developing nations, and relieve them of onerous international debt.

c. Ensure that all trade supports sustainable resource use, environmental protection, and progressive labor standards.

d. Require multinational corporations and international financial organizations to act transparently in the public good, and hold them accountable for the consequences of their activities.

11. Affirm gender equality and equity as prerequisites to sustainable development and ensure universal access to education, health care, and economic opportunity.

a. Secure the human rights of women and girls and end all violence against them.

b. Promote the active participation of women in all aspects of economic, political, civil, social, and cultural life as full and equal partners, decision makers, leaders, and beneficiaries.

c. Strengthen families and ensure the safety and loving nurture of all family members.

12. Uphold the right of all, without discrimination, to a natural and social environment supportive of human dignity, bodily health, and spiritual well-being, with special attention to the rights of indigenous peoples and minorities.

a. Eliminate discrimination in all its forms, such as that based on race, color, sex, sexual orientation, religion, language, and national, ethnic or social origin.

b. Affirm the right of indigenous peoples to their spirituality, knowledge, lands and resources and to their related practice of sustainable livelihoods.

c. Honor and support the young people of our communities, enabling them to fulfill their essential role in creating sustainable societies.

d. Protect and restore outstanding places of cultural and spiritual significance.

IV. DEMOCRACY, NON-VIOLENCE, AND PEACE

13. Strengthen democratic institutions at all levels, and provide transparency and accountability in governance, inclusive participation in decision making, and access to justice.

a. Uphold the right of everyone to receive clear and timely information on environmental matters and all development plans and activities which are likely to affect them or in which they have an interest.

b. Support local, regional and global civil society, and promote the meaningful participation of all interested individuals and organizations in decision making.

c. Protect the rights to freedom of opinion, expression, peaceful assembly, association, and dissent.

d. Institute effective and efficient access to administrative and independent judicial procedures, including remedies and redress for environmental harm and the threat of such harm.

e. Eliminate corruption in all public and private institutions.

f. Strengthen local communities, enabling them to care for their environments, and assign environmental responsibilities to the levels of government where they can be carried out most effectively.

14. Integrate into formal education and life-long learning the knowledge, values, and skills needed for a sustainable way of life.

a. Provide all, especially children and youth, with educational opportunities that empower them to contribute actively to sustainable development.

b. Promote the contribution of the arts and humanities as well as the sciences in sustainability education.

c. Enhance the role of the mass media in raising awareness of ecological and social challenges.

d. Recognize the importance of moral and spiritual education for sustainable living.

15. Treat all living beings with respect and consideration.

a. Prevent cruelty to animals kept in human societies and protect them from suffering.

b. Protect wild animals from methods of hunting, trapping, and fishing that cause extreme, prolonged, or avoidable suffering.

c. Avoid or eliminate to the full extent possible the taking or destruction of non-targeted species.

16. Promote a culture of tolerance, nonviolence, and peace.

a. Encourage and support mutual understanding, solidarity, and cooperation among all peoples and within and among nations.

b. Implement comprehensive strategies to prevent violent conflict and use collaborative problem solving to manage and resolve environmental conflicts and other disputes.

c. Demilitarize national security systems to the level of a non-provocative defense posture, and convert military resources to peaceful purposes, including ecological restoration.

d. Eliminate nuclear, biological, and toxic weapons and other weapons of mass destruction.

e. Ensure that the use of orbital and outer space supports environmental protection and peace.

f. Recognize that peace is the wholeness created by right relationships with oneself, other persons, other cultures, other life, Earth, and the larger whole of which all are a part.

3.6 GLOBAL EFFORTS FOR ENVIRONMENTAL CONSERVATION

Various efforts towards Environmental Conservation can be traced to the origin of the concept of Sustainability as an approach with started gaining popularity among several environmentalists, scientists, scholars and alike who argued over the notions of growth and the limited resources resulting into environmental degradation and global implications. Serious debates began with the publication of the book "Limits to Growth" and later The "Silent Spring" by Rachael Carson in 1962 aroused public awareness related to the harmful effects of use of chemicals in form of pesticides and insecticides, also the release of the image known as Earthrise, taken by astronaut William Anders in 1968 during the Apollo 8 mission.[15]Since then global attention focused on various environmental issues throughout the 1960's. In the United Nations Conference on Human Environment, 1972 the Stockholm declaration was concluded on the Human Environment from which the concept of Sustainable development became popular at the global forum. The declaration was the first international document to recognize the right to a healthy environment through 26 principles. The conference was marked as a watershed in the history of international relations as it discussed about the protection and conservation of biosphere which was of the utmost importance worldwide. The initial approach focused on the control to human actions which would include control on pollution and conservation of the natural environment[10]. The United Nations Environment Programme (UNEP) got established at Stockholm as the central body in charge of environmental affairs by The UN General Assembly.

Since 1980's the discussions were directed from limits to growth towards the idea of sustainable development. First mention of this term is in 1980 by the International Union for the Conservation of Nature and Natural Resources. In 1983, the UN created the World Commission on Environment and Development, known as the Brundtland Commission. Its work, which focused on the difficult relationship between environment and development, resulted in the report Our Common Future (1987).[15] This document coined the concept of sustainable development - defined as "meeting the needs of the present generation without compromising the ability of future generations to meet their own needs" - which is the basis for the evolution of International Environmental Law.[15]The Commission recommended to the United Nations the creation of new charter or Universal Declaration on Environmental Protection and Sustainable

Development to set “new norms” that would guide the way to sustainable development.[4]The idea of the Earth Charter originated in 1987, by Maurice Strong and Mikhail Gorbachev as members of The Club of Rome, when the United Nations World Commission on Environment and Development called for a new charter to guide the transition to sustainable development. It thus paved way for The Earth Charter as proposed by the Secretariat of the UNCED.After a series of discussion a New Earth Charter Project was formally initiated in 1994 and the first international workshop on the Earth Charter was held at the Peace Palace, The Hague in Netherlands.[4] The year 1987 also marked signing of The Montreal Protocol as an international effort to combat the depletion of the ozone layer. The first international Earth Summit was held in Rio de Janeiro from 3 June to 14 June 1992. This global conference, held on the occasion of the 20th anniversary of the first Human Environment Conference in Stockholm, Sweden, in 1972, brought together political leaders, diplomats, scientists, representatives of the media and non-governmental organizations (NGOs) from 179 countries for a massive effort to focus on the impact of human socio-economic activities on the environment and address issues of environmental conservation. [14]It was held with the motive of Reaffirming the declaration of the United Nations Conference on the Human Environment, adopted at Stockholm on 16th June 1972, and seeking to build upon it. The Rio Declarationon Environment and Developmentwas yet another important Declaration in the history of Environmental Law. The conference highlighted how different social, economic and environmental factors are interdependent and evolve together, and how success in one sector requires action in other sectors to be sustained over time. The primary objective of the Rio 'Earth Summit' was to produce a broad agenda and a new blueprint for international action on environmental and development issues that would help guide international cooperation and development policy in the twenty-first century. [14]Two principles of the Rio Declaration deserve special consideration: the Precautionary Principle, the most advanced form of prevention and important to the formation of modern IEL; and Principle 10, which recognizes the right to information, participation, and justice in environmental matters.[15]

One of the major results of the UNCED Conference was Agenda 21.This declaration consists of 27 principles which guide the behaviour of the country towards an environmentally sustainable pattern of development. It is called as Agenda 21 because it is a comprehensive blue-print for local, national, regional, and global actions to affect the transition to sustainable development in the 21st Century. The declaration sought to achieve the goal of establishing a new and equitable global partnership by bringing in cooperation among the nations and their people. Its recommendations ranged from new methods of education, to new ways of preserving natural resources and new ways of participating in a sustainable economy. According to Maurice Strong, Secretary General of UNCED, "Agenda 21 constitutes the most comprehensive and far reaching programme of action ever approved by the world community". Thus the agenda lays emphasis

on the International co-operation for achieving the goal of sustainable development. [7]

The 'Earth Summit' had many great achievements: the Rio Declaration and its 27 universal principles, the United Nations Framework Convention on Climate Change (UNFCCC), the Convention on Biological Diversity; and the Declaration on the principles of forest management . The 'Earth Summit' also led to the creation of the Commission on Sustainable Development, the holding of first world conference on the sustainable development of small island developing States in 1994, and negotiations for the establishment of the agreement on straddling stocks and highly migratory fish stocks.[7]"Following Rio Declaration, all major economic treaties sought to include environmental protection. One such is the Marrakesh Agreement, which created the World Trade Organization in 1994 and was the first economic treaty to recognize the goals of sustainable development and environmental protection. The Convention on Climate Change of 1995 deserves special mention, since its signatories have met every year at the so-called Conference of the Parties (COP). Within this framework, in 1997, the Kyoto Protocol was presented. Despite not having been successful in mitigating greenhouse gas emissions, it was the first international agreement to establish legally binding obligations for developed countries. In Sept. 2000, 189 countries adopted the Millennium Declaration at the UN headquarters in New York, which reemphasized the principles of sustainable development by recognizing the need for sustainable economic growth with a focus on the poor and respect for human rights. The declaration was a commitment of the nations towards achieving a global partnership to reduce extreme poverty and hunger and it set out time bound series of eight targets with 21 goals to be achieved in the next fifteen years thus from 2000 to 2015. This came to be known as the Millenium Development Goals. (MDGs). Two years later, in 2002, representatives from 190 countries attended the UN World Summit on Sustainable Development in Johannesburg to follow up on the commitments of the Rio Summit. On that occasion, they adopted the Declaration on Sustainable Development, which focused on development and poverty eradication with a legal-economic approach on "public-private partnerships". And in 2012, the UN organized the third Conference on Sustainable Development, known as Rio + 20, in Rio de Janerio which brought together 192 Member States, private sector companies, NGOs, and other organizations. The result was a non-binding document called 'The Future We Want' in which the new agenda for the post 2015 era was presented in the form of the Sustainable Development Goals (SDGs). SDGs contain 17 goals with 169 targets and 304 indicators as proposed by the United Nations General Assembly's Open Working Group to be achieved by 2030. The agenda titled "Transforming our World: the 2030 Agenda for Sustainable Development" was formally adopted at the summit.[4]

Source : https://www.un.org/sustainabledevelopment

A substantial development which took in the mid-twentieth century place at global level backed by legal acceptance was the formulation of various International environmental laws, a body of international law concerned with protecting the environment, primarily through bilateral and multilateral international agreements. The Kyoto Protocol to address climate change gave way to the Paris Agreement (2015). In this agreement, the signatory countries committed themselves to doing everything possible to prevent the average temperature of the planet from rising by 2°C. It aimed to accelerate global action on climate change mitigation, adaptation and finance. The preamble highlighted the relationship between human rights and climate change. A contemporary landmark of great relevance, especially for Latin America, is Advisory Opinion 23 (2017) on the environment and human rights of the Inter-American Court of Human Rights. In it, the Court recognized for the first time the right to a healthy environment as fundamental to human existence, as well as the impacts of environmental degradation and climate change on human rights. [15]The Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer, which had come into force in 2019, aimed to phase down the production and consumption of hydro-fluorocarbons, potent greenhouse gases. The Stockholm+50, an international meeting convened by the United Nations General Assembly was held in Stockholm, Sweden -June 2022 to commemorate the 50 years since the 1972 United Nations Conference on the Human Environment. Some 122 countries attended, and participants called for accelerated action on existing internationally agreed objectives, including the targets of the 2030 Agenda and the Paris Agreement. In terms of areas for priority action carbon neutrality was mentioned as an important goal for their country through reduced forest and land degradation, enhanced reforestation, a move towards renewable energy, energy efficiency in the built infrastructure, and resource efficiency in key sectors such as agriculture. The recognition of the right of every human being to a healthy environment; and on a recognition of "ecocide" as an international crime has been of mention in its report. (Stockholm +50 Report, 2022).

Some other major instrumental legal initiatives include :

1. Vienna Convention for the Protection of the Ozone Layer, 1985
2. Montreal Protocol on Substances that Deplete the Ozone Layer, 1987
3. Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, 1989
4. Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters, 1998
5. Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, 1998
6. Stockholm Convention on Persistent Organic Pollutants, 2001
7. Compilation of key documents of the Antarctic Treaty system, Second edition (Buenos Aires : Secretariat of the Antarctic Treaty) 2014

3.7 ROLE OF INDIAN GOVERNMENT TOWARDS ENVIRONMENTAL CONSERVATION

The role of the state is of prime significance in bringing about long term positive environmental changes by influencing the civilian and industrial practices of resource use and management for achieving ultimate aim of sustainability. National implementation of environmental governance is the key, both to the efficacy of environmental governance system and to meaningful environmental improvements. (C.T Emejuru and Dike, 2019). Various provisions of Article 48A of the Indian constitution upheld the importance of environmental resources and quality as fundamental right to life and personal liberty of the citizens. The facilitation of public interest litigation has empowered the public to ensure a check on private and government actions affecting the environmental resources and easing out the process of individuals in seeking judicial redress. To bring about civic awareness and invoke environmental responsibility environmental education has been included as an essential component at all levels of schooling and higher education. In February 1971, the University Grants Commission (India), in collaboration with other organizations, launched a symposium on the development of environmental studies in the Indian Universities. The consensus that emerged at the symposium was that ecology and environmental issues should form part of the courses of study at all levels.

The role of Indian government in environmental conservation is evident through the following paragraphs.

I. CONSTITUTION OF INDIA AND THE PROTECTION OF ENVIRONMENT: To protect and improve the environment is a constitutional mandate. It is a commitment for a country wedded to the ideas of a welfare State. The Indian Constitution contains specific provisions for environment protection under the chapters of Directive Principles of State Policy and Fundamental Duties. The following provisions of Constitution of India well elucidate the states conviction in the protection of environment –

a. The Preamble of the Indian Constitution - The "Socialistic" pattern denotes the inclusion of "decent standard of living", which relates to the basic things, such as water, air, shelter and education. Such a type of environment would essentially mean pollution free environment to achieve a decent quality of life. India being a "Democratic Republic" the people can exercise their right to clean environment and discuss, oppose, support and show affirmative action in response to the policies made by the state which is essential for the success of environmental policies. [7]

b. Federal System of the Government and Environmental jurisdiction - To ensure appropriate allocation of legislative authority India has adopted a quasi federal system in which the governmental powers are shared between the Central Government, the State Government and the local level governments. The matters of environment are dealt by various statutes. Part XI of the Constitution (Article 245 to 263) regulates the legislative and administrative relations between the Union and the State. The subjects are divided among three lists, which are the Union List, State List and the Concurrent List. The subjects mentioned in the concurrent list pertaining to environmental protection and conservation include forests, protection of Wild animals and birds, population control and family planning. Those which have a larger national interest are left to be tackled by the Centre as well as the State.

The Constitution of India has made a double provision:

(i) A directive to the State for protection and improvement of environment.
(ii) (ii) Imposing on every citizen in the form of fundamental duty to help in the preservation of natural environment.

II. Fundamental Duties of Indian Citizens - The Constitution (Forty Second Amendment) Act, 1976, added a new part IV-A dealing with the Fundamental Duties in the Constitution of India.42 Article 51-A of this part enlists the ten Fundamental Duties.

a. Article 51-A(g) specifically deals with the fundamental duty towards the environment. It provides : It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife, and to have compassion for living creatures. The fundamental duties are intended to promote peoples' participation

in restructuring and building a welfare society. The protection of environment is matter of constitutional priority. While Article 48 provides for cows and calves and other milch and drought cattle', Article 51-A(g) enjoins it as a fundamental duty of every citizen "to have compassion for living creatures", which is in wider fold embraces the category of cattle spoken of specifically in Article 48.

III. Directive Principles of State Policy - Part IV of the Indian Constitution deals with directive principles of State policy. They represent the socio economic goals which the nation is expected to achieve. These principles are designed to guide the destiny of the nation by obligating three wings of the State, i.e., legislature, judicature and executive to implement these principles. Article 47 of the Constitution is one of the Directive Principles of the State policy and it provides that the State shall regard the raising of the level of nutrition and standard of living of its people and the improvement of public health as among its primary duties. The improvement of public health also includes the protection and improvement of the environment without which public health cannot be assured.

a. Article 14 deals with the PROTECTION OF THE ENVIRONMENT. It lays down the role of the government and the contractor regarding the necessary guidelines to be followed while undertaking a project so that the environment remains unharmed. The studies mentioned in Article 14.5 above shall contain proposed environmental guidelines to be followed in order to minimize Environmental Damage and shall include, but not be limited to, the following, :

(a) proposed access cutting; (b) clearing and timber salvage; (c) wildlife and habitat protection; (d) fuel storage and handling: (e) use of explosives; (f) camps and staging; (g) liquid and solid waste disposal; (h) cultural and archaeological sites; (i) selection of drilling sites; (j) terrain stabilization; (k) protection of freshwater horizons; (I) blowout prevention plan; (m) flaring during completion and testing of Gas and Oil Wells; (n) abandonment of Wells; (o) rig dismantling and site completion; (p) reclamation for abandonment; (q) noise control; (r) debris disposal; and (s) protection of natural drainage and water flow.

(a) Government shall convey its decision regarding any proposal for environmental clearances submitted by the Contractor pursuant to the provisions of this Article or Contract or required under any laws of India within one hundred and twenty (120) days from the date of submission of application by Contractor seeking such clearance.

b. Article 48-A -Global consciousness for the protection of environment in the seventies, Stockholm Conference and increasing awareness of the environmental crisis prompted the Indian Government to enact 42nd Amendment to the Constitution in 1976. The Constitution was amended to introduce direct provisions for protection of environment. This 42nd Amendment added Article 48-A to the Directive Principles

of State Policy. This new directive principle in Article 48- A dealing specifically with protection and improvement of environment. It provides: The State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country. Thus, Indian Constitution became one of the rare constitutions of the world where specific provisions were incorporated in the Supreme Law putting obligations on the State as well as the Citizens to protect and improve the environment. The State cannot treat the obligations of protecting and improving the environment as mere pious obligation. They are fundamental in the governance of the country and they being part of the Supreme Law of the land, have to be implemented. The Directive principles serve the courts as a code of interpretation. Part III dealing with Fundamental Rights and Part IV dealing with the directive principles are complementary and supplementary to each other.

c. Article49-A: states: "The State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country." The said amendment imposed a responsibility on every citizen in the form of Fundamental Duty.

d. Article 51-A (g) – the protection and improvement of natural environment is the duty of the State (Article 48-A) and every citizen (Article 51- A (g)). It employs the expression "the natural environment" and includes therein "forests, lakes, rivers and wild life". While Article 48 provides for "cows and calves and other milch and draught cattle", Article 51-A(g) enjoins it as a fundamental duty of every citizen "to have compassion for living creatures", which in its wider fold embraces the category of cattle spoken of specifically in Article 48.

e. Article 253: Article 253 states that 'Parliament has power to make any law for the whole or any part of the country for implementing any treaty, agreement or convention with any other country. In simple words this Article suggests that in the wake of Stockholm Conference of 1972, Parliament has the power to legislate on all matters linked to the preservation of natural environment. Parliament's use of Article 253 to enact Air Act and Environment Act confirms this view.

IV. Fundamental Rights - Principle 1 of the Stockholm declaration finds reflection in Articles 14,19 and 21 of the Constitution of India dealing with the right to equality, freedom of expression and right to life and personal liberty respectively. Fundamental Rights are means to achieve the goals indicated in part IV of the Indian Constitution and thus must be construed in the light of the Directive Principles i.e. the Part IV. Articles 21, 39(e), 41, 43 and 48-A of the Constitution of India substantiate that social security, just and humane conditions of work and leisure to workmen are part of his meaningful right to life.

a. Right to Life and Right to Healthy Environment Article 21 of the Constitution states that every individual has the right to life and personal liberty except according to the procedure established by law. So, it guarantees all people "Right to life and Personal Liberty". With the development of law and pronouncement of judgments by the Supreme Court of India, Article 21 of the Constitution has been expanded to take within its ambit the right to a clean and decent environment. Article 21 is the heart and soul of fundamental rights. For healthy existence and preservation of the essential ingredients of life, stable ecological balance is required. Article 21 guarantees a fundamental right to life - a life of dignity, to be lived in a proper environment, free of danger of disease or infection. The expression 'life' enshrined in Article 21 of the Constitution does not connote mere animal existence or continued drudgery through life. It has a much wider meaning which includes right to livelihood, better standard of living, hygienic conditions in the workplace and leisure.

b. Right to Livelihood - The judicial grammar of interpretation has further broadened the scope and ambit of Article 21 and now "Right to Life" includes the" right to livelihood". This broad interpretation of the right to life is very helpful in checking the governmental action which has an environmental impact that threatens the poor people of their livelihood by dislocating them from their place of living or otherwise depriving them of their livelihood.

c. Right to Freedom of Speech and Expression - Article 19(1)(a) guarantees every citizen a fundamental freedom of speech and expression. In India most of the environmental cases are dealt and filed with the help of Public Interest Litigations so that people have a right to express their concerns about the environment and exercise their right to freedom of speech and expression, sometimes even by writing letters to the Court or otherwise filing petitions before it, highlighting the violation of rights of the people to live in healthy environment in one way or the other. From time to time it is evident that the judiciary has treated the condition of protection and preservation of environment and wildlife as a reasonable restriction in the public interest on the fundamental freedom under Article 19(1)(g) of the Constitution.

d. Right to Equality - Article 14 of the Constitution provides: The state shall not deny to any person equality before the law or equal protection of the laws within the territory of India. The principle for non arbitrariness pervades article 14 like a brooding omnipresence. Whenever there is arbitrariness in State Action, whether of the legislative or of the executive or of an authority under article 12, article 14 immediately springs into action and strikes down such action.

V. ENACTMENT OF VARIOUS ENVIRONMENTAL LEGISLATIONS -

There exist a host of legislation in India aimed at protecting the environment from pollution and maintaining the ecological balance. Indian environmental law concerns the law and policy of India concerning the protection of the environment, The detailed and developed framework for environmental protection came after the UN conference on Human Environment in Stockholm, in 1972. This led to the formation of the National Council for Environmental Policy and Planning in 1972 within the science and technology department. This was set up to establish a regulatory body for the overview of the environmental-related issues and concerns. This council was later converted to the Ministry of Environment and Forests. The government of India has made numerous laws and acts to protect the environment and biodiversity. These can be broadly categorized into four distinct but overlapping phases as below:

FIRST PHASE – 1972-1983: There were numerous legislations following the 1972 Stockholm declaration and India's commitment towards it. Constitutional provisions as explained earlier such as Article 226, Article 21, Article 32. Article 48-A, Article 51A(g) ensured state obligation, fundamental rights and duties and Directive Principles of State Policy towards environmental protection. Several Acts such as the Wildlife (Protection) Act of 1972,the Water (Prevention and Control of Pollution) Act of 1974, the Forest Conservation Act of 1980 and the Air (Prevention and Control of Pollution) Act of 1981 were enacted pertaining to environmental protection and conservation.

SECOND PHASE - (1984-1997) This period focused on ensuring social equity and justice. In response to the 'Bhopal Gas Disaster' in 1984, there was a growth in 'judicial activism' which led to a reinterpretation of existing laws and legislations. The Air (Prevention and Control of Pollution) Act of 1981 underwent a major modification in 1987. In 1991 the Public Liability Insurance Act, was enacted to provide for immediate relief to persons affected by accidents from handling of notified hazardous substance, on a 'no fault basis'. In response to the 'Rio Declaration' that called upon Nations to develop laws regarding liabilities and compensation to victims of pollution and other environmental damages two Acts were formulated the National Environment Tribunal Act, 1995 (Repealed) and the National Environment Appellate Authority Act. These have been subsequently repealed and replaced by the new National Green Tribunal Act of 2010. The Environment (Protection) Act (EPA) was enacted in 1986. Under the EPA, Environmental Impact Assessment (EIA) Notification was introduced in 1994, it was modified in 2006 and the latest amendment was in 2009. Other legislations that have been introduced for the protection of the environment and prevention of pollution are the Motor Vehicles Act, 1988, to control air pollution due to vehicles.

THIRD PHASE – (1984-2004) The third phase coincides with India's membership of the WTO in 1998. The focus is on combining economic development with social and environmental issues. Legislations and amendments to the existing legislations have been done to achieve compliance with the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) keeping in mind the principles of the 'Convention on Biological Diversity' (CBD). The Biological Diversity Act 2002 was framed keeping in mind the principles of CBD. The legislations are directed towards ensuring the sovereign rights of countries over their genetic and biological resources and the acceptance of the need to share benefits flowing from the commercial utilization of biological resources with holders of indigenous knowledge. The Patents (Amendment) Act of 2005 has a provision to prevent misappropriation of indigenous knowledge of communities by making it nonpatentable. The Geographical Indications of Goods (Registration and Protection) Act, 1999 facilitates protection of the collective rights of the rural and indigenous communitiesin their unique products. the EPA several secondary legislations dealing with waste management and recycling of substances such as:

Municipal Solid Wastes (Management and Handling) Rules, 2000; Recycled Plastics Manufacture and Usage Rules,1999; Manufacture, Storage and Import of Hazardous Chemical (Amendment) Rules, 2000; Batteries (Management and Handling) Rules, 2001; Ozone Depleting Substances (Regulation and Control) Rules,2000; A series of notifications delegating power to State, River Conservation Authorities to deal with water pollution; and The Noise Pollution (Regulation and Control) Rules, 2000. The emphasis in this phase was also on energy conservation and use of renewable sources of energy. Consequently the Energy Conservation Act, 2001 was enacted, which also set up the Bureau of Energy Efficiency. The Electricity Act of 2003 has tried to ensure better development in the power sector and also emphasise the use of renewable energy. Under the orders of the Supreme Court, Compensatory Afforestation Management and Planning Agency (CAMPA), was set up in 2004, to compensate for deforestation for development work through afforestation.

FOURTH PHASE (2005 AND BEYOND) : This phase is marked by a proactive rights based approach. A rights based approach is one in which the focus is on ensuring the rights of all sections of community particularly the marginalised. These include legislations like the Human Rights Act 1993 with Amendment Act, 2006; The Right of Children to Free and Compulsory Education Act, 2009 and Commission for the Protection of Child Rights Act, 2005; Maintenance and Welfare of Parents and Senior Citizens Act, 2007; People with Disabilities Act, 1995. For instance the rights of the traditional forest dwellers have been codified in the Forest Rights Act, 2006. The Act seeks to reconcile the needs of the forest dwellers with the need to conserve wildlife and forests. The Wildlife (Protection) Act of 1972 was amended in, 2002 and it seeks to provide for

participatory management of the buffers around the National Parks and Sanctuaries and introduces the concept of 'Community Reserves'. This phase also continued to focus on the environment through the Environment Impact Assessment Notification of 2006 and the Hazardous was notified Wastes (Management, Handling and Transboundary Movement)Rules, 2008. In 2011, the E-Waste (Management and Handling)Rules, for environmentally sound practices for management of electronic waste were notified. The National Green Tribunal Act of 2010 seeks to give effect to the promise made at Rio and to provide for the effective and expeditious disposal of cases related to environmental protection, forests and natural resourcesand provide relief and compensation for damages.

VI. ENVIRONMENTAL INSTITUTIONS IN INDIA

To address the diverse environmental issues a number of environment related institutions and organization have been setup at national level. The state plays a vital role in environmental pollution control, conservation and improvement of environment for promoting sustainable development. In 1972 the National Committee on Environmental Planning and Coordination (NCEPC) was formed which gradually evolved as a separate department of environment and reached the full-fledged stage of Ministry of Environment and Forests in 1985. The Ministry of Environment and Forest, Central Pollution Control Board, Indian Board for Wildlife are the main national environmental agencies.

a. The Ministry of Environment and Forests (MoEF) is the nodal agency in the administrative structure of the Central Government, for planning, promoting, coordinating and overseeing the implementation of environmental and forestry programmes in the country. The main activities undertaken by the ministry include conservation and survey of the flora and fauna of India, forests and other wilderness areas; prevention and control of pollution; afforestation and reducing land degradation. It is responsible for the administration of the national parks of India. The main tools utilized for this include surveys, environmental impact assessment, control of pollution, regeneration programmes, support to organizations, research to find solutions and training to augment the requisite manpower, collection and dissemination of environmental information and creation of environmental awareness among all sectors of the country's population.The Ministry is also the nodal agency in the country for the United Nations Environment Programme (UNEP).

b. Central Pollution Control Board The Central Pollution Control Board (CPCB), is statutory organisation, was constituted in September, 1974 under the Water (Prevention and Control of Pollution) Act, 1974. Further, CPCB was entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981. It serves as a field formation and also provides technical services to the Ministry of Environment and Forests of the provisions of the Environment

(Protection) Act, 1986. Air Quality Monitoring is an important part of the air quality management. The National Ambient Air Quality Monitoring (NAAQM) Programme has been established with the objectives to determine the present status of air quality, for controlling and regulating emission of air pollutants from industries and other sources to meet the air quality standards.

c. Indian Board for Wildlife (IBWL) The IBWL was constituted in 1952 as an apex advisory body in the field of Wildlife Conservation in the country. It was replaced by National Board for Wildlife (NBWL) which is a statutory body constituted under Section 5A of the Wildlife (Protection) Act, 1972 (WLPA). It is primarily responsible for the promotion of wildlife conservation and the development of wildlife and forests. It approves projects (including government projects) in and around the protected areas (national parks, wildlife sanctuaries, etc.). It is an advisory board and advises the central government on policy matters concerned with wildlife conservation in the country.

VII. COMPULSORY ENVIRONMENTAL EDUCATION –

The Supreme Court (writ petition (Civil) No. 860 of 1991) has directed the University Grants Commission to prescribe a course on 'Man and Environment'. In the light of this directive, the UGC issued a circular to various universities to introduce the course on 'Environmental Education'.

3.8 SUMMARY

The need for environmental sustainability has arisen as the global demand on natural resources and ecosystems have escalated beyond the nature's carrying capacity. Environmental degradation risks economic growth and human development. In the wake of present environmental crisis resulting from impact of human activities, it is essential to understand the fundamental principles of ecological conservation. Human activities need to be conducted in a way that maintains ecological equilibrium. This can be achieved by practicing environmental sustainability which is centered on human well-being and environmental interface. There needs to be a balance between resource availability and its utilization following the sustainability approach. To achieve this fine balance between environmental protection and socio-economic development, the principles of environmental conservation have been seen as a key instrument and are therefore accepted as an integral part of global and national policies and governance.

3.9 CHECK YOUR PROGRESS/EXERCISE

A. True or False

i. The Supreme Court directed the University Grants Commission to prescribe a course on 'Man and Environment'

ii. Ecological integrity is least concerned with the biodiversity aspects of the environment.

iii. Eradication of poverty helps in ensuring social and economic justice.

iv. Article 10 of Indian Constitution deals with protection of environment.

v. The Wildlife (Protection) Act in India was passed in 1972 following India's commitment to Stockholm declaration

B. Fill in the blanks

i. _____ is scientific study of the interactions between organisms and their environments.

ii. The term _____ finds it origin in the Latin word 'conservare' meaning "to keep, preserve, guard" from.

iii. Reduce, Reuse and _____ ensure that production and consumption patterns are maintained within the ecological systems.

iv. The Declaration on Sustainable Development was adopted at the UN World in _____ to follow up on the commitments of the Rio Summit.

v. Article 21 of Indian Constitution deals with the right to healthy _____.

C. Multiple Choice Questions

i. The _____ as an international effort to combat the depletion of the ozone layer.

a. Montreal Protocol

b. Kyoto Protocol

c. Earth Chater

d. Agenda 21

ii. The UN organized the third Conference on Sustainable Development, known as _____.

a. Earth Summit

b. Rio + 20

c. Stockholm Declaration

d. Vienna Convention

iii. Vienna Convention was adopted for the Protection of the _____.

a. biodiversity

b. wildlife

c. Ozone Layer

d. amazon forests

iv. Article of Indian Constitution specifically deals with the fundamental duty of citizens towards the environment.

a. 51-A(g)

b. 10

c. 13

d. 5

v. Article _____ lays down the role of the government and the contractor regarding the necessary guidelines to be followed while undertaking a project for environmental protection.

a. 14

b. 10

c. 13

d. 5

D. Answer the following questions

i. What is meant by the term ecological equilibrium?

ii. Write a note on environmental conservation. Explain its significance.

iii. Write about the various environmental legislations in India.

iv. Discuss the various global initiatives for environmental conservation since 1960's.

v. Briefly explain the principles of environmental conservation.

3.10 ANSWERS TO SELF LEARNING QUESTIONS

A. True or False

i. True

ii. False

iii. True

iv. False

v. True

B. Fill in the blanks

i. Ecology

ii. conservation

iii. Recycle

iv. iv Johannesburg.

v. environment.

C. Multiple Choice Questions

i. Montreal Protocol

ii. ii.Rio + 20

iii. Ozone layer

iv. iv.51-A(g)

v. 14

3.11 TECHNICAL WORDS AND THEIR MEANING

a. Ecosystem equilibrium - refers to the balance between the ecosystem functions of resource creation and our consumption of the resources.

b. Conservation – refers to the act of Conservation is the act of safeguarding or protecting Earth's natural resources for current and future generations.

c. Environmental sustainability - refers to the ability to maintain the qualities of the physical environment in a way that ecosystem diversity and productivity is carried out infinitely.

d. Sustainable development is defined as the development "meeting the needs of the present generation without compromising the ability of future generations to meet their own needs"

3.12 TASK

Analyse the progress achieved by India towards fulfilling its commitment towards the Sustainable Development Goals. Comment on the challenges and measures needed to achieve its goal.

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4

ENVIRONMENTAL RESEARCH

Unit Structure :

After going through this chapter, you will be able to understand the following features:

4.1 OBJECTIVES

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

- Understand how to write the concept, objectives and scope in a research report
- Compile a review of literature suitable for a good research
- Present the findings, limitations and suggestions of a research study

4.2 INTRODUCTION

Presenting a research takes equal efforts just as put in conducting the research. A research is a systematic process which needs to be followed appropriately and presented systematically. There is a systematic sequence of writing the parts of the research that help to follow the process without

losing out on any component. The present chapter highlights the important parts of a research report whether it is an article, a paper, a dissertation or a thesis.

4.3 SUBJECT DISCUSSION

Research is finding new facts in an existing aspect or concept. It can be undertaken in each and every field including environment as a discipline. Research plays a crucial role in assessing the potential risks posed by an ever-increasing variety of environmental pollutants. Environmental research in its most scientific way

4.4 CONCEPT, OBJECTIVES AND SCOPE

4.4.1 Concept

The first step in the research process is to define the concepts we are studying. Researchers generate concepts by generalizing from particular facts. Concepts can be based on real phenomena and are a generalized idea of something of meaning. Examples of concepts include common demographic measures: Income, Age, Education Level, and Number of Siblings.

We can measure concepts through direct and indirect observations:

- Direct Observation: We can measure someone's weight or height. And, we can record the color of their hair or eyes.

- Indirect Observation: We can use a questionnaire in which respondents provide answers to our questions about gender, income, age, attitudes, and behaviors.

In other words concept can be defined as variables under study. The researcher needs to clearly enlist the concepts focused in the research. He/she needs to define each concept in detail so that the reader can understand the meaning and applicability of each concept in the study.

The concepts must be written as points with their respective meanings and definitions at the beginning of the research report. At times, some concepts have a formula associated with their measurement or calculation which must also be added to the explanation.

4.4.2 Aims/ Objectives

A very useful and practical approach is considering your research questions in terms of aim(s) and objectives. The aim of the work, i.e. the overall purpose of the study, should be clearly and curtly defined.

In general, research objectives describe what we expect to achieve by a project. Research objectives may be linked with a hypothesis or used as a statement of purpose in a study that does not have a hypothesis.

Even if the nature of the research has not been clear to the layperson from the hypotheses, s/he should be able to understand the research from the objectives.

A statement of research objectives can serve to guide the activities of research. Consider the following examples.

- Objective: To describe what factors farmers take into account in making such decisions as whether to adopt a new technology or what crops to grow.

- Objective: To develop a budget for reducing pollution by a particular enterprise.

- Objective: To describe the habitat of the giant panda in China.

- In the above examples the intent of the research is largely descriptive.

In the case of the first example, the research will end the study by being able to specify factors which emerged in household decisions.

In the second, the result will be the specification of a pollution reduction budget.

In the third, creating a picture of the habitat of the giant panda in China.

These observations might prompt researchers to formulate hypotheses which could be tested in another piece of research. So long as the aim of the research is exploratory, i.e., to describe what is, rather than to test an explanation for what is, a research objective will provide an adequate guide to the research.

4.4.3 Scope

The scope of a study explains the extent to which the research area will be explored in the work and specifies the parameters within the study will be operating.

Basically, this means that you will have to define what the study is going to cover and what it is focusing on. Similarly, you also have to define what the study is not going to cover. This will come under the limitations. Generally, the scope of a research paper is followed by its limitations.

As a researcher, you have to be careful when you define your scope or area of focus. Remember that if you broaden the scope too much, you might not be able to do justice to the work or it might take a very long time to complete. Consider the feasibility of your work before you write down the scope. Again, if the scope is too narrow, the findings might not be generalizable.

Typically, the information that you need to include in the scope would cover the following:

1. General purpose of the study
2. The population or sample that you are studying
3. The duration of the study
4. The topics or theories that you will discuss
5. The geographical location covered in the study

4.5 REVIEW OF LITERATURE AND RESEARCH METHODOLOGY

4.5.1. Review of Literature

A literature review is a survey of scholarly sources that provides an overview of a particular topic.

The basic components of a literature review include:

- a description of the publication/ sources;
- an organizational pattern that combines summary & synthesis; - A summary is the recap of the important information of the source and synthesis is a re-organization, or a reshuffling of that information. It might give a new interpretation of old material or combine new with old interpretations or it might trace the intellectual progression of the field.
- a discussion of gaps in research;

It is a critical and analytical account of the existing research on a particular topic.

One of the essential preliminary tasks when you undertake a research study is to go through the existing literature in order to acquaint yourself with the available body of knowledge in your area of interest.

Reviewing the literature can be time consuming, daunting and frustrating, but it is also rewarding. The literature review is an integral part of the research process and makes a valuable contribution to almost every operational step.

It has value even before the first step; that is, when you are merely thinking about a research question that you may want to find answers to through your research journey. In the initial stages of research it helps you to establish the theoretical roots of your study, clarify your ideas and develop your research methodology. Later in the process, the literature review serves to enhance and consolidate your own knowledge base and helps you to integrate your findings with the existing body of knowledge.

Since an important responsibility in research is to compare your findings with those of others, it is here that the literature review plays an extremely important role. During the write-up of your report it helps you to integrate

your findings with existing knowledge – that is, to either support or contradict earlier research. The higher the academic level of your research, the more important a thorough integration of your findings with existing literature becomes.

The aim of undertaking a review of literature is:

- To provide an organized overview of existing research on a specific topic
- To take a critical and evaluative perspective toward published research
- To summarize, synthesize and analysesthe arguments of other authors
- To uncover similarities and differences or consistencies and inconsistencies within existing research
- To identify a gap within the body or research
- To help you generate and justify your research question and hypotheses

4.5.1.1. Creation of a literature review

IS NOT	IS
A descriptive summary of existing literature	A critical, analytical account
A presentation of your own argument	A synthesis of the arguments of others
Organised by source or written as an annotated bibliography	Organised around ideas or arguments
An account of every existing piece of research related to your topic	An account of a selection of writings relevant to your work

The length and depth of the literature review depends on the length of the project. If we are writing a 10-page argument paper, we may have room to include 5-6 sources to review, because we will also be establishing your argument as well, but there's no hard equation for how many or how much. We should use our judgment.

4.5.1.2. Types of Literature Review

There are many types of literature review and the following types of literature review are the most popular in business studies:

1. Narrative literature review critiques the literature and summarizes the body of a literature. The primary purpose of a traditional or narrative literature review is to analyse and summarise a body of literature. This is achieved by presenting a comprehensive background of the

literature as well as highlight new research streams, identify gaps or recognize inconsistencies. This type of literature review can help in refining, focusing and shaping research questions as well as in developing theoretical and conceptual frameworks.

2. Systematic literature review requires more rigorous and well-defined approach compared to most other types of literature review. Systematic literature review is comprehensive and details the timeframe within which the literature was selected. It focus on very specific empirical questions – often in cause and effect form- To what extend does A contribute to B.

Systematic literature review can be divided into two categories: meta-analysis and meta-synthesis.

- When you conduct meta-analysis you take findings from several studies on the same subject and analyze these using standardized statistical procedures. In meta-analysis patterns and relationships are detected and conclusions are drawn. Meta-analysis is associated with deductive research approach.

- Meta-synthesis, on the other hand, is based on non-statistical techniques. This technique integrates, evaluates and interprets findings of multiple qualitative research studies. Meta-synthesis literature review is conducted usually when following inductive research approach.

3. Argumentative literature review, as the name implies, examines literature selectively in order to support or refute an argument, deeply imbedded assumption, or philosophical problem already established in the literature. The purpose is to develop a body of literature that establishes a contrarian viewpoint. It should be noted that a potential for bias is a major shortcoming associated with argumentative literature review.

4. Integrative literature review reviews, critiques, and synthesizes secondary data about research topic in an integrated way such that new frameworks and perspectives on the topic are generated. If your research does not involve primary data collection and data analysis, then using integrative literature review will be your only option.

4.5.1.3. Steps in conducting Literature Review

The first step is to plan. Before starting to write identify a research topic. When choosing the topic make sure it is specific. Narrowed topic is better so that you can find the most relevant sources of literature review. There are hundreds or even thousands of books on most areas of study. Narrowing your topic will help to limit the number of sources you need to read in order to get a good survey of material.

If the topic is broad, the researcher will have to go through several material which is time consuming and would result in nothing.

For helping narrowing your topic use the table like this ---

General Topic	Specific Topic	Narrowed Topic
Anxiety	Social Anxiety	Impact of Social Anxiety on the Learning of the Students
Anxiety	Separation Anxiety	Role of Parenting Style on Childhood Separation Anxiety
Anxiety	Generalized Anxiety	Impact of Generalized Anxiety on Voting Behaviour of College Students

The second step is to conduct your research. First find the most relevant scholarly resource on the topic.

The third step is to organize the reviews that are collected in chronological, temporal, thematic, methodological and theoretical order.

4.5.2 Research Methodology

A research methodology gives research legitimacy and provides scientifically sound findings. It also provides a detailed plan that helps to keep researchers on track, making the process smooth, effective and manageable. A researcher's methodology allows the reader to understand the approach and methods used to reach conclusions.

Advantages of a good research methodology are as follows:

- Other researchers who want to replicate the research have enough information to do so.
- Researchers who receive criticism can refer to the methodology and explain their approach.
- It can help provide researchers with a specific plan to follow throughout their research.
- The methodology design process helps researchers select the correct methods for the objectives.
- It allows researchers to document what they intend to achieve with the research from the outset.

4.5.2.1. Types of Research Methodology

1. Qualitative

Qualitative research involves collecting and analyzing written or spoken words and textual data. It may also focus on body language or visual elements and help to create a detailed description of a researcher's

observations. Researchers usually gather qualitative data through interviews, observation and focus groups using a few carefully chosen participants.

This research methodology is subjective and more time-consuming than using quantitative data. Researchers often use a qualitative methodology when the aims and objectives of the research are exploratory. For example, when they perform research to understand human perceptions regarding an event, person or product.

2. Quantitative

Researchers usually use a quantitative methodology when the objective of the research is to confirm something. It focuses on collecting, testing and measuring numerical data, usually from a large sample of participants. They then analyze the data using statistical analysis and comparisons. Popular methods used to gather quantitative data are:

- Surveys
- Questionnaires
- Test
- Databases
- Organizational records

This research methodology is objective and is often quicker as researchers use software programs when analyzing the data. An example of how researchers could use a quantitative methodology is to measure the relationship between two variables or test a set of hypotheses.

3. Mixed-method

This contemporary research methodology combines quantitative and qualitative approaches to provide additional perspectives, create a richer picture and present multiple findings. The quantitative methodology provides definitive facts and figures, while the qualitative provides a human aspect. This methodology can produce interesting results as it presents exact data while also being exploratory.

4.6 FINDINGS, LIMITATIONS, SUGGESTIONS

4.6.1. Findings

Findings are basically the key outcome of the investigation. It is basically a key fact which you can discover during an investigation. Research findings are facts and phrases, observations, and experimental data resulting from research.

It's important to note here that "finding" does not always mean "factual information" because conductive research relies on results and implications rather than measurable facts.

For example, A researcher is conducting research for measuring the extent up to which globalization impacts the business activities of firms.

The findings of the research reveal that there has been a great increase in the profitability of companies after globalization. An important fact which researcher has discovered is that it is globalization which has enabled firms to expand their business operations at the international level.

Objectives of finding section in the research paper

- The main objective of the finding section in a research paper is to display or showcase the outcome in a logical manner by utilizing, tables, graphs, and charts.

- The objective of research findings is to provide a holistic view of the latest research findings in related areas.

- Research findings also aim at providing novel concepts and innovative findings that can be utilized for further research, development of new products or services, implementation of better business strategies, etc.

For example, an academic paper on "the use of product life cycle theory with reference to various product categories" will not only discuss different dimensions of the product life cycle but would also present a detailed case study analysis on how the concept was applied using several contemporary case studies from diverse industries.

Importance of findings in the research paper

The finding section in the research paper has great importance as

- It is the section in a research paper or dissertation that will help you in developing an in-depth understanding of the research problems.

- This is the section where the theories where you can accept or reject theories.

- The findings section helps you in demonstrating the significance of the problem on which you are performing research.

- It is through analysis of the finding section you can easily address the correlational research between the different types of variables in the study.

Steps in writing research findings

- Review the guidelines or instructions of the instructor
- Focus on the results of the experiment and other findings
- Design effective visual presentations
- Write findings section
- Review draft of findings section

4.6.2 Limitations

The limitations of a study are its flaws or shortcomings. Study limitations can exist due to constraints on research design, methodology, materials, etc., and these factors may impact the findings of your study. However, researchers are often reluctant to discuss the limitations of their study in their papers, feeling that bringing up limitations may undermine its research value in the eyes of readers and reviewers.

In spite of the impact it might have (and perhaps because of it) you should clearly acknowledge any limitations in your research paper in order to show readers—whether journal editors, other researchers, or the general public—that you are aware of these limitations and to explain how they affect the conclusions that can be drawn from the research.

Although limitations address the potential weaknesses of a study, writing about them towards the end of your paper actually strengthens your study by identifying any problems before other researchers or reviewers find them.

Furthermore, pointing out study limitations shows that you've considered the impact of research weakness thoroughly and have an in-depth understanding of your research topic. Since all studies face limitations, being honest and detailing these limitations will impress researchers and reviewers more than ignoring them.

Some limitations might be evident to researchers before the start of the study, while others might become clear while you are conducting the research. Whether these limitations are anticipated or not, and whether they are due to research design or to methodology, they should be clearly identified and discussed in the discussion section—the final section of your paper. Most journals now require you to include a discussion of potential limitations of your work, and many journals now ask you to place this "limitations section" at the very end of your article.

Common Limitations of the Researchers:

- Common Methodological Limitations of Studies
- Issues with research samples and selection
- Insufficient sample size for statistical measurements
- Lack of previous research studies on the topic
- Methods/instruments/techniques used to collect the data
- Limited access to data
- Time constraints
- Conflicts arising from cultural bias and other personal issues

4.6.3. Suggestions/ Recommendations

Recommendations are arguably the most important part of the analysis phase—this is where you'll suggest specific interventions or strategies to address the issues and constraints identified in the assessment.

Recommendations should directly respond to key findings arrived at through data collection and analysis. A process of prioritization is essential to narrowing down findings, and once this is done, recommendations should be developed that align with the most important findings.

Recommendations should be one-sentence, succinct, and start with an action verb (create, establish, fund, facilitate, coordinate, etc.). They should use a "SMART" format (Specific, Measurable, Attainable, Realistic, Timely). Each recommendation should be followed by a few sentences of explanatory text.

In addition to being "SMART," recommendations should be feasible. Both operational feasibility and political feasibility (i.e., political will) should be considered when developing recommendations. Experience has demonstrated that gauging potential public sector receptivity to proposed private health sector initiatives is essential.

A final consideration for recommendations is timing. Often solutions to identified problems are sequential, building upon intermediate steps. Teams sometimes frame recommendations as near-term (e.g., 6 to 12 months) and longer term (e.g., one to three years).

Recommendations are typically summarized in the Executive Summary, and presented in full within specific technical sections, usually as a short list of bullets following the findings summary. In some reports, there may be a section at the end of the document that consolidates recommendations and highlights the linkages across core areas (e.g., service delivery and health financing) prior to the conclusion section.

Recommendations stem from the findings. Link each of your recommendations to the finding that supports it, to highlight the direct connection between assessment and action. You can show this link visually by using a two-columned table: the first column lists the finding, and the respective recommendation is listed adjacently in the second column.

Sources of recommendations in a research paper

- Recommendations in the research paper should be the objective of the research. Therefore at least one of your objectives of the paper is to provide recommendations to the parties associated or the parties that will benefit from your research.

- Recommendations in the research paper should come from your review and analysis

- Recommendations in the research paper should also come from the data you have analyzed.
- Recommendations in the research paper should also come from observation.
- Recommendations in the research paper should be written in the order of priority.
- Recommendations in a research paper if associated with different categories then you should categorize them.
- Recommendations in the research paper should come purely from your research.

4.7 EXAMPLE RESEARCH: CONDUCT PILOT RESEARCH ON THAT WITH RESPECT TO ALL ENVIRONMENTAL FACTORS AND ITS DEGRADATION POINT

APPRAISAL OF TOURISM IN SANJAY GANDHI NATIONAL PARK

Introduction

WTO defined the term tourism in 1993, "Tourism encompasses the activities of persons traveling and staying in places outside their usual environment for not more than one consecutive year for leisure, business, and other purposes." Tourism has been identified as the major export industry in the world (Gosh, 1998). Tourism has a unique contribution towards the national economy and generated the various kind of employment opportunities in tourism activities. Economic, social and physical developments are major and essential part of tourism. The development is based on proper planning and controlling the tourism industry. Tourism development is dependent on four basic elements, they are accommodation, attraction, supporting facilities and appropriate infrastructure. In this study, tourist's point of view with respect to the development of tourism in Sanjay Gandhi National Park is analyzed.

Concepts

- Appraisal: a judgement about the value or quality of somebody/ something
- Sanjay Gandhi National Park: Sanjay Gandhi National park (SGNP) is located in Mumbai City of Maharashtra, previously known as Krishnagiri National park.

Review of Literature

(Thathang 2005) in their study, "Tourism in Nepal Since, 1980: Impact on the Economy, Society and Environment" have tried to study the tourism

development in Nepal and have concluded that the number of tourists have increased between 1960 and 1990. (Sigala, 2020) "Tourism and COVID-19: Impacts and Implications for Advancing and Resetting Industry and Research". In this paper, the focus is on impacts of COVID-19 tourism which brought not only socio cultural and economic impact, but psychological impacts too. (Chavda, 2019) In the study titled"Economics of tourism sector A: case study of development of tourism sector in Gujarat", the researcher has studied the problems of tourist, employees (who worked in tourist places of Gujarat) and infrastructure development in Gujarat for tourism purpose. The study was based on primary data and brought to light many facts related to tourism in Gujarat.

Research Objectives

- To understand tourism scenario in the study area.
- To examine the perspective of tourists in the study area.
- To give recommendation for the problem.

Research Methodology

- **Coverage**

Sanjay Gandhi National Park (SGNP) is the part of Borivali taluka which falls within the Mumbai region of Maharashtra and located in Western Ghats region of India. The latitudinal extension of SGNP is between 19^{o} 08'20'' to 19^{o} 20'44'' North and longitudinal extension is between 72^{o} 51'49'' to 72^{o} 58'32''East. SGNP covers 104 sq.km. area. This area has green forest patches along mountainous range. It was recognized by the government as national park in the year of 1969 and headquarter of SGNP is located in Borivali. Mumbai covers 10% greenery of SGNP. Two lakes i.e., Vihar and Tulsi Lake are found inside the park. These lakes are still providing drinking water to habitants of Mumbai city; therefore both lakes have their great history in Mumbai. This national park has existence of historical place (Kanheri cave) shows the history of Buddhism of 4^{th} century BCE, rich in flora and fauna, Biodiversity and wildlife, are the attraction of tourist. Every year above 2 million people visited in a year and in Asia it is considered as one of the most visited national parks.

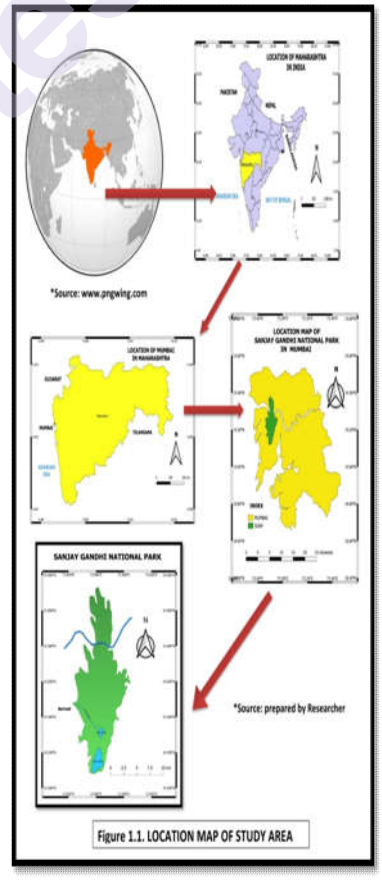
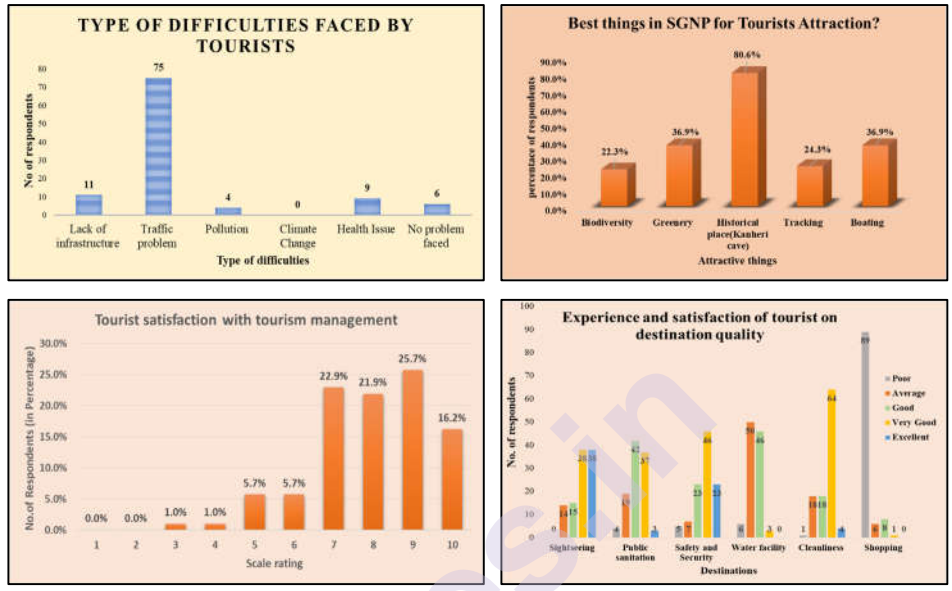


Figure 1.1. LOCATION MAP OF STUDY AREA

- **Data Collection and Analysis**

Secondary data from online and offline sources have been referred to for compiling the review of literature. The study is based on primary data collection of 105 respondents using a mixed type of questionnaire prepared in Google Forms. The data has been analyzed using MS-Excel.



Results, Analysis and Discussion

From the above graphs, it is observed that maximum tourists in the national park face issues like traffic congestion, lack of infrastructure, healthcare and pollution. Only a few do not face any issues. This implies that there needs to be stricter traffic management rules in the park.

Most of the tourists visit the park for its historical heritage followed by boating activities, enjoying the greenery and for trekking. This indicates that the park is not only an animal gazing point but it serves the local people in a variety of ways. Educational field trips are most common in the park alongwith people who practice running, jogging and cycling. Hence, the park has daily visitors and occasional tourists also.

It is observed that 25.7% are highly satisfied with tourism management in the study area i.e., they have rated it 9 on a 10 point scale followed by 22.9 % rating it as 7, 21.9% rated 8 and others. This signifies that the tourist are highly satisfied with the management of tourism related activities in the park.

It is observed that most of the tourists find sightseeing, public sanitation, safety and security and cleanliness to be excellent to be good. However drinking water facility is marked good to average. Shopping which is a major attraction is found poor as the park does not have anything to offer for shopping. This is primarily to keep it away from unwanted shops and crowd.

Major Findings

- In SGNP, more than two million people visit every year and the daily average is 300-350 visitors which is higher on weekends (Saturday and Sunday).
- Many tourists who stay near the park, visit it daily for walks and exercise.
- SGNP has more than 50% tribal population.
- SGNP provides cycling facilities to the visitors.
- Water facilities inside the park is not appropriate.
- Most tourists find the tourism management excellent to good.

Conclusion

Tourism is an important economic activity for the residents of SGNP. The park receives domestic and international tourists both as the park is considered Asia's largest visiting park. The study shows that the tourists are satisfied with the park's management and therefore it attracts larger number of people every day and every year. However certain facilities like sanitation, drinking water and traffic management need to be improved.

Recommendations

- Washrooms must be renovated and highly maintained
- There must be development of food eateries and safe drinking water must be provided
- Plastic and vehicles must be banned inside the park
- There should be provision of electric or CNG vehicles inside the park with properly planned routes and fixed charges. This will help reduce pollution and decongest the park as well.

References

- Chavda, R. 2019. Economics of tourism sector: A case study of development of tourism sector in Gujarat.
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- Thathang, V. 2005. Tourism in Nepal since 1980: Impact on the economy, society and environment.

4.8 SUMMARY

The chapter has presented the entire process of research report writing in a sequential format. Each part of the report is equally important and needs to be given fair justice. The concept in a research paper explains the technical words and concepts that will be covered in the report, objectives explain the concepts that need to be understood through the research, scope covers the related aspects that could be included in the research. The review of literature is a compiled presentation of the existing literature and research methodology helps to follow the methods of data collection and analysis in an appropriate way. The findings help to understand the main conclusions at once, limitations show the researcher's realization of the loopholes in the research and recommendations are a list of constructive solutions by the researcher.

4.9 CHECK YOUR PROGRESS/ EXERCISE

4.9.1. Fill in the Blanks

a. _____ literature review reviews, critiques, and synthesizes secondary data.

(Integrative, Argumentative, Narrative, Systematic)

b. _____ is based on non-statistical techniques.

(Integrative, Argumentative, Narrative, Meta-synthesis)

c. In _____ we can measure someone's weight or height.

(Indirect observation, Direct observation, Survey, Schedule)

d. In _____we can use a questionnaire in which respondents provide answers to our questions about gender, income, age, attitudes, and behaviours.

(Indirect observation, Direct observation, Survey, Schedule)

e. A _____ gives research legitimacy and provides scientifically sound findings.

(research methodology, direct observation, objectives, scope)

4.9.2. State True of False

a. The concept in a research paper explains the technical words and concepts that will be covered in the report

b. Objectives explain the concepts that need to be understood through the research

c. Scope covers the related aspects that could be included in the research.

d. The review of literature is a compiled presentation of the existing literature

e. The findings help to understand the main conclusions at once

4.9.3. Chose the Correct Alternative

a. This organisation defined tourism in 1993

(UNICEF, WTO, UNESCO, SAARC)

b. This in a research study are its flaws or shortcomings.

(findings, scope, limitations, objectives)

c. This aims at providing novel concepts

(findings, scope, limitations, objectives)

d. This contemporary research methodology combines quantitative and qualitative approaches to provide additional perspectives, create a richer picture and present multiple findings

(organizational records, mixed method, quantitative, qualitative)

e. Researchers usually use a this methodology when the objective of the research is to confirm something

(organizational records, mixed method, quantitative, qualitative)

4.10 ANSWERS TO THE SELF-LEARNING QUESTIONS

4.9.1.a. Integrative

4.9.1.b. Meta synthesis

4.9.1.c. Direct observation

4.9.1.d. Indirect observation

4.9.1.e. Research methodology

4.9.2.a. True

4.9.2.b. True

4.9.2.c. True

4.9.2.d. True

4.9.2.e. True

4.9.3.a. WTO

4.9.3.b. Limitations

4.9.3.c. Findings

4.9.3.d. Mixed method

4.9.3.e. Quantitative

4.11 TECHNICAL WORDS AND THEIR MEANING

- Research:a detailed and careful study of something to find out more information about it

- Limitations: The limitations of a study are its flaws or shortcomings which could be the result of unavailability of resources, small sample size, flawed methodology, etc. No study is completely flawless or inclusive of all possible aspects.

- Recommendations: Recommendations are based on the results of your research and indicate the specific measures or directions that can be taken.

4.12 Task

The learners must attempt to make a research paper on any one environmental issue in the same flow as shown here.

4.13 REFERENCES FOR FURTHER STUDY

- Kumar, R. (2010). Research Methodology: A Step-by-Step Guide for Beginners. United Kingdom: SAGE Publications.
- Lester, J. D. (2014). Writing Research Papers: A Complete Guide. United States: Pearson Education.
- Research Methodology for Social Sciences. (2019). United Kingdom: Routledge.