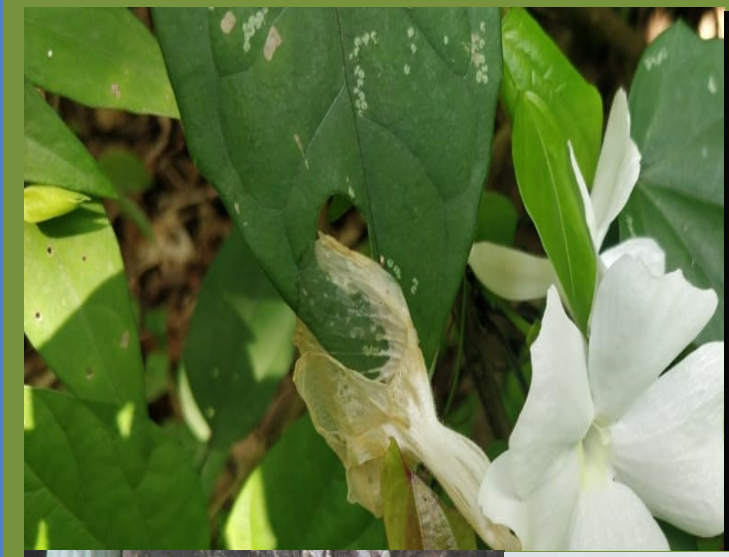



Rural Management
Rural Ecology and Environment

First Edition

सत्यमेव जयते

MHRD | Government of India
Ministry of Human Resource Development

First Edition: 2020

ISBN: 978-93-89431-25-4

Price: ₹ 750/-

Department of Higher Education

Ministry of Human Resource Development, Government of India

5-10-174, Shakkar Bhavan, Ground Floor, Fateh Maidan Road, Hyderabad - 500 004

Telangana State. Tel: 040-23422112, 23212120, Fax: 040-23212114

E-mail : editor@mgncre.org Website : www.mgncre.org

Published by: Mahatma Gandhi National Council of Rural Education (MGNCRE), Hyderabad

About the Book

Biodiversity constitutes the most vulnerable element of environmental studies. With accelerating rates of extinction and more and more species at the brink of it, the best time to understand the tenets of biodiversity was at least a couple of decades ago! Well, better late than never, as the saying goes.

It is critical to note that ecology, biodiversity and the related concepts of environmental studies are not meant to be studied by a handful of experts – these streams of knowledge must be understood by each of us, as basic skills of life, as basic as our breath itself, for we depend on biodiversity for every ounce of oxygen on this earth. We depend on it for the clean water we drink, for the food we eat, for most of our medicines and for many of our clothes. The cycle of seasons and that of nutrients, protection from natural disasters and from many a disease, largely depend on biodiversity.

This book attempts to collate the fundamental concepts of ecology and biodiversity in as simplified a manner as possible, to ensure that it is a fluent read for all. As much as possible, it has been attempted to explicate concepts through figures, flowcharts and tables. Practical to-do activities have been inserted wherever deemed necessary. However, it must be understood that these topics are far too vast to be captured in the printed pages of a book – indeed, when nature itself is the teacher, the globe is your classroom. Biodiversity concepts can be imbibed with far greater ease in middle of a forest or the shore of a lake, and this book may only be considered as the first step in the long journey of understanding biodiversity.

This book has been arranged into five chapters, and each chapter, in turn, divided into five units. The first chapter attempts to describe the multiple disciplines that make up the subject of Environmental Studies, with especial focus on Ecology. The concept of Ecosystem Valuation has been yielded especial accord because it helps envisage environmental conservation in sharply focused contours. The national and international organizations dedicated to environmental conservation have been briefly described in this chapter, too. Ecosystems yield a variety of natural resources on which human life is heavily dependent. It is critical to understand the nature of each resource, with special emphasis on the rate of its renewability. With this, the related concepts of sustainable harvest, resource regeneration and using technology to reduce dependence on non-renewable resources have also been discussed in the second chapter.

The third chapter is dedicated solely to the tenets of Biodiversity, its underlying concepts, its uniqueness in the Indian context, the biodiversity monitoring methodologies, the threats it faces and the strategies of conservation. In the fourth chapter, the challenge of environmental pollution has been expanded upon. The five units that make up this chapter deal with various forms of pollution, monitoring pollution levels, attempts to check pollution, efforts to reverse pollution impacts on degraded ecosystems through restoration, and finally, environmental disaster management.

The last chapter delves into the social aspects of environmental studies, with conceptual discussions on socio-environmental linkages, environmental ethics, resettling and rehabilitating project affected persons and disaster affected persons, impact of pollution on human health, and finally, environmental laws.

I thank the contribution of Dr Deepti Sharma, Founder-Director of TerraNero Environmental Solutions Pvt. Ltd to this book for her outstanding insights. Also, I would like to thank MGNCRE Team members for extending their extreme support in completing this text book.

Dr W G Prasanna Kumar
Chairman MGNCRE

Contents

List of Tables

List of Figures

Chapter 1 Multidisciplinary Nature of Environmental Studies

Introduction

Environmental studies constitute a uniquely diverse branch that has emerged after the fusion of many seemingly unconnected streams of study. With the alarmingly rising pollution and degrading natural resources, environmental studies have acquired immense significance. This is a largely application-based and solution-oriented study with new technologies getting introduced every few weeks. In a way, each individual is a custodian of the environment, and incorporating the nuances of this complex branch of study can be critical for one's survival.

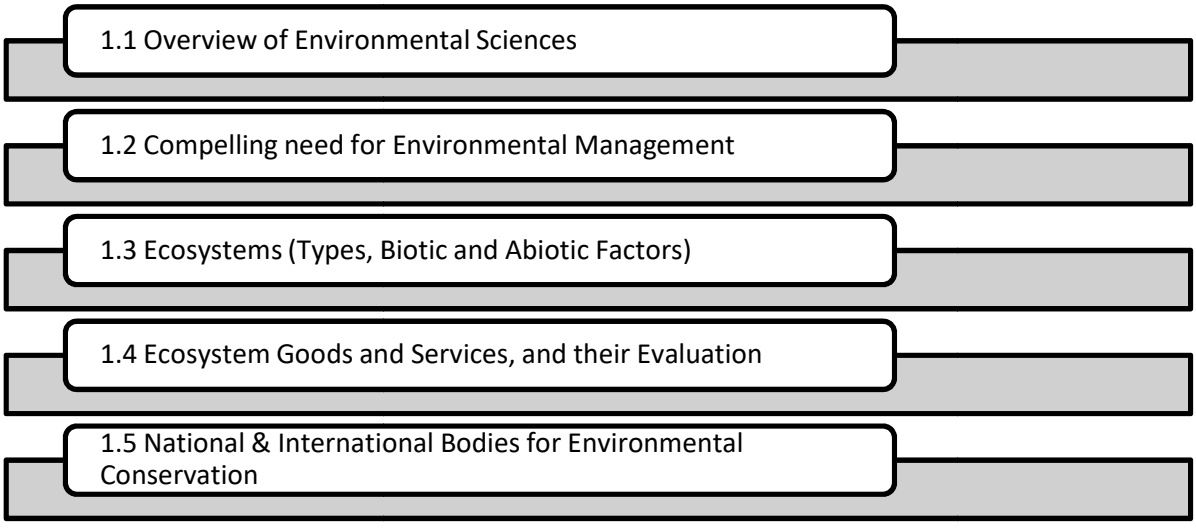
In this chapter, there are five sections. In the first section, the complex, multi-disciplinary nature of environmental studies is explained, and each of the constituting disciplines is described in brief. The inter-relationship of the various disciplines is also described. A brief history of how the fairly recent branch of environmental studies was initiated is provided. The section also briefly touches upon environmental ethics and environmental sociology, which have been elaborated upon in the later sections. The compelling need for environmental management, with rising pollution, global warming, climate change, increasing incidences of natural disasters, has been brought to the readers' notice in the next sub-section. In the next section, the various theoretical concepts of Ecology have been explained. Ecosystem goods and services have been described in the next section, and methods for evaluating the same have also been outlined. In the last section, the various organisations of international and national significance that are involved in environmental conservation have been briefly described.

Objectives

The objectives of this chapter are to:

- Provide insights on the various disciplines that make up environmental studies
- Explain why it is critical for every individual to understand the basics of environmental studies
- Familiarise the basic concepts of ecology
- Introduce how to comprehend on many of the goods and services we obtain from the environment in terms of money
- Familiarise main international and national-level organisations in the field of environmental conservation

Structure



1.1 Overview of Environmental Sciences

The word environment is derived from the French word “environ,” which means surrounding or enveloping. The environment includes earth, lakes, forests, farms, vegetation and other biological life such as animals, plants, bacteria, microorganism etc. Environmental science is a multidisciplinary science that combines many seemingly disconnected silos such as geography, physics, chemistry, life sciences, ecology, soil science, geology, oceanology, mineralogy and natural history, as well as environmental engineering and social sciences) for the twin purposes of:

- Assessing environmental status, and
- Providing solutions to environmental problems

Environmental science tackles issues such as:

- Comprehending the fundamental environmental phenomena
- Checking and mitigating pollution
- Studying alternative energy sources
- Natural resource management
- Studying the effects of global climate change
- Eco-restoration
- Environmental Disaster Management

Thus, the scope of environmental sciences is extremely wide and deep. The inter-disciplinary and applied nature of the Environmental Sciences branch of study can be exemplified by **Fig. 1.1**.

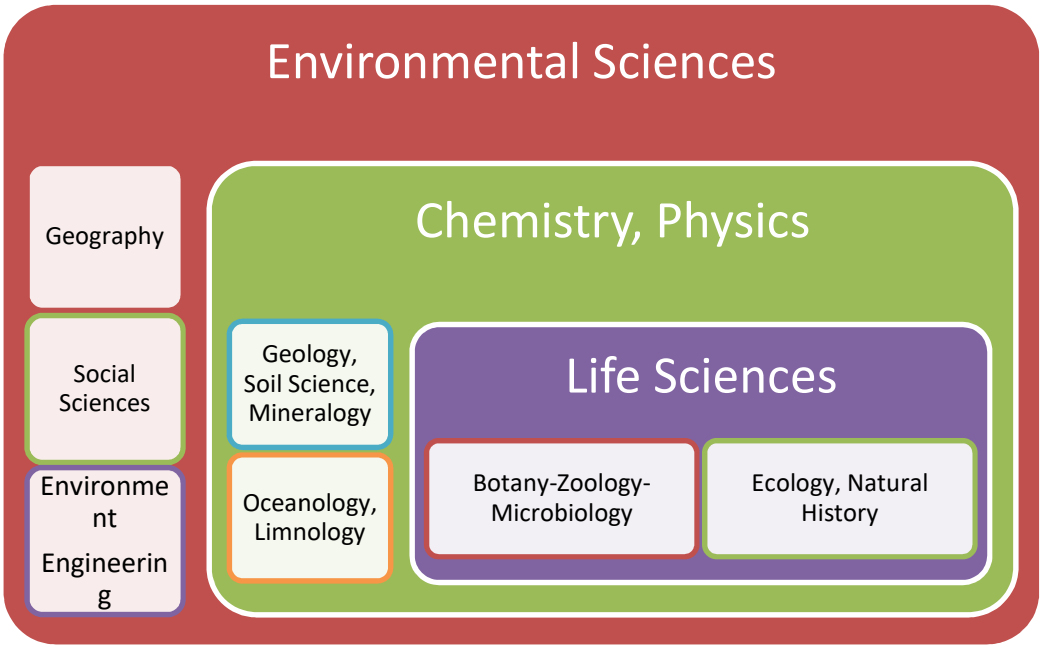


Fig. 1.1: The Inter-disciplinary Nature of Environmental Science

Details of the various branches of Environmental Science

- **Environmental Chemistry**
  It is the study of the chemical and biochemical reactions taking place in natural environments. It studies the bio-geochemical processes and elemental cycles within ecosystems.
- **Environmental Physics**
  Environmental physics studies the inherent factors of physics involved in organisms' interactions with their soil, air or water environment.

- **The Life Sciences**
  Botany (the study of plants), Zoology (the study of animals), and Microbiology (the study of microorganisms) broadly make up the Life Sciences.
- **Ecology**
  Ecology is the study of species, and how they interact with each other as well as their surroundings. Ecology of a single species is called Autecology.
- **Natural History**
  Natural history is the observation-based study of species in their natural environments - it is not hard-core experimentation-based like Ecology or Life Sciences studies.
- **Geology**
  Geology studies the structure of the Earth, and the processes that lead to that. Rock formation, soil studies, hydrology and geophysics are studied herein.
- **Soil Science**
  It is the detailed study of soil as a valuable natural resource, its formation processes, its types, its physico-chemical properties and its fertility studies.
- **Geography**
  Geography is the study of the various natural features of the earth (mountains, deserts, grasslands, seas, oceans, rivers and lakes) as well as man-made features (national and international boundaries, monuments etc.) and how they change over time.
- **Mineralogy**
  Mineralogy is a scientific discipline that is concerned with all aspects of minerals, including their physical properties, chemical composition, internal crystal structure, and occurrence and distribution in nature and their origins in terms of the physicochemical conditions of formation.
- **Oceanology**
  Oceanography, also known as oceanology, is the study of the physical and biological aspects of the ocean. It is an important Earth science, which includes marine ecosystem studies, waves & ocean currents, geophysical fluid dynamics, plate tectonics and sea floor geology, as well as biogeochemical cycles operating in the waters and the sea bed.
- **Limnology**
  This branch of science targets the inland water bodies, freshwater as well as saline, and ranging from lakes to reservoirs, rivers to streams, ponds to wetlands, and even groundwater. Aspects studied include bathymetry, inherent chemistry, geology and ecology.
- **Social Science**
  Social sciences aim at studying the dynamics of human societies, which are shaped by various factors such as cultural history, demographics and individual psychology.
- **Environmental Engineering**
  Environmental engineering brings together broad scientific topics such as chemistry, physics, mathematics, life sciences, ecology, microbiology and geology with the aim of providing engineering solutions to water, air, soil and noise pollution control.

To Do Activity
Make a list of all the personnel who made their contribution in the field of environmental sciences and briefly discuss their work.

Inter-relations of the Various Branches of Environmental Science

As discussed above, conducting baseline environmental monitoring studies to identify environmental problems and providing environmental solutions are the two main purposes of studying environmental science. In this aspect, how the various branches of environmental science relate with each other has been provided in Fig. 1.2.

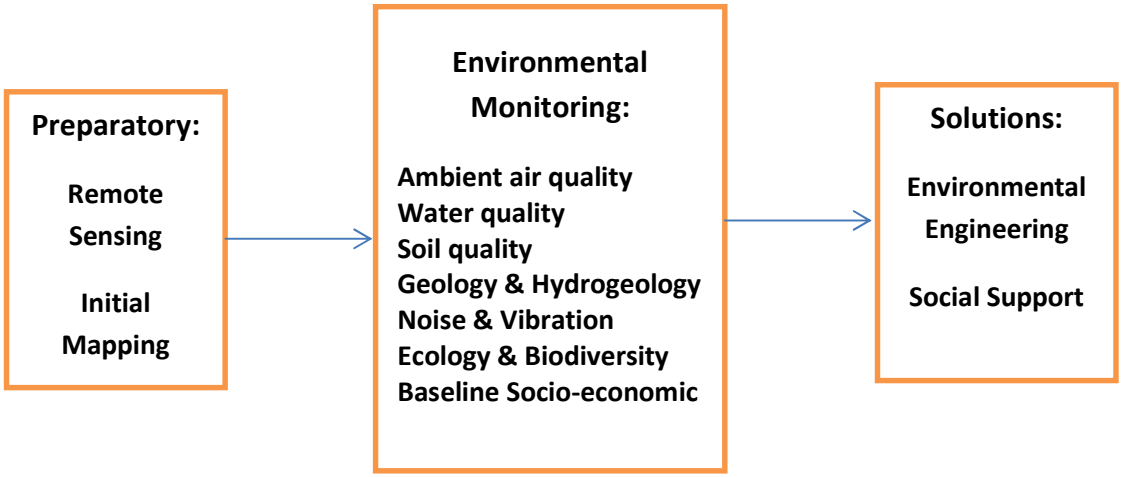


Fig. 1.2 Inter-relation of Various Aspects of Environmental Sciences

History of Environmental Science Research and Academia

The discipline of Environmental Science emerged as an academic course and a research stream fairly recently. Details of the same have been provided in Table 1.1 below:

Table 1.1: History of Environmental Science Research and Academia

Year	Event
1956	The New York State College of Forestry at Syracuse University started a Bachelor of Science degree in environmental studies in the early 1950s; the first degree was awarded in 1956
1965	The Middlebury College initiated a majors in environmental studies
1971	'A\J: Alternatives Journal' an environmental magazine, was first published
1974	United Nations celebrated the first World Environment Day on 5th June; the tradition continues

Public Awareness on the Subject

Environmental awareness needs an environmental attitude, which can be developed only through an increased intensification towards environmental conservation. A very small population is actually aware of the impacts on the environment due to human activities, while the other section is either unaware of it or even passively aware about it. People work in diverse sectors, wherein small or big negative impact on the environment is generated, but it limits people from taking appropriate actions due to lack of awareness.

Consider the example of tourism, which if allowed to continue without checks leads to issues of solid waste mismanagement, air, water, noise and light pollution, disturbance to local flora and fauna and interference with local socio-cultural aspects. As a result, the very natural resources driving the tourism industry will end up getting destroyed. In addition, tourism involves travelling, in which fossil fuel is utilised by vehicles. Hence, sustainable and ecologically friendly tourism is needed, wherein the human foot fall is restricted through proper carrying capacity studies, proper rules are implemented for solid waste management, use of eco-friendly products is encouraged, plastic usage is restricted to the extent possible, construction of eco-homes and optimum utilisation of resources is mandated.

To Do Activity

Design a questionnaire containing basis questions related to environmental sciences and attitude of people towards the conservation of the environment. Using this questionnaire survey a defined number of individuals and understand the present scenario related to environmental sciences.

Hence, adoption of environment-friendly techniques in different sectors is important and the attitude of people will only change when they are made aware of it. The knowledge of environmental education is very important for everyone in this web of life. It helps to create awareness and an understanding of the evolving social and physical environment as a whole, and the judicious balance of natural and man-made resources for sustainable development of the society. Environmental education is vitally important to find ways to avoid self- destruction.

Environmental Ethics

Environmental ethics is a philosophical branch of study that analyses the morality behind human interaction with their non-human and non-living elements of the environment. This branch studies the applied ethics that shape human lifestyle from the individual to the organisational and societal levels. Also, the focus is on how an ethical code of conduct shapes policies for environmental management. The branch of environmental ethics raises moral queries such as whether all other species are as important as human beings with respect to the right to survival, how to consciously reduce consumption to ensure sustainable living, and whether it is advisable to give up luxury for a few to ensure necessity for all. Environmental ethics, therefore, expound upon morality to help tackle crucial environmental challenges such as pollution, climate change and species loss.

Environmental Sociology

Environmental social science a very broad field of study cutting across various silos of inter-related branches such as sociology, anthropology, psychology, economics, geography, history, political science, and connecting it with the relatively unrelated branch of environmental science. The purpose of Environmental Social Science is to study how the biosphere and the society are shaped by each other. While on one hand it studies how societal actions can help conserve or lead to the degradation of the surrounding environment, it also analyses how the natural resources cater to human needs, comforts and luxuries. The aim of this complex branch of study is to find that middle ground where there is no trade-off between social welfare and environmental conservation and both the natural world and human societies continue to thrive, each benefitting from each other.

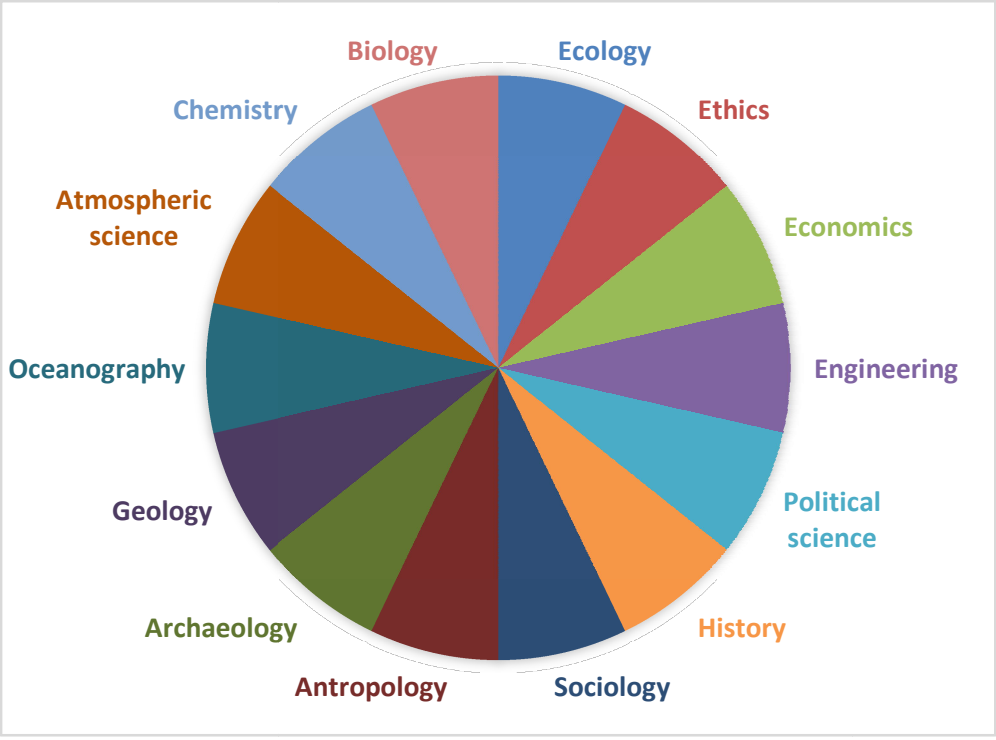


Fig.1.3: Aspects of Environmental Sociology

1.2 Compelling Need for Environmental Management

After the Second World War, the development phase started all over the world. While many countries became developed, riding high on the benefits of colonisation and industrial revolution of a few centuries before, several countries are still in the phase of achieving development. Earlier, development took place due to the abundance of resources, its manufacturing and trading. This led to the beginning of industrial revolution and rapid development and a rise in the standards of living was observed.

Increase in living standards brought a change in attitude, leading to wasteful consumption demands. Hence, waste generation and environmental pollution were the unfortunate outcomes. Excess and unnecessary growth in production, services and consumption gradually led to an extraordinary pressure on the biosphere, exhausting the natural resources, at the same time loading it with pollution, ultimately creating conflicts and resulting in environmental and social issues.

Indeed, it is a challenge for the developing countries of today to grow economically following the high growth trajectory of a few centuries ago, given the high costs associated with waste management technologies, paying government fines and lawsuits if environmental standards are violated, or green PR to appear good in the eyes of an increasingly environment-conscious consumer.

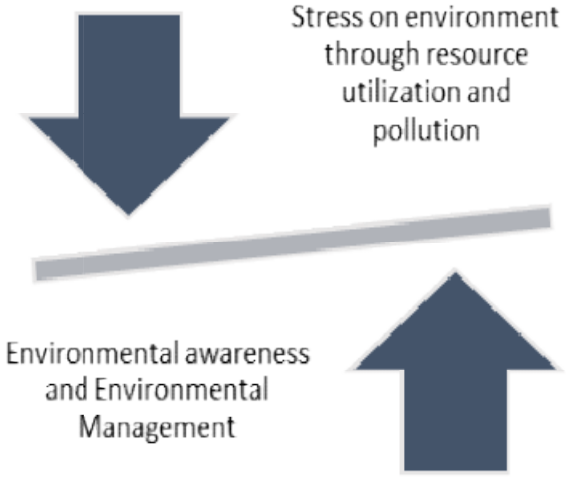


Fig.1.4: Imbalance in Environment Management

Factors Causing Environmental Imbalance

Increase in population

Development and increase in population have led to the destruction of natural resources, leading to their depletion. One of the major resources, i.e., land has been exploited for agricultural purposes and setting up houses for the increasing population, leading to unplanned urbanisation and destruction of forest.

Urbanisation

Unplanned urbanisation gives rise to many socio-economic, environmental and health problems. For example, slum settlements arise as part and parcels of a city and are essentially the result of an acute shortage of housing in cities and towns. People who fail to find a dwelling tend to occupy any vacant land outside and inside the city, where they build a dwelling with any available material. This is done haphazardly, with no civic facilities of water supply, drainage, roads, transport and other amenities. A slum settlement becomes a burden not merely due to the poor quality of structures, but also on account of the environment of insanitation that leads to several social evils. Slum expansion leads to the destruction of natural ecosystems surrounding the towns and cities.

Industrialisation

Industrialisation came into existence in the middle of 1700, after which production of goods increased. For raw materials for several industrial processes, forests were targeted and deforestation was initiated. Also, activities such as mining of ores and minerals, extraction of fossils, timber production were. Increase in the industrial revolution and more demand for goods, the production was accelerated due to which the resources got exhausted with time. Another impact that industrialisation added was pollution in the environment and depletion of unused resources.

Mining Activities

Mineral extraction and processing have a wide range of ecological impacts on land, atmosphere, water and socio-economic environment of local people. Direct effects of mining on the landscape such as surface disturbances and generation of wastes tend to be roughly proportional to the quantity of minerals extracted. Reclamation of land disturbed by mining activities is an important factor in reducing the environmental damage caused by mining wastes. If surface mining is extended more and more to areas with fragile ecosystems, the rehabilitation of land after mining becomes a severe problem. Progress in rehabilitation is expensive and slow in areas where soil cover is thin, the over-burden is high in acidity or salinity and rainfall is sparse. Air pollution generated from mining and ore processing activities creates serious environmental and health problems.

Environmental Pollution

The major causes of environmental pollution are industrialisation, urbanisation and motorisation. In many countries, a large number of industries have been set up inside or near large cities. The stack emissions from these industries pollute the air that man breathes. The industrial effluents pollute the streams, rivers and oceans. Domestic sources are also contributing to increase in pollution by releasing of domestic waste into the water bodies, open dumping of waste, dumping of waste into oceans, wasteful use of resources, etc.

Fig 1.5: Industrial Pollution

Lack of Environmental Awareness

Lack of environmental awareness is has become a foundation for the problems that environment is facing today. Due to a lack of awareness, the actions taken in development are not mindful and sustainable and are hence, leading to environmental issues. Introducing awareness among citizens is an important need for protecting the environment today.

The cumulative impact of all these events has led to major changes in the environment causing global issues such as climate change and greenhouse effect, which again loop up with the already

existing causes of environmental instability, resulting in increased impact. Fig.1.6 represents the inter-linkage between several aspects that lead to environmental imbalance.

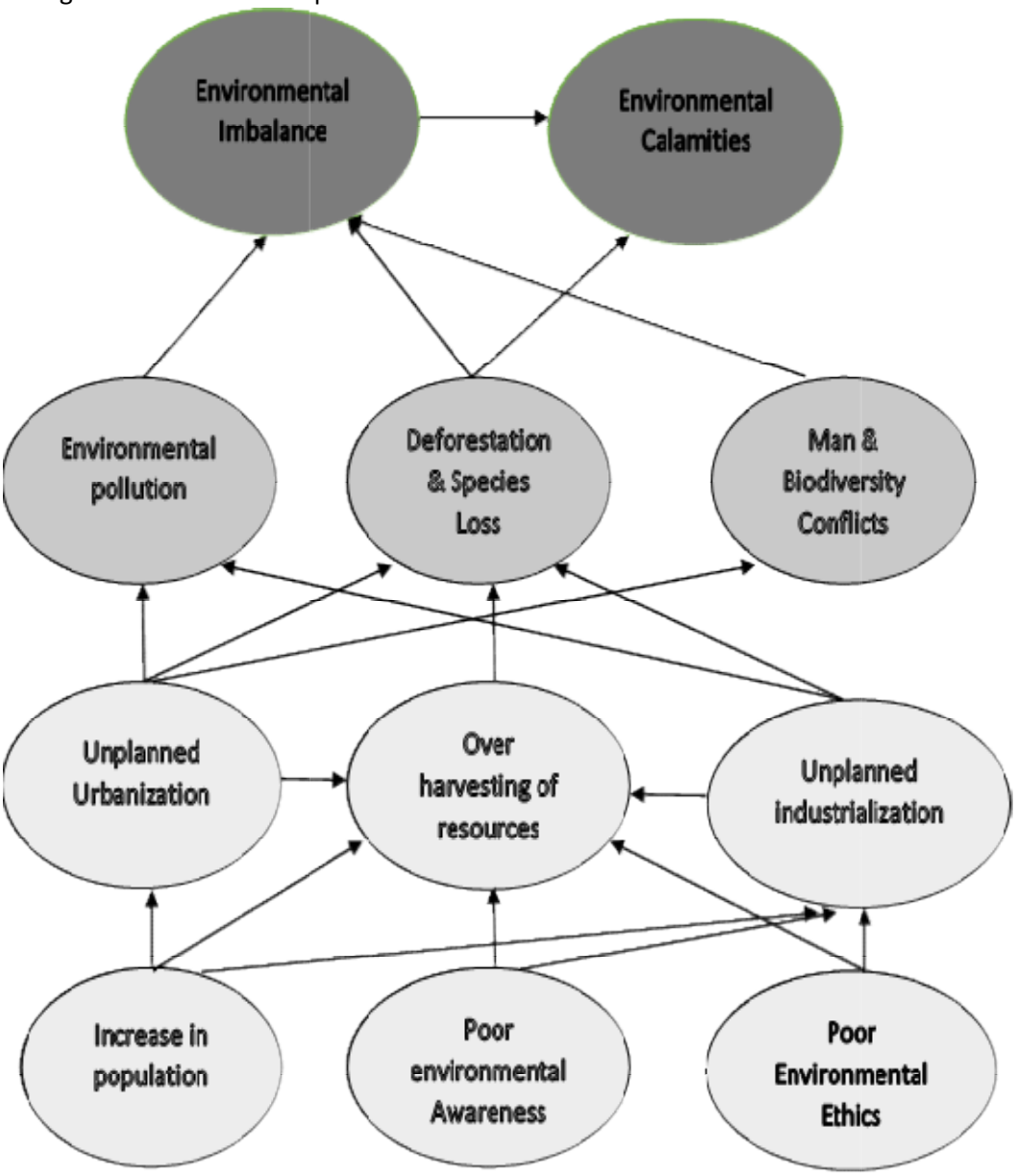


Fig.1.6: Inter linkages between Several Activities Leading to Imbalance in Environment

To Do Activity

Select an area which has been extremely influenced by human activity and study its past situation, further adding a comparison between both situations.

"Global Warming" - The Phenomenon

Generally, the sun is hot and radiated heat in the form of short-wavelengths of visible radiation. These short wavelengths reach the earth and absorb some of the radiations, getting heated. They also radiate about 30% of the energy back into space in the form of long wavelengths, which are invisible infrared rays. Most of the gases and other matters in the atmosphere allow these radiations to pass freely. However, some radiations released by Earth are absorbed by ozone, carbon dioxide, water vapour, methane and other gases and are radiated back to the earth. The gases that radiate energy back into the earth's atmosphere are known as greenhouse gases. This re-absorption of gases and radiating them back into the earth is considered beneficial as otherwise; the earth temperature would have been cooler, making it unsuitable for human survival.

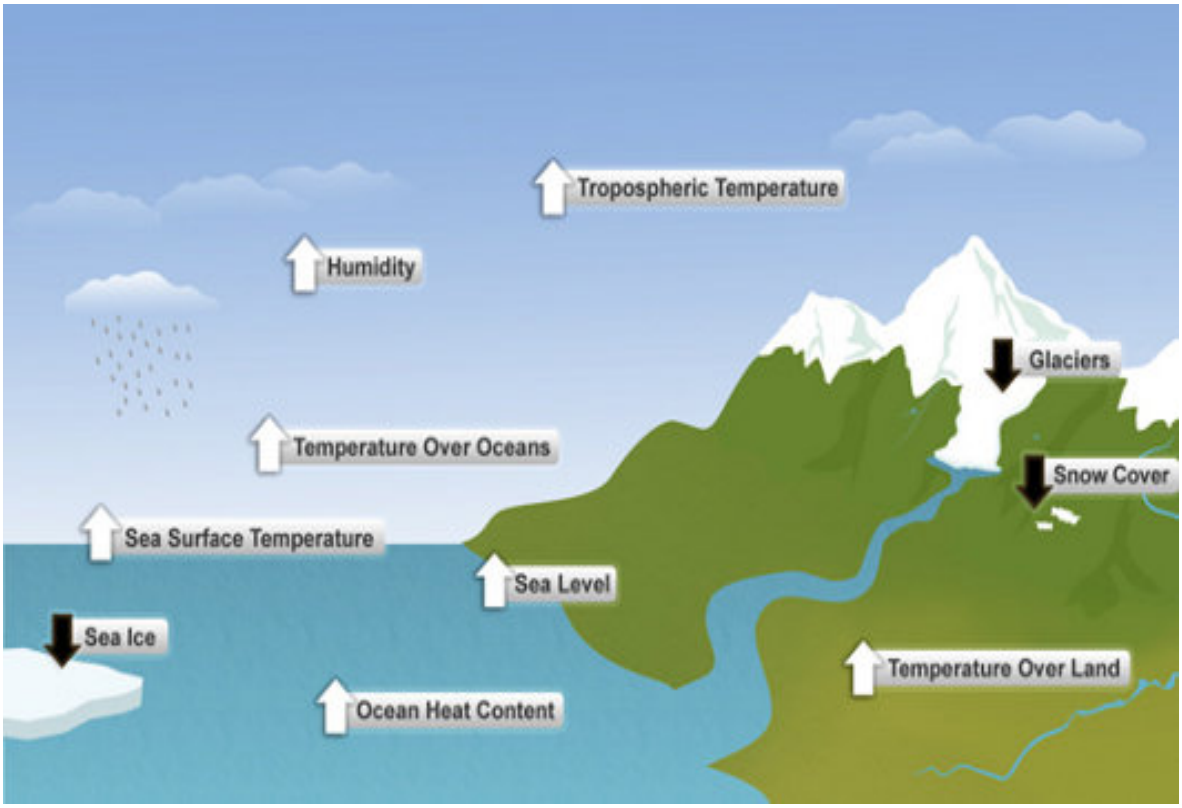


Fig. 1.7: Environmental Impacts of Global warming

However, interference in the natural processes took place due to pollution and anthropogenic activities leading to artificially increase the concentration of Greenhouse gases in the atmosphere heating up more of the Earth and this phenomenon known as Global Warming Effect.

Greenhouse Gases and their Sources

Water Vapour

As a greenhouse gas, the higher concentration of water vapour absorbs more thermal infrared energy in the atmosphere than is directed from the earth's surface. A rise in temperature leads to an increase in the water vapour in the atmosphere as water gets evaporated into the atmosphere from water sources like ocean, river, reservoirs, soil, etc. This again results in more water vapour absorbing earth radiation and warming the atmosphere; thus, this forms a loop.

Carbon dioxide (CO_2)

Carbon dioxide occurs naturally in the atmosphere but has increased in concentration due to human activities. Human activities are increasing the concentration in two ways: by adding more CO_2 to the atmosphere and by reducing the ability of natural sinks like forests to sequester CO_2. Since the industrial revolution, the concentration of CO_2 in the atmosphere has drastically kept on increasing at an alarming rate. In 2019, the concentration of CO_2 in the atmosphere is rising, which is. The major source of CO_2 is due to incomplete combustion of fossil fuel. Other factors such as release from industrial activities, domestic activities, consumption of electricity, etc. further contribute to the release of this gas. **Fig. 1.8** presents the CO_2 emission of the top eight countries.

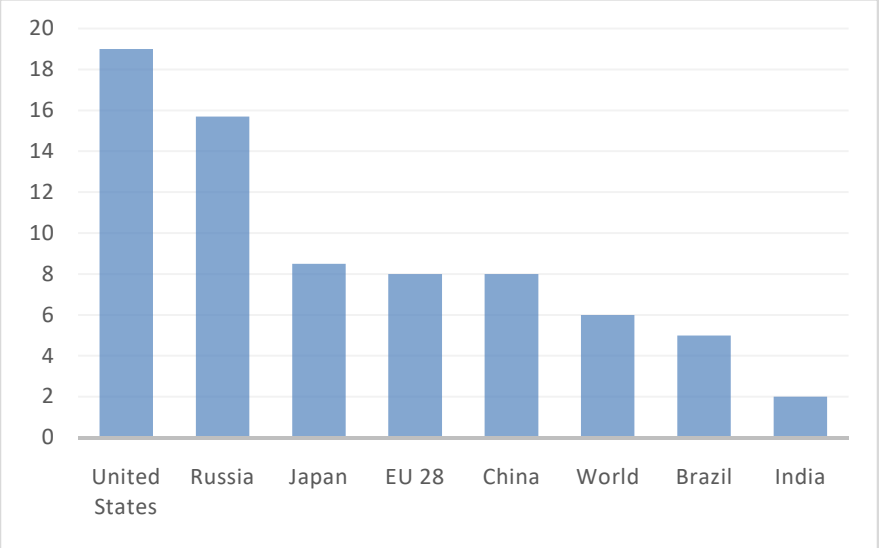


Fig.1.8: Per Capita GHG Emission in 2017 of Top Eight Countries (Source: International Energy Agency, 2019)

Methane (CH_4)

Methane is a hydrocarbon gas resulting from natural as well as anthropogenic activities. According to a study conducted by EPA, human activities contribute to about 60% emission of total methane, from industry, agriculture and waste management activities. Natural sources include wetland sites, oceans, sediments, volcanoes and wildfire. Methane is found in comparatively less concentration in the atmosphere than CO_2. It is 20% more potent than CO_2 but has a shorter lifespan of 12 years and gets oxidised to CO_2 after about a decade in the atmosphere.

Nitrous Oxide (N_2O)

Nitrous oxide occurs naturally in the atmosphere as a part of nitrogen cycle, but human activities such as Agriculture, transportation and industry activities have contributed in increasing the concentration of nitrous oxide emissions. Nitrous oxide has a longer lifespan of about 120 years before getting destroyed in any chemical reaction. NO_2 is more potent than carbon dioxide, as a pound of NO_2 has 300 times more warming effect than that of a pound of CO_2.

Fluorinated Gases (HFCs, PFCs, SF_6)

Fluorinated gases are emitted in smaller quantities through several sources like use of electronic equipment, manufacturing of aluminium and semiconductors, etc. The lifespan of these gases is longer (1-270 years for HFCs, 800-50,000 years for PFCs, about 3,200 years for SF6). They have the ability to disperse widely in the atmosphere. They are the most potent gases and hence are also known as 'high global warming potential (GWP) gases'.

To Do Activity

Calculate your Carbon footprint online

Consequences of Global Warming – Shift in Environmental Balance

Increase in Overall Temperature

As global warming is a complete temperature oriented phenomenon, increase in temperature is the first impact one can observe due to global warming. Change in temperature has led to change in other events, such as rainfall, drought, melting of ice and glaciers, increase in sea well, etc.

Floods and Droughts

As water vapours are a result of evaporation, due to global warming there is increase in temperature and increase in the process of evaporation, this has resulted in increase of rainfall due to which

floods arise. Also, there are otherwise cases where, the evaporation is rapid but is not compensated through rainfall causing drought conditions. This variation in rainfall will further lead to loss in crop production and famine especially in those areas where the temperature stays high. Rising of sea level is another severe impact of global warming. Melting of ice and glaciers will increase the level of water in sea, leading to calamities like Tsunami.

Water Scarcity

Water scarcity is another problem that is being faced by the places in snowfall area. As, the people in these areas are completely dependent for water on melting of ice, the glaciers in the world are shrinking at a rapidly and the melting of ice has also speeded. According to the Intergovernmental Panel on Climate Change (IPCC), about one-sixth of the total population of the world lives in the regions which shall be affected by a decrease in melting water.

Loss of Biodiversity

Global warming is also impacting the biodiversity, events such as flood and forest fire have led to a larger impact, destructing forest and wild biodiversity. Increase in temperature is also interfering with the natural processes of animals. Due to extreme evaporation the salinity of water is increasing impacting the avifaunal species. The melting ice is another hazard for the polar bear.

Reduction in Food Supply

Global warming can disrupt food availability through reduce access to food and deterioration of its quality. As the temperature is projected to increase, irregular precipitation patterns, extreme weather events and depletion of water resources lead to impact on agricultural productivity, which ultimately impacts food supply. Also, increased natural calamities lead to spoilage of stored food, limiting its availability. Natural calamities that occurred as a result of Global warming are enlisted in **Table 1.2.**

Table 1.2: Natural Calamities - India

Sr. No.	Year	Calamity and Location	Causalities	Human hand
1	2019	Kerala and Maharashtra Flood (Kerala and Maharashtra)	~ 300 killed and more than two lakh displaced	Unplanned urbanisation, deforestation
2	2019	Fan Cyclone(Odessa)	~ 100 dead	Mangrove destruction
3	2014	Jammu & Kashmir Floods (Jammu & Kashmir)	~300	Unplanned urbanization, River watershed mismanagement, Over-concretization
4	2013	Himalayan Tsunami (Uttarakhand)	~ 6000 declared dead	Incessant tree-cutting, slope-instability and unplanned urbanization
5	2014	Maline Landslide (Pune)	~ 150	Incessant tree-cutting, slope-instability
6	2010	Jaisalmer Floods (Jaisalmer&Barmer)	~ 500	Poor DMP
7	2005	Mithi River Flood (Mumbai)	~ 5000	Unplanned urbanisation, River watershed mismanagement, Over-concretisation, Waste mismanagement
8	2004	Indian Ocean Tsunami (Tamil Nadu &Andman - Nicobar	~ 10,000 dead/ missing	Poor DMP
9	1999	Odisha Cyclone (Odisha)	~ 10,000 dead	Mangrove Destruction

To Do Activity
Write a report on one of the natural calamity that occurred in your area and understand the causes behind them. Also, estimate the loss in life and economy due to the calamity.

Environment Management and Sustainability

In the absence of an Environment Management system, one is risking one's future sustainability, as EMS ensures that one is taking the right environmental decisions at the right time. If action isn't taken immediately worldwide to reduce carbon emissions, the consequences could be catastrophic. It is about humanity. It's about the right to protection against deliberate and careless destruction of human .homelands, property, and livelihoods. It's about the right to observe one's native culture. It's about the basic human right to physical integrity. All these rights will cease to exist once the human race becomes instinct due to a global cataclysm brought about by climate change. In other words, global warming is a human rights issue.

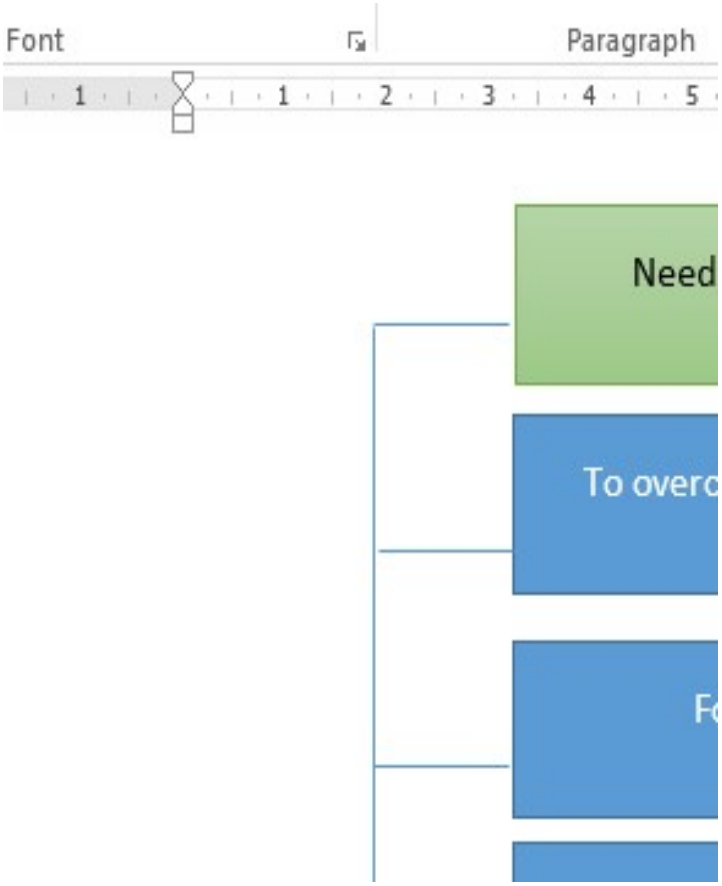


Fig.1.9: Need for Environmental Management

Environmental Management is concerned with the management for the environment while encompassing a business. It represents the organisational structure, responsibilities sequences, processes and preconditions for the implementation of an environment al corporate policy. Environment brings together all inanimate organisms and forces functioning in nature, including man. Environmental Management is needed for the following reasons:

Optimum Utilisation of Resources

The earth has limited resources, and if we are mindlessly using them, they will soon get exhausted. For the sustainable and long-term use of resources, environment management is a must. It is our basic responsibility to create accurate coordination and equilibrium between our needs and procedures of the environment.

Overcome Environmental and Ecological Crisis

Presently, Economic development has reached a point where environment and ecology are facing a crisis; if the same continues unabated the environment will soon reach a tipping point, a point of no-return from where it will be impossible to recreate the pristine conditions.

Sustainable Development

Sustainable development helps ensure current development without overusing natural resources, keeping pollution in check and preventing degradation of nature, such that development in the future can continue at the present rates. Sustainable development is critical to ensure that the future generations' right to continued usage of the critical, irreplaceable natural resources is not compromised because of today's overuse.

Economic Development

Without reasonable economic development, businesses cannot survive. Hence, a good environment management system helps enhance or maintain profits by aiding reuse of waste, making processes more efficient, identifying cheaper energy sources, enhancing the brand image of the business among environment-conscious consumers, and preventing loss through payment of fines or involvement in court cases due to non-compliance with environmental regulations.

Reduce Disasters

A good Environmental Management system foresees the risk of disasters such as flooding, forest fire, earthquakes, desertification, transport accidents, global warming, etc. It is required by a good EMS to help prevent disasters, ensure preparedness for dealing with the same in case it still occurs, and have procedures in place to deal with its aftermath.

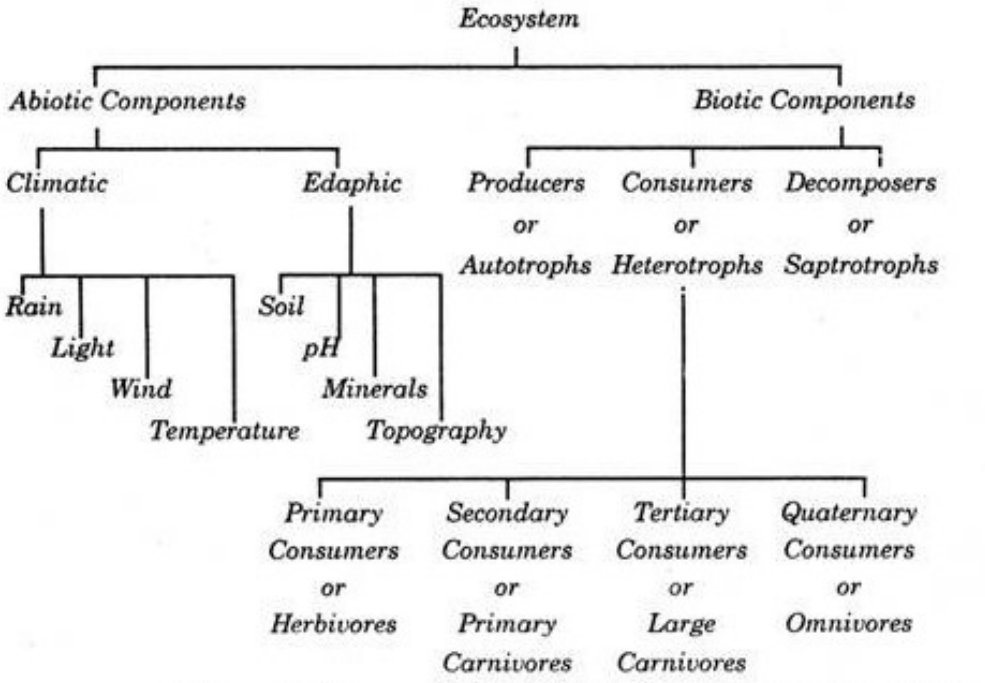
Balancing Development and Environmental Sustainability

The tightrope walk between development/profit-making and environmental sustainability can be managed with a well-planned environmental management system. A good EMS ensures that future harvest of resources is not rendered impossible because of the current profit-making activities.

1.3 Ecosystems (Types, Biotic and Biotic Factors)

The term Ecosystem was first mentioned in a publication by the British ecologist, Arthur Tinsley in 1935.Ecosystem refers to a part of the world 'Eco' and the coordinating units ' system'. As a part of the environment, ecosystem is a single unit consisting of living organisms belonging to a habitat and their surroundings, which together function as a single unit. It is an assemblage of living and non-living organisms and interaction between them (Fig. 1.10).

Living organisms are referred to the biotic forms that include plants, animals and other living beings. The whole earth can be referred to as a single complex ecosystem that is a combination of several small ecosystems.



Schematic Representation of the Structure of an Ecosystem.

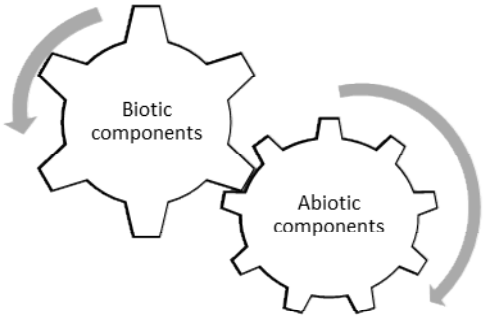


Fig.1.10: Ecosystem – Interaction of Biotic and Abiotic Components

An Ecosystem is distinguished from another due to its biotic and biotic components. Interaction between the biotic and biotic component results in a unique structure that forms the characteristic of each type of the ecosystem.

Within each ecosystem, different organisms have different areas in which they grow, feed, breed, and move about for these purposes, which are known as habitat. Simply put, if ecosystem is a village then habitat is a house within it. Different habitats provide specific combinations of nutrition, water and space, and each organism chooses its habitat depending upon its suitability. Among animals, their habitat selection depends on food, mate, rest and protection from predators. A habitat is, therefore, the natural environment within which a particular species lives, feeds and breeds.

The concept of niche in ecology is a complicated one, incorporating not only the physical space occupied by a species but also its role in the ecosystem, its resource usage pattern and its interaction with its competitors. The related concept of Niche Partitioning is a highly interesting one, wherein different species alter their resource usage pattern in a way that several species can exist in the same habitat.

An ecosystem is constant with the type of biotic and biotic factors in it, any deviation of the introduction of new factors leads to impacts on the ecosystem, even leading to a collapse of the ecosystem.

Components of Ecosystem

As Ecosystem is a combination of biotic and abiotic aspects, these two are considered as major components of the ecosystem.

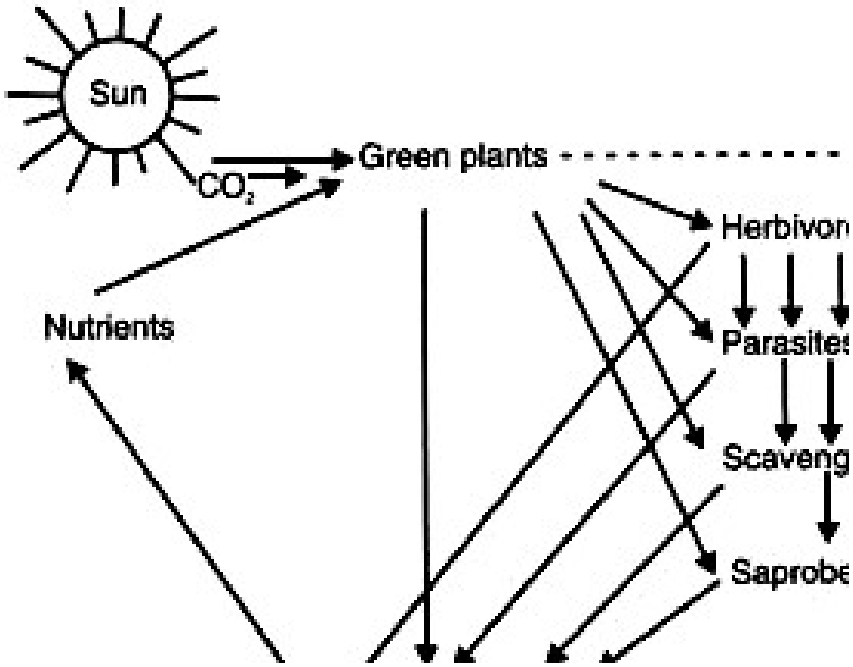


Fig 1.11: Pictorial Representation of Biotic and Abiotic Components

Table 1.3: Structural and Functional Aspects of the Ecosystem

Structural Aspects of Ecosystem	Functional Aspects of Ecosystem
• Inorganic aspects – C, N, CO_2, H_2O • Organic compounds – Protein, Carbohydrates, Lipids – link abiotic to biotic aspects • Climatic regimes – Temperature, Moisture, Light & Topography • Producers – Plants • Consumers • Decomposers	• Energy cycles • Food chains • Diversity inter-linkages between organisms. • 4Nutrient cycles-biogeochemical cycles. • Evolution

Biotic Components

The living components range from extremely small micro-organisms to large mammals species. Among plants, the life ranges from extremely small bacteria living in air, water, and soil; algae living in water bodies to terrestrial plants ranging from herbs, climbers, shrubs to giant long trees. The living components of the animal world range from microscopic animals to small insects and further to larger animals such as fish, amphibians, reptiles, birds and mammals.

Population and Community

The individuals of a single species make up the Population of that species in an ecosystem. The collection of all the interacting population of different species existing in the geographical area make up a community.

Flora and Fauna

Flora includes all the plant species in a given area. Fauna may be defined as the animal species present in an ecosystem. Faunal diversity is a critical element of biological diversity studies. Based on the activities of the biotic components, they can be further divided into:

a. Producers

In an ecosystem, a producer is the one that uses the process of photosynthesis to produce energy in the form of carbohydrate. In photosynthesis plants and other organisms in the presence of light energy covert water and carbon dioxide to chemical energy, this energy is further utilised to produce more complex molecules like starches, proteins and lipids which are crucial for several life processes. Producers are mostly green plants and are also called autotrophs

Producers play the role of funnelling energy into the ecosystem for its biological processes.

b. Consumers

The consumers are called so because they do not make their own food, but obtain it from eating other plants and animals. The energy produced by plants is utilised by consumers, specifically primary consumers. The primary consumers comprise of herbivorous animals as they eat plants to obtain energy. Further, the secondary consumers obtain energy by eating primary consumers and the tertiary consumers obtain it from Secondary consumers. Tertiary and secondary consumers may be carnivores or omnivores.

c. Decomposers

Decomposers are the organisms that obtain energy from dead material. They decompose organic matter of plants and animals into carbon dioxide and other nutrients. In this process raw nutrients such as nitrogen, magnesium and phosphorus are released in its usable form, it is further utilised by plants to build important elements in their cell. At this stage, the energy is resupplied to the ecosystem.

Interaction between Biotic Components

The biotic components vary in the number of species and different species interact differently. In an ecosystem, intra specific and inter specific interactions arise mostly between populations of two different species. This interaction could be beneficial, detrimental or neutral on either one or both of the species. A brief of the type of interaction and its effects is given in **Table 1.4**

Table 1.4: Interaction between Biotic Components

Type of Interaction	State of Species A	State of Species B
Mutualism	**+**	**+**
Competition	**-**	**-**
Predation	**+**	**-**
Parasitism	**+**	**-**
Commensalism	**+**	**0**
Amensalism	**+**	**0**
'+' : Beneficial **'-' : Detrimental** **'0': Neutral**		

- **Mutualism**: In this type of interaction, both the species are benefitted and none is harmed. This is the most common type of interaction.
  E.g. Pollination of flowers by bees

- **Competition**: In this type of interaction, both the species are harmed. Competition occurs among species due to limited supply of resources such as water, food or territory.
  E.g. Competition between tiger species for territory

- **Predation:** In this type of interaction, one organism called as 'predators' kills and eats another organism called as ' prey'. Such interaction can occur for food/ energy.
  E.g. A leopard consumes a deer for food

- **Parasitism**: In this type of interaction, a symbiotic relation between species occurs. One organism, the 'parasite' lives on another organism, the 'host', causing harm to it. Usually, the parasite gains food and shelter from the host.
  E.g. Tapeworms are segmented flatworm, they attach themselves to the insides of the intestines of animals such as pig, cows and humans.

- **Commensalism**: In this type of interaction, an individual of one species gains benefits while the other species is neither benefited nor harmed.
  E.g. Cattle egret eat insects that are stirred up by cattle when they graze
- **Amensalism**: In this type of interaction, one species is harmed while the other remains unaffected.
  E.g.: Cattles trample grass

Abiotic Components

The abiotic components are the non-living components of the ecosystem. They are of three categories

1. Climatic and physical factors -air, water, soil and sunlight; rainfall, temperature, humidity, soil texture and geomorphic conditions.
2. Inorganic substances- There are various nutrient elements and compounds, such as carbon, nitrogen, sulfur, phosphorous, carbon-di-oxide, water, etc. These are involved in the cycling of materials in the ecosystems.
3. Organic compounds- These are proteins, carbohydrates, lipids, humic substances, etc. They largely form the living body and link the abiotic compounds with the biotic factors.

The abiotic factors have a strong impact on the species composition of an ecosystem, as these abiotic factors provide the selective forces that decide which organisms can successfully live in a particular area. Some of the major non-living factors of an ecosystem are:

- Sunlight - Sunlight is necessary for photosynthesis, which produces oxygen as a by-product; thus, it influences organisms and their environment. It has a critically significant impact on the growth and development of life. Also, solar energy is the ultimate source of energy on earth – potent and easily available.
- Temperature - All living things have a range of temperatures in which they can survive; beyond those limits it will be difficult for them to live.
- Oxygen- oxygen is necessary for all aerobic organisms, which form a large group of species; oxygen is used for cellular respiration, wherein energy is obtained from a carbon source. Certain bacteria are anaerobic, though, and are killed in the presence of oxygen. Other bacterial species are microaerophilic that require lower than the naturally available level of oxygen (i.e., 21%)
- Soil - Factors such as the texture of soil, its pH, moisture content, nutrient availability (such as nitrogen, phosphorus, potassium, boron, magnesium etc.) are critical for determining the type of floral and soil biodiversity it will support.
- Water –While anaerobic life (life without oxygen) has been reported, anhydrous life (life without water) has not been reported till date. This emphasises the criticality of water for all life. Water

is the medium in which all metabolic reactions take place. It is the most critical element of aquatic ecosystems.

The inorganic substances like nitrates, carbonates and phosphates occur either freely or in the form of compounds dissolved in water and soil. Some of them are recycled by micro-organisms on the dead bodies of plants and animals.

Energy Flow in the Ecosystem

- Food Chain and Food Web

Photosynthesis is the process of conversion of light energy into chemical energy, which is passed through various organisms in the food chain. Photosynthesis is performed by the Producers, which are consumed by the primary consumers, which are subsequently consumed by the secondary consumer. The energy finally flows up to the apex predator, which upon demise, releases it back to the environment via the detritivores. A simple food chain is presented in **Fig. 1.12**.

Fig.1.12 : A Simple Food Chain

Scavengers break down or decompose the dead and decaying material, regenerating the simple building blocks of the animal and plant tissues, such that the same can enter the various nutrient cycles with the help of reducers and become a part of newly synthesised cells by the producers. Several inter-twined food chains formulate a food web. All the food chains in an ecosystem formulate a food web. The more intricate a food web, the more stable it is. The food web in a forest can be understood in the **Fig. 1.13**.

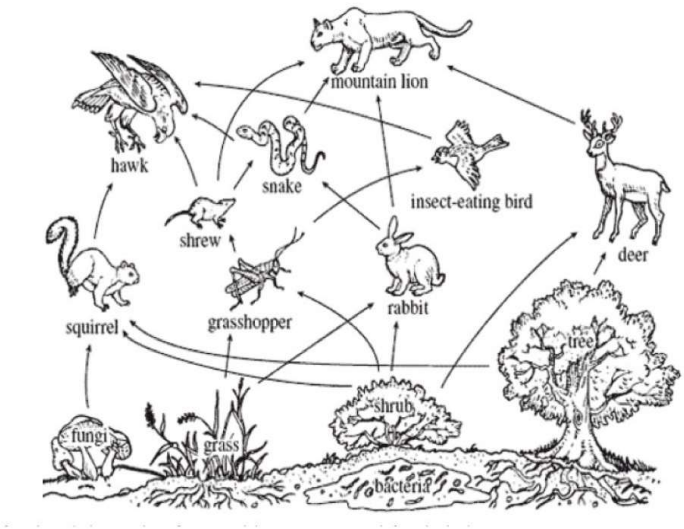


Fig.1.13: A Food Web

To Do Activity
Visit to a nearby Ecosystem and list maximum species in it and try to make a food web.

- **Trophic Levels**
  Trophic levels indicate the position of a species in the food chain, with producers being at Trophic Level 1.
- **Energy pyramid**

An energy pyramid, also referred to as trophic or ecological pyramid, is a graphical representation to demonstrate how energy flows from one trophic level to the other within an ecosystem. While the width of each bar represents the units of energy available within each trophic level, the height is always the same. **Fig 1.14** represents the levels of a food pyramid.

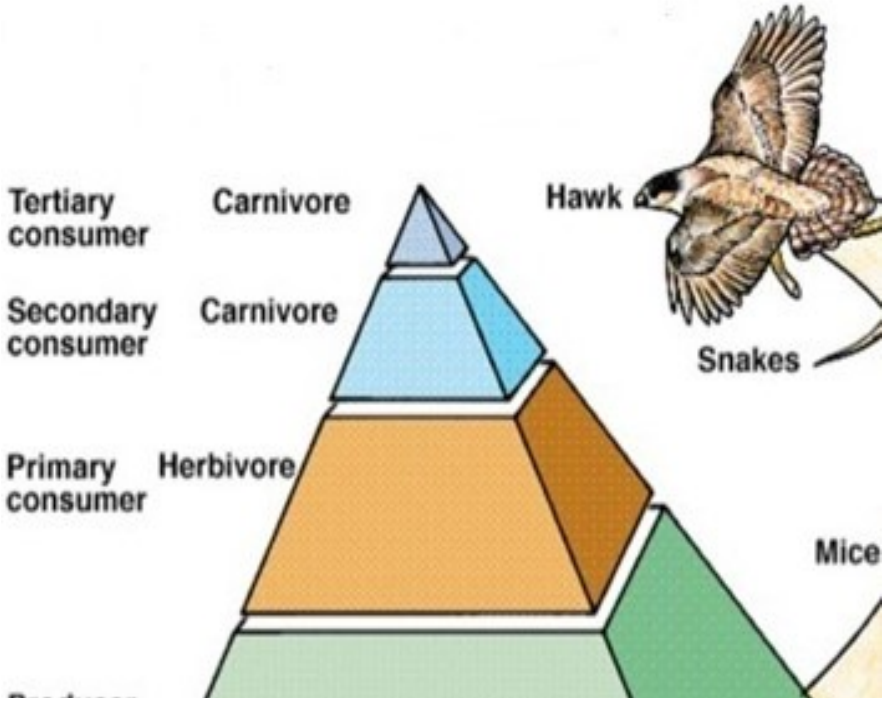


Fig. 1.14: Energy Pyramid

The 10 Per cent Rule

As per this rule, during energy transfer from one trophic level to the other, as much as 90% of the energy is dissipated and only 10% is transferred.

Nutrition Flow in the Ecosystem

Carbon Cycle

Carbon is the basic building block of all the molecules in living organisms and it is circulated through the carbon cycle in the Ecosystem. Carbon is stored in various forms in nature, such as in gaseous form, dissolved in water, as part of rocks, organic matter, etc. During the process of photosynthesis, inorganic carbon is converted into organic form. The energy in the biological system is transferred through this cycle only.

Oxygen Cycle

In oxygen cycle, there is interchange of elements like CO2, H2O and organic matter during the process of photosynthesis. During combustion and metabolism processes the elemental oxygen bound to other elements is released in its gaseous form in the atmosphere, which is further inhaled by all living beings other than primary producers, i.e., plant species. In return carbon dioxide is released in the atmosphere, which is utilised by plants for photosynthesis.

Nitrogen Cycle

The major constituent of the air is nitrogen, being about 78% in volume of the total gases. In the atmosphere, when highly energetic processes occur, the elemental nitrogen combines with hydrogen and oxygen in the atmosphere and gets converted to ammonia (NH_3) and nitrous oxide

(NO_2) respectively. Elemental nitrogen is also converted into chemical bound form by microorganisms through biological processes. This biological nitrogen is returned to the nature in inorganic form during the process of decomposition, which is utilised by plants to form constituents of cells and is transferred to other consumers through consumers of the higher energy level.

Type of Ecosystem

Ecosystems are separated from each other due to geographical barriers (e.g. a mountain is separated from an ocean) or being isolated (e.g. a lake in a forest). As the borders of the ecosystems are not rigid, they blend into their neighbouring ecosystem, forming connectivity. On a larger scale, there are two types of Eco-systems on Earth, i.e., Terrestrial Ecosystem and Aquatic Ecosystem.

Natural Ecosystem

A natural ecosystem is the one that has not been under any influence by human beings and has largely been in the same state since evolution. Classification of Natural Ecosystems is given in **Fig.1.15.**

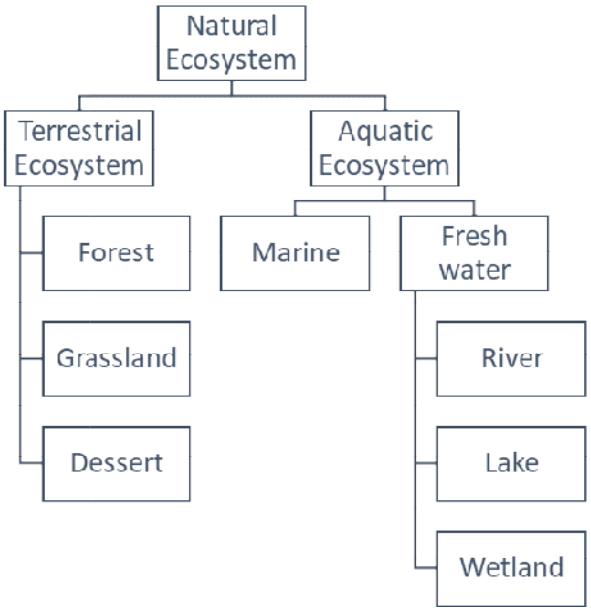


Fig.1.15 : Natural Eco-system

Terrestrial and Aquatic Ecosystems

While a Terrestrial ecosystem includes ecosystems such as forest, desert, grassland, etc. that are located on land, an aquatic ecosystem is associated with water. Areas permanently under water, with the area in the perimeter seasonally covered by water constitute aquatic habitats.

1. Forest Ecosystem

Wooded areas with native flora species, dependent fauna species and microorganisms as well as associated abiotic factors such as water bodies together constitute the Forest Ecosystem. The forest ecosystem has high ecological productivity as well as being a rich source of economic growth for human beings. Hence, most forest ecosystems on earth are heavily stressed. Indian forests types include tropical evergreens, tropical deciduous, swamps, mangroves, sub-tropical, montane, scrub, sub-alpine and alpine forests.

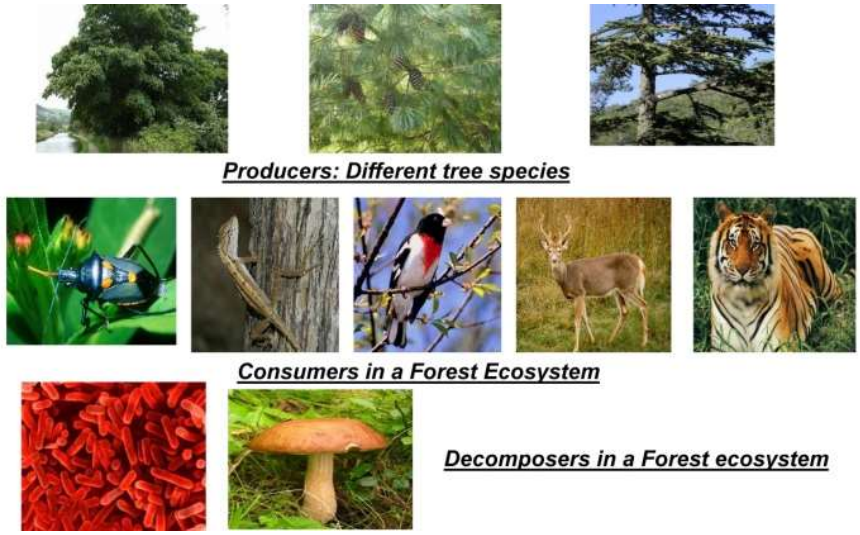


Fig 1.16: Producers, Consumers and Decomposers in a Forest Ecosystem

2. Grassland Ecosystem

These are ecosystems where the dominant vegetation are grasses or other non-woody plants like herbs. In such places, woody plants like trees are rarely found as the environment is not suitable to support such vegetation. Savannah and Shola are the major type of grasslands observed in India. The Gir National Park and the Kaziranga National Park are examples of Grassland Ecosystem.

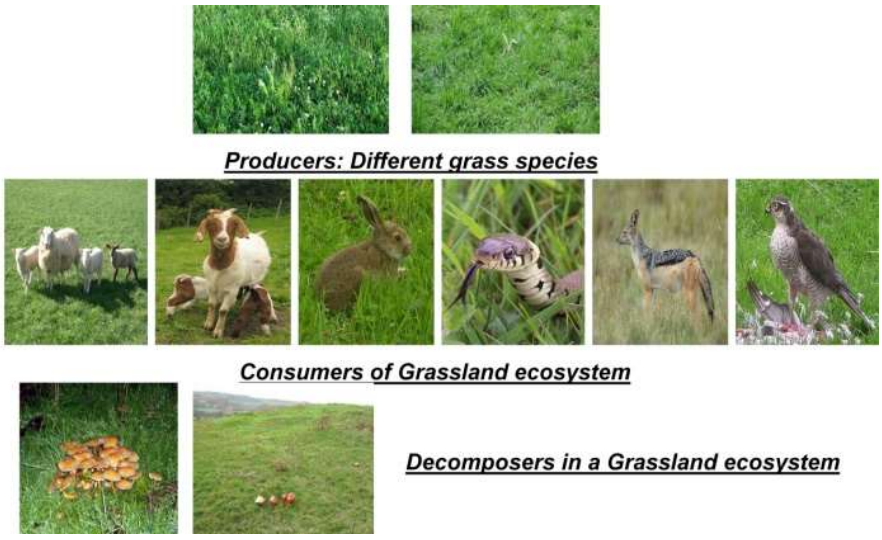


Fig 1.17: Producers, Consumers and Decomposers in a Grassland Ecosystem

3. Desert Ecosystem

Desert is an ecosystem where the temperature is extreme and arid. Here the plant species found are found scattered in the location. The plants and animals have been evolved gained resistance to such climate and ecosystem. E.g. a cactus is found in dessert ecosystem, it has adapted to less water loss by modifying its leaves. Most of the large deserts are found inland, away from coast. In India, such deserts are found in the north-west of the country in states like Gujarat and Rajasthan.

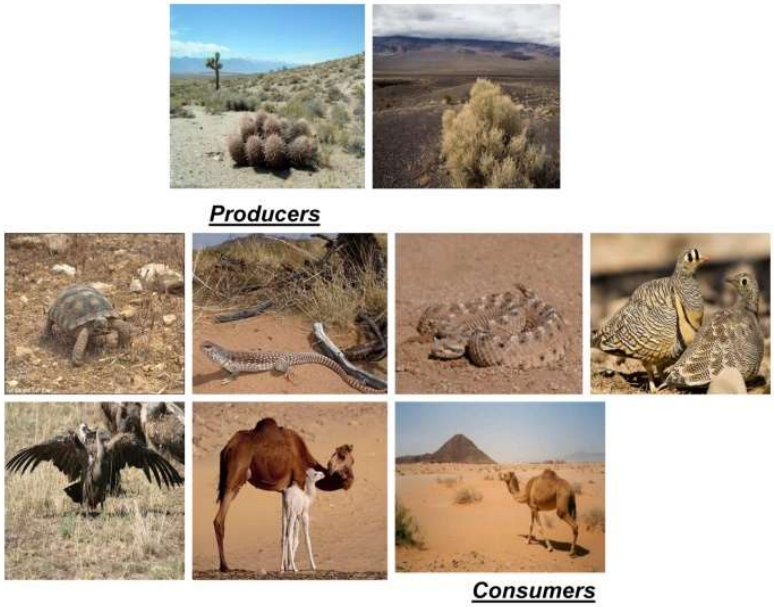


Fig 1.18: Producers and Consumers in a Desert Ecosystem

Aquatic Ecosystem

1. Marine Ecosystem

These are Ecosystems with water having large salt content (saline). Marine ecosystems are large in size compared to all other ecosystems. They provide half of the Earth's oxygen

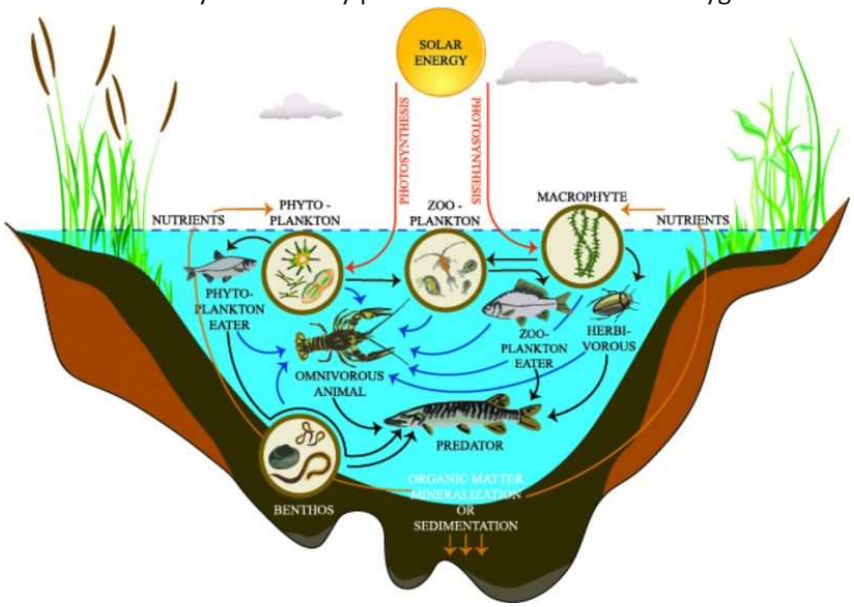


Fig 1.19: Marine Ecosystem

2. Freshwater Ecosystem

Freshwater ecosystems are a type of aquatic ecosystems which include lentic ones like wetlands, lakes and ponds and lotic ones like rivers, streams and springs. They are starkly different from marine ecosystems with water having appreciable salt content/high salinity.

Manmade/Modified Ecosystems

Manmade or modified ecosystems are the ones in which a change in land use or land cover of the actual habitat occurs due to the influence of human activities. Modified habitats such as settlements, paddy fields and orchards, village ponds, gardens etc. are common. Classification of Man-made/Modified Ecosystems is presented in **Fig.1.20**.

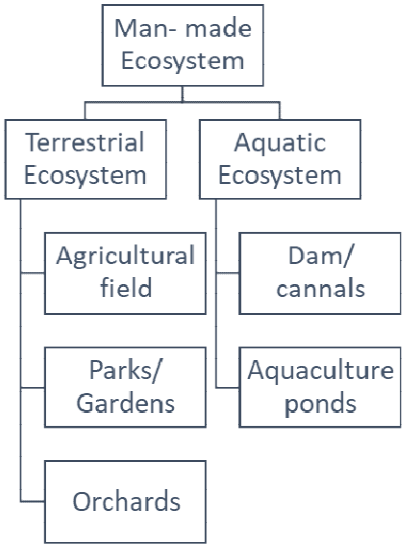


Fig.1.20: Man-made Ecosystems

Terrestrial Ecosystems

1. Agricultural Field: An agricultural field is a parcel of land, with or without formal boundaries, which is used for growing crops, raising orchards, silviculture or rearing cattle. Agricultural fields may be left fallow to recuperate its fertility.

2. Parks/ Gardens: A park is an area with natural, semi-natural or planted space, it is specially developed for human enjoyment and recreation purpose. Urban parks are green spaces set aside for recreation inside towns and cities.

3. Orchards: An orchard is a place where floral species are grown for food production, which are further utilised for commercial purpose. In orchards, trees bearing fruits or nits are grown. Majorly orchards have a mono plantation.

Aquatic Ecosystems

1. Dams/ Canals: Dams are constructed on a particular section of the river, where the flow of water is obstructed and controlled. Dams are constructed for irrigation purpose wherein the water is diverted through canals. Canals are waterways channels, or artificial waterways, for water conveyance.

2. Aquaculture ponds: Aquaculture also known as aqua-farming, is the farming of fish, crustaceans, molluscs, aquatic plants, algae, and other organisms. Aquaculture is the art and science of cultivating freshwater and saltwater species under controlled conditions, and is in direct contrast with fishing activities involving the trapping of wild fish directly from the river or sea.

1.4 Ecosystem Goods and Services, and their Evaluation

What are Ecosystem Goods and Services?

The Earth's ecosystems provide humanity with a wide range of benefits known as 'ecosystem goods and services'. Goods produced by ecosystems include food (meat, fish, vegetables etc.), water, fuels, and timber, while services include water supply and air purification, natural recycling of waste, soil formation, pollination, and the regulatory mechanisms that nature, left to itself, uses to control climatic conditions and populations of animals, insects and other organisms.

Because many of these goods and services have always been freely available, with no markets and no prices, their true long-term value is not included in society's economic estimates. Ecosystems

underpin all human life and activities. But human activities are destroying biodiversity and altering the capacity of healthy ecosystems to deliver this wide range of goods and services.

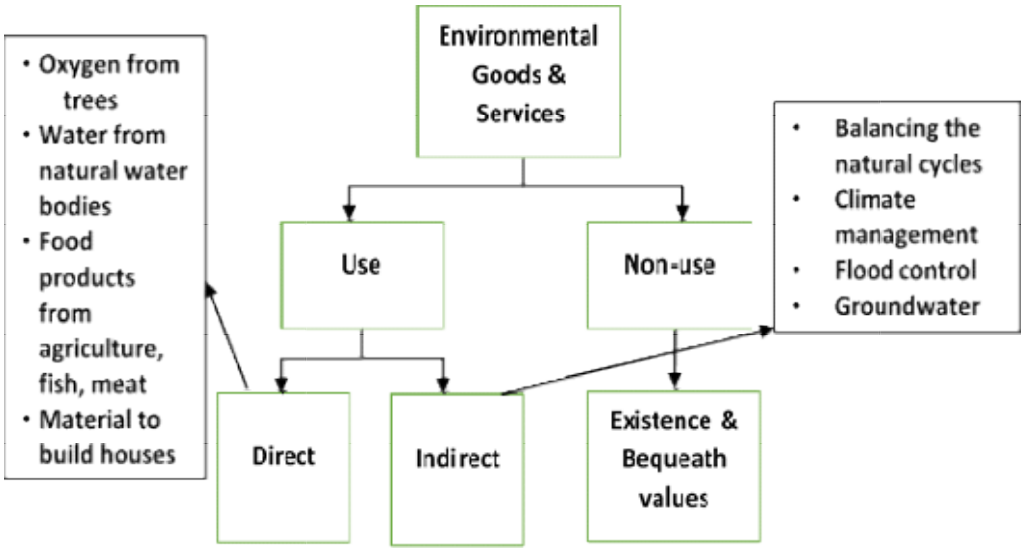


Fig.1.21: Ecosystem Goods and Services

Type of Ecosystem Services

Provisioning Services

Provisioning Services include the actual harvest of material or energy from ecosystems. Thus, the food, water, medicines, fibres and other raw materials for industrial processes and other resources that are harvested from an ecosystem constitute its provisioning services. These harvests have a clear market value. In addition, rural households depend on provisioning services for subsistence. Thus, even provisional services of an ecosystem can have non-marketable values.

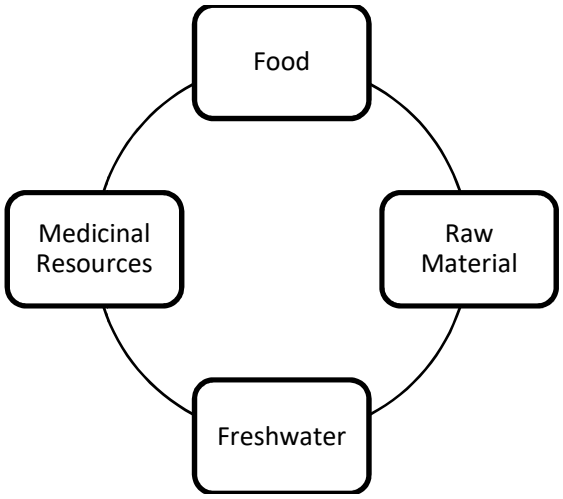


Fig. 1.22: Provisional Services of Ecosystem

Regulating Services

Regulating Services are provided by ecosystems when they emerge as regulators of natural processes. E.g., ecosystems regulated air, water and soil quality through drainage, natural bioremediation and disease control. Unfortunately, the Regulating Services of ecosystems have no market value and difficult to evaluate - hence, they remain largely invisible and not considered when calculating compensations or assessing most beneficial usage of an area.

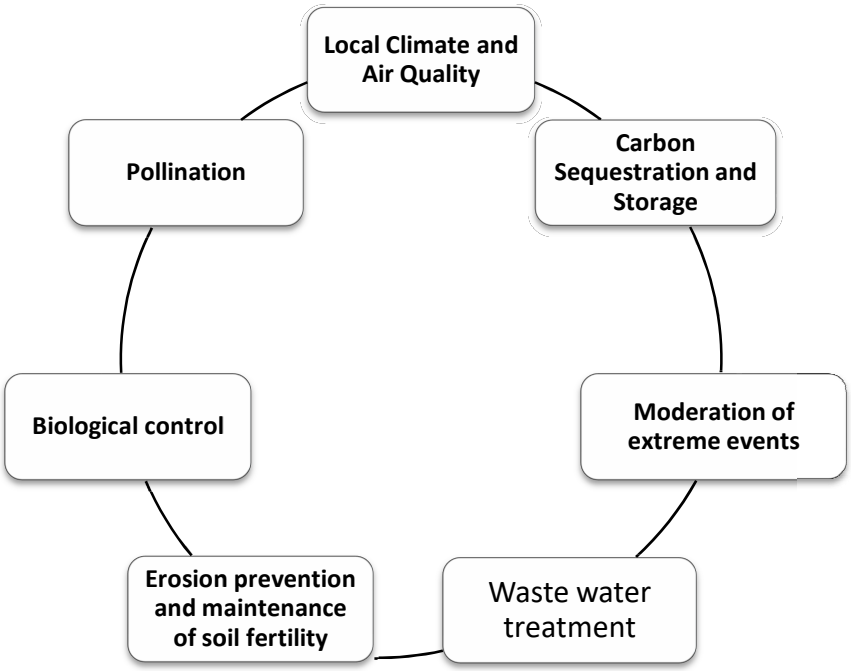


Fig. 1.23: Regulating Services of Ecosystem

- Local climate and air quality: Trees help control local climate by providing a cooling effect and influencing the rainfall pattern, thereby impacting water availability. Also, several trees have high pollutant tolerance and help purify local air.
- Carbon sequestration and storage: Greenhouse gases such as carbon dioxide are sequestered by algae and green plants during the process of photosynthesis. Carbon dioxide is converted to glucose, which is used to build tissues. Thus, forest ecosystems act as carbon sinks.
- Moderation of extreme events: Wetlands soak up floods, while mangroves and coral reefs protect shorelines from tsunamis and storms. Trees on mountain slopes help bind loose soil together through their roots, thereby according protection from landslides.
- Waste-water treatment: Wetlands can purify water through natural bioremediation and phytoremediation processes. Natural microbes in wetlands edge out pathogens from sewage, and the level of nutrients and pollution is reduced. It has been proved that wetlands and other water bodies with natural, non-concretised edges can have up to three times cleaner water.
- Erosion prevention and maintenance of soil fertility: Vegetation cover on soil ensures erosion control and keeps the fertile top soil intact. Also, humus, which is a critical element of soil fertility is a result of ecosystem processes.
- Pollination: One of the most critical element on which human existence depends is successful pollination of flora species which we feed on - many of these are insect-pollinated. Thus, maintaining a rich diversity of pollinators, especially bees, which have recently been recognised as earth's most significant species, is crucial for human existence.
- Biological control: Natural ecosystem processes such as predation and parasitism help maintain population balance, such that one species does not begin to overgrow at the cost of the others and over-utilise ecosystem resources. This naturally keeps in check vectors of diseases, pests and pathogens.

Supporting Services

The habitat/living space provided by ecosystems for species on this planet and supporting the immense biodiversity are the supporting services provided by ecosystems.

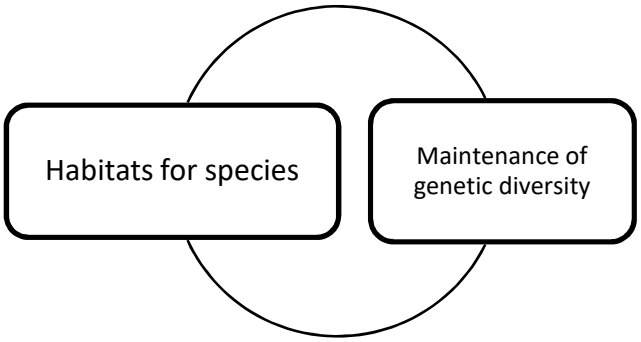


Fig. 1.24: Supporting Services of Ecosystem

Cultural Services

Cultural services of an ecosystem largely constitute of the non-marketable emotional aspects of ecosystems, such as spiritual connectivity, appreciation of aesthetics, inspiration for art and music, recreational benefits and community-level socio-cultural aspects

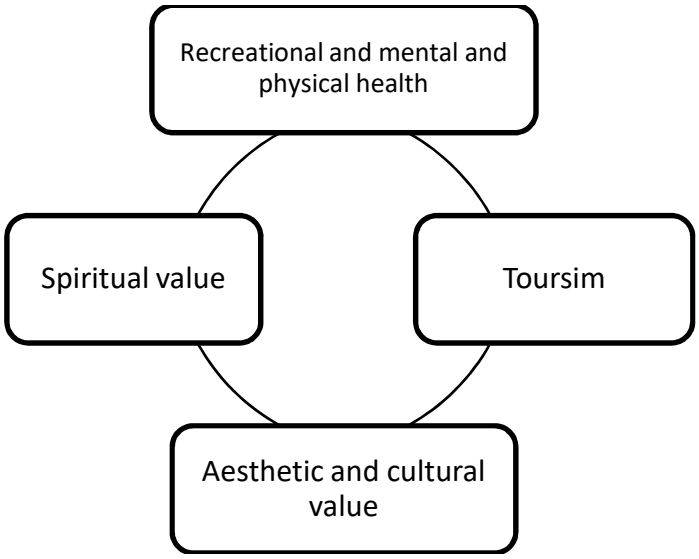


Fig. 1.25: Cultural Services of Ecosystem

Tourism, Recreation and Health Benefits: Tourism in natural areas accords benefits of eco-tourism and recreation. Natural spaces are known to aid physical and mental health recuperation.

Art and Aesthetics: Nature has been the source of inspiration for many an artist, musician, composer and painter. The aesthetic attributes of nature is completely beyond monetary valuation.

Spiritual experience: In several cultures, natural ecosystems such as forests, caves and hilltops have been deemed fit for meditation and spiritual experiences.

To Do Activity

Visit to a trip area and understand the services they avail from the nature.

Valuation of Ecosystem Goods and Services

At the outset, economic valuation may be defined as "the attempt to assign quantitative values to the goods and services provided by environmental resources, whether or not market prices are available to assist us (Barbier et al. 1997)." The calculation of the total economic value of ecosystems has been reviewed in detail by Costanza et al. (1997) who conducted a detailed meta-

analysis to elaborate the worth of the different ecosystems of the world. Several methods have been used for the valuation of ecosystem goods and services. Short descriptions as per Brander et al. (2006) have been provided:

Contingent Valuation is a popular, stated-preference method in which the respondents are directly interrogated through interview and/or questionnaires about the price they are willing to pay or accept for an ecosystem good or service. The market pricing method has been utilised to estimate the direct use value wherein the market worth of goods is worked out. Restoration/Replacement cost approaches the valuation exercise from the angle of estimating the replacement cost of providing that service should the ecosystem no longer function properly or no longer exist. Another much-used method is the travel cost method. The travel cost approach uses information about the number of trips to particular sites and the cost of those trips to infer how much individuals are willing to pay for access to the site. Travel cost studies are applied primarily to studies of the value of recreation, in which people travel to particular sites to hunt, fish, hike, or watch wildlife. Hedonic pricing is a method based on the principle that environmental factors such as scenic views, distance from hills or lakes can affect the price of marketable goods such as residential areas. Method selection depends on the suitability of the method for the given type of service, data availability and response from the interviewed public (Branders et al. 2006; Barbier 1989).

Several authors have made notable efforts in evaluating wetlands across America, Europe and Australia (Bingham et al. 1995; Daily 1997; Loomis et al. 2000; Lee & Han 2002; Crase& Gillespie 2008; Baerenklau et al. 2010; Kimmel et al. 2010; Bennett 2011). However, such studies regarding sub-tropical wetlands, and especially those present in India, remain few and insufficient (Brander et al. 2006) despite notable efforts by Ambastha et al. (2007a& 2007b), Badola&Hussain (2005) and Ramachandra et al. (2011).

Significance of Ecosystem Valuation

In the absence of valuation, the worth of an aquatic ecosystem's indispensable goods and services can be – and has been – taken as zero as wetlands have even been looked upon as 'wastelands' (Mitsch&Gosselink 1993). Hence, the most significant aspect of ecosystem valuation is that it brings these services down to the common denominator of money. This raises awareness among the local populations and accentuates the importance of these services in the public psyche. Consequently, a larger number of stakeholders are likely to emerge.

It is also imperative to attach a price tag to the non-marketable services that wetlands provide so that they can be included in planning and budgeting exercises conducted by the government bodies. This assists long-term and large-scale efforts at conservation and efficient wetland management. Ecosystem valuation has the potential to be a valuable asset to policy-makers (Anton et al. 2010).

> The question is, are we happy to suppose that our grandchildren may never be able to see an elephant except in a picture book?
>
> - David Attenborough

Another aspect is the grant of compensation to stakeholders in the event of draining a wetland ecosystem. Actual payment of compensation to dependent locals in the event of loss of environmental goods and services has been encountered in some Indian case studies (Appasamy&Nelliyat 2007). Raju et al. (2006) have brought out the outcome of a workshop on payment of compensations against loss of ecosystem services in Asian countries as "(the) discussion revealed that the political process for the implementation of CES (Compensation for Ecosystem Services) is strongly dependent on the local perceptions of ecosystem services." This indicates that the emphasis must be paid on better, regular and frequent valuation exercises for vulnerable ecosystems.

Table 1.5: Summary of Average Global Value of Annual Ecosystem Services

Biome	Area (ha X 10^6)	Gas Regulation	Climate regulation	Disturbance regulation	Water regulation	Water supply	Erosion control	Soil formation	Nutrient cycling	Waste treatment	Pollination	Biological control	Habitat/ refugia	Food production	Raw materials	Genetic resources	Recreation	Cultural	Total Value per ha	Total global flow value
Marine	36,302																		577	20,949
Open ocean	33200	38							118			5		15	0			76	252	8381
Coastal	3102			88					3677			38	8	93	4		82	62	4052	12,568
Estuaries Seagrass /algae beds Coral reefs Shelf	180 200 62 2660			567 2750					21100 19002 1431	 58 		78 5 39	131 7 	521 220 68	25 2 27 2		381 3,0 08	29 1 70	22832 19004 6075 1610	4110 3801 375 4283
Terrestrial	15323																		804	12,319
Forest	4855		141	2	2	3	96	10	361	87		2		43	138	16	66	2	969	4706
Tropical Temperature/boreal	1900 2955		223 88	5	6 0	8	245	10 10	922	87 87		4		32 50	315 25	41	112 36	2 2	2007 302	3813 894
Grass rangelands	3898	7	0		3		29	1		87	25	23		67		0	2		232	906
Wetlands	330	133		4539	15	3800				4177			304	256	106		574	881	14,785	4,879
Tidal marsh/mangroves swamps/ floodplains	165 165	 265		1839 7240 	30	7600				6,696 1659 			169 439 	466 47	162 49 		658 491	1761	9990 19580	1648 3231
Lakes/river	200				5445	2117				665				41			230		8498	1700
Desert	1925																			
Tundra	743																			
Ice Rock	1640																			
Cropland	1400																			
Urban	332										14	24		64					92	128
Total	51625	1341	684	1779	1115	1692	576	53	17,075	2,277	117	417	124	1386	721	79	815	3015		3268

Source: Costanza et al. (1997)

1.5 National & International Bodies for Environmental Conservation

Several international organisations have been striving to provide a formal shape to the struggle for planet conservation. In this unit, brief details have been provided about the prominent, internationally active organisations that aim specifically at species and ecosystem conservation, by providing guidelines on the positive efforts and controlling the negative impacts. The objective of this unit is to make the reader aware of the various organisations, their aims and activities, and most significantly, how an individual can play his/her role through these existing channels to ensure a sustainable planet.

International Organisation

UNEP (United Nations Environment Programme)

The UNEP is a leading environmental authority that is set globally to address environmental issues, promote implementation of environmental development one of the goal of sustainability of UN and it serves as an authorized advocate for global environment.

The UNEP works with the mission to provide and encourage partnership in caring the environment by informing, inspiring and enabling nations and peoples to improve their quality of life with sustainability.

The head quarter of UNEP is located in Nairobi, Kenya. It has various divisions regionally, out posted offices and several centres. They also host different environmental conventions, secretariats and inter-agency coordinating bodies.

Their work is broadly categorized into seven areas:

- Climate change
- Disasters and conflicts
- Ecosystem management
- Environmental governance
- Chemicals and waste
- Resource efficiency
- Environment

They work with the aim to maintain sustainability while achieving the above goals. They have partners, who fund 95% of their income. They encourage people by honoring individuals and institutions who show outstanding performance in the field.

WWF (World Wide Fund for Nature)

The WWF is an international non-governmental organisation. It was formerly named as World Wildlife Fund. It was founded in 1961 for working in the field of wilderness preservation, reduction of human impact on environment. It works with the goal to reduce degradation of the planet's natural environment and envisage a future in which there is perfect harmony between human beings and nature, through conservation of other species in the world, sustainable use of renewable natural resources, pollution reduction and consumption control.

They work in following fields:

- Protecting endangered species and critical areas/landscapes
- Promote low carbon growth & reduce the impact on climate change
- Work closely on policy, research & innovation with governments & partners
- Satellite mapping of natural resources
- To make rivers & wetlands healthy, rich and free flowing
- To help businesses be more nature friendly

- Action against poaching with an aim to eradicate illegal wildlife crime
- Protecting India's coast and marine life
- To help grow food sustainability with lesser environmental footprint
- Empowering local communities to be nature protectors
- Inspiring younger generation through environmental education
- Legal centre of excellence for protecting nature

WWF is working in India since 50 years and to conserve ecology of India, they have adopted following steps:

- To ensure conservation of the Countries biodiversity, protection of major ecosystems and landscapes
- Reduce wasteful consumption of natural resource and promote sustainable development
- Involvement of rural as well as traditional communities in conservation and sustainable management of natural resources
- Working on reducing the impact of climate change
- To minimise pollution, reduce use of toxic chemicals and improved management of toxic waste
- Enhance participation of all section of society and contribute in conservation of environmental protection by education, awareness and capacity building.
- Ensuring implementation of environmental principles into development planning, policy and practices
- Promoting environmental governance through legislation, policy and advocacy

Intergovernmental Panel on Climate Change (IPCC)

The IPCC was established in the year 1988 by the World Meteorological Organization (WMO) in coordination with United Nations Environmental Programme (UNEP) for assessing scientific basis related to climate change, impacts and future risks associated with the same, apart from exploring options to mitigate its impact.

IPCC assessments provide a scientific basis for governments at all levels to develop policies pertaining to climate management, also underlie negotiations at the UN Climate Conference – the United Nations Framework Convention on Climate Change (UNFCCC). It provides unique opportunities to decision-makers because of its scientific and intergovernmental nature. Any member country of UNEP and WMO can participate in IPCC. The IPPC contains of a bureau consisting of elected members. It provides guidance to the Panel on scientific and technical aspects of the work and provide advice on management and strategic issues. IPCC assessments are written by many leading scientists and other experts to provide expertise in specific fields. IPCC assessments provide a scientific basis for governments at all levels to develop climate-related policies, and they underlie negotiations at the UN Climate Conference – the United Nations Framework Convention on Climate Change (UNFCCC).

IUCN (International Union for Conservation of Nature)

The IUCN came into existence on 5th October 1948, in the French town of Fontainebleau, as the first international conservation-related organisation. It is a membership Union consisting of governments

as well as civil societies. ICUN brings together on one platform more than 15000 experts and 1300 member organisations with the single aim of biodiversity conservation. IUCN is the only environmental organisation to enjoy observer status at the United Nations. The IUCN aims at stemming biodiversity loss due to anthropogenic causes, and has now widened its ambit to include sustainable development in its scope.

IUCN's mission is to "influence, encourage and assist societies throughout the world to conserve nature and to ensure that any use of natural resources is equitable and ecologically sustainable". IUCN is chiefly aimed at education, research, awareness, data collection-analysis and high quality field work. The most significant contribution of IUCN towards society is the scientifically sound compilation and classification of the extinction risk faced by species based on their conservation status. It may well be referred to as the world's most exhaustive and reliable list of threatened species. This list is referred to as IUCN Red List of Threatened Species. IUCN Red List came into being in the year 1964. In addition, there are Regional Red Lists to provide regionally relevant data on extinction risk and conservation status.

IUCN Red List classifies species into nine distinct groups, as described below in **Fig.1.26** and **Fig.1.27**.

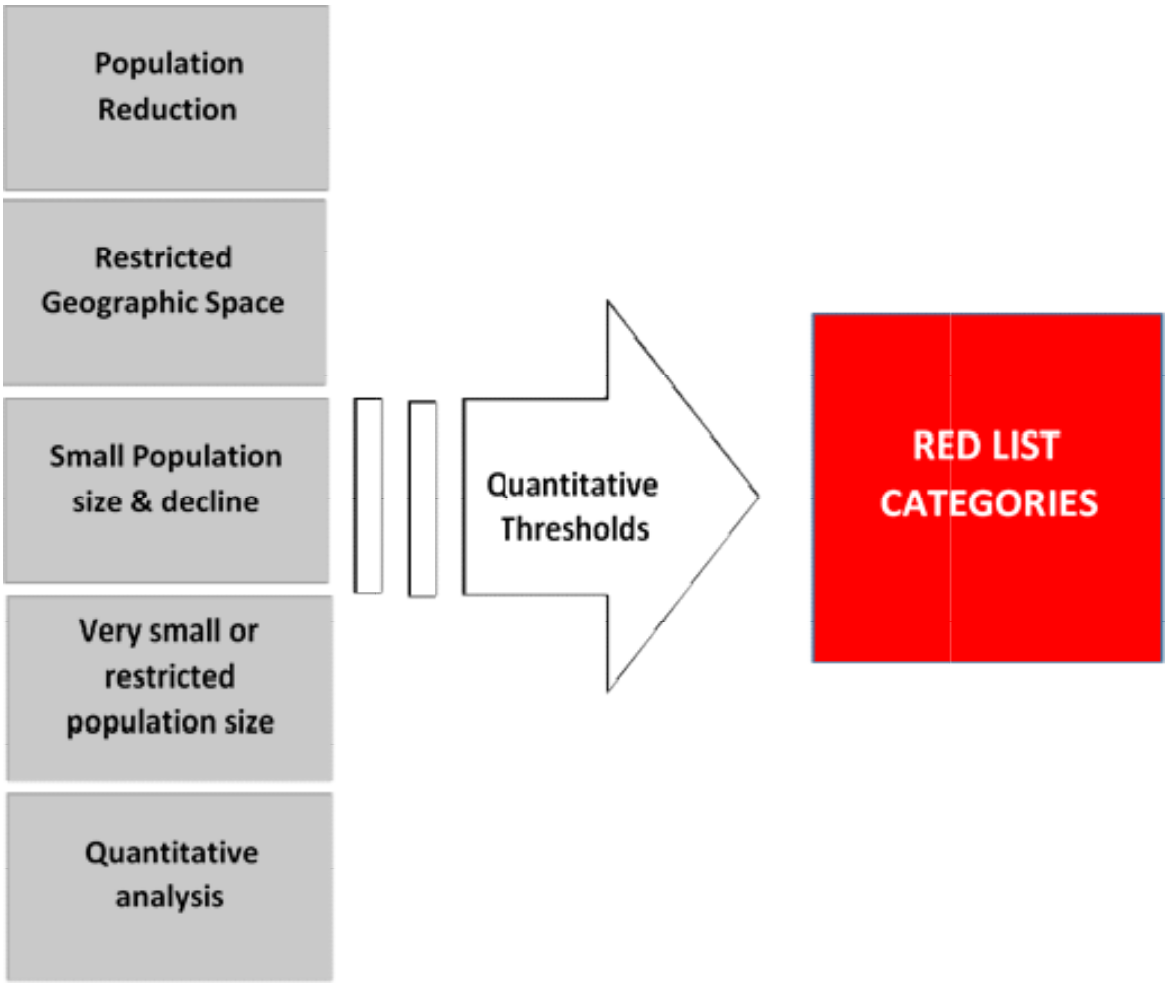


Fig.1.26: IUCN –Five Red List Criteria

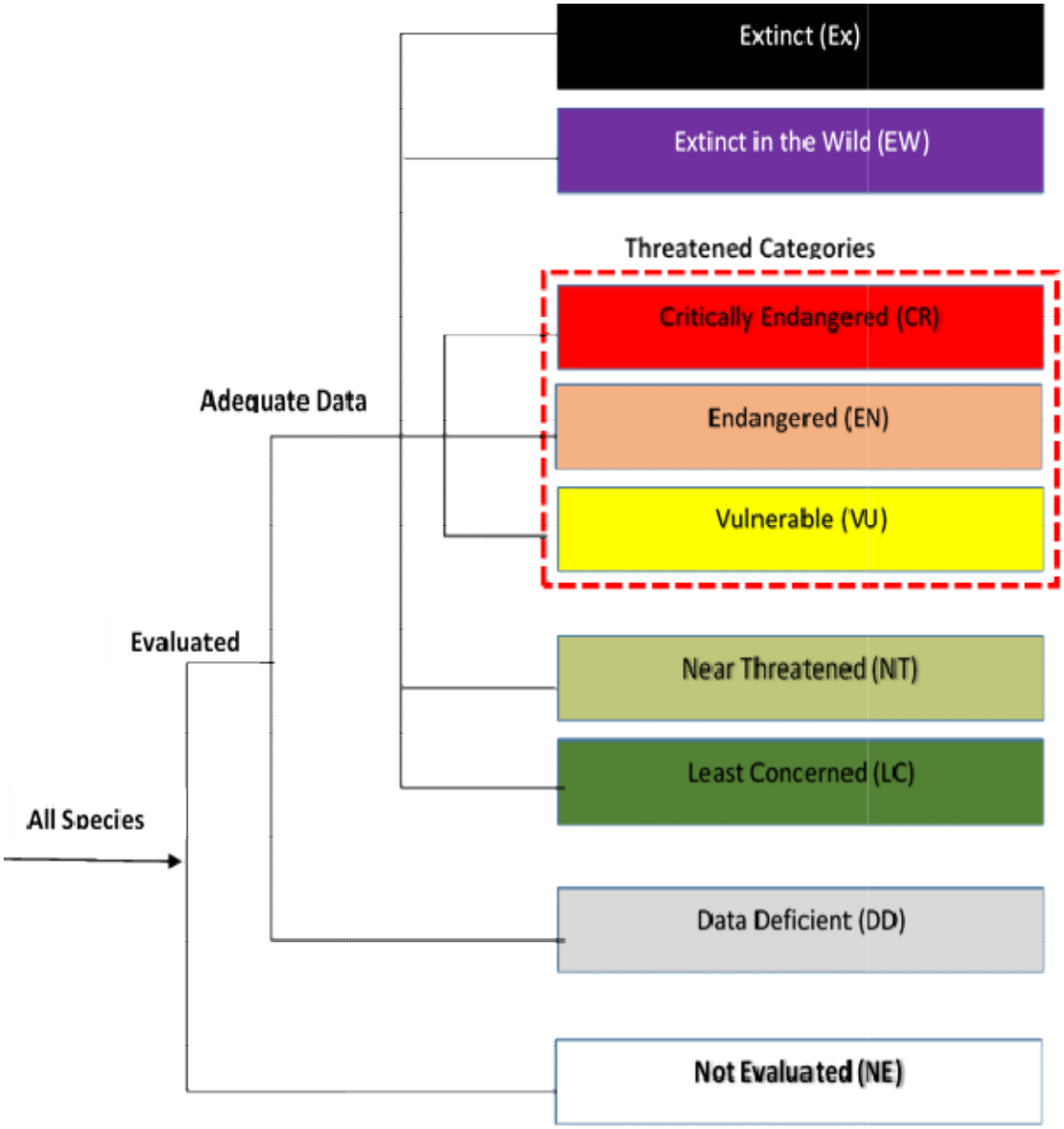


Fig.1.27: IUCN Structure of the Red List Category

UNDP (United Nations Development Programme)

UNDP is working in around 170 countries and territories to achieve the goal of eradication of poverty, reduction of inequality and exclusion. They help countries in developing policies, partnering abilities, leadership skills, and institutional capabilities and build resilience in order to achieve sustainable development. It has adopted total 17 sustainability goals in which environment and climate change are also included.

UNDP has taken several steps to tackle climate change. Its key areas of interventions are climate change, sustainable natural resource management and integrated chemical management. It is committed to promote low carbon, climate resilient and inclusive development with a major focus

on conservation of natural resources. In India, they support the government to meet national development objectives along with commitments under key multilateral environment agreements by providing support in leadership development, creating innovative partner in public and private sectors. UNDP also aims to generate new models for energy efficiency.

UN (United Nations)

The name "United Nations" was given by Franklin D. Roosevelt, the then President of the United States of America. It was first used in the Declaration by United Nations on 1 January 1942, during the Second World War. Founded in 1945, the United Nations is an international organisation with 193 Member States as of now. The UN's founding Charter enlists the organizations' aims and objectives.

UN Secretary-General arranged a summit for addressing issues in climate change through reduction of greenhouse gases by 45% till 2020. The Climate Action Summit and the Climate Youth Summit of the United Nations brought into sharp focus the urgency of acting upon climate change and global warming, calling it a climate emergency and urging all the world leaders to take affirmative action against this global calamity.

The International Plant Protection Convention (1952)

The International Plant Protection Convention came into being under the aegis of the Food and Agriculture Organisation in 1952, as a multi-lateral treaty. Each of the signing party came together to formulate a governing body of the Convention, titled the Commission on Phytosanitary Measures. The objectives of the Commission on Phytosanitary Measures include:

- Preventing spread of pests to help enhance food production, ensure food security and lead to sustainable agriculture
- Ensuring that plant pests do not lead to forest and other natural biodiversity loss
- With the help of phytosanitary measures help improve trade and commerce
- Capacity building in the novel field of phytosanitary measures to help achieve the previous three measures

Thus, the IPPC aims at protecting not only food biodiversity but wild biodiversity as well, and recognises the negative impacts of weeds and pests. Research materials, biological pesticides, germplasm banks, containment facilities, food and emergency aid and potential vectors involved in plant pest spread, which includes containers, packaging materials, soil, vehicles, vessels and machinery – all fall within the purview of IPPC.

Convention on International Trade in Endangered Species of *Wild Fauna* and Flora (1963)

International trade in plant and animal species (live or products obtained from them) has been estimated to be in the range of up to billions of dollars. Covering the wide gamut of items from food to pets, from medicine to souvenirs, from jewellery to musical instruments, from timber to items of black magic and superstition, trade in living species is a booming business. Unfortunately, several species have been overharvested/hunted close to extinction thanks to human greed. Given that a substantial chunk of such trade takes place across international borders, the necessity of an international watchdog was felt.

The Convention on International Trade in Endangered Species of *Wild Fauna* and Flora (CITES) thus came into existence. CITES was drafted in the year 1963, after a resolution adopted at an IUCN meeting. CITES is an international agreement between governments, with the chief aim of checking international trade in wild animals and plants (or their parts/products derived from them) to help check their overexploitation and possible extinction.

As of now, as many as 35,000 species of animals and plants are accorded protection under CITES.

CITES authorises the import, export, re-export and introduction of its enlisted species through a licensing system. For parties ratifying the Convention, it is mandatory to designate at least one Management Authority to regulate a licensing system. Further, at least one scientific authority is required to advise them on the effects of trade on the status of the species.

Ramsar Convention

The Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat (Convention on Wetlands) was adopted on the 2nd February 1971 and came into force in 1975. Incidentally, 2nd February came to be celebrated as the World Wetlands Day. As per the Ramsar Convention, wetlands can be defined in a very broad sense. According to the Convention, wetlands are *"areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres"*. Thus, wetlands include freshwater or brackish, permanent or natural, lentic or lotic, natural or artificial areas of marsh, fen, peatland or water.

Understanding the high value of ecosystem goods and services provided by wetland ecosystems, the Government of India became a Contracting Party to the Ramsar Convention. The basic tenets of the treaty text have been developed and interpreted by the Conference of the Contracting Parties. The developments and changes are made taking into consideration the environmental impact that those changes/developments would bring forth. In **Fig.1.28**, the socio-scientific approach for the restoration of a Ramsar Wetland has been provided.

Man and Biosphere Programme of UNESCO (1971)

Recognizing the important pro-conservation role played by human beings in the ecosystem where they reside in, the Man and Biosphere (MAB) programme was envisaged by the UNESCO in the year 1971. MAB programmes include terrestrial as well as marine ecosystems, and though they are nominated by the respective governments and remain within their jurisdiction, these sites are internationally recognised. An MAB has a core, buffer and transition zones.

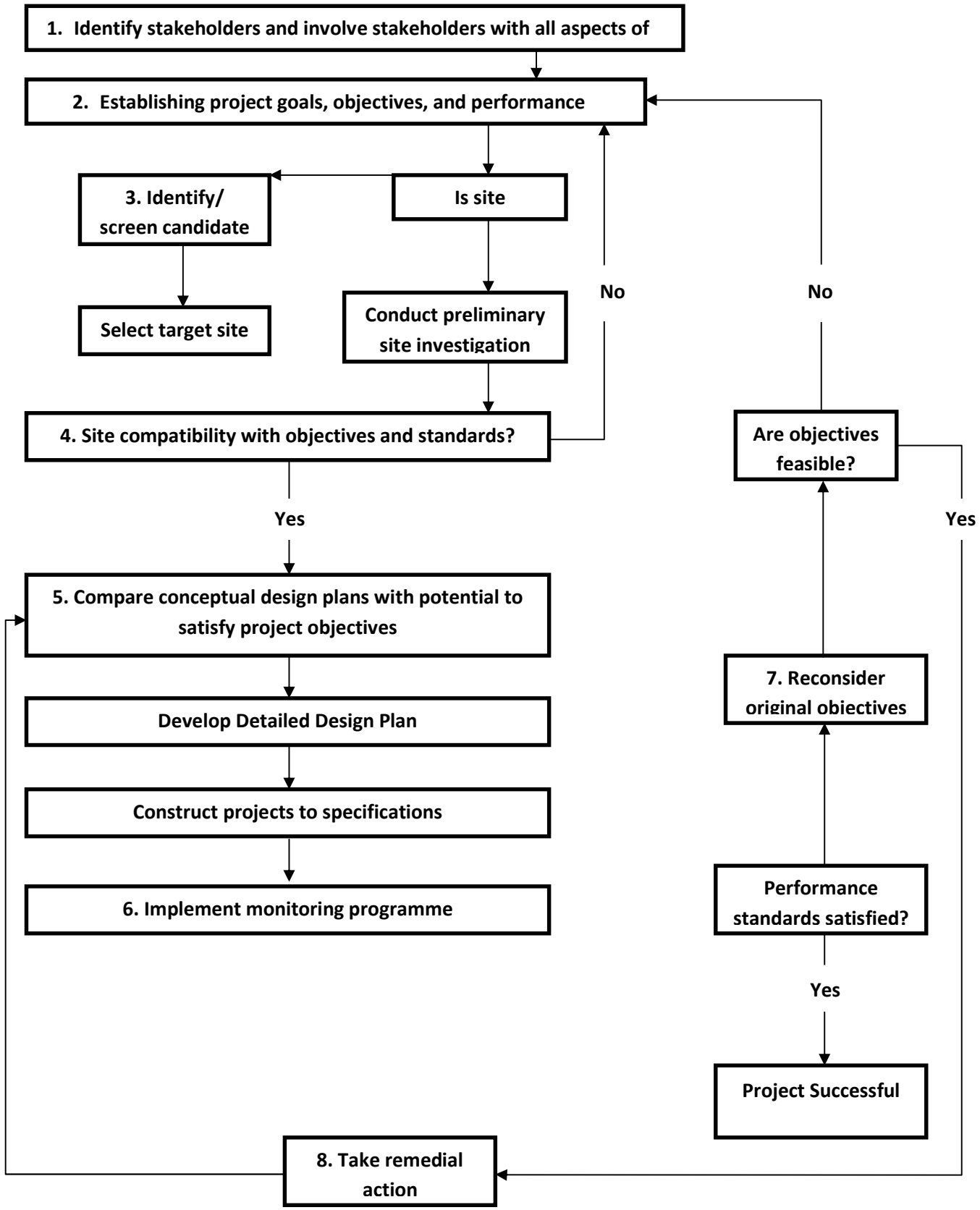


Fig. 1.28: A Flowchart for Ramsar Wetland Restoration

Source: Ramsar COP8 Resolution VIII.16, page 9http://www.ramsar.org/sites/default/files/documents/pdf/guide/guide-restoration.pdf

Convention Concerning the Protection of the World Cultural and Natural Heritage (1972)

This is a unique attempt at conjoining cultural and natural heritage and joining the idea of cultural conservation with nature conservation. The concept of a World Heritage Trust was floated in a White House conference in the USA in the year 1965, aiming at the preservation of "the world's superb natural and scenic areas and historic sites for the present and the future of the entire world citizenry". Similar proposals were prepared by the IUCN in the year 1968. Finally, the General Conference of UNESCO adopted the "Convention Concerning the Protection of the World Cultural and Natural Heritage" on 16 November 1972, coming into force in 1975. The process of enlisting a site as a world heritage site has been flowcharted below:

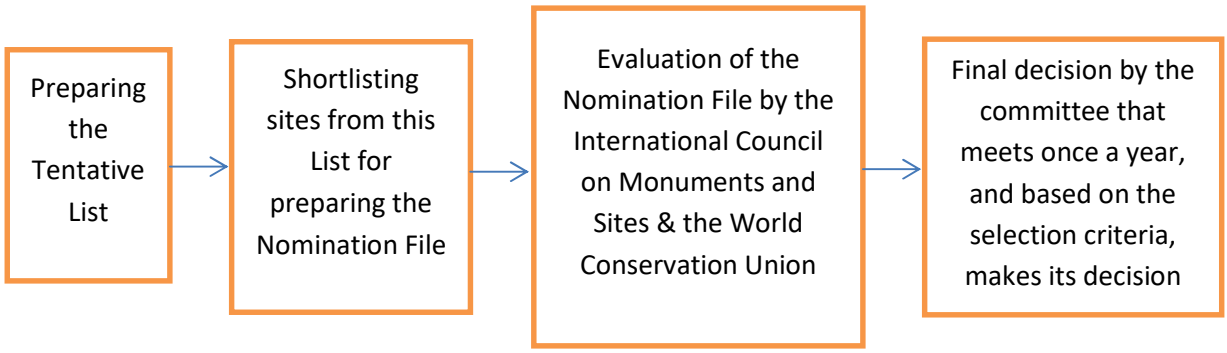


Fig.1.29: Process of Enlisting a Site as World Heritage Site

Among the 10 selection criteria, 6 are based on cultural attributes while 4 are based on unique natural assets. These have been enlisted below.

i. "to represent a masterpiece of human creative genius and cultural significance"
ii. "exhibits an important interchange of human values, over a span of time, or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning, or landscape design"
iii. "to bear a unique or at least exceptional testimony to a cultural tradition or to a civilisation which is living or which has disappeared"
iv. "is an outstanding example of a type of building, architectural, or technological ensemble or landscape which illustrates a significant stage in human history"
v. "is an outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture, or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change"
vi. "is directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance"
vii. "contains superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance"
viii. "is an outstanding example representing major stages of Earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features"
ix. "is an outstanding example representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems, and communities of plants and animals"
x. contains the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation"

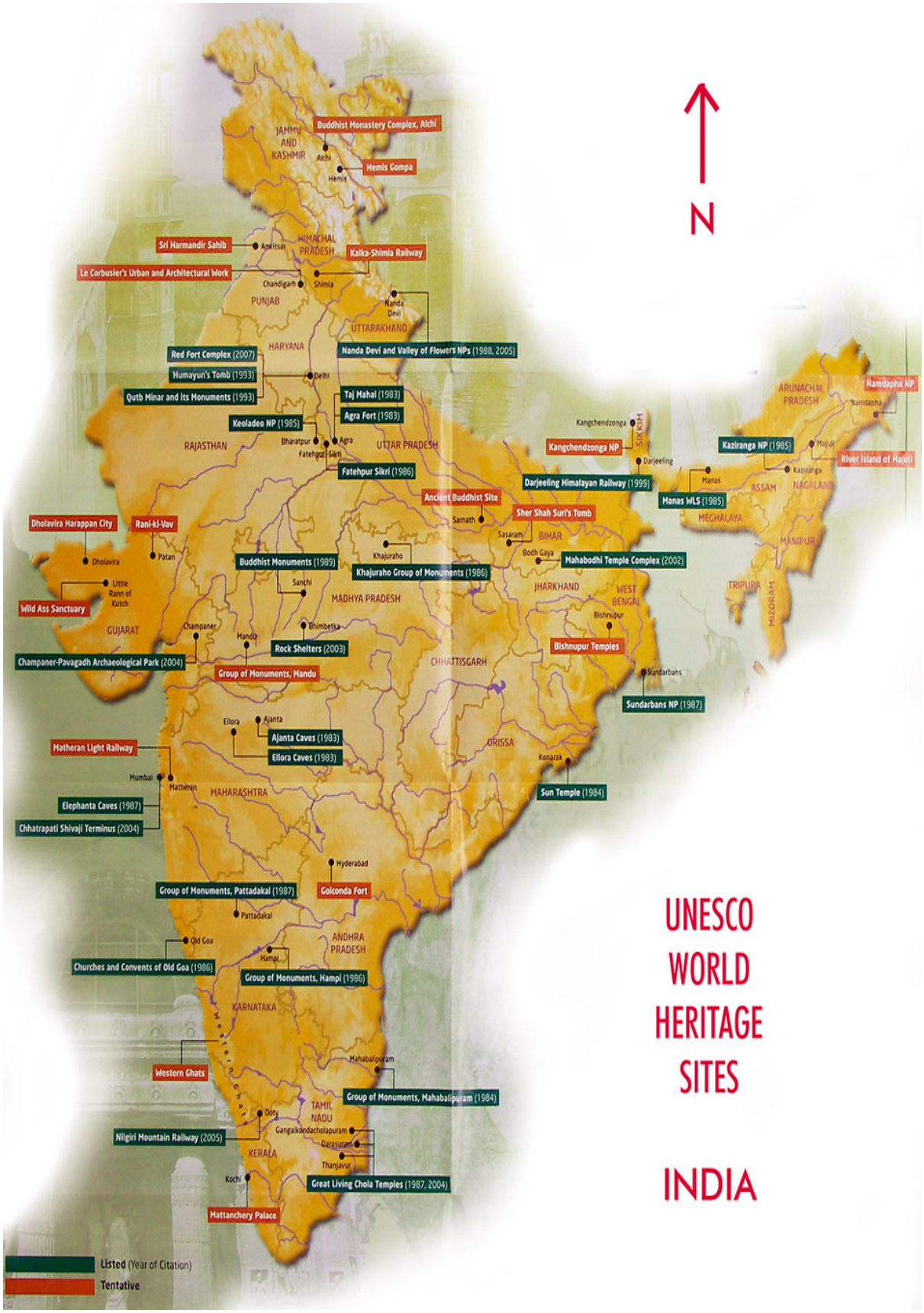


Fig.1.30: UNESCO World Heritage Sites in India

The Convention on Conservation of Migratory Species of Wild Animals (1979)

Also known as the Bonn Convention and the Convention on Migratory Species, the United Nations Environment Programme (UNEP) brought this international treaty into being with the aim of conserving migratory species. Signed in Bonn, Germany in the year 1979, the treaty came into force in 1983. It is the only United Nations-based international organisation aimed at conservation.

Article 2(3) of the Convention states that the Parties:

a. Should promote, cooperate in and support research relating to migratory species;
b. Shall endeavour to provide immediate protection for migratory species included in Appendix I; and
c. Endeavour to conclude agreements covering the conservation and management of migratory species included in Appendix II.'

A large number of migratory species are covered under this Convention. Appendix I enlists the Threatened Migratory Species while Appendix II has migratory species requiring international cooperation. Among the various instruments under the convention, different taxons are specifically covered. EUROBATS has 52 species of bats covered, whereas 254 species of wetland birds have been enlisted in (AEWA) Agreement on the Conservation of African-Eurasian Migratory Waterbirds ; 76 species of birds of prey have been accorded protection under the Raptors MoU. IOSA Marine Turtle MoU protects 6 species of marine turtle while the MoU on the Conservation of Migratory Sharks covers 7 species of shark.

Convention on Biodiversity

Conservation of its biodiversity is one of the most formidable challenges facing mankind today. Unfortunately, even the blaring alarms of biodiversity loss have failed to generate adequate corrective action. Biodiversity remains a mute victim of mindless development.

The Convention on Biological Diversity (CBD) was signed on World Environment, 5th June in the year 1992 in Rio de Janeiro during the Earth Summit; it came into action on 29th Dec 1993 to address the challenge of making biodiversity protection a socio-culturally popular as well as scientifically sound activity. However, the birth of the CBD concept took place as early as in November 1988 at a United Nations Environment Programme (UNEP) Ad Hoc Working Group of Experts on Biological Diversity.
The Convention on Biological Diversity (CBD) is an international, multi-lateral legally-binding treaty with three main goals: conservation of biodiversity, sustainable use of biodiversity and the fair and equitable sharing of the benefits arising from the use of genetic resources, with the ultimate aim to ensure a sustainable future.

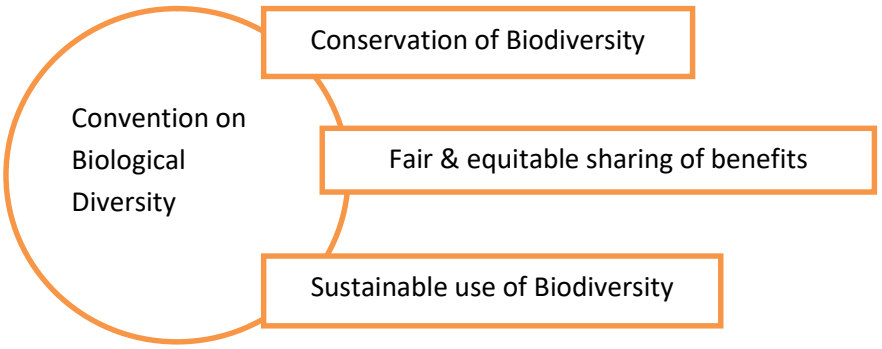


Fig.1.31: The Three Aims of the Convention on Biological Diversity

All the governments who signed the treaty, solemnly pledged to conserve biodiversity, recognise it as a finite resource that had to be sustainably used and equitably shared. The participating governments were required to develop biodiversity management strategies and action plans at the

national, regional and local levels, and to integrate them with their developmental goals. Sectors such as forestry, agriculture, fisheries, energy, transportation and urban planning were considered to be particularly important. Other treaty commitments include:

- Identifying the fundamental components of biodiversity, i.e., genetic, species and ecosystem levels, and monitor them and ensure their sustainable usage.
- Demarcating protected areas to conserve biodiversity while ensuring environmentally responsible developmental activities around these.
- Involving the local residents to help restore degraded ecosystems and reducing the threats to rare and threatened species.
- Ensuring that traditional knowledge about conservation and ecosystems are formally documented, making ethno-biology a critical element of biological diversity conservation.
- Raising awareness about exotic and invasive species.
- Controlling the risks posed by genetically modified organisms (GMOs).
- Ensuring sufficient public participation, encouraging public watchdog groups to keep an eye out for development-induced environmental degradation.
- Awareness raising about conservation and making biodiversity socially relevant.
- A regular reporting mechanism to keep a check on how each signee country is achieving its biodiversity conservation mission.

ESS6 of the World Bank's Environment and Social Framework - Biodiversity Conservation and Sustainable Management of Living Natural Resources

The World Bank promotes sustainable development and hence considers protecting and conserving biodiversity and natural resources as fundamental. The standard applies to maintaining of resources like habitats, forests and biodiversity. It also considers livelihood of project affected community and their access to various resources that can be affected by any project. It mandates the borrower to adopt mitigation strategies and various precautions in planning and designing that will avoid or minimise impacts on biodiversity and also to support livelihood of local communities, indigenous people being part of it.

National Organisations

MoEFCC (Ministry of Environment, Forest and Climate Change)

The Ministry of Environment, Forest and Climate Change (MoEFCC) is the most important, central agency in the Central Government for the planning, promoting, coordinating and managing the implementation of the sustainable management of India's environmental resources.

The prime concern of MoEFCC is to implement several policies and programmes related to conservation of the natural resources of the country that also includes lakes, rivers, biodiversity, forest and wildlife, welfare of animals, and prevention of pollution. Along with implementing these polices and programme, the Ministry also ensures to adopt the principle of sustainable development and enhancement of human well-being.

The MoEFCC aims to:

- Conserve flora and fauna in their natural habitats to the extent possible
- Keep pollution under control
- Conduct afforestation, reforestation and eco-restoration activities
- Protect the environment

The objectives of the MoEFCC are achieved by enacting a series of pertinent legislation, which are implemented with the help of the ministry's nodal agencies. The Ministry also regulates other authorities (**Fig1.32**) under it for well-functioning and conservation of the environment.

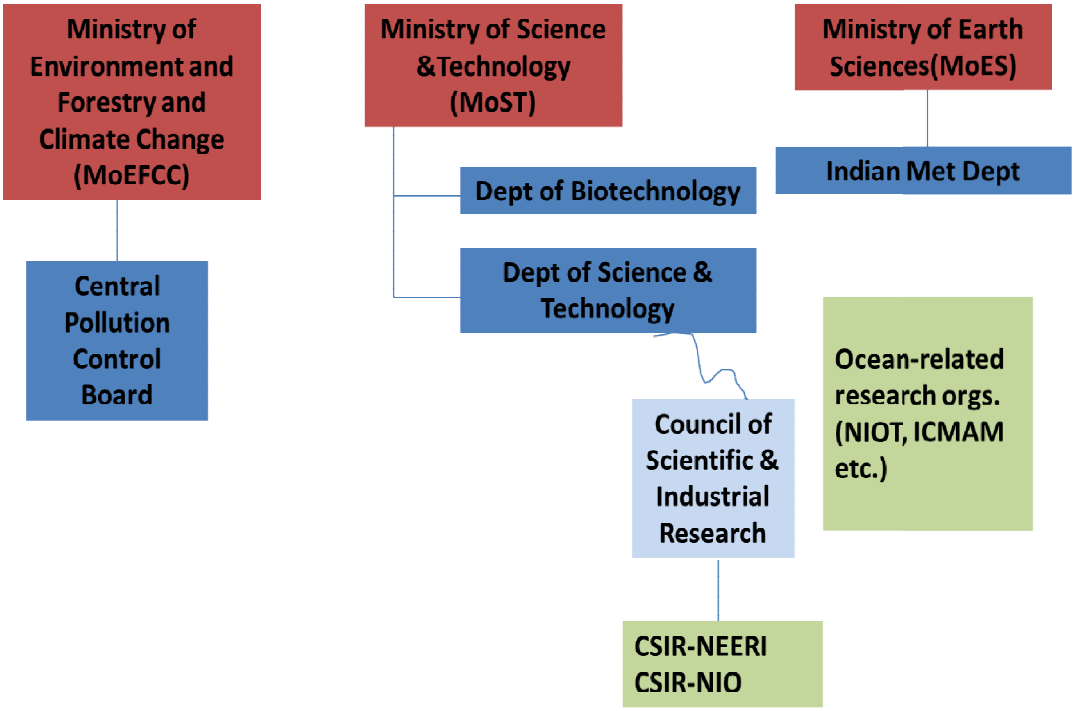


Fig.1.32: Regulation of Several Bodies by MoEF

The MoEFCC is also the nodal agency for UNEP(United Nations Environment Programme), South Asia Co-operative Environment Programme and International Centre for Integrated Mountain Development; also, it is the agency for the follow-up of the United Nations Conference on Environment and Development. MoEFCC is also responsible for issues relating to multilateral bodies such as the Commission on Sustainable Development, Global Environment Facility and of regional bodies like Economic and Social Council for Asia and Pacific and South Asian Association for Regional Co-operation on matters pertaining to the environment.

CPCB (Central Pollution Control Board)
The Central Pollution Control Board was constituted in September, 1974 under the Water (Prevention and Control of Pollution) Act, 1974. Further, CPCB was also entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981.

It serves as a technical service provider to the MoEFCC of the provision of Environment (Protection) Act, 1986. The main functions of the CPCB is "to promote cleanliness of streams and wells in different areas of the States by prevention, control and abatement of water pollution, and to improve the quality of air and to prevent, control or abate air pollution in the country." It regulates all the State Pollution Control Board by formulation several regulations and monitoring strategies.

SPCB (State Pollution Control Board)
The State Pollution Control Board plans a comprehensive programme to prevent, control or avoid pollution of environment in their respective states. The State Pollution Control Board advices the state government on any matter concerning to the prevention, control or abatement of pollution.

The State Pollution Control Board is mandated to plan a detailed set of actions for preventing, controlling and abating the pollution of air and water at the state level, and to ensure the implementation of the same. The various SPCBs have to advise the state government on matters pertaining to pollution control. The SPCBs collaborate with the Central Board in organizing training

programmes related to pollution. It also functions as prescribed or entrusted by the Central Pollution Control Board from time to time.

BSI (Botanical Survey of India)
Established in 1890, the Botanical Survey of India was envisaged to conduct scientifically sound exploration of the plant resources and identifying plant species with high economic value. In 1954, the BSI objectives were re-imagined by the Government of India to include:

- Intensive surveys of the flora and collate in-depth and accurate information regarding their taxonomy, autecology, ethnobotany and economic worth.
- To collate adequate research materials for use by educational and research institutions.
- To oversee the preparation of well-maintained herbaria and other plant resources.

ZSI (Zoological Survey of India)
The Zoological Survey of India (ZSI) was established on 1st July, 1916 to promote survey, exploration and research leading to the advancement in our knowledge of various aspects of exceptionally rich life of the erstwhile ´ British Indian Empire. The Zoological Section of the Indian Museum at Calcutta may be credited to be origin of ZSI in 1875. Initially, the Survey acquired the Zoological collections of more than a century old from former Museum (1814 -1875) of the Asiatic Society of Bengal and Zoological Section of the Indian Museum(1875-1916) in Calcutta. With the increasing interest in the life sciences and with the advent of country´s Five Year Plans, the expansion programme of the survey was initiated. It functions as the guardian of the National Zoological Collections, containing over a million identified specimens from all animal groups ranging from Protozoa to Mammals. Extensive and intensive field explorations are undertaken by the Survey in different parts of the country for the studies of fauna, systematic zoology, animal ecology, wildlife and zoogeography, animal behavior, animal population and also marine fauna and the results of the explorations and research are published in its own journals as well as National and International periodicals of repute regularly.

MNRE (Ministry of New and Renewable Energy)
The Ministry of New and Renewable Energy is the nodal Ministry of the Government of India for all matters related to new and renewable energy. The aim of the body is to develop and deploy new and renewable energy for supplementing the energy requirements of the country.
Following CASE and Ministry are created by MNRE:

- Commission for Additional Sources of Energy (CASE) in 1981.
- Department of Non-Conventional Energy Sources (DNES) in 1982.
- Ministry of Non-Conventional Energy Sources (MNES) in 1992.
- Ministry of Non-Conventional Energy Sources (MNES) renamed as Ministry of New and Renewable Energy (MNRE) in 2006.

Since the concern of County's energy security has increased, the role of MNRE has been increased significantly. After the two oil tragedies in 1970s the importance and need of new and renewable energy in the country arise. It was the time when CASE was established. It was provided with the responsibility of policy formulation and implementation of the various programmes for research & development in new and renewable energy as well as its popular usage.

To Do Activity
Visit a local NGO working for Environment and understand how they contribute in tackling environmental issues.

Summary

The chapter provides details of the field of environmental sciences and various disciplines that make up the field. One can get information on how the subject is important for an individual and how every individual must ensure they are aware about the nitty-gritty of environmental management. The chapter also provides details on various concepts of ecology, given that ecology is the most critical element of the environment and one that cannot be resurrected fully if lost. The benefits of the environment and all the goods and services one can avail from nature have been described in this chapter, too. A brief description of several national and international bodies actively working for conservation of the environment is provided in the chapter.

Model Questions

- What do understand from the term Environment?
- What are the various branches of Environmental Sciences?
- Which branch of Environmental Sciences would you like to explore? Why?
- How important do you think is the study of environmental sciences important? (If yes, why)
- What grabs our attention towards environment management?
- In what kind of ecosystem do we live?
- Give a brief description about some of the important Environmental National Bodies.
- How can one reduce the wasteful use of resources at home?
- Which eco-system service do we avail to obtain food?
- Give a brief description about some of the important Environmental National Bodies.
- What are the various International Environmental bodies? Explain their role in terms of
- Environmental Conservation.
- What do you think the regulating bodies in India should do towards achieving sustainable development?
- What can you do at an individual or community to achieve the goal of sustainable use of resource?

References

- Ambastha, K, Hussain, SA & Badola R 2007a,'Socio and Economic Considerations in conserving wetlands of Indo-Gangetic Plains – A case study of Kabartal wetland , India',Environmentalist, vol. 27, pp. 261-273.
- Anton, C. et al. 2010,'Research needs for incorporating the ecosystem service approach into EU biodiversity conservation policy',Biodiversity and Conservation, vol. 19, no. 10, pp. 2979-2994.
- Appasamy, PP & Nelliyat, P 2007,Compensating the Loss of Ecosystem Services Due to Pollution in Noyyal River Basin, Tamil Nadu, Working Paper, Madras School of Economics.
- Badola, R & Hussain, SA 2005,'Valuing ecosystem functions: an empirical study on the storm protection function of Bhitarkanika mangrove ecosystem, India',Environmental Conservation, vol. 32, no. 1, 85-92.
- Baerenklau, KA, Gonza´lez-Caba´n, A, Paez, C & Chavez, E 2010,'Spatial allocation of forest recreation value',Journal of Forest Economics, vol. 16, pp. 113-126.
- Balasubramanian, A.. (2008). ECOSYSTEM AND ITS COMPONENTS.
- Barbier, EB 1989,The Economic Value of Ecosystems: 1- Tropical Wetlands, Gatekeeper Series No. LEEC 89-02, London Environmental Economics Centre, London
- Barbier, EB Acreman, M & Knowler, D, 1997,Economic Valuation of Wetlands - A guide for policy makers and planners, Ramsar Convention Bureau.
- Bennett J 2011,'Estimating the value of Australian environmental assets',AustralasianJournal of Environmental Management, vol. 18, no.1, pp. 21-32.
- Bingham, G, Bishop, R, Brody, M, Bromley, D, Clark, E, Cooper, W, Costanza, R, Hale, T, Hayden, G, Kellert, S, Norgaard, R, Norton, B, Payne, J, Russell, C & Suter, G 1995,'Issues in ecosystem valuation: improving information for decision making',Ecological Economics,vol. 14, pp. 73-90.

- Brander, LM, Florax, RJGM& Vermaat, JE 2006,'The empirics of wetland evaluation: A comprehensive summary and a Meta-analysis of the Literature',Environmental and Resource Economics,vol. 33, pp. 223-250.
- Catton Jr, W. R., & Dunlap, R. E. (1978). Environmental sociology: A new paradigm. The American sociologist, 41-49.
- Costanza, R, d'Arge, R, de Groot, R, Farber, S, Grasso, M, Hannon, B, Limburg, K, Naeem, S, O'Neill, RV, Paruelo, J, Raskin, RG, Sutton, P & van den Belt, M 1997,'The value of the world's ecosystem services and natural capital',Nature, vol. 387, pp. 253-260.
- Crase, L & Gillespie, R 2008,'The impact of water quality and water level on the recreation values of Lake Hume',Australasian Journal of Environmental Management, vol. 15, no.1, pp. 21-29.
- Daily, G (ed.) 1997,Nature's services: societal dependence on natural ecosystems, Island Press, Washington DC.
- Eleanor Imster and Deborah Byrd(2019),Atmospheric CO2 hits record high in May 2019, Earth, Retrieved on 22nd December 2019.
- Environmental Protection Agency(2018),Sources of Greenhouse Gas Emissions, Retrieved on 22nd December 2019.
- Goosen, Mattheus. (2012). Environmental management and sustainable development. Procedia Engineering. 33. 6–13. 10.1016/j.proeng.2012.01.1171.
  http://eagri.org/eagri50/ENVS302/pdf/lec05.pdf
  http://ncert.nic.in/ncerts/l/lebo113.pdf
  https://earthsky.org/earth/atmospheric-co2-record-high-may-2019
  https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions
  https://www.nationalgeographic.com/animals/reference/poaching-animals/
  https://www.rite.or.jp/English/lab/syslab/about-global-warming/download-data/global-warming.pdf
- Jani Actman (2019), Poaching animals, explained, National Geography,Retrieved on 21rd December 2019 from
- Kimmel, K, Kull, A, Salm, J & Mander, U 2010,'The status, conservation and sustainable use of Estonian Wetlands',Wetlands Ecology and Management, vol. 18, pp. 375-395
- Lee, C & Han, S 2002,'Estimating the use and preservation values of national parks' tourism resources using a contingent valuation method',Tourism Management,vol. 23, pp. 531-540
- Loomis, J, Kent, P, Strange, L, Fausch, K & Covich, A 2000,'Measuring the total economic value of restoring ecosystem services in an impaired river basin: results from a contingent valuation survey',Ecological Economics,vol. 33, no. 1, pp. 103-117.
- Mitsch, WJ & Gosselink, JG 1993,Wetlands, 2nd ed. John Wiley, New York
- National Council of Educational Research and Training, Unit X- Ecology, Retrieved on 21st December 2019 from
- Raju, KV, Puttaswamaiah, S, Sekhar, M & Rumley, R2007,Asia Regional Workshop on Compensation for Ecosystem Services,A Component of the Global Scoping Study on Compensation ofEcosystem Services ICRAF Working Paper no. 34, Nairobi: World Agroforestry Centre.
- Ramachandra, TV, Alakananda, B, Rani, A &Khan, MA 2011,'Ecological and Socio-Economic Assessment of Varthur Wetland (Bengaluru), India',Journal of Environmental Science & Engineering, vol. 53, no. 1, pp. 101-108
- RITE, Global Warming- Cause, Impact and Mitigation, Retrieved on 23rd December 2019.
- Rolston, H. (2012). Environmental ethics. Temple University Press.
- Shahzad, Umair. (2015). Global Warming: Causes, Effects and Solutions
- Tamil Nadu Agricultural University, Producers, consumers and decomposers of an ecosystem. Energy flow in the ecosystem. Types of ecosystems,Retrieved on 21st December 2019 from

Chapter 2 Natural Resources- Renewable and Non-Renewable Resources

Introduction

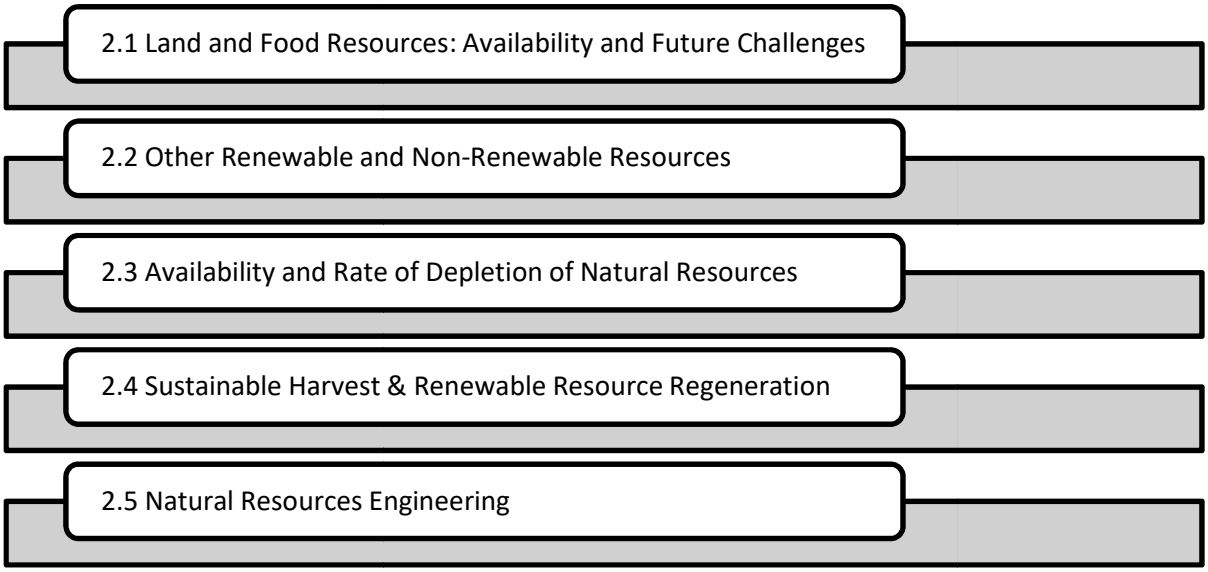
The second chapter has five sections. The first section addresses the current availability of land and food resources and the future challenges against its continued availability, touching upon hunger and food insecurity, and land degradation challenges across the world. In the second section, resources - both renewable and non-renewable - other than land and food are discussed. In the third section, the alarming rate of depletion of natural resources has been discussed. In the fourth section, sustainable natural resource management practices have been collated, while in the last section, natural resources engineering technologies have been put together.

Objectives

The objectives of this chapter are to

- Enumerate that most of the things that we heavily depend upon for our existence are provided by nature
- Explain that most of these natural resources are depleting at an alarming rate
- Provide insights on how to ensure that our natural resources are maintained stably

Structure



2.1 Land and Food Resources: Availability and Future Challenges

The second chapter has five sections. The first section addresses the current availability of land and food resources and the future challenges against its continued availability, touching upon hunger and food insecurity, and land degradation challenges across the world. In the second section, resources - both renewable and non-renewable - other than land and food are discussed. In the third section, the alarming rate of depletion of natural resources has been discussed. In the fourth section, sustainable natural resource management practices have been collated, while in the last section, natural resources engineering technologies have been put together.

World Population Rising Trend

The world population was estimated to be 2.6 billion people in the year 1950. In 1987, it reached 5 billion and 6 billion in 1999. In 2011 (month of October), the world population was estimated to be 7 billion. As per some projections, the world population will reach 9.7 billion in the year 2050 and 11

billion around 2100. Reduced child mortality, new antibiotics, enhanced fertility rates, rising trends of migration and increasing urbanisation may be mentioned as the contributing factors.

61% of the world population inhabits Asia (4.7 billion), while 17 % are in Africa (1.3 billion). 750 million people, i.e., 10 % of the global population reside in Europe. 8 % people live in Latin America and the Caribbean (650 million). Rest of the 5 % global citizens reside in Northern America (370 million) and Oceania (43 million). With 1.44 billion and 1.39 billion citizens, respectively, China and India are the two countries with 19 % and 18 % of the world's population, respectively. As per some simulation studies, India will overtake China as the world's most populous country in 2027.

A rising population translates into a rising demand for physical space and natural and manmade resources. Unfortunately, it is difficult to ensure the requisite supply of both space and resources.

Table 2.1: Annual Growth Rate in World Population

Year	Total World population	Yearly Growth Rate (%)
2020	7,79,47,98,739	1.05%
2019	7,71,34,68,100	1.08%
2018	7,63,10,91,040	1.10%
2017	7,54,78,58,925	1.12%
2016	7,46,40,22,049	1.14%
2015	7,37,97,97,139	1.16%
2014	7,29,52,90,765	1.17%
2013	7,21,05,81,976	1.19%
2012	7,12,58,28,059	1.20%
2011	7,04,11,94,301	1.21%
2010	6,95,68,23,603	1.22%

(Source:United Nations, Department of Economic and Social Affairs, Population Division)

Land Resources

Land is the most critical natural resource that forms the basis of all terrestrial ecosystems and ensures the survival of the Homo sapiens by forming the basis of agriculture, livestock, forests and surface waters. It is difficult to differentiate land as a renewable or non-renewable resource, as it can get renewed only at very slow rates and this rate of renewal is far less than the speed at which this resource is getting degraded. Land has been regarded as a Stock Renewable Resource by environmental economists.

The critical functions served by land have been enumerated below:

- an asset for individuals and communities
- source of food, fibre and fuel for human beings
- source of space for settlement, industry and recreation
- supporting floral, faunal and microbial biodiversity
- a critical element of global energy balance as well as the global hydrological cycle, being a source as well as a sink of greenhouse gases
- hydro geological regulation
- source of minerals
- natural remediation for chemical pollutants
- storage for archaeological remains and fossils

With the rising human population, increasing awareness for allowing other species to exist, and more intensive exploitation of land resources, land is becoming scarcer and dearer with every passing day.

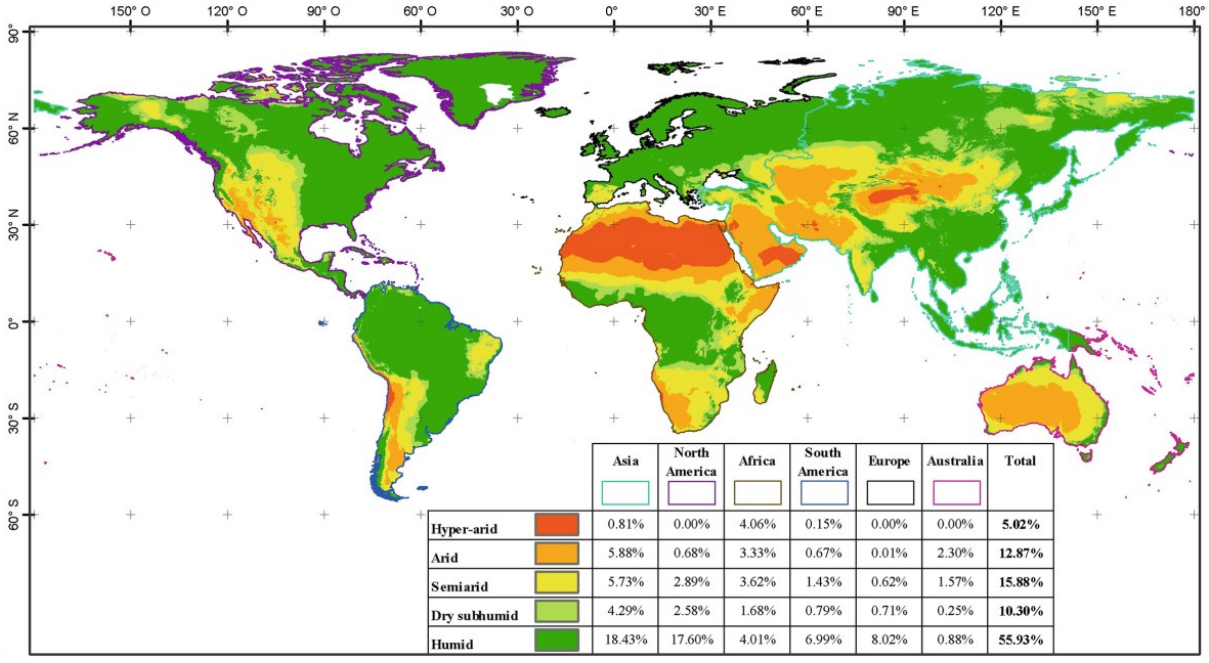
Land use planning is critical because of the

a) critical role of land for enabling human existence
b) presence of multiple stakeholders
c) unequal distribution of land resources among its multiple stakeholders
d) ever-rising demand of each stakeholder

Availability of Land

Land resources are limited and can support only a limited number of individuals, advances in technology notwithstanding. Global Land Degradation Information System (GLADIS) is FAO's modelling tool to conduct environmental as well as socio-economic analysis which provides indices to quantify degradation of land.

Desertification of land and degradation in land quality can be observed from the **Figure 2.1**below, with Africa, Asia and Australia struggling with rising aridness.



	Asia	North America	Africa	South America	Europe	Australia	Total
Hyper-arid	0.81%	0.00%	4.06%	0.15%	0.00%	0.00%	**5.02%**
Arid	5.88%	0.68%	3.33%	0.67%	0.01%	2.30%	**12.87%**
Semiarid	5.73%	2.89%	3.62%	1.43%	0.62%	1.57%	**15.88%**
Dry subhumid	4.29%	2.58%	1.68%	0.79%	0.71%	0.25%	**10.30%**
Humid	18.43%	17.60%	4.01%	6.99%	8.02%	0.88%	**55.93%**

Fig.2.1: Desertification of Land

Source: Becerril-Piña and Mastachi-Loza (2020)

Stresses on Land Resources

Rising population apart, land resource degradation has other socio-political and physical causes. Several times, short-term political gains tend to compromise long-term environmental wellness. There seems to be an insurmountable trade-off between natural resource conservation and alleviating poverty and hunger. Immediate survival benefits, therefore, overshadow long-term sustainability. Technologies to prevent this trade-off are either not available or not affordable for areas where they are needed the most. It is difficult for policies to keep pace with the land degradation rate.

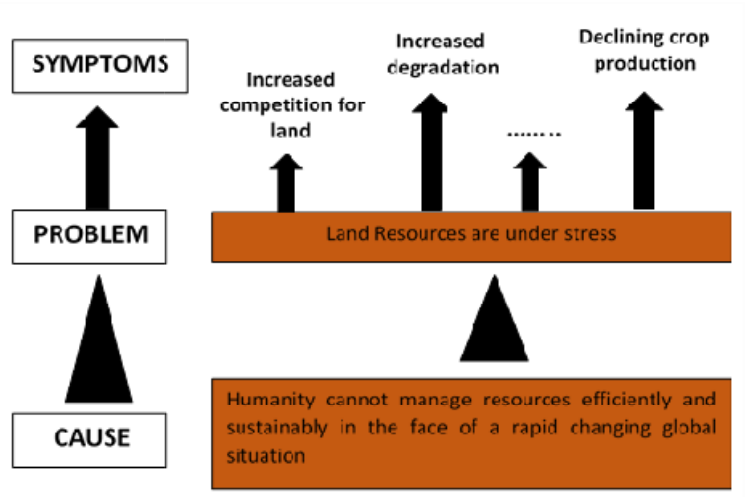


Fig.2.2: Causes for Land Degradation

Agriculture and the Environment

Agriculture accounts for a substantial part of India's economic development, as it is the only source of food for more than 1.2 billion people and the employment dependence of about 54.6% of its people, as per Census of India, 2011.

One may also consider the negative impact that agricultural practices have on the environment - It is a water-guzzling activity

- Forests are cut and degraded to yield land for agriculture, leading to loss of habitat and biodiversity
- Nitrogen oxides released from chemical fertilisers contribute to air pollution and global warming
- Livestock release carbon dioxide, contributing to global warming
- Nutrient-rich agricultural run-off causes eutrophication of nearby water bodies

Land Degradation

Land degradation is defined as the loss in quality of land with respect to pollution, nutrient depletion and fertility loss. Recent estimates suggest that 5 –6 million hectares of cultivable land in the world are irrevocably lost per year due to soil erosion, salinisation and other degradation processes. UNCCD's vicious cycle of land degradation has been provided in **Fig.2.3**.

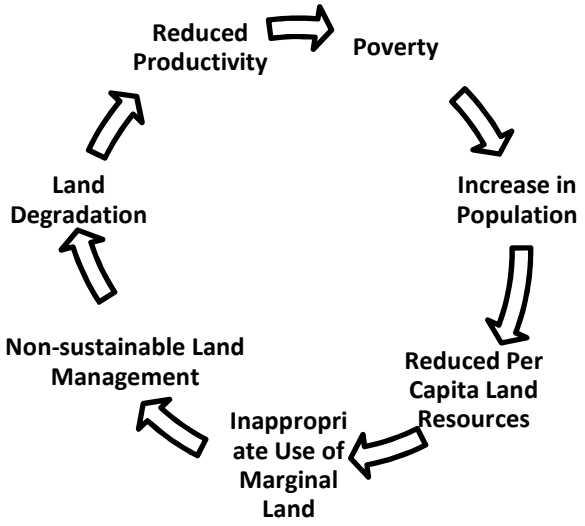


Fig.2.3: The Vicious Cycle of Land Degradation (UNCCD 2013)

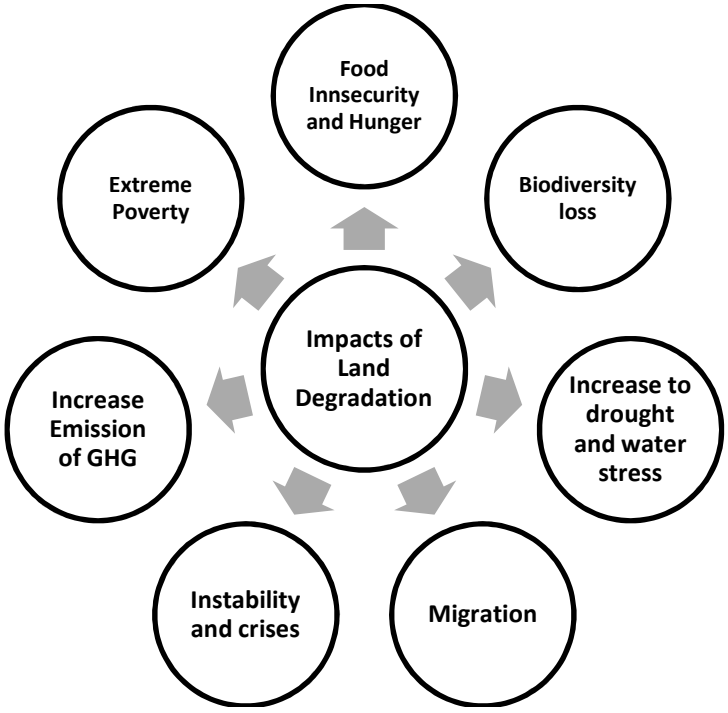


Fig.2.4: Impact of Land Degradation

Land degradation is a stark reality in India - 96.4 million ha, i.e., 29.3% of total land area in India was found to be degraded during 2011-2013. There was an increase of 0.57% as compared to 2003-2005 estimate, which translates into an area equal to the Indian state of Nagaland. Of this, only 1.95 million ha were reclaimed/restored.

Indian states of Rajasthan, Gujarat, Maharashtra, Jammu & Kashmir, and Karnataka had the highest area of lands undergoing degradation/desertification, amounting to 18.4 % (out of India's total 29.3 %) while the other states each had less than 2 % of degraded land.

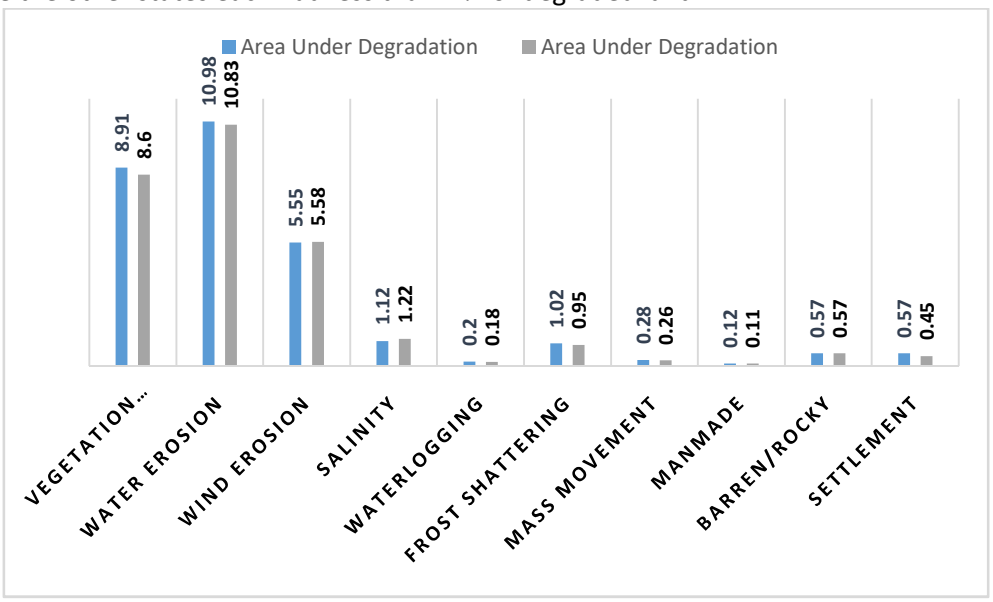


Fig.2.5: Degraded Area in India through Various Degradation Processes
(Source:ISRO's Desertification and Land Degradation Atlas of India)

Relationship between Land Degradation and Food Security

The two most important driving forces of land degradation in many countries of the world are limited land resources and population increase which has given rise to food insecurity. Quality of life, food security and environmental conservation are inextricably linked with land resources, and hence, prevention of land degradation will continue to be a critical global issue.

Land quality and agricultural productivity are linked through complex and dynamic technical and bio-physical processes. On one hand, due to land degradation, agricultural productivity goes down while on the other, it also reduces livelihood and income from agricultural land or labour.

Food security, as defined by the World Food Summit (WFS) and the Food and Agricultural Organisation, 'exists when all people at all times have physical and economic access to sufficient, safe and nutritious food that meets their dietary and food preferences for an active life.' Food security is has complex linkages with several factors, such as, socio-economic development, human rights and the environment with political factors as well.

The resultant effect of Land Degradation is reduction in acreage of farms, low production per person and rising landlessness. Land shortage and reduction in productivity further lead to land degradation where one attempts to raise productivity by applying chemical fertilisers and pesticides, over-grazing lands, clearing forests and cultivating steep slopes.

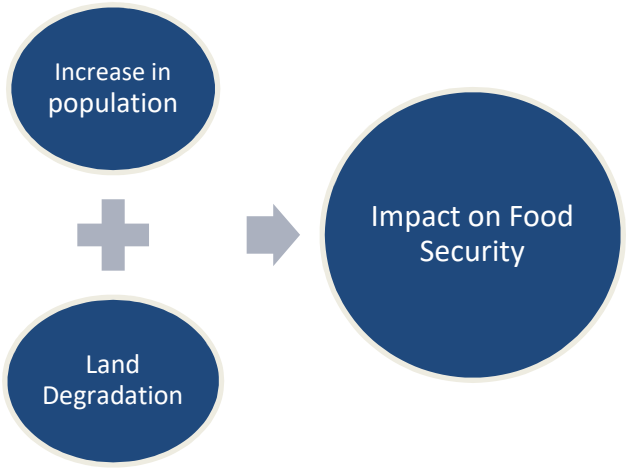


Fig.2.6: Relationship between Land Degradation and Food Security

India ranked 76th in 113 countries assessed by The Global **Food Security** Index (GFSI) in the year 2018, based on four parameters—affordability, availability and quality and safety. As per the Global Hunger Index, 2018, **India** was ranked 103rd out of 119 qualifying countries.

Hunger and Food Insecurity

Malnourishment is a traditional measure of hunger, which may be defined as "the inability to acquire enough food to meet dietary energy requirements." Unfortunately, world hunger shows a definitely rising trend. In the year 2017, about 821 million people – i.e. one in every nine people – do not have access to sufficient food for leading a healthy life. As per the Food Insecurity Experience Scale (FIES) approximately 10 % (770 million people) of the global population has faced severe food insecurity.India particularly faces serious food security issues and poverty challenges. There are gender and caste fault lines along which food insecurity works, with women and girls and dalit and tribal populations being particularly disadvantaged. Inspite of national food self-sufficiency, new challenges continue to rise: slow agriculture growth, climate change, land degradation and reducing bio-diversity. Land degradation becomes an added challenge.

Table 2.2: Challenges to Food Security

Fresh water reserves and irrigation	Water unavailability is a crucial concern to agricultural practices. Indian agriculture is mainly dependent on rain. Despite several decades of independence, 60% farms are rain-fed. In the absence of irrigation facilities, not more than one crop a year can be harvested in many areas where scope is of at least two crops per year.
Labour	In India, agriculture remains a labour-intensive practice, with little usage of automation or mechanisation. However, with rising awareness about labour laws, and rising migration to urban areas, there is less and less availability of labour for agricultural practices
Economy	Agriculture currently requires high investment in increasing per worker productivity and introduction of mechanisation and automation
Environmental Impacts	With rising trends of droughts, floods, untimely rain, unprecedented temperature changes, crop yield is reducing drastically.

2.2 Other Renewable and Non-Renewable Resources

What are Resources?

Traditionally a resource may be defined as "a product of biological, ecological or geological processes (natural resources) that satisfies human wants." Resources are part of an ecosystem, intertwined with ecosystem services and maintenance of biodiversity and the planet's life-support systems (Costanza et al., 1997).

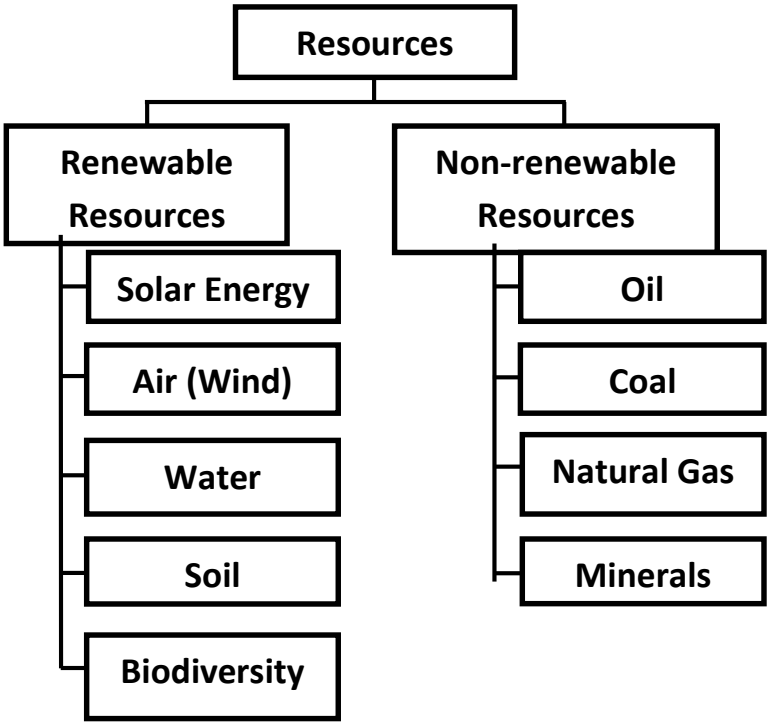


Fig.2.7: Classification of Resources

Classification of Resources

Though for several resources, it may be difficult to put them in a discrete silo, resources have been largely classified as renewable and non-renewable.

Renewable Resources

Resources that can be replaced naturally at a rate faster than they are consumed are called Renewable. Renewable resources such as oxygen, freshwater, soil, forests, biomass etc. can be

renewed at a rate comparable to the rate at which they are consumed, if managed judiciously. However, the stress here is on judicious management, which if not undertaken, can cause a resource to deplete beyond redemption. Unfortunately, since it appears more profitable in the short-term, several renewable resources are over-harvested. Resources such as sunlight, hydroelectricity, wind and tide are continuously available and their quantity is unaffected by consumption, and are also called perpetual resources.

Solar Energy

The Earth receives 174 petawatts (PW) of solar radiation at the upper atmosphere. Of this, about one-third is reflected back to space and the remainder is absorbed by clouds, sea and land masses. The spectrum of solar light at the Earth's surface is mostly spread across the visible and near-infrared ranges with a small part in the near-ultraviolet.

Solar energy is absorbed as light and heat from the sun and harvested using novel technologies such as solar heating, photovoltaic, solar thermal energy, solar architecture, molten salt power plants and artificial photosynthesis. In comparison to the finite fossil fuel resources, solar energy is perpetual. In addition, despite inherent pollution from a contained point source where solar photo-voltaic cells are manufactured, solar energy is pollution free. Active solar techniques include the use of photovoltaic systems, concentrated solar power and solar water heating to harness the energy.

A photovoltaic (PV) system is a system composed of one or more solar panels combined with an inverter and other electrical and mechanical hardware that use energy from the sun to generate electricity. PV systems differ in size from portable systems to rooftop net-metering systems to enormous solar parks.

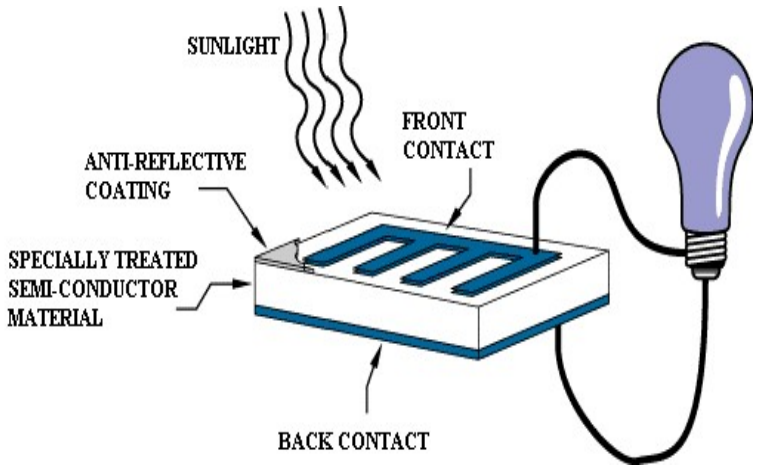


Fig.2.8: Working of a Photovoltaic System

A PV cell is arranged into a module, and modules are arranged to yield a solar panel. Several panels form an array. A PV system comes complete with a plethora of other equipment such as inverters, connectors, cabling, batteries for storage of electricity, fuse box, earthing system, a mounting system, and a tracking system among others. Solar panels must be kept clean so that the efficiency of their reflecting surface is not compromised. In fact, cleaning of solar panels is the most important maintenance activity for solar panels.

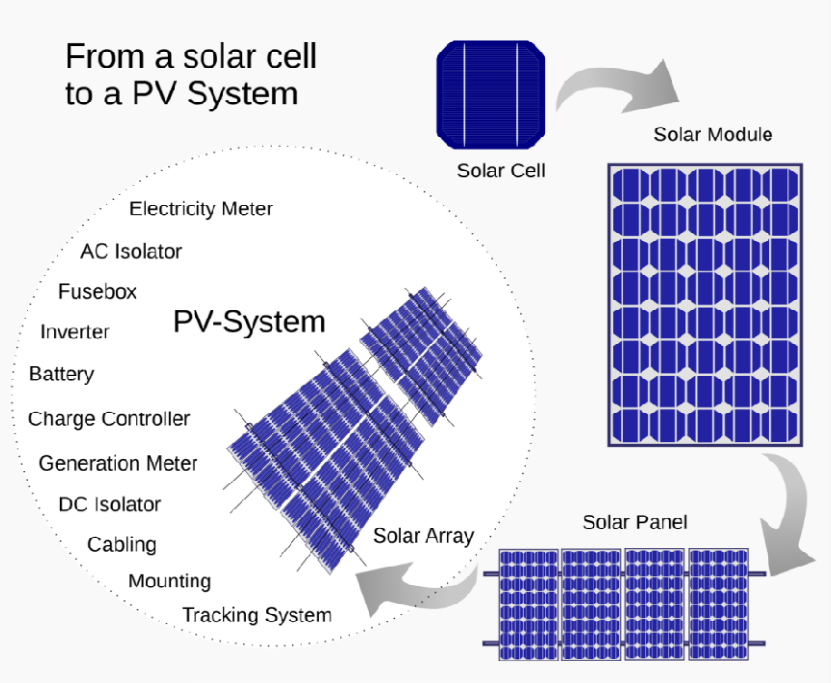


Fig.2.9: A PV Cell to a PV Panel

Photovoltaic cells generate direct current (DC) electricity, which is usually converted to AC using inverters or consumed as such. PV cells come largely as monocrystalline and polycrystalline panels, of which monocrystalline are preferred due to higher efficiency. The photovoltaic cells can be also used for other purpose like lighting, pumping and generation of electricity. As on October 31, 2019, a total grid connected solar power generation capacity of 31,696 MW has been set up in India; on the other hand, projects of 17,998 MW capacity are at various stages of installations.

The largest solar park in India (and till 2017, the largest in the world), is the Kurnool Solar Park in the Gani and Sakunala villages of Kurnool in Andhra Pradesh. Covering an area of 5932 acres, this solar park can generate up to 8 million KWh electricity that can fulfil the electricity demand of the entire Kurnool district. This solar park has 4 million solar panels of 315 and 320 watt capacity.

Solar Thermal Power systems, which are also known as Concentrating Solar Power systems, employ concentrated solar radiation as a high temperature energy source and produce electricity via the thermal route. Solar thermal systems are mostly used for applications such as domestic water heating, heating of swimming pools, space heating, water processes for industrial heating and agricultural drying. These products have proven to be reliable and can easily address low temperature demand.

Table 2.3: Top Five Largest Solar Parks in India

Sr. No.	Location	Capacity
1	Muppandal in Kanyakumari District, Tamil Nadu	1500MW
2	Amarsagar in Jaisalmer district, Rajasthan	1,064 MW
3	Brahmanvel in Dhule district, Maharashtra	32 wind turbines
4	Damanjodi in Koraput district, Odissa	99 MW
5	Tuppadahalli, Karnataka	56.1MW

Source: http://www.walkthroughindia.com

Wind Energy

Wind Energy is the most well-researched and well-developed source of renewable energy. However, despite this being a source of clean energy, wind speeds are difficult to predict, turbines are expensive, and wildlife losses are reported.

Fig.2.10: Wind Park in Jaisalmer, Rajasthan

Wind power has been used since antiquity to move boats powered by sails or to operate the machinery of mills to move their blades. Since the early twentieth century, it produces energy through wind turbines. The wind drives a propeller and through a mechanical system, it rotates the rotor of a generator that produces electricity. Wind turbines are often grouped together in wind farms to make better use of energy, reducing environmental impact.

Two types of wind turbines namely stall regulated and pitch regulated are being deployed in the country and abroad for grid-interactive power. The stall regulated wind turbines have fixed rotor blades whereas pitch regulated wind turbines have adjustable rotor blades that change the angle of attach depending upon wind speed. Both technologies have their own advantages and disadvantages. Wind turbines are also available with lattice, steel tubular and concrete tubular towers. India is the world's fifth largest wind power producer and these wind energy facilities are installed in eight major states across India, Tamil Nadu, Gujarat, Maharashtra, Karnataka etc.

Water

Increase renewable electricity sources have generated interest in the water impacts of solar, wind, geothermal and other renewables. The data are put on a per unit energy output basis for comparability. Renewables can have water use, per unit energy, comparable to conventional systems like coal and nuclear, when the entire cycle, including possible backup, is considered. Of those systems using freshwater, hydro has the highest water withdrawal and consumption.

Hydropower Electricity

Hydropower is power derived from the energy of falling water, running water or ocean energy (power of waves), which may be harnessed for useful purposes. It is a very common resource which can be used to generate electricity or to do useful work.

A dam usually raises the water level of the river to create falling water and it also makes it possible to control the flow of water. The reservoir that is formed is, in effect, stored energy. The force of falling water pushing against the turbine's blades causes the turbine to spin. The turbine converts the kinetic energy of falling water into mechanical energy. A generator is connected to the turbine, so when the turbine spins, it causes the generator to spin also. It converts the mechanical energy from the turbine into electric energy. The amount of electricity a hydropower plant produces

depends on two factors: how far the water flows and the amount of water. Transmission lines conduct electricity from the hydropower plant to homes and business.

Table 2.4: List of Hydropower Plants in India

Name	Operator	Location	Configuration
Tehri Dam (3 Stages)	THDC Limited, Uttarakhand	Uttarakhand	2400 MW
Koyna Hydroelectric Project (4 Stages)	MAHAGENCO, Maharashtra State Power Generation Co Ltd.	Maharashtra	1960 MW
Srisailam	APGENCO	Andhra Pradesh	1670 MW
NathpaJhakri (6 Turbinesx25 MW)	SatlujJalVidyut Nigam	Himachal Pradesh	1500 MW
SardarSarovar Dam,	SardarSarovar Narmada Nigam Ltd	Navagam, Gujarat	1450 MW
BhakraNangal Dam (GobindSagar)	Bhakra Beas Management Board	Sutlej River, Bilaspur - Himachal Pradesh	1325 MW
Chamera I	NHPC Limited	Himachal Pradesh	1071 MW
Sharavathi Project	Karnataka Power Corporation Limited	Karnataka	1035 MW
Indira Sagar Dam, Narmada River	Narmada Valley Development Authority	Madhya Pradesh	1000 MW
KarchamWangtoo Hydroelectric Plant	Jaypee Group	Himachal Pradesh	1000 MW
Dehar (Pandoh) Power Project	Bhakra Beas Management Board	Himachal Pradesh	990 MW
NagarjunaSagar Dam Guntur	Andhra Pradesh Power Generation Corporation Limited	Andhra Pradesh	960 MW
Purulia Pass	West Bengal Electricity Distribution Company	West Bengal	900 MW
Idukki	Kerala State Electricity Board	Kerala	780 MW
Salal I & II	NHPC Limited	Jammu & Kashmir	690 MW
Upper Indravati	Odisha Hydro Power Corporation	Orissa	600 MW
RanjitSagar Dam	Punjab State Power Corporation Limited	Punjab	600 MW
Omkareshwar	Narmada Hydroelectric Development Corporation	Madhya Pradesh	520MW
Belimela Dam	Odisha Hydro Power Corporation	Orissa	510 MW
Teesta Dam	NHPC Limited	Sikkim	510 MW

(Source: https://www.mapsofindia.com/maps/india/hydropowerproject.htm)

Tidal Energy

Tidal power or tidal energy is the form of hydropower that converts the energy obtained from tides into useful forms of power, mainly electricity. Although not yet widely used, tidal energy has potential for future electricity generation. Tides are more predictable than the wind and the sun. Tidal energy is a renewable energy powered by the natural rise and fall of ocean tides and currents. Some of these technologies include turbines and paddles.

Tidal energy production is still in its infancy. The amount of power produced so far has been small. There are very few commercial-sized tidal power plants operating in the world. The first was located in La Rance, France. The Ministry of New and Renewable Energy estimated that the country can produce 7000 MW of power in the Gulf of Khambhat in Gujarat, 1200 MW of power in the Gulf of Kutch in Gujarat and about 100 MW of power in the Gangetic delta of Sunderbans in West Bengal.

Soil Resources

Soil is the grainy material in the earth's crust on which plants grow. It is comprised of both organic and inorganic material. The creation of soil is dependent on the geological processes of weathering and transportation of weathered material. In many cases, soil is a slowly renewable resource, and degraded soil can sometimes be restored to serve much of its original ecological function, though restoration may take decades or longer.

Fig.2.11: Soil

Biodiversity

Biodiversity consists of flora and fauna species, their ecosystems and their genetic variations. Significantly, floral species are renewable resources because, if planned sustainably, they can be planted and harvested by human beings. Also, they can reproduce naturally through pollination, and natural seed dispersal. Our dependency on floral species is so high that human race survival is impossible without them, as they give us oxygen and absorb the carbon dioxide we breathe out.

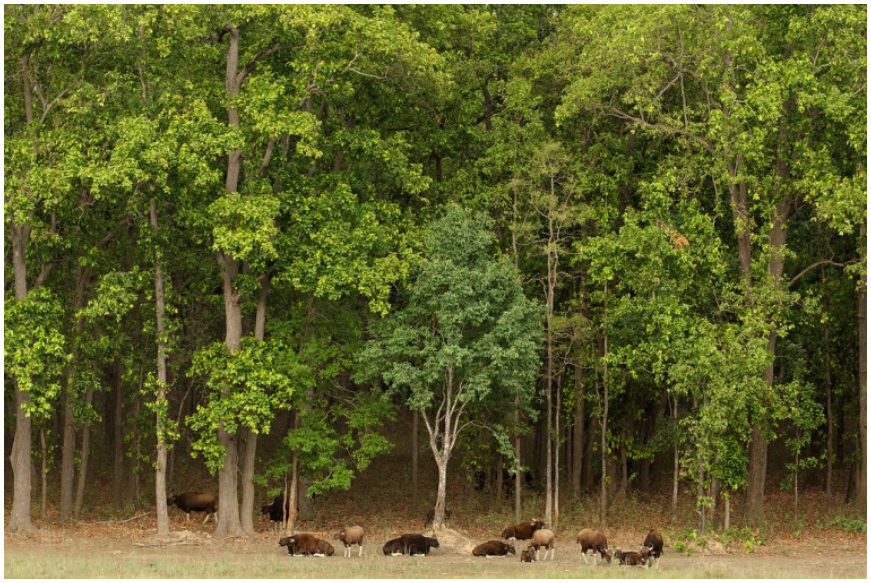


Fig.2.12: Forest

Animals are also renewable resources because they can reproduce and propagate their species. However, be it flora or fauna, if the harvesting/hunting occurs at a pace that outmatches their reproduction rate, they cease to be renewable resources.

Non- renewable Resources

A non-renewable resource is one that is utilised faster than it can replenish itself. It only has a finite supply. Ores, coal and petroleum, nuclear fuel are prime examples ofnon-renewable resources. Given our very high dependency on these non-renewable resources, it will be a problem of mammoth proportions for mankind if they run out.

Oil

Oil was made primarily from the dead remains of animals and plants from millions of years ago. With the passage of centuries, as these decaying remains got buried under mud and sand, and under high temperature and pressure conditions created thus, raw oil and natural gas were formed. Several items like plastics, artificial food flavours, heating oil, petrol, diesel, jet fuel, and propane can be prepared using crude oil as the raw material. Russia, Saudi Arabia, and the United States are the world's top three crude oil producers.

In India, the largest O&G reserves are in the Western Offshore (Mumbai High, Krishna-Godavari Basin) (40%), and Assam (27%). On 31 March 2018, India had estimated crude oil reserves of 594.49 million tonnes (MT). The oil and gas sector is among the eight core industries in India and plays a major role in influencing decision-making for all the other important sections of the economy.

Coal

Coal is a black or brown-black sedimentary rock that is highly combustible and is made largely of carbon and hydrocarbons. Coal is a fossil fuel, made when the remains of plants underwent decomposition millions of years ago under the high pressure and high temperature conditions created by the overlying layers of mud and earth. The chemical and organic process of coal formation is called Carbonisation. Longer the carbonisation period, better is the quality of coal. The four categories of coal are peat, lignite, bituminous, and anthracite, with anthracite having the highest heat content.

Fig.2.13: Bituminous Coal

Natural Gas

Natural gas is a naturally occurring mixture of hydrocarbon gases, mostly methane, though there are few higher alkanes and carbon dioxide in small percentages, too. It forms in a similar fashion as petroleum resources, with plant and animal tissues slowly converting under heat and pressure over millions of years. It burns with a blue flame. It is considered a clean fuel as it does not produce soot. The estimated reserves of natural gas in India as on 31 March 2018 was 1,339.57 billion cubic metres (BCM), which marked an increase by 3.87% from the previous year. The largest reserves of natural gas are located in the Eastern Offshore (38.13%) and the Western Offshore (23.33%).

Minerals and Metal Ores

Minerals are widely present in the earth's crust, but are extracted through mining only when the concerned element can be obtained from them in an economically viable manner. Several natural processes such as weathering, organic activity and heat and pressure regimes lead to ore formation.
India ranks fourth in terms of iron ore production globally. Production of iron ore in FY19 (up to Feb 19) stood at 187.60 million tonnes. India has around 8 % of world's deposits of iron ore. India became the world second largest crude steel producer in 2018 with output 106.5 million tonnes. According to Ministry of Mines, India has the 7th largest bauxite reserves- around 2,908.85 million tonnes in FY18. Aluminium production stood at 2.25 MT in FY19 (up to February 2019) and is forecasted to grow to 3.33 million tonnes in FY20.

Fig.2.14: Iron-ore

2.3 Availability and Rate of Depletion of Natural Resources

Earth's Carrying Capacity and Depletion of Resources

The earth was formed about 4.5 billion years ago,whereas the modern humans have existed only for about 315,000 years. According to a study by the World Wildlife Fund (WWF), more than a third of earth's natural resources have been destroyed by humans in just thirty years. The industrial revolution is when this destruction started. As our culture advanced and *Homo sapiens* invented several things to ease and comfort life, our demand for raw materials increased by leaps and bounds. Not only has humanity used up a third of nature's resources, but the consumption also continues at an increasing rate. Our planet cannot keep up with our ever-increasing demands. Today, we need about 1.75 planets to provide the resources for our consumption and absorb our waste. By 2030, we will be needing 2 planets! The change in carrying capacity of earth from 1970 to 2018 is given in Fig.2.15

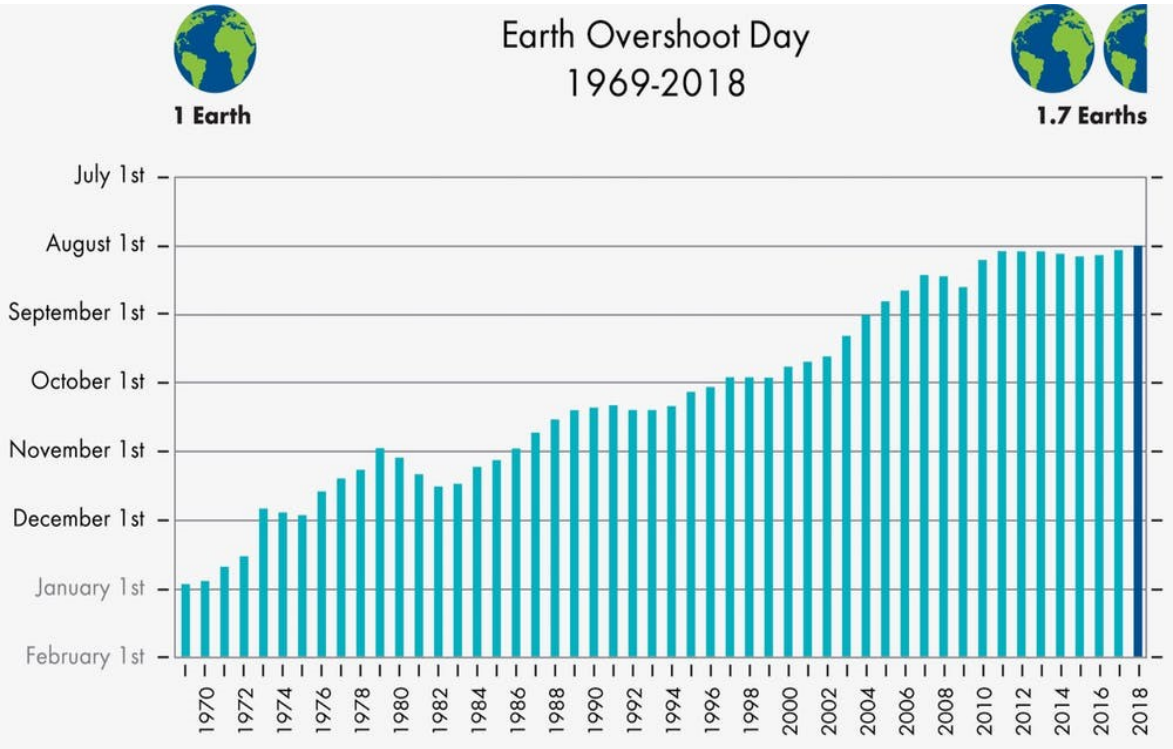


Fig.2.15: Statistical Data of Increasing Dependency on Earth
(Source: Global Footprint Network National Footprint Accounts 2018)

One factor working against the exhaustion of any resource is the depletion effect, which is manifested in the higher marginal recovery costs encountered as the resource stock is depleted. For the example of mining, depletion effects occur because lower grade ores are encountered as more of the resources is extracted. Likewise, depletion effects are observed in harvesting of fish because it is more difficult to locate and capture the fish as the stock becomes less dense. Consequently, some portion of the resources may be left unexploited if depletion effects cause further utilisation of the resources to be unprofitable. (Lewis T.R., 1979)

Reasons for Depletion of Natural Resources

As discussed in the sections above, the various causes of natural resource depletion have been summarised in **Fig. 2.16**.

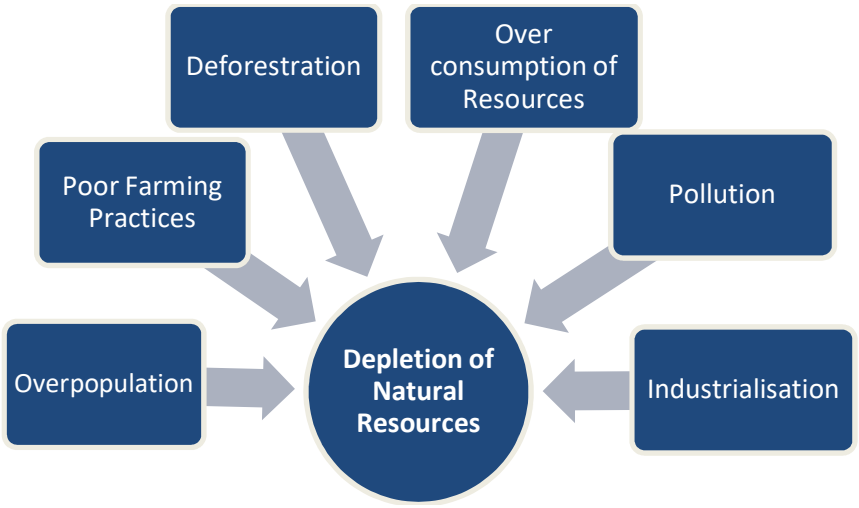


Fig.2.16: Reasons for Depletion of Natural Resources

Land Resources

Land is an essential natural resource without which the very survival of human beings will be threatened. Land is the basis for all terrestrial ecosystems. Unfortunately, over the last thousands of years as human civilisation has progressed, land resources have steadily declined.

According to the UNCCD, land degradation is the "reduction or loss of biological or economic productivity… resulting from land uses or from a process or combination of processes, including … human activities." When land degradation occurs in dry land areas, more specifically arid, semi-arid and dry sub-humid areas, it is referred to as desertification. Around 69 % of India falls under dry lands.

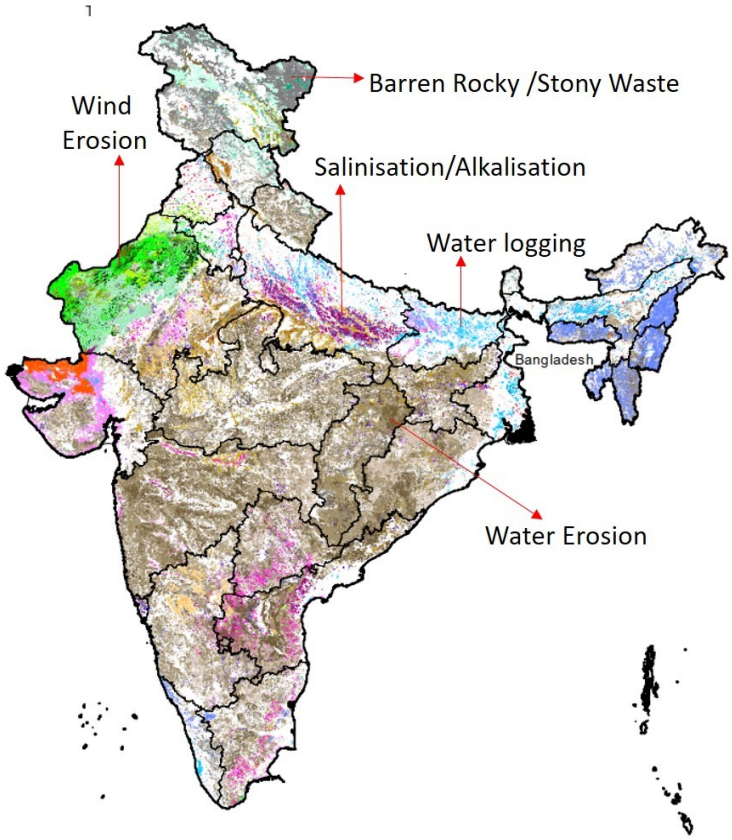


Fig.2.17: Land Degradation Map of India (generated using LISS-III data of 2015-16)
(Source: https://www.isro.gov.in/earth-observation/land-degradation)

With the erratic patterns in temperature and rainfall, and anthropogenic efforts to maximise agricultural production, healthy top soil is being lost at an alarming rate. As per some reports, 19-23 ha of land are lost per minute owing to desertification and erosion. About 1.5 million sq km land is projected to be lost by 2030 because of urbanisation.

Forest Resources

According to the latest India State of Forest Report (ISFR), India reported a rise of 8021 sq km (1 % rise)in overall forest and tree cover between 2015 and 2017. This is laudable as India has a massive population and livestock pressure. Satellite reports obtained from the study conducted by the Forest Survey of India (FSI) in 2019 put the total forest and tree cover at 802,088 square km, which is 24.39 % of India's geographical area.

However, one must keep in mind that by planting fast-growing exotic species like eucalyptus, ear leaf acacia, quicksitck etc. merely to enhance green cover growth does not count as true eco-restoration and will not support rich faunal biodiversity. The Global Forest Resources Assessment (FRA), coordinated by FAO, found that the world's forest have decreased from 31.6 % of the global land area to 30.6 % between 1990 and 2015. However, that the pace of loss has slowed in recent years.

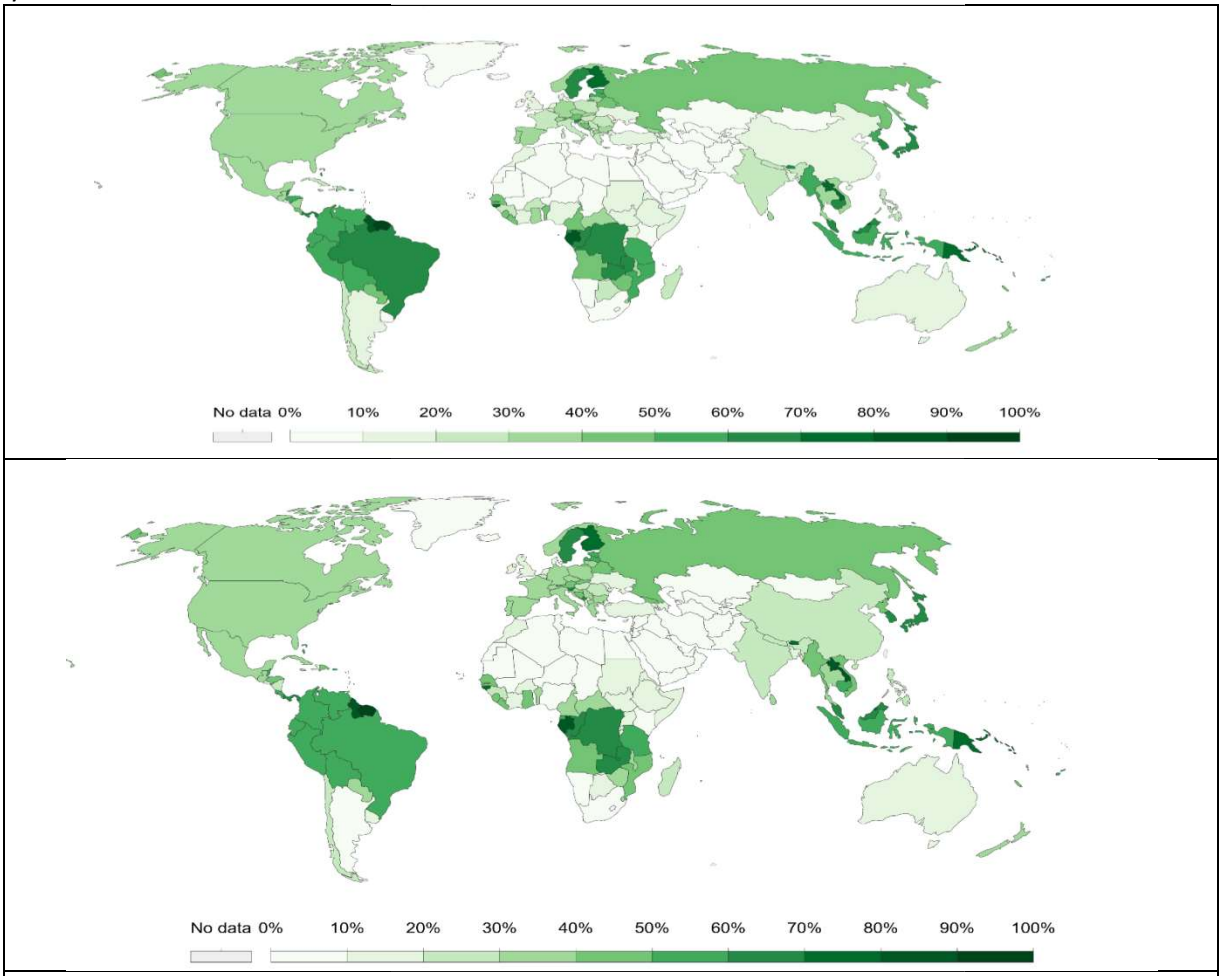


Fig.2.18: Comparison Depletion of Forest Cover from 2000 to 2015

(Source: https://ourworldindata.org/grapher/forest-area-as-share-of-land-area?year=2000)

Fig.2.19 : Forest Area as a Proportion of Total Land Area in 1990, 2010 and 2015

Water Resources

Water scarcity is a critical challenge today, with the challenge being two-fold – lack of quantity of water (with low rainfall, high evaporation) and lack of quality of water (pollution, salinisation, anthropo-geogenic arsenic and fluoride).

Depletion of Water has occurred due to following reasons:

- Excessive demand of water for consumption
- High evaporation
- Low rainfall
- Pollution
- Poor storage
- Saltwater intrusion
- Agriculture

Table 2.5: Assessment of Ground Water in India from 2004 to 2017

Sr. No.	Ground Water Resources Assessment	2004	2009	2011	2013	2017
1	Annual Replenish able Ground Water Resources	433 bcm	431 bcm	433 bcm	477 bcm	432 bcm
2	Net Annual Ground Water Availability	399 bcm	396 bcm	398 bcm	411 bcm	393 bcm
3	Annual Ground Water Draft for Irrigation, Domestic & Irrigation Uses	231 bcm	243 bcm	245 bcm	253 bcm	249 bcm
4	Stage of Ground Water Development	58%	61%	62%	62%	63%

bcm = billion cubic metres

(Source: Central Ground Water Board, 2017)

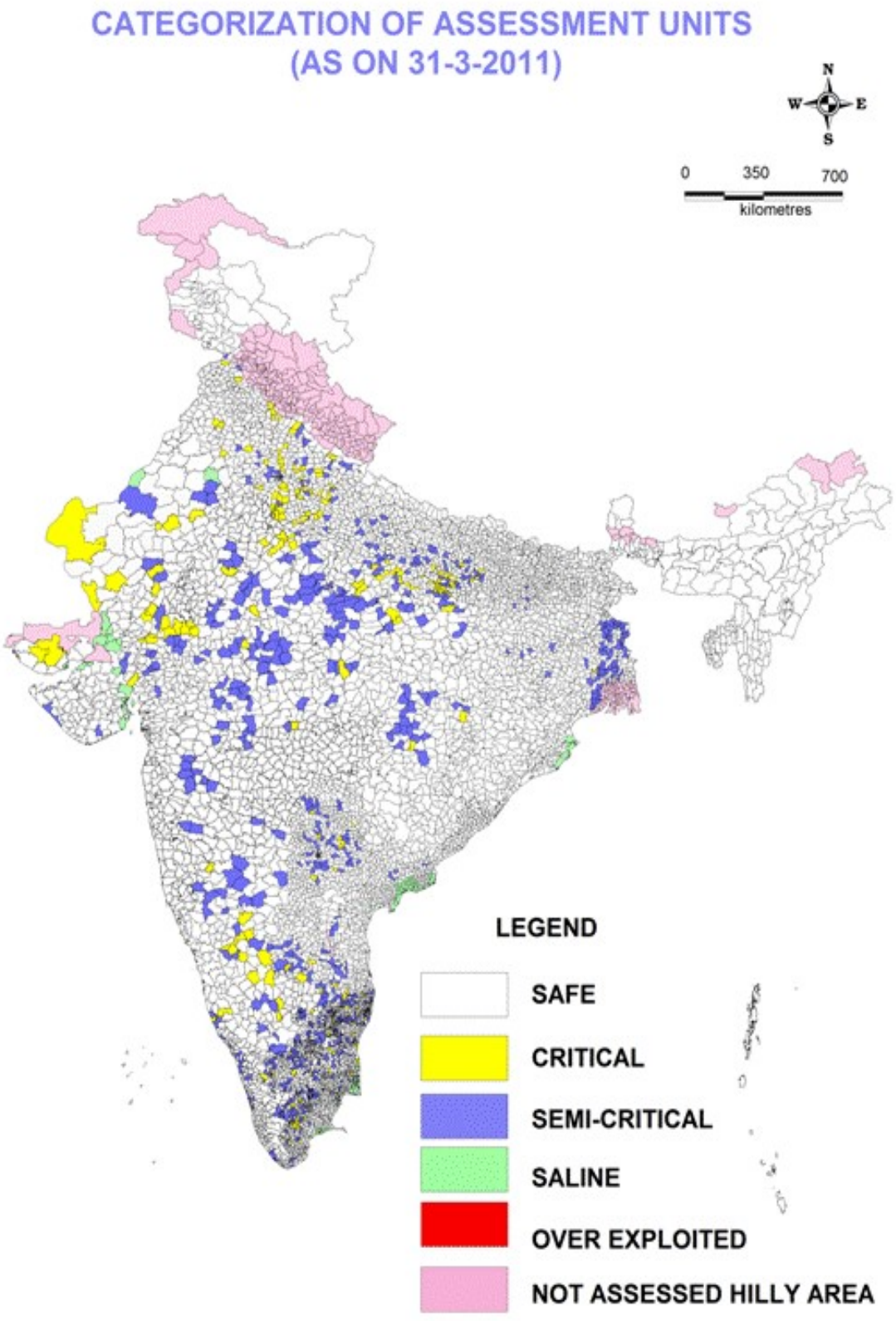


Fig.2.20: Categorisation of Water Assessment
(Source: Nation water Mission)

The global water demand is projected to rise by 55% from 2000 to 2050. Agriculture is the most significant guzzler of water, and uses up to 70% of the global freshwater resources. Water withdrawal for energy, used for cooling power stations, is also expected to increase by over 20%.

Fossil Fuel

Global fossil fuel consumption is on the rise, but new reserves are scarcer and scarcer. Even if new reserves are found, they are far smaller than the previous ones. For instance, 16 of the 20 largest oil fields in the world have reached peak level production – but they are not large enough to meet the ever-rising global demand. In order to keep average global temperature increases below 1.5°C, we must avoid using up to 80% of fossil fuels – unfortunately, our reliance on fossil fuels is not decreasing.

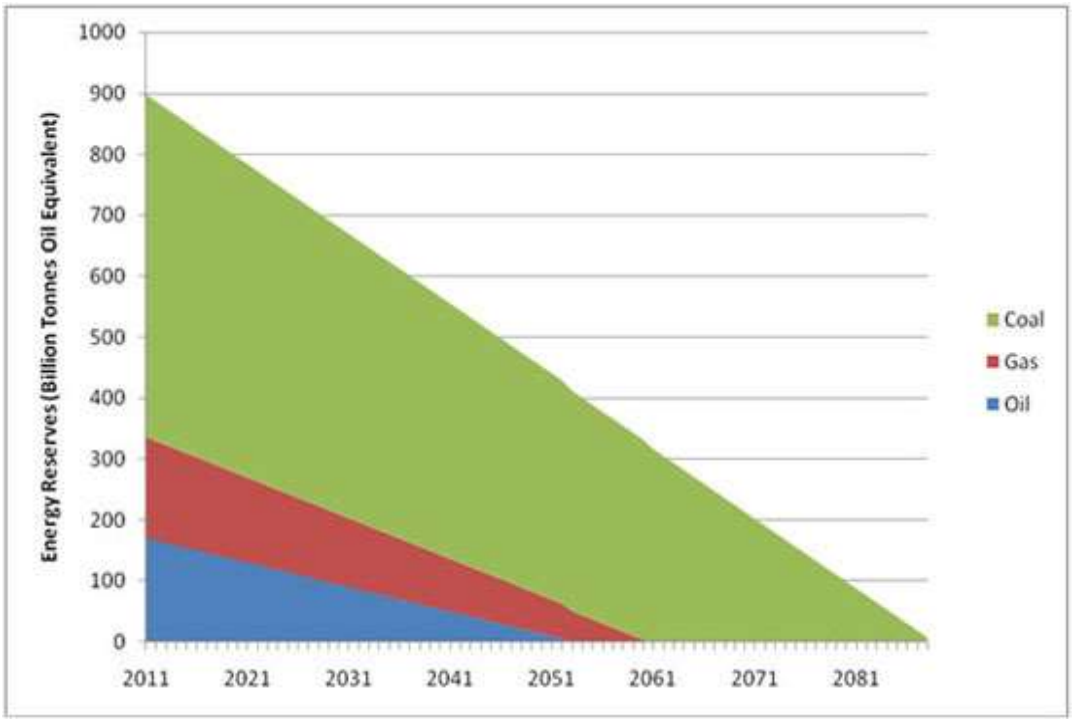


Fig.2.21 : Status of Fossil Fuel Reserves in Present and Future

Coal reserves are available in almost every country worldwide, with recoverable reserves in around 70 countries. Approximately 1.1 trillion tonnes of proven coal reserves remain. This means that there is enough coal to last us for around 150 years only at current rates of production. Also, proven oil and gas reserves are equivalent to around 50 and 52 years at current production levels. As Fig. 2.21 shows, oil will be first of the fossil fuels to show a decline; the volume of oil, covering the liquid fossil fuels (includes conventional oils, shale oil, extra-heavy oils, liquids extracted from natural gas and synthetic oils) that can be exploited each year will decline from 2020-2025, despite the rapid development of shale oil since 2010.

The volume of conventional oil extracted has already been on the decline since 2006. Also, importantly, the energy supplied to the world population for use each year from all liquid oil has stagnated since 2011, as the volume of energy per barrel of oil has decreased significantly in recent years. In terms of the amount of energy available per person globally, the decline is already under way, with the continually rising world population. Natural gas widespread exploitation started a little later than oil; hence, natural gas will also see a dip but slightly little later than oil, around 2030 or little later.

2.4 Sustainable Harvest & Renewable Resource Regeneration

Sustainable harvesting can be defined as a method of harvesting that ensures a constant supply of resources during the present without compromising future yields, either by using the current harvesting methods or improving upon the same. In other words, sustainable harvest ensures that the rate of harvest never exceeds the rate of population regeneration. As may be observed from **Fig.2.22** unsustainable harvest leads to an ultimate decline in the population, while sustainable harvest ensures that the rate of harvest is low enough to permit the population to bounce back to stability. To assess this threshold value beyond which the harvesting intensity must instantly be checked, is ascertained through detailed field studies.

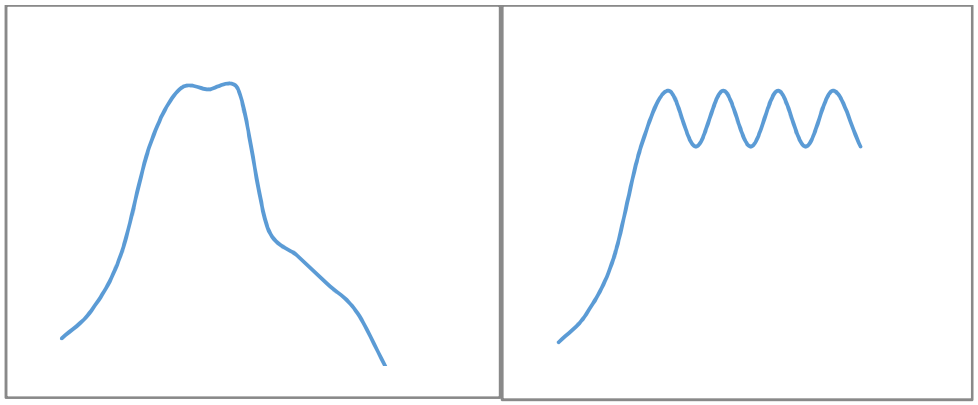


Fig.2.22: Unsustainable Vs. Sustainable Harvest

Sustainable harvesting, thus, steers clear of the following three caveats:

- Destructive harvesting
- Over-exploitation
- Lack of information about basic population ecology of the species of interest

The first step of assessing sustainable harvest is to understand whether the species selected for harvest has a stable population structure, that is, whether it is sturdy enough to withstand even sustainable exploitation pressure. For instance, **Table 2.6** provides guidance to select the right species to harvest (as in the case of non-timber forest product).

Table 2.6: Selection of Non-timber Forest Product for Sustainable Harvest: A Guideline

Source: Peters 1994

	Potential for Sustainable Management		
	Low	Medium	High
Resource Group	Bark, stem tissue, roots	Some resins, fruits and seeds	Latex, fruits and leaves
Yield/plant	Low	Medium	High
Species Characteristics:			
Flowers	Few, large	Intermediate	Small, many
Fruits	Few, large	Intermediate	Small, many
Seed germination	Low viability	Intermediate	High viability
Sprouting capability	None	Low	High
Population Structure:			
Size-class distribution	Type III curve	Type II curve	Type I curve
Tree density/hectare	0-5 adults	5-10 adults	10+ adults
Spatial distribution	Scattered	Clumped	Homogenous
Regeneration Guild	Early Pioneer	Late Secondary	Primary
Flower/Fruit Phenology	Unpredictable	Supra-annual	Annual
Reproductive Biology:			
Pollination	Biotic, with specialised vector	Biotic, with generalist vector	Abiotic
Pollinator Abundance	Rare; bats, hummingbirds	Intermediate; beetles, moths	Common; small insets
Seed Dispersal	Biotic with specialised vector	Biotic; with generalist vector	Abiotic
Disperser Abundance	Rare; large birds, primates	Intermediate; small mammals	Common; bats, small birds

Clearly, species following Type I curve are most amenable for sustainable harvest. Baseline surveys further reveal the population distribution studies and age/size class distribution, whereas systematic, long-term regeneration studies record the regeneration potential of the species in question. Regeneration studies will yield the threshold values below which the harvesting intensity should be discouraged.

Traditional Methods of Sustainable Harvest

- Kolis are the traditional fisher community of Maharashtra, India. Local kolis avoid fishing in the ocean during the monsoon, starting with the monsoon months and ending around *naralipoornima*(full moon night of the *shravan* month) which is also the breeding season for nearly 300 species of fish and also shrimp. During this period, dried fish and crabs and shellfish are consumed.

- Traditional community-based fishery management has been observed in other parts of India as well. The traditional 'padu' system of community-based fishery management in south India is a rotational access approach where lottery is used to decide who will fish and when.
- Kurien (2001) describe various cultural fishery management systems prevailing in India. The Kadakkody /Kadakodi (literally, court of the sea) system of north Kerala, which is centuries old and still exists in some communities such as Arya and Dheevara, observes the following sanctions:
    - No night fishing during the months of June-July-August
    - Preventing the use of gillnets
    - Conflict resolution via thaKadakodi court

  Similarly, the Karanila system of income-sharing among fishermen existed in south Kerala during 1940-1950.
- In Canada, traditionally, the SaugeenOjibway Nation (collectively the Chippewas of NawashUnceded First Nation and Saugeen First Nation) occupy territory in southern Ontario Canada and Lake Huron/Georgian Bay of the Laurentian Great Lakes. The Nawash have been known to traditionally harvest a wide variety of flora and fauna species for their subsistence, trade and cultural practices. LaRiviere and Crawford (2013) conducted a detailed social survey of the Nawash community to understand their traditional sustainable harvest practices. The interesting findings of this study include:
    - Avoidance of harvest during the spring season, with the ‘falls’ being the season of harvest
    - Conscious effort not to harvest beyond one’s needs
    - Formally offering thanks to nature for providing them the goods and services for their existence; most commonly, tobacco was left at the harvest location by way of gratitude
    - Strictly no wastage
    - A tradition of sharing the harvest amongst the community members
- Jones et al. (2007) found that the traditional Madagascar system of taboos and prohibitions called ‘fady’ accorded protection to several species such as the lemur *Propithecusedwardsi* and the cat-like species fossa (*Cryptoproctaferox*). The hunting of freshwater crayfish was controlled through this system of taboos by putting seasonal restrictions on harvest. Also, tenrec hunting and *Pandanus* harvest were found to be under better control when checked through the traditional social norms and taboo system of fady rather than under top-down governmental control.
- Turner et al. (2000) put together a set of sustainable harvesting practices followed by the aboriginal people of British Columbia in northwest America. The same has been reproduced below:

Table 2.7: Sustainable Harvesting Practices

Plant Resources Harvested and Sustained by Aboriginal Peoples in North Western North America			
Type of Resource	**Species Example**	**Sustainable Harvesting Method**	**References**
Fibrous tree bark	Western red –cedar, *Thujaplicata;* birch*, Beta papyrifera*	Strip pulled off partial circumference of trunk; only outer birch bark harvested	Baos (1921), Stryd (1997), Turner (1998), Mary Thomas, personal communication to N. Turner, 1997
Wooden planks	Western red-cedar	Planks split from standing trees	Stewart (1984),
Bark for medicinal use	Red alder, Alnus*rubra*; cascara, *Rhamnuspurshiana*	Narrow strip cut from four different trees	Turner and Hebda (1992)
Roots for basketry	Red-cedar; Sikta spruce, Piceasitchensis	Only a few roots taken from each tree	Turner (1998)
Fibrous stems and leaves for mats, cordage or baskets	Cattail, *Typhalatifolia*; tule, *Scripusacutus*; stinging nettle, *Urticadioica*; Indian-hemp, *Apocynumcannabinum*; slough sedge, *Carexobnupta*	Cut from perennial plants at end of growing season; often only vegetative plants taken; plants regenerate next season	Turner (1998)
Witches and branches for basketry, rope, fish traps Pitch for medicine, adhesives	Saskatoon berry, *Amelanchieralni-folia*; hazelnut, *Coryluscornuta*; red-cedar; willow, *Salix* spp. Western hemlock, *Tsugaheterophylla*; lodgepole pine, *Pinuscontorta*; sitka spruce; subal-pine fir, *Abieslasiocarpa*; and other conifers	Collected from natural human- made wounds in trees, or pitch blisters; not permanently damaging	Turner et al.(1990)' Turner (1998); Christine Joseph, personal communication to N. Turner, 1999
Medicinal plants and roots	Mountain valerian, *Valerianasitchensis*; Indian hellebore, *Veratrumviride*	Selectively harvested; often regenerated from fragments left in the ground (like a pulled-up dandeliuon in one's lawn) picked from bushes or from branches broken off from main bushes; sometimes bushes burned or pruned to renew their growth	Mary Thomas, personal communication to N. Turner, 1997

Type of Resource	Species Example	Sustainable Harvesting Method	References
Edible berries, fruits and nuts	Salmonberry, *Rubusspectabilis*; highblush cranberry, *Viburnum edule*; salal, *Gaultheria shallon*; hazelnut, *Coryluscrnuta*; huckleberries, *Vaccinium*spp.;soapberries, *Shepherdiacanadensis*	Picked from bushes or from branches broken off from main bushes; sometimes bushes burned or pruned to renew their growth	Turner (1995, 1997, 1999)
Green leaves, shoots as vegetables	Cow-parsnip, *Heracleumlanatum*; fireweed, Epilobiumangustifolium, Indian Celery, *Lomatiumnudicaule*	Pickled selectively in spring from patches; plants perennial, and soon regenerate (e.g.,like asparagus)	Turner (1995, 1997), Kuhnlein and Turner (1983)
Seaweed	Red laver, *Porphyraperfoarata*	Pickled from rocks when young; plants allowed to regenerate	Turner (1995)
Root vegetables	Blue camas, *Camassia*spp.; yellow avalanche lily, *Erythronium*grandiflorum; spring beauty, *Claytonia lanceolate*; balsam-root, *Balsamorhizasagittata*; rice –root, Fritillria spp.; springback clover, *Trifoliumwormskjoldii*; silverweed, *Potentilla anserine* ssp. *pacifica*	Harvested selectively by size; smaller "roots" and propagulates replanted; enhanced with tilling soil, sometimes weeding; burning said to enhance growth	Turner(1995, 1997, 1999), Turner and Kuhnlein (1982, 1983)
Edible tree cambium	Western hemlock, sitka spruce, black cottonwood, *Populusbal-samifera*ssp, *trichocarpa*; pines, Pinus spp.	Patch of bark removed, but trees not grindled	Styrd (1997)' Turner (1987, 1995, 1997)
Edible mushrooms	Pine mushroom, Tricholomamagnivelare; cottonwood mushroom, T. *poplinum*	Matre individuals cut at base; soil carefully replaced to protect those still growing	Turner t al. (1985), Turner (1997)

Source: Turner et al. (2000)

Scientific Interventions for Sustainable Harvest

- Ex-situ conservation practices discussed in detail in Sect. 3.4 below help relieve the pressure of continual harvest from natural ecosystems.
- Understanding the optimum harvest rate through experimentation and mathematical modelling - NTFP harvesting can be called sustainable if it does not cause a decline in the harvested populations and ensures no negative impact on other species or ecosystem functions (Ticktin and Shackleton 2011). For instance, Hernández-Barrios et al. (2015) found empirical evidence that up to 50% harvest of *Chamaedoreaernesti-augustii* (palm leaves)

twice a year from Mesoamerica was sustainable. The authors defined sustainability in this case as "the defoliation intensity at which economic profit is maximised under the constraint that survival and growth of individuals are not significantly reduced (when compared to non-defoliated plants)." The projected period of sustainability was mid-term (ten years).

- Rotational grazing – the concept of rotational grazing is in contrast with the traditional approach of continuous grazing with little or no respite to the pasture grass and allowing it no fixed regrowth period. On the other hand, rotational grazing involves dividing a pasture into distinct paddocks and rotating the cattle from paddock to paddock, such that when the cattle reach the paddock they had started with, the grass there has had the time to grow.

A comparison of both the systems has been provided in the **Table 2.8** below:

Table 2.8: Comparison of Continuous and Rotational Grazing Pattern

Grazing Pattern	Advantages	Disadvantages
Continuous Grazing	• Low fencing cost • Low managerial inputs • If stocking rate is correct, net gains	• Difficulty in controlling the timing and intensity of grazing • Reduced availability of pasture grass, affecting net gains • Longer recuperation time for the pasture after drought as plants are more stressed
Rotational Grazing	• Grazed paddock gets adequate time to recuperate • Forage productivity increases overall, leading to net gains	• Additional cost of fencing, which can be overcome by using movable/temporary fencing • Additional time to move the cattle • Additional cost of piping/portable water tanks etc. to make water available for cattle in the different paddocks

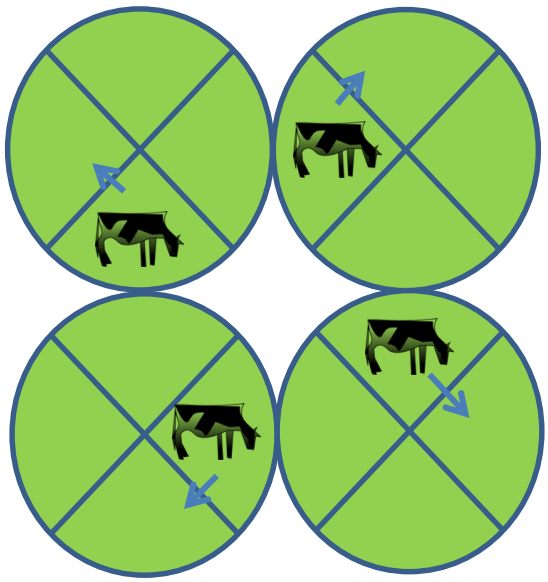


Fig.2.23: Diagrammatic Representation of Rotational Grazing

Socio-politic Interventions for Sustainable Harvest

- Participatory Management: Joint forest management (JFM) committees – The comprehensive National Forest Policy, 1988 and the Joint Forest Management Guidelines, 1990 - both formulated by the Government of India contain details about the concept of Joint Forest Management. Popularly abbreviated as JFM, this is a unique approach to forest management, putting together all stakeholders - the local community and the government officers in one group. Broadly, a formal agreement is made between the Forest Department and a committee of the villagers (usually called the Forest Protection Committee), under which the villagers are permitted sustainable harvest of NTFPs in return of protecting the forest and forest species from fires, over-grazing, hunting, trapping over-harvest etc. Similarly, there are approaches of community-based fishery management.

- Government regulation – *Ophiocordycepssinensis* the caterpillar fungus, which has high medicinal value and fetches a substantial price (up to USD 12,500 per kg) in the international market, has been protected against over-harvesting by the Bhutan government through a strict system by which only licensed collectors can harvest the fungus, and its sale is regulated through government-managed auctions where only licensed purchasers are permitted to participate (Canon et al. 2009).

  Forest certification systems are in place in India to encourage responsible sourcing and usage of timber and non-timber forest products. This system broadly consists of two phases - Forest Management Unit (FMU) certification and Chain of Custody (COC) certification. While the former verifies whether the ecosystem from which harvest is taking place has been maintained up to previously-defined standards, the latter aims at tracking the forest product from harvest to sale to ensure that no irresponsibly sourced product makes it way to the market. The certification scheme in India needs better implementation

  Similar regulations have been put in place in several other countries to control the harvest of other wild species from the forest. To regulate over-fishing, the Government of India formulated the Comprehensive Marine Fishing Policy, 2004 aims at mandating ocean-going fishing vehicle registration, regulating mesh size of the nets, preventing fishing during main breeding season and close surveillance and monitoring.

- Improved marketing skills – the communities involved in sustainable harvesting of products often lack in such skills that would help them gain sufficient profit from lesser harvest, further aiding the cause of sustainable harvest.

Innovative Examples of Renewable Resource Usage

- Floating Solar
- Bioplastics
- Road from Plastic and Bio-asphalt
- Plastic Fuel
- Fly Ash Bricks
- Bio-renewable Chemicals

- Body Heat
- Energy from Footsteps
- Algal Biomass

Legal Encouragement for Usage of Renewable Resources

The task of switching over from conventional to renewable resource is one requiring massive effort and expenditure towards infrastructural changes, but a more concerted effort is needed to encourage entrepreneurs and markets in this direction. Government legislation is a strong step in this direction. In India, the Electricity Act, the National Electricity Policy 2005, the National Renewable Energy Act 2015 and the Tariff Policy 2016 encourage renewable energy usage by the private sector.

2.5 Natural Resources Engineering

Natural Resource Engineering is an environmental engineering branch that draws on different sciences to create new technology for protection, maintenance and establishment of sustainable natural resources. Natural resources engineering aims at the sustainable management of living (plants, animals, microbes) as well as non-living (fossil fuels, renewable energy, land, air, water, ores, soil, sediments) resources.

Natural Resources Mapping

Natural resources mapping refers to the use of GIS and mapping tools and techniques to map the available natural resources in a given region. Several different types of maps can be generated under natural resource mapping. Natural resource mapping is the critical first step of natural resource engineering and management. It helps confirm the

- location
- total area/extent
- boundaries
- condition (forest cover, forest type)
- disturbances (encroachment, logging leading to bald patches within forests, pipelines for effluent discharge, blockage to natural flow etc.)

of a given natural resource such as forest, grazing ground, water body, etc. to generate maps like Land Use Land Cover (LULC) maps, vegetation mapping, soil maps, etc. Satellite imageries can be purchased from the National Remote Sensing Centre (NRSC), Hyderabad. The common GIS tools used to process satellite imageries and generate map outputs include ArcGIS, QGIS, GRASS GIS etc.

A typical LULC map has been shown in Fig. below.

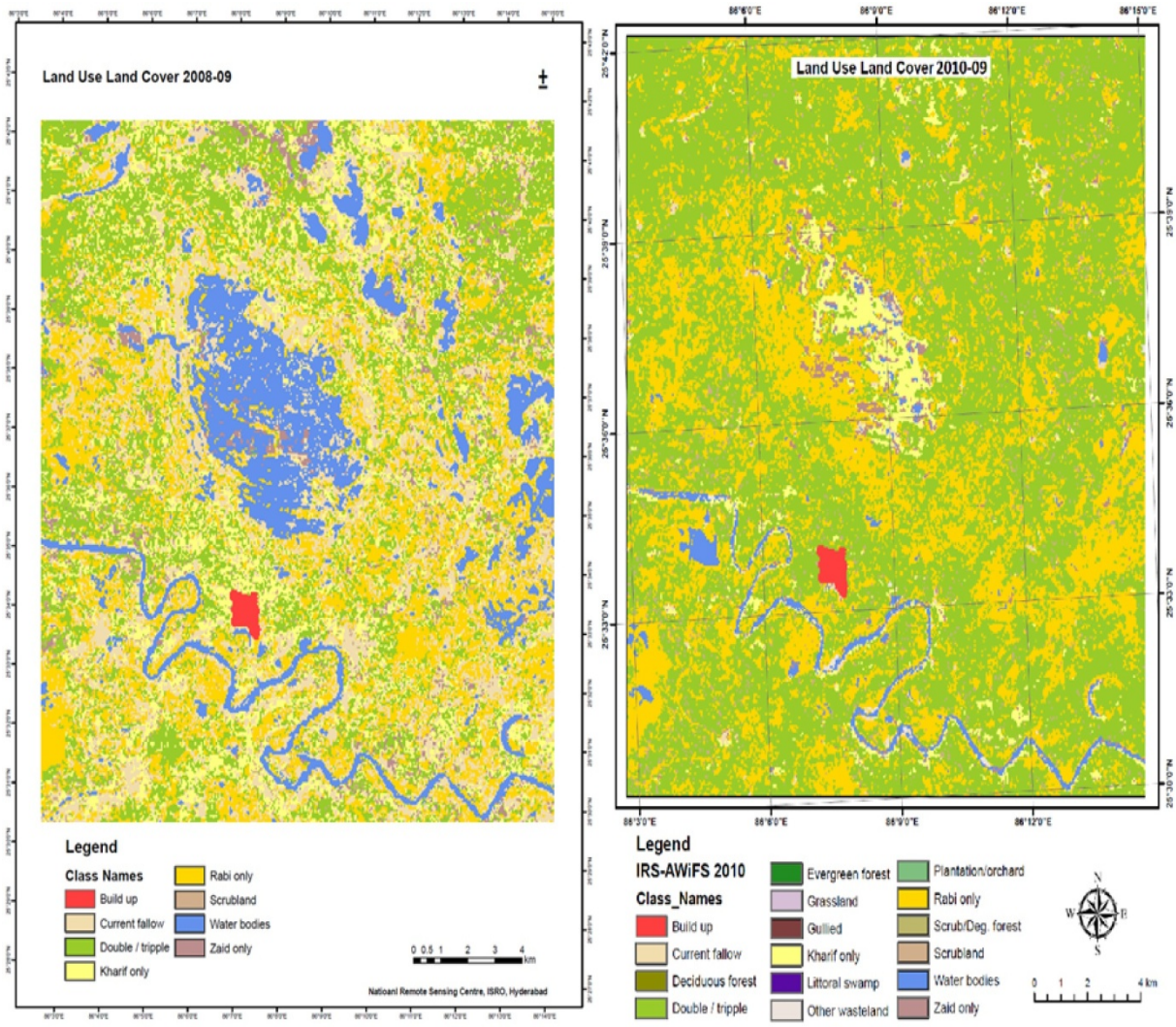


Fig.2.24: A Typical LULC Map Showing Shrinkage in the Kabar Wetland, Bihar

Common GIS and mapping tools used for natural resource mapping include aerial photography (vertical/oblique) and satellite imagery (supplemented with ground-truthing /ground verification).

Natural Resources Evaluation

Natural resources must be envisaged as assets that need to be evaluated so they can be managed and enhanced. The outline of a Natural Resource Evaluation Plan is provided below:

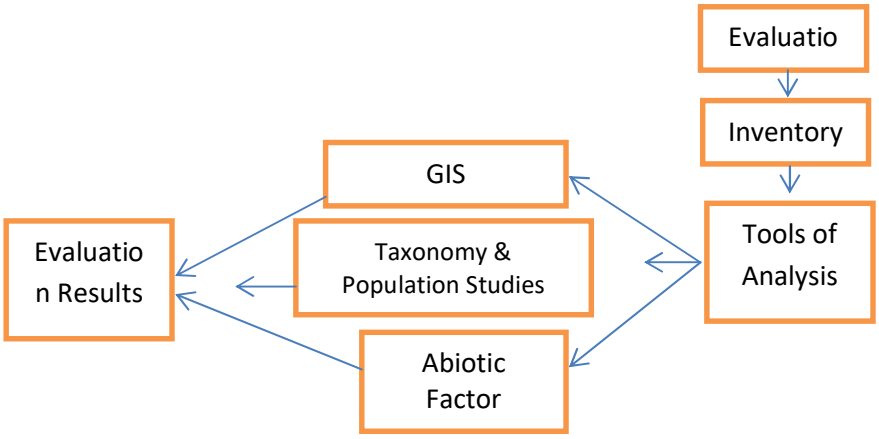


Fig.2.25: Outline of a Natural Resource Evaluation Plan

Natural Resource Modelling

Natural resources modelling, largely simulation modelling is a powerful tool to help the resource manager predict how a natural ecosystem will work under different possible combinations of factors that can modify the ecosystem. Simulation modelling may be defined as "the process of creating and analyzing a digital prototype of a physical model to predict its performance in the real world."

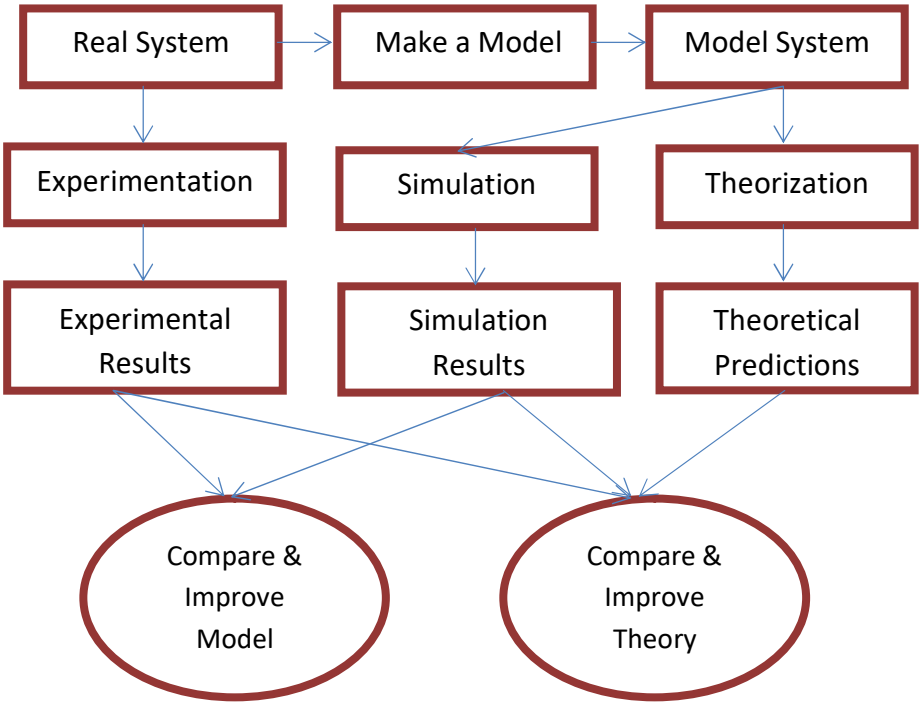


Fig.2.26: An Outline of Simulation and Theoretical Approaches to Prediction, Aided by Experimentation

Most common simulation methods were found to be Agent-based modelling and simulation, System dynamics modelling and simulation and Discrete event modelling and simulation, the first two being most commonly used by researchers (as shown in a review study by Moon 2017). Moon (2017) further revealed that Vensim, Arena, NetLogo, Powersim and Stella were the most frequently used software packages for simulation studies to predict sustainability of natural resources under various scenarios.

Novel Techniques for Regeneration of Natural Resources

Forest Regeneration

Forest regeneration is the act of renewing tree cover on degraded forest land – it is an act of forest eco-restoration and hence, must be planned and implemented observing the fundamental ecological principles. As per the Global Forest Resources Assessment (FRA), under the Food and Agriculture Organisation (FAO), reported that between the period of 1990 to 2015, the forest cover on earth decreased from 31.6% of the total land area to 30.6% only. As per an alarming WWF report, as many as 27 football fields of forest are being degraded every minute.

As per several reports (Wang and Akbari, 2016; Hof et al. 2017; Seddon et al. 2019), tree plantation is a technologically simple and positive step towards challenging climate change. In the Paris Climate Change Agreement, all parties were called upon to acknowledge "the importance of ensuring the integrity of all ecosystems, including oceans, and the protection of biodiversity, recognised by some

cultures as Mother Earth". As many as 66% of the signatory nations agreed that green and nature-based solutions must be envisaged to fight climate change.

Drone-based Seedling Plantation

However, at the current level of an average individual's lifestyle, deforestation and climate change, billions of trees must be planted to combat climate change. This, if undertaken manually, can be a humongous task. A novel solution to this may be drones for seedling plantation. By using these unmanned aerial vehicles, firstly the baseline soil conditions and local geography are determined, post which the drone fires seedlings in biodegradable pods. 2 operators, manning 10 drones, can plant up to 400,000 seedlings per day. Apart from labour and cost-saving, the drones can reach locations where humans would find it difficult to get to for manual tree plantation. Mangrove saplings were planted using drones in Yangon, Myanmar in the year 2018 – as per a news report, the saplings have taken root and are growing well.

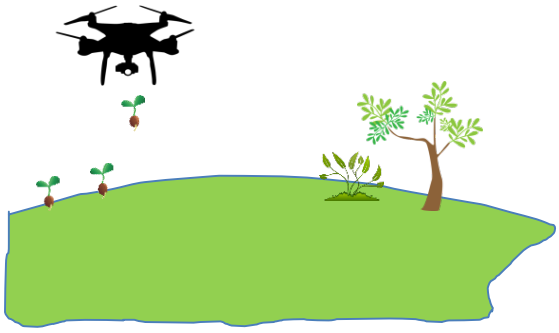


Fig.2.27: Drone based Seedling Plantation

Tree transplantation

While it is important to plant new trees, which according to several reports sequester more carbon and are more efficient at fighting climate change, it is critical to prevent the felling of mature ones. Mature trees support faunal biodiversity apart from providing benefits like fruit and non-timber forest products. Mature trees help regulate the flow of water and prevent natural disasters like flooding. Unfortunately, on many occasions, the felling of thousands of trees becomes unavoidable for developmental projects. Transplanting grown trees becomes a potential solution under such situations.

Transplanting is the term used to describe the digging and replanting of trees from one location to a new location. Due to the wide extent and morphology of tree root system, transplanting of trees usually involves substantial removal of roots. A preliminary evaluation is necessary to study whether a tree is likely to be a successful transplant. Plants which are already in advanced stages of decline will succumb to the transplantation stress. When deciding whether or not to transplant a tree, there is a necessity to consider a few criteria:

I. Selection of species
II. Selection of healthy individual
III. Season to transplant
IV. Suitability of receptor site

Main steps involved in a tree transplantation procedure are given below:

- Initial Preparation - taking stock of the tree species to be transplanted, its health status and accessibility
- Measuring Girth at breast height (GBH)
- Soil Sampling, testing and replantation site selection
- Root pruning and initiating root growth
- Pruning of the crown
- Tree packing, feeding and monitoring for adaptation

- Preparation of the receptor site
- Transplantation of trees
- Planting
- Post-planting care by regular irrigation, provision of manure, mechanical support and phyto-hormone treatment to help regrow the roots

Tree transplantation can be done mechanically using a machine called a tree spade. Alternately, tree transplantation can be attempted manually, when earth is dug in an area around the tree, the area being large enough to encompass the entire root ball. The tree is then pulled out using a crane, transported in open tractors to the transplantation venue where a suitable hole has already been dug, and placed there with adequate physical supports till it takes root at the new location.

Fig.2.28: A Tree Spade **Fig.2.29: Manual Tree Transplantation**

Phyto-hormones play a strong role in stabilizing the tree at its new location. Several trees were transplanted during the Mumbai Metro project.

Reducing pressure on Land & Food Resources

Hydroponics

This is a form of hydroculture where plants – usually of agricultural significance – are grown in a soil-less environment with water soluble nutrients provided to them through a pump and piping-based system.

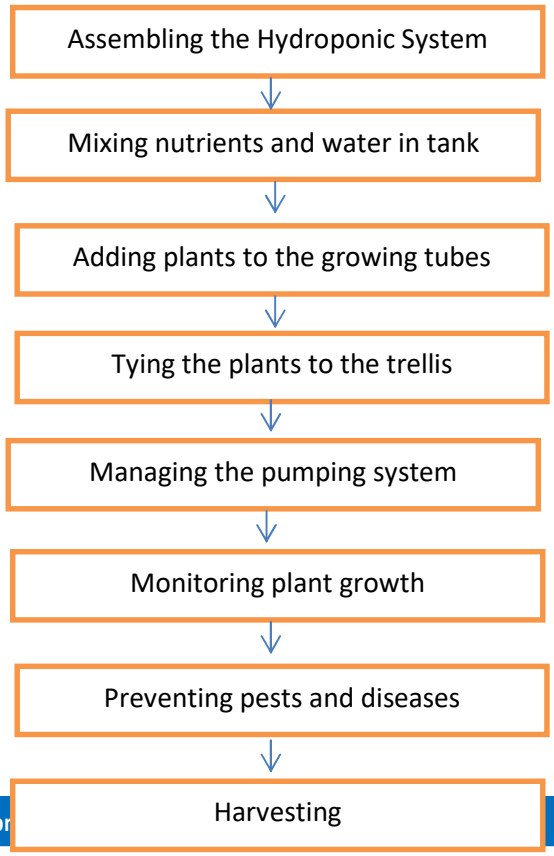


Fig.2.30: Overview of Hydroponics Procedure

Hydorponics has several advantages:

- Agricultural production increases up to 10 times, utilizing the same area
- Water efficiency enhances by as much as 90%
- Some species can grow faster in a hydroponics system
- Hydroponic accords more climate-resistant agriculture
- Weed growth is restricted
- Excessive use of pesticides is not required

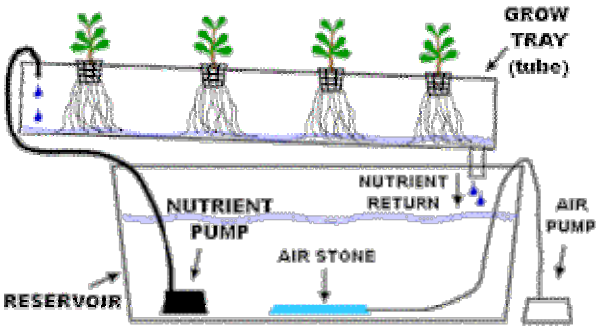


Fig.2.31: Outlook of a Hydroponics System

Lab-grown Meat

Lab-grown meat, *in vitro* meat or cultured meat is a befitting technological answer both to spiritual and moralistic vegetarians opposing animal cruelty and to the growing voice that avoiding meat is good for the environment. Lab-grown meat is the application of animal tissue culture technology, under which the animal muscle tissue collected by experts is permitted to multiply under suitable lab conditions and produce meat resembling that obtained from slaughtering. Lab-grown meat is likely to hit Indian markets in the coming few years. The overview of growing clean meat in the lab has been provided in the **figure 2.32** below:

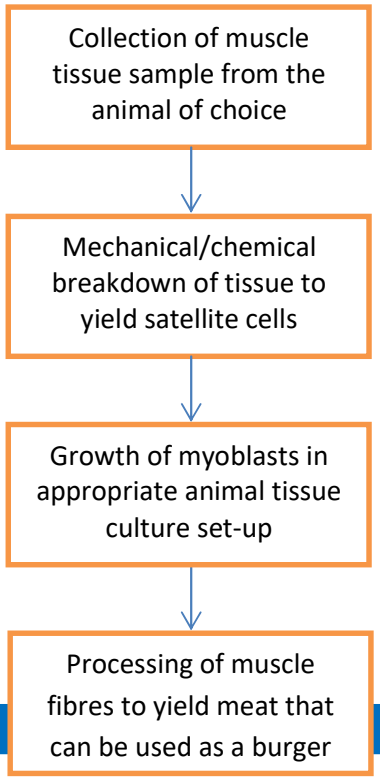


Fig.2.32: Overview of Obtaining Lab-Grown Meat through Animal Tissue Culture

Water Resource Engineering

Artificial groundwater recharge

Alarmingly reducing groundwater levels are threatening conventional agricultural practices on one hand and urban drinking water supply in many cities on the other. Artificial groundwater recharge emerges as a solution. Artificial groundwater recharge involves actively injecting or pumping treated water or excess good quality surface water into the aquifers to help increase groundwater level. Approaches to artificial groundwater recharge include:

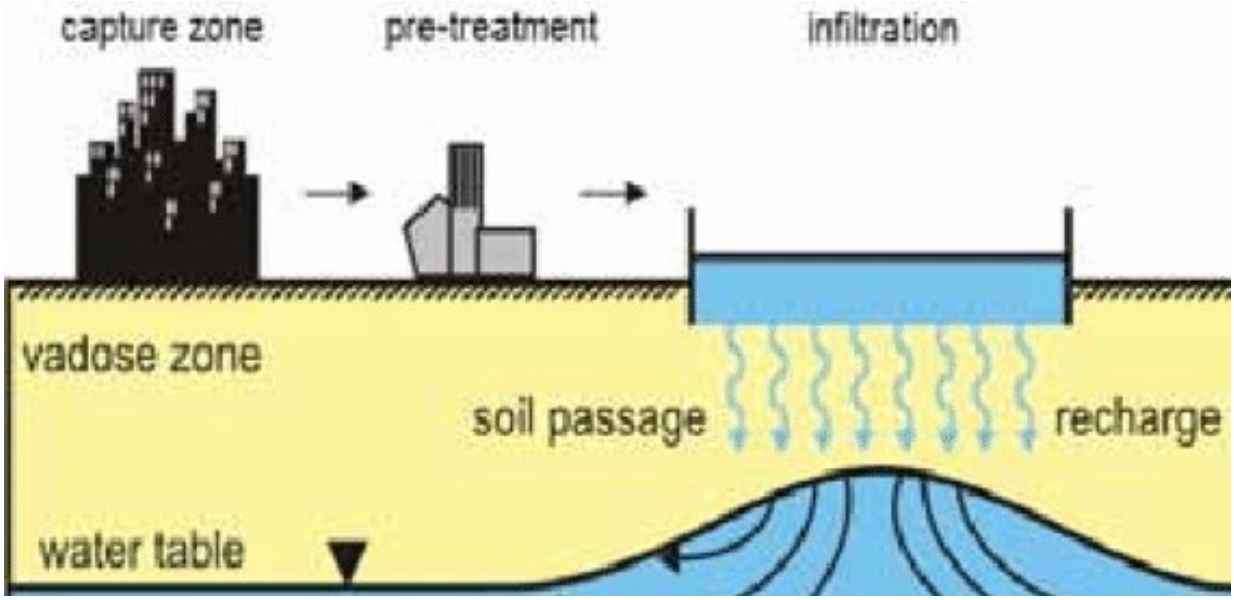


Fig.2.33: Approach of Ground Water Recharge

To Do Activity http://cgwb.gov.in/documents/ArtificialRecharge-Guide.pdf for further reading

Atmospheric Water Generator

If the ambient air is high in humidity, water can be extracted from it using an Atmospheric Water Generator by converting the water vapour to water. An AWG either uses cooling condensation or wet desiccation methodology to generate water. Interestingly, the Inca civilisation in South America

had collected drinking water by making Fog Fences that could condense dew.

Principle diagram

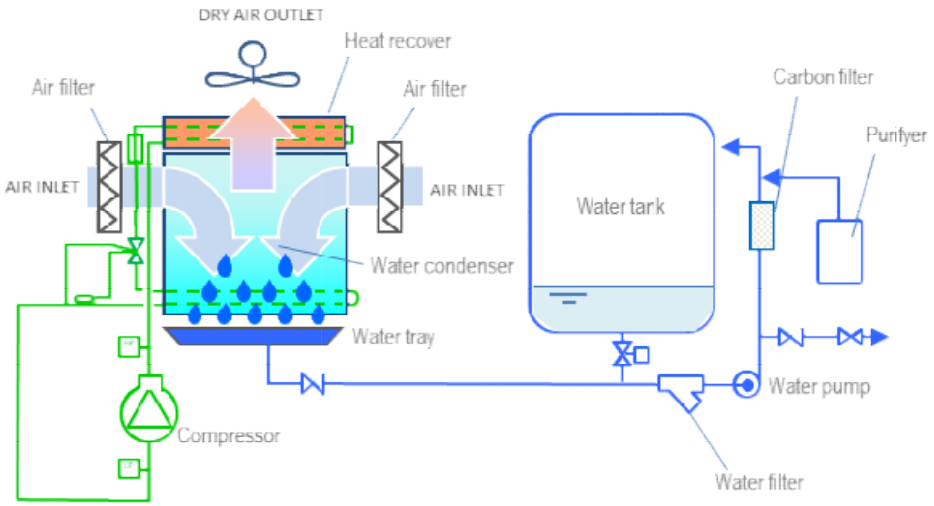


Fig 2.34: Atmospheric Water Generator

Summary

This chapter briefs about different services the nature provides us and how humans are exploiting the nature without mindful utilisation of resources, which has led to their depletion. Also, the rate of depletion is alarming and has led to several issues and imbalance in the environment. Lastly, the chapter provides a few technical solutions for sustainable use of resources through use of traditional, scientific, and technological practices.

Model Questionnaire

- What are Land resources, what does it include?
- How land resources are important to wildlife and humans
- How urbanisation is leading to deterioration of land resources
- What are the different sources of food and state the importance of each
- How decrease in food production affects Human?
- What is leading to the decrease in quality of food production?
- What should be done to improve the food production and its quality?
- What are renewable and non-renewable resources
- State the Pros and cons of Renewable resources
- What are the steps to be taken for conservation of natural resources
- Is any renewable energy used in your campus? state its function or calculate how much electricity is used up in your department per day.
- How would you make your campus or home dependent on renewable resources?
- What are the causes for resource depletion?
- What impacts are we facing and would be faced because of resource depletion?
- What are the technical and practical solutions for combating resource depletion?
- Describe some of the practical solutions for food and energy conservation in your campus.
- What are the three legs of sustainability?
- What is sustainable agriculture and what is the need for sustainable harvest?
- Identify one way a dietic professional can impact sustainable agriculture through practice.
- What are the four major non-renewable resources?
- How non-renewable resources affect the environment?
- Give some examples on how we can limit the dependency on non-renewable resources in our day to day life?

References

- Becerril-Piña R., Mastachi-Loza C.A. (2020) Desertification: Causes and Countermeasures. In: Leal Filho W., Azul A., Brandli L., Özuyar P., Wall T. (eds) Life on Land. Encyclopedia of the UN Sustainable Development Goals. Springer, Cham
- Hof, A. R., Dymond, C. C., &Mladenoff, D. J. (2017). Climate change mitigation through adaptation: the effectiveness of forest diversification by novel tree planting regimes. Ecosphere, 8(11), e01981.
- http://petroleum.nic.in/exploration-production/about-exploration-production
- http://www.eai.in/ref/ae/sol/sol.html
- https://economictimes.indiatimes.com/small-biz/productline/power-generation/india-sets-up-31696-mw-solar-power-generation-capacity/articleshow/72288187.cms?from=mdr
- https://energyeducation.ca/encyclopedia/Photovoltaic_cell
- https://india.mongabay.com/2018/02/state-of-forest-report-says-that-indias-forest-and-tree-cover-has-increased-by-1-percent/
- https://mnre.gov.in/scheme/Solar%20-%20Grid%20Connected
- https://mnre.gov.in/wind
- https://www.nationalgeographic.org/encyclopedia/nonrenewable-resources/
- https://www.tandfonline.com/doi/abs/10.1080/00908310490266698
- https://www.worldcoal.org/coal/where-coal-found
- Moon, Y. B. (2017). Simulation modelling for sustainability: a review of the literature. International Journal of Sustainable Engineering, 10(1), 2-19.
- Seddon, N., Turner, B., Berry, P., Chausson, A., &Girardin, C. A. (2019). Grounding nature-based climate solutions in sound biodiversity science. Nature Climate Change, 9(2), 84-87.
- Wang, Y., &Akbari, H. (2016). The effects of street tree planting on Urban Heat Island mitigation in Montreal. Sustainable Cities and Society, 27, 122-128
- Zabel, F., Putzenlechner, B., &Mauser, W. (2014). Global agricultural land resources–a high resolution suitability evaluation and its perspectives until 2100 under climate change conditions. PloS one, 9(9).

Chapter 3 Biodiversity and Its Conservation

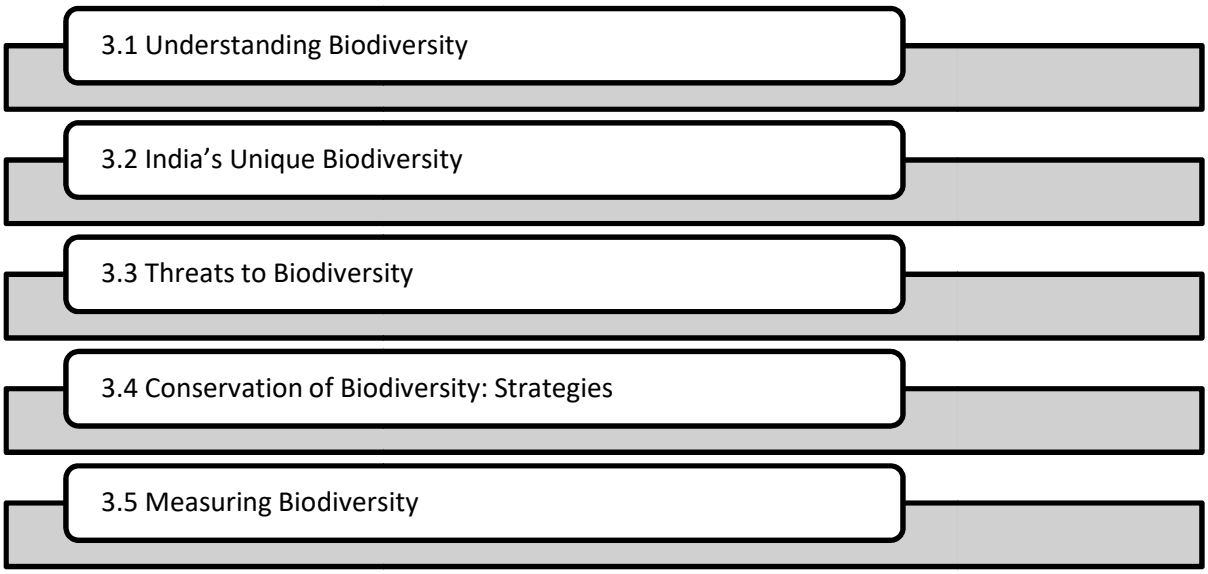
Introduction

The five sections of this chapter deal with the basic concepts of biodiversity (which is a relatively novel concept), describe the uniqueness of biodiversity in India (which is one of the mega-diverse countries of the world), describe the scientific methodologies to monitor biodiversity, caution against the threats to biodiversity and finally, outline the strategies for conserving biodiversity.

Objectives

- To provide insights on the fundamental concepts involved in biodiversity
- To familiarize on unique beauty of India's biodiversity and its incredible richness
- To comprehend on the various methodologies by which the various aspects of biodiversity
- To provide alarming nature of the threats to the rich biodiversity
- To provide an overview of the strategies for biodiversity conservation

Structure



3.1 Understanding Biodiversity

Biodiversity or biological diversity is a term given to "the variety of life on the earth and natural patterns it forms. Biodiversity is also defined as the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems" , as defined by the UN Earth summit 1992. The term biodiversity was first coined by W. G. Rosen in 1985 and further popularised in 1988 by E. O. Wilson in 1988.

Importance of Biodiversity

- As many as 271 empirical findings demonstrated that high genetic diversity led to higher fodder yield (Cardinale et al., 2011)
- Higher genetic diversity among plant species raises crop yield, as came out as the finding of 575 experimental studies (Kiaer et al., 2009)
- Daniel (2008) reported that higher species diversity of trees increased overall wood production

- 479 studies led to the conclusion that higher species diversity of plants led to more efficient carbon sequestration (Cardinale et al., 2011)
- As per Quijas et al., (2010), as many as 85 studies helped prove that higher species diversity of plants increased soil organic matter while 103 studies reported that soil mineral cycles became more efficient with higher species diversity
- Gene pool includes a variety of genes that are beneficial for human health and economy
- Biodiversity has immense cultural and aesthetic significance

Most importantly, though, biodiversity is the basis for evolution and adaptation to changing environments, making it essential for the survival of life. Biodiversity is broadly studied at three levels (Fig.3.1):

1. Genetic diversity
2. Species diversity
3. Ecosystem diversity

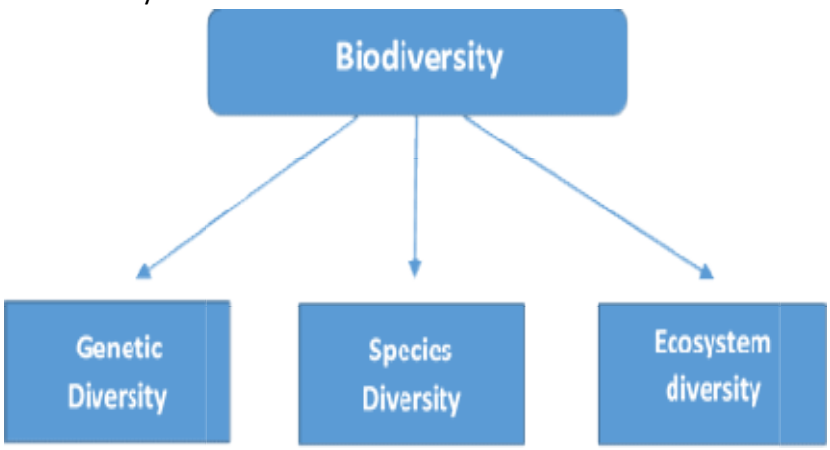


Fig.3.1: Type of Biodiversity

Genetic diversity

Genetic diversity can be defined as a diversity or variability within species, community or assemblage. It is well-known that, every individual is distinct because of the uniqueness in their genes.

The genetic material in microbial, floral and faunal species contains specific information that determines their characteristics which contributes towards the diversity in the world. Genetic diversity is the difference in genetic make-up between distinct species and to genetic variation within a single species. All individual belonging to a species share a certain characteristic, but it is the genetic variation only that adds a particular characteristic. To put it simply, genetic material controls every feature of each species.

Genetic diversity not only determines a particular characteristic of individuals but also their ability to survive in a particular habitat or under certain environmental conditions. It is well understood that there are certain plant species that grow on the coast but are not seen far on non-saline land *viz.*, mangroves. It is only the genetic variation in the mangroves that help them survive in saline conditions. Also, the genetic variation not only depends on the internal factors, but external as well. How isolated or wide-ranged a species is determines the rate of gene flow and genetic diversity. Studies show that even behavioral traits can influence the geographical distribution of intraspecific genetic characteristics (Foster 1999). Fig.3.2 represents the diversity in corn. Several corn varieties may be observed not only due to human intervention through genetic manipulation but also owing to mobile genetic elements called transposes. The different coloured kernels of corns are visible proofs of their high genetic diversity.

Fig.3.2: Genetic Diversity

Importance of Genetic Diversity

Evolution thrives on diversity at the genetic level. Genetic diversity ensures that in the population of species there will always be a genetic constitution that will be pre-suited to an environmental eventuality and will hence, survive any environmental calamity and ensure that the population does not go extinct. Thus, the very species survival depends on genetic diversity.

A good example of genetic diversity ensuring local species survival can be observed among experimental populations of bacteria. During a student experiment, three loopfuls of bacterial suspension containing glucose, obtained from the same flask, were inoculated onto three different agar plates, each containing a different sugar (mannose – sucrose – maltose) as the only carbon source. In each loopful of the suspension (which contains millions of bacterial colony forming units), there was at least one bacterial cell that – due to a previous mutation – already carried a gene capable of translating into an enzyme that could help digest maltose/mannose/sucrose, in addition to glucose. Thus, bacterial colonies were observed in each of the three agar plates.

In addition, evolution and new speciation is ultimately driven by variation at the genetic level. Thus, the significance of genetic diversity is very high with respect to the survival of existing species and the emergence of new ones.

To Do Activity

Make a list of five plants with genetic diversity and enlist their varieties providing the difference between them.

Species Biodiversity

The most commonly studied element of biodiversity is species diversity. Species diversity is studied with respect to a given geographical area in a given time span.

As per a study conducted by Mora et al. (2011), there are as many as 8.7 million species on earth. Each species plays a distinct role in the ecosystem, and is essential for maintaining a healthy ecosystem. Species diversity studies largely target

a) the larger species (vertebrates, especially mammals and birds)
b) species of higher human significance (positively as well as negatively – i.e., from pets to pests)
c) species that are easier to observe

Hence, more diverse taxonomic groups such as micro-organisms and insects, are not as deeply studied yet as desired.

The Fig.3.3 and Fig.3.4 show diversity in species of kingfisher bird.

Fig.3.3 White Breasted Kingfisher

Fig. 3.4: Common Kingfisher

Importance of Species Diversity

Each species has a distinct role to play in the ecosystem. Species diversity contributes to ecosystem health. Each species is like a thread holding together an ecosystem. If a species disappears, an entire ecosystem can start to unravel. Species diversity is crucial for ecosystem health. From serving as a source of our food, medicine, and other items of use, comfort and luxury, species diversity is critical to human existence. Besides, each species has its own intrinsic value, as described above.

Ecosystem Diversity

Ecosystem diversity studies is the broadest level at which biodiversity operates. From tropical rainforests to temperate forests, from permafrost cold deserts to hot deserts, from riverine to marine ecosystems, from mangroves to open scrubs – the earth has a wide variety of ecosystems. Each ecosystem, depending on the abiotic resources available with it, supports its own set of species communities. Tropical rainforests, for example, are more diverse than tundra. Islands have high degree of endemic species, i.e., species found only in a given geographical area and not anywhere else.

Fig.3.5 and **Fig.3.6** show variation in ecosystem. One is a forest ecosystem while other is a river ecosystem.

Fig.3.5: Forest Ecosystem

Fig.3.6: River Ecosystem

Importance of Ecosystem Diversity

We see ecosystem diversity all around us in nature even in the harshest environs. The various roles that organisms play within an ecosystem keep that ecosystem healthy and able to cope with changes in climate and the conditions of the planet. We know from natural history that species come and go, but we also know that the variety that we see in nature is what makes the existence of that particular period of time more efficient.

Example of Ecosystem Diversity:
An example of ecological diversity on a global scale would be the variation in ecosystems, such as deserts, forests, grasslands, wetlands and oceans.

To Do Activity
Map several ecosystems in your locality on Google Earth and understand which kind of biodiversity covers maximum surface area.

A critical element of Biodiversity studies is Taxonomy. Taxonomy studies aim at species identification and their classification into appropriate taxonomical groups, depending on their degree of similarity. Scientific nomenclature of a species has two halves – the Genus name comes first, followed by the species name. Species identification indicates identification of a given organism down to the species level. For example, the house crow is called by the scientific name *Corvussplendens*. Hence, *Corvus*is the genus, while *Corvussplendens* refers to the species house crow. The related species jungle crow has the same genus *Corvus*but has a different specific name and is known as *Corvusmacrorhynchos* scientifically. All crows, apart from birds such as magpies, treepies etc. belong to the Family Corvidae.

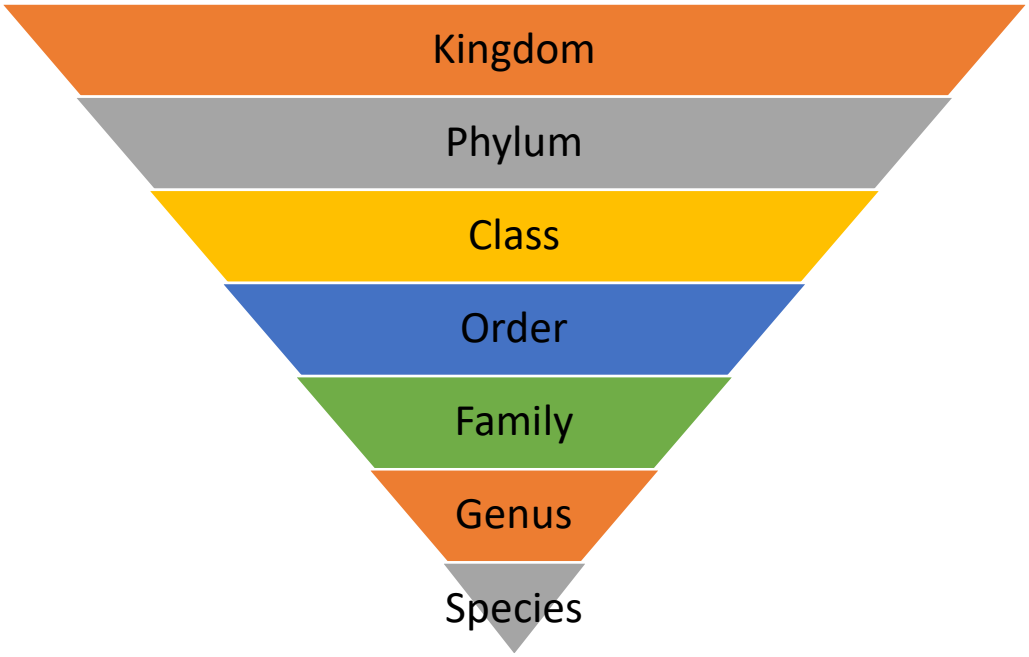


Fig. 3.7: Taxonomical Hierarchy

Terms in biodiversity
Species
The term species refers to a group of individuals that share several similar characteristics, but over and above that, can interbreed to produce viable offspring.
Carrying Capacity
The carrying capacity of an ecosystem is the highest possible number of individuals of the various species that can exist indefinitely in the given ecosystem, with regard to the nutrients, niches and threats.
The Biodiversity Hotspots
Popularly coined by Norman Myers in the year 1988, the term Biodiversity Hotspots refers to regions on the earth with exceptionally high species richness – with a substantial percentage of them being endemic (at least 1500 species of vascular plants) – and a serious threat of ecosystem destruction (at

least 70% of the habitat lost). Thus, with this combination of high diversity and threat to diversity, the concept of Biodiversity Hotspots has been used to prioritise the areas where concentrated conservation efforts need to be targeted.

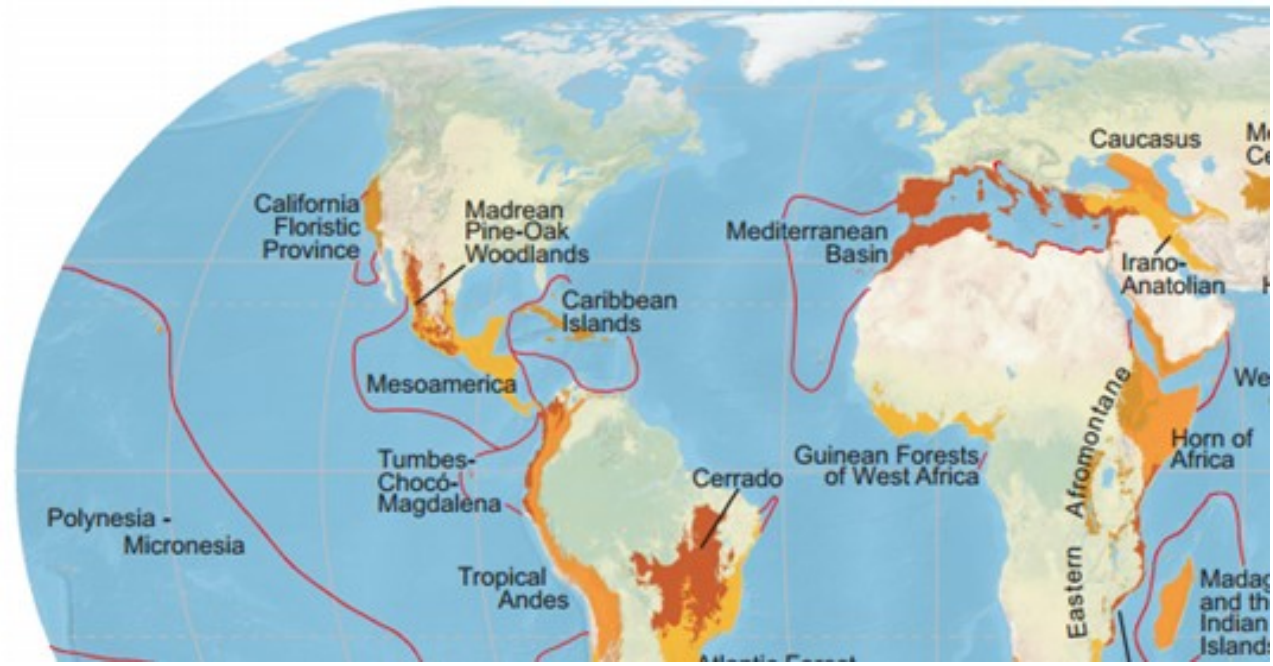


Fig.3.8: Biodiversity Hotspots

Intrinsic Value of Diversity

Instead of showcasing biodiversity importance from the anthropocentric viewpoint, each species has an inherent value of itself, for which it must be conserved. "In the physiocentric view, worthiness of protection stems from an inner value that is unique to each living being. Nature has an intrinsic value that does not depend on the functions that it presently fulfils or might later fulfill from humankind's point of view" (Schellnhuber 2001).

Alpha, Beta and Gamma Diversity

Alpha, Beta and Gamma diversity indicate the different spatial levels at which biodiversity is studied.

- Alpha Diversity is simply the biodiversity of a locality, or local biodiversity
- Beta Diversity is a comparison of species diversity among different sites.
- Gamma Diversity operates at the highest scale, and refers to the diversity of an entire region.

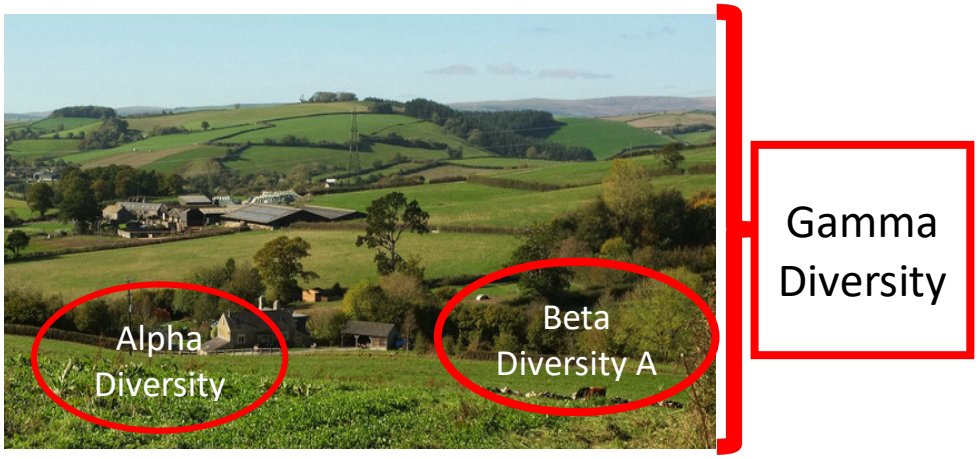


Fig.3.9: Alpha, Beta and Gamma Biodiversity

Species Richness and Species Evenness

Species Richness and Evenness measure two different aspects of biodiversity. Species richness is a straightforward estimation of the number of species present in an ecosystem. On the other hand, Species Evenness is a comparison of the population sizes of the individual species present in an ecosystem. An ecosystem is considered stable if it has high species richness as well as evenness.

For instance, let there be two grassland ecosystems A and B. In both grasslands A and B, there are 5 species each. However, in grassland A, one species has 460 individuals while the other 4 species have 10 individuals each. On the other hand, in grassland B, each of the 5 species has 100 individuals each. Thus, while both ecosystems have equal species richness, grassland B has higher species evenness.

Biodiversity Linkages

Species are linked to each other in a way that they thrive, keep their populations under control, and maintain the health of the ecosystems in which they are. An intricate web of species forms a food web – and higher the diversity of a food web the more stable it is.

To Do Activity

Visit to a nearby area and list the type of ecosystems in the area. Also, record unique features of each ecosystem.

3.2 India's Unique Biodiversity

A brief about Biodiversity of India

India is one of the world's "Mega diverse' nations. In terms of biodiversity and species richness, it ranks 9th in the World. India has a vast genetic as well as of species and ecosystem diversity. Of the total biodiversity on the Earth's surface, there is 7% of the World's biodiversity. This diversity is due to the vast variety of landscapes and climate resulting in ecosystems as diverse as tropical as well as temperate, mangroves to scrubs and snow-capped hilltops to hot deserts. As per an estimate, as many as 45,523 plant species (11.8% of world's flora) are in India itself. These include approximately 17,500 flowering plants among which 4,950 species are endemic to India (Raole and Desai 2012).

Biogeographic Zones in India

India has high ecosystem diversity with as many as 10 bio geographic zones.

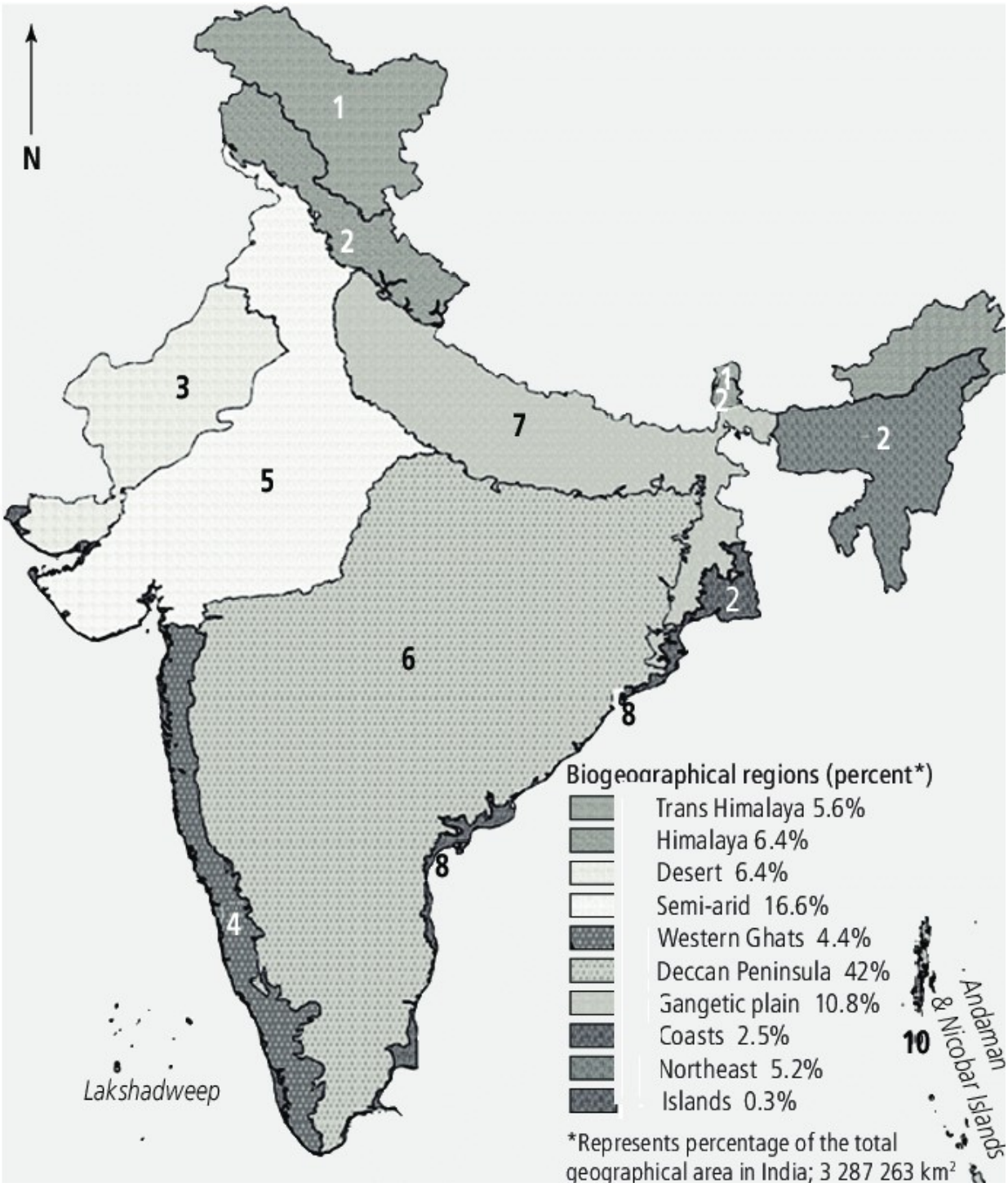


Fig.3.10: Map of Bio-geographical Zones in India

Details of the zones is given in **Table 3.1**

Table3.1: Bio geographical Zones of India

Sr. No.	Name	Biotic Province	Total Area (Sq. km.)
1	Trans Himalaya		**174225**
		Ladakh	98618
		Tibetian Plateau	75607
2	Himalaya		**210385**
		North-Western	69033
		Western	52596
		Central	6575
		Eastern	82182
3	Desert		**213672**
		Kachchh	36160
		Thar	177512
4	Semi-arid		**545686**
		Central India	121629
		Gujarat-Rajputana	424057
5	Western Ghats		131491
		Malabar Coast	65745
		Western Ghats mountains	65745
6	Deccan Peninsula		**1377363**
		Deccan South Plateau	341875
		Deccan Central Plateau	410908
		Eastern Plateau	207098
		Chhota Nagpur	177512
		Central Highlands	239970
7	Gangetic Plains		**355024**
		Upper Gangetic	207098
		Lower Gangetic	147927
8	Coasts		**82182**
		East Coast	62458
		West Coast	19724
9	North East		**170938**
		Brahmaputa Valley	65745
		North-Eastern Hills	105192
10	Island		**12971**
		Andaman Islands	6575
		Nicobar Islands	3287
		Lakshadweep Islands	3110
	Marine Influenced Area		**10440**
Grand Total			**3287263**

(Source: Wildlife Institute of India/ Zoological Survey of India)

Fig 3.11.: Forest Ecosystem (Bio-geographical zone- Northeast)

Fig.3.12: Mudflat Ecosystem (Bio-geographical zone- Arid/Semi arid)

Biodiversity Hotspots in India

The concept of Biodiversity Hotspots has been discussed above. In India there are four major biodiversity hotspots.

Himalaya: Includes the entire Indian Himalayan region (and that falling in Pakistan, Tibet, Nepal, Bhutan, China and Myanmar). The Himalaya Hotspot also includes the World's highest mountains, including Mount Everest. The ecosystem diversity in this region ranges from alluvial grasslands and subtropical broadleaf forests to alpine meadows above the tree line.

Table3.2: Estimation of the Flora and Fauna of Himalaya*(Source: bsienvis.nic.in)*

Taxonomic Group	Species	Endemic species
Plants	10000	3160
Mammals	300	12
Birds	977	15
Reptiles	176	48
Amphibians	105	42
Freshwater Fishes	269	33

The hotspot is home to a vast population of birds and mammals such as vultures, elephants, tigers, rhinos and wild buffalo.

Indo-Burma: Includes entire North-eastern India, except Assam and Andaman group of Islands (and Myanmar, Thailand, Vietnam, Laos, Cambodia and southern China). Indo-Burma conserves a vast biological treasure. In past years six large mammal species (the Annamitemuntjac, the large-antlered muntjac, the Annamite striped rabbit, the grey-shanked douc, the saola and the leaf deer) have been discovered in the area.

Table3.3: Estimation of the Flora and Fauna of Indo- Burma Region*(Source: bsienvis.nic.in)*

Taxonomic Group	Species	Endemic species
Plants	13500	7000
Mammals	433	73
Birds	1266	64
Reptiles	522	204
Amphibians	286	154
Freshwater Fishes	1262	553

The hotspot is also home to fresh water turtle species and a diverse bird life with more than 1300 species.

Sundalands: Includes Nicobar group of Islands (and Indonesia, Malaysia, Singapore, Brunei, Philippines). The Sundaland hotspot covers the western half of the Indo-Malayan archipelago, an arc of some 17,000 equatorial islands, and is dominated by two of the largest islands in the world: Borneo and Sumatra.

Table 3.4: Estimation of the Flora and Fauna of SundalandsHotspot*(Source: bsienvis.nic.in)*

Taxonomic Group	Species	Endemic species
Plants	25000	15000
Mammals	380	172
Birds	769	142
Reptiles	452	243
Amphibians	244	196
Freshwater Fishes	950	350

The Sundaland hotspot is a tropical forest and is home to spectacular flora and fauna. Population of orangutan is only found in this hotspot.

Western Ghats and Sri Lanka: Includes entire Western Ghats (and Sri Lanka). The hostspot is most influenced hotspot by human activities. The Western Ghats, also called Sahyadri Hills, are formed by the Malabar Plains and mountain range that runs roughly parallel to India's western coast, about 30 to 50 kilometres inland. It is a UNESCO World Heritage Site and one of 8 'hottest' of the world's biodiversity hotspots.

Table 3.5: Estimation of the Flora and Fauna of Western Ghats and Sri Lanka

Taxonomic Group	Species	Endemic species
Plants	5916	3049
Mammals	140	18
Birds	458	35
Reptiles	267	174
Amphibians	178	130
Freshwater Fishes	191	139

(Source: bsienvis.nic.in)

To-do-activity: Make a study of importance of tigers and understand why they are called as the National animal.

Flora of India

India is particularly rich in floral diversity. Given its wide range of climatic and altitudinal variations and being at the juxtaposition of three bio-geographic realms (Indo-Malayan, Eurasian, Afro-tropical), Indian floral species has high degree of nativity and endemicity. Indeed, India has been recognised as one of the 12 centres of origins of plant species globally. Type of floral species and their endemicity is given in **Table 3.6.**

Table 3.6: Floral Species Diversity in India

Sr. No.	Type	Number of known species		No. of En species in India	Threatened Species
		World	India		
1	**Flowering Plants**				
	Gymnosperms	1021	82	12	12
	Angiosperms	268600	18,666	4303	416
2	**Non-flowering Plants**				
	Bryophytes	16236	2780	629	7
	Pteridophytes	12000	1302	66	2
3	**Others**				
	Viruses	11813	1223	Not known	Not known
	Algae	40000	7411	1924	Not known
	Fungi	98998	15396	4100	1
	Lichen	17000	2581	520	Not known

To Do Activity
Make a list of different types of flora in your college campus to understand the diversity.

Fig.3.13: Flora of India

Fauna of India

In India there are about 423 species of mammals, 1233 plus species of birds and about 63423 species of insects. Also, there are several hundred species of fish and reptiles. India is the only country in the world to have lion as well as tiger – two of the most popular big cats. Among birds as well India is particularly rich (~1300 species out of 9000 in the world), be it resident or migratory birds. Reptiles of India show a high degree of endemicity (as high as 50%). The Royal Bengal Tiger, the Indian elephant, one-horned rhinoceros, Asiatic lion are among the most charismatic Indian wildlife species attracting global eco-tourists.

Table3.7: Faunal Species Diversity in India

Taxa	India	World
Mammalia	423	5416
Aves	1233	9026
Reptilia	526	9230
Amphibia	342	6771
Pisces	3022	32120
Insecta	63423	1020007
Protochordata	119	2106
Other invertebrates	8329	87121
Arthropoda	74175	1181398
Mollusca	5169	66535
Protista	2577	31250
Total	**96,373**	**14,30,439**

(Source: wiienvis.nic.in)

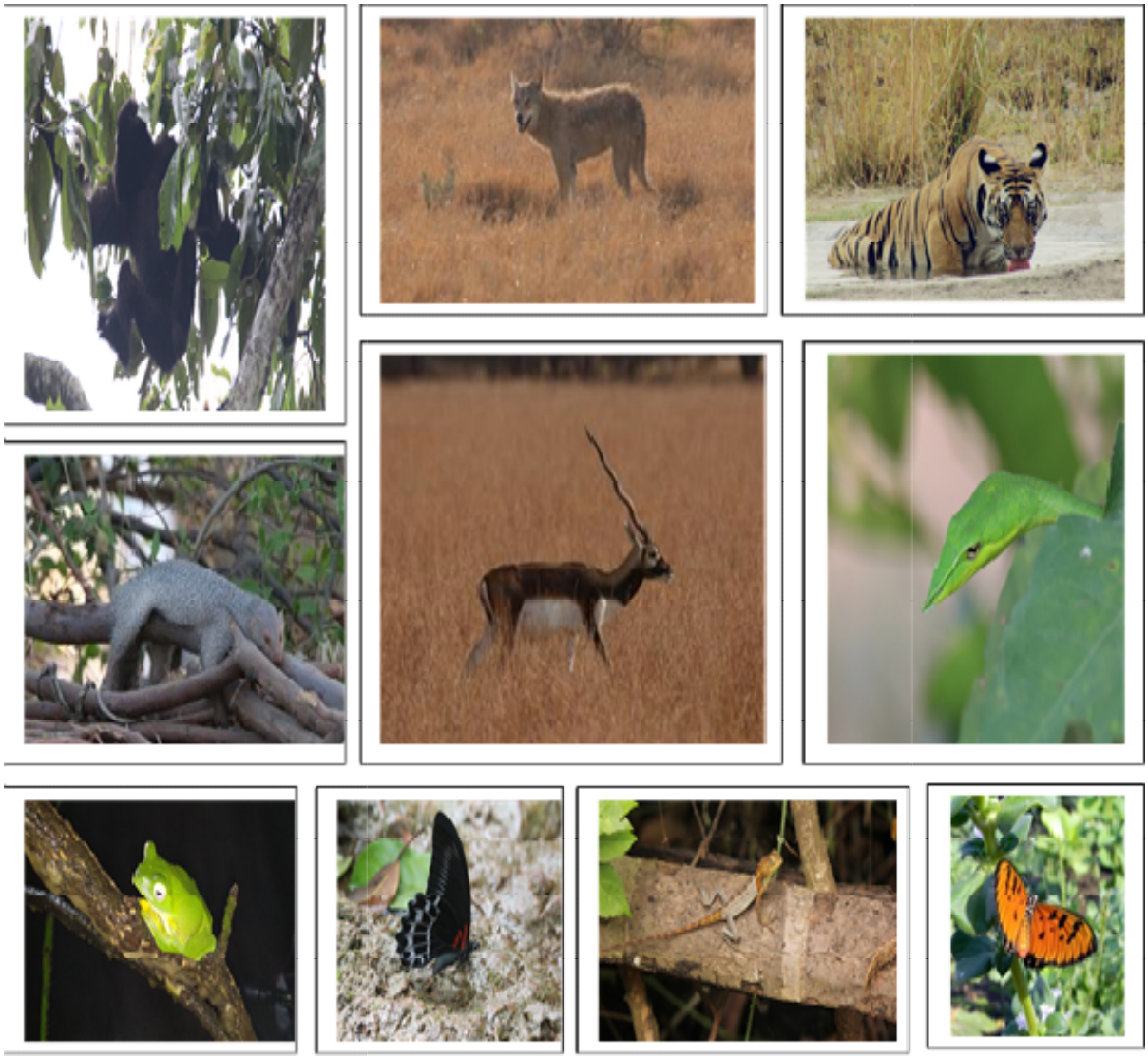


Fig.3.14: Fauna of India

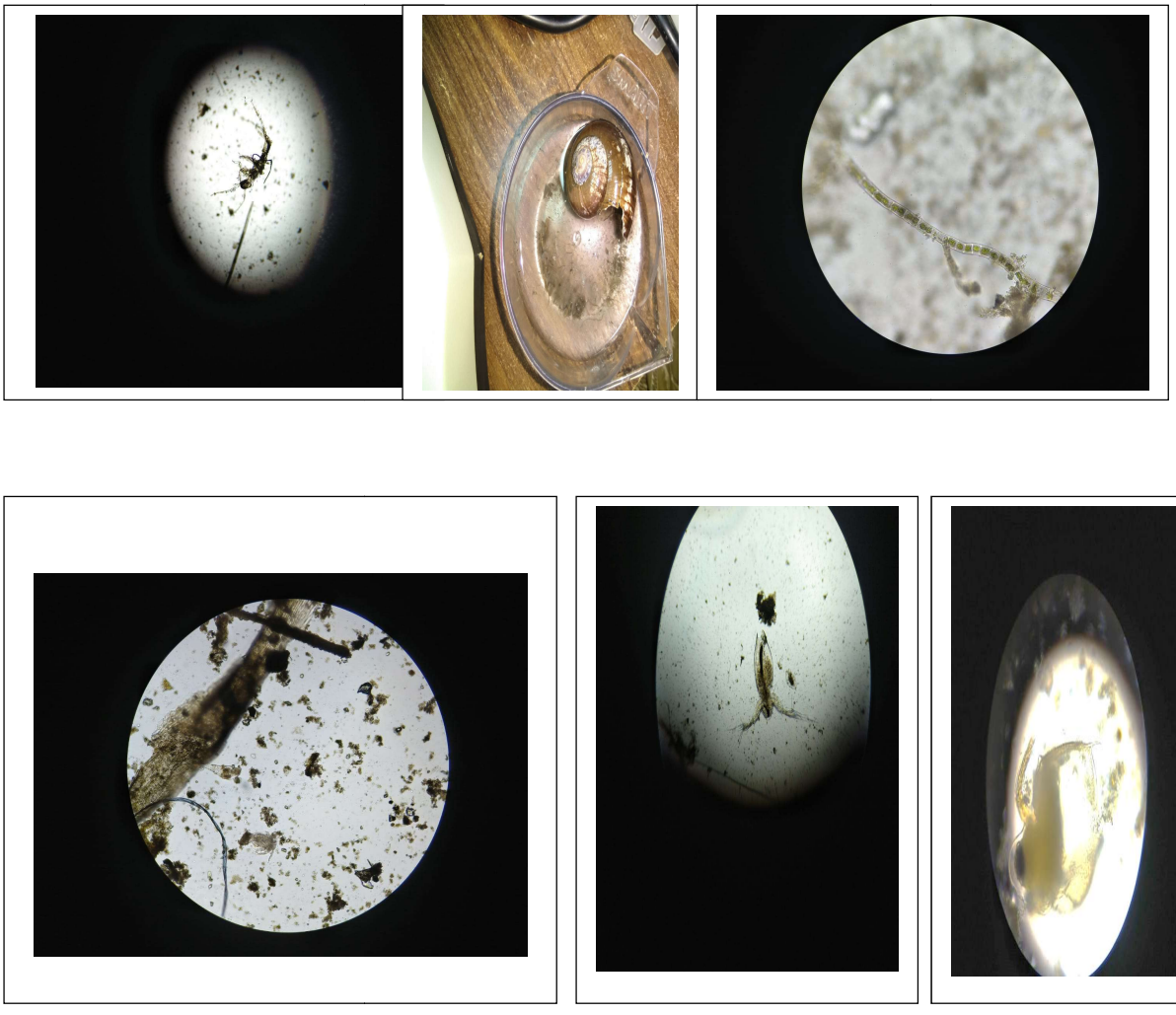


Fig. 3.15 Planktonic and Benthic Biodiversity

3.3 Threats to Biodiversity

The last 100 years have witnessed an alarming decline in biodiversity, with negative anthropogenic intervention the chief cause of it. As per Pimm et al. (2011), as many as 140,000 species may be going extinct every year, based on species-area theory. A few studies also suggest that one-fourth of all mammals may go extinct in the next couple of decades. The rapid interference of humans is leading to disappearance of wildlife from the globe. Habitat loss and degradation negatively affected 89% of avifauna, 83% of mammals and 91% of the floral species, as per an IUCN study.

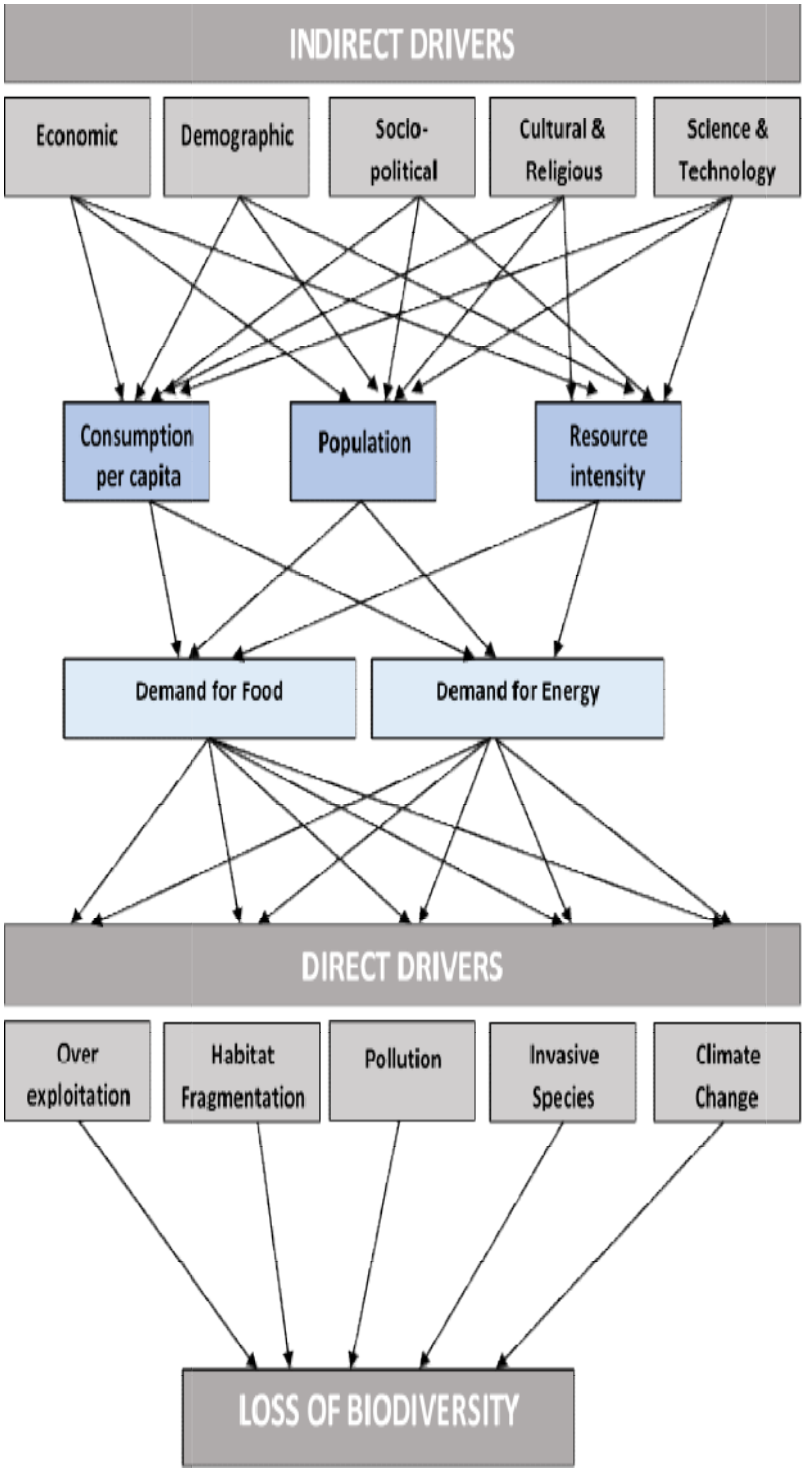


Fig.3.16: Threat to Biodiversity

Habitat Fragmentation

Habitat Destruction is one of the major causes for alteration of habitat, it divides smaller habitats into smaller isolated fragments. Natural causes can also contribute to habitat fragmentation, but today the main reason behind it is human activities. Along with development, several activities are involved such as construction of roads, mining of minerals, land clearance for agricultural purpose, urbanisation, industrialisation are carried out while collaterally impact the habitat leading to its destruction. A study by Nick in 2015 highlights the strong and typically degrading impacts of habitat fragmentation on biodiversity and ecological processes.

Habitat fragmentation has major impact on the terrestrial animals as loss of habitat causes them to enter into human inhabited areas and roads to reach their own habitat and resources for their survival. This increases human-animal conflict and road-kills of wild animals. In a situation where the natural habitat gets destroyed, it negatively impacts food supply and loss of breeding and nesting grounds. A drastic reduction in the number of species can, thus, ensue subsequently. Also, prey-predator interactions and pests and pathogens help create an intricate web of linkages keeping species population in check – habitat fragmentation disturbs this delicate balance and can either cause one species to spin out of control (at the cost of others), or decline close to extinction. Hence, habitat fragmentation has become one of the main causes for the extinction of wildlife in India. Human animal conflicts or death due to collision with vehicles are unfortunate outcomes of habitat degradation and fragmentation.

Agriculture and commercial plantations have largely led to habitat fragmentation in the Western Ghats. A case study by Conservation India showed that habitat fragmentation occurred due to tea plantations bordering Kalakkad Mundanthurai Tiger Reserve (KMTR), located in the Southern Western Ghats in Tamil Nadu (Mudappa et al. 2007).

Human Biodiversity Conflicts

Human biodiversity conflict is defined as any event in which animals injure, destroy or damage human life or property (including destruction of crops), and are killed, injured, captured or otherwise harmed as a result i.e. both humans and animals suffer from the interaction with each other (T. B. Jones *et al*., 2006). As per Distefano*et al*. (2011), while human-wildlife conflicts occur in rural and urban areas, the frequency of the same is higher in locations around protected areas where wild animals foray into agricultural fields and human habitations. Human biodiversity conflict has far reaching environmental impacts. Species most involved to conflict are also shown to be more prone to extinction (Ogada*et al.,* 2003).

Human-wild animal conflicts can manifest as:

- Wild animal killing during road and railway accidents
- Accidental trapping into snares set for other animals
- Falling into wells
- Retaliatory shooting/poisoning

Human-wildlife conflict is becoming a serious threat to species survival, with elephants in the northeast getting killed or injured in railway accidents, leopards in several parts of India being killed/trapped because of them straying into human habitation, poisoning of bears reported apparently due to vicious attacks on humans, and retaliatory killing of tigers due to perceived loss of cattle as well as human life. The killing of snakes because of their inherent fear factor and illegal hunting of migratory birds for their flesh have also been reported.

Human-animal conflicts also inflict losses on humans. Several human lives have been lost to wild animals. Also, one must note the morbidity and lingering impact of injuries and loss of limbs caused due to wild animal attacks. Loss of cattle to predation is also very common. Crop loss due to elephants, deer, nilgai and wild boars is a common occurrence in many areas. For instance, elephant herds wreak havoc in the Assam tea estates, nilgais raid crops in Bihar and wild boars have caused heavy damage in Uttarakhand and Kerala fields. In urban areas like Mumbai, residents reported loss of pets, fear of moving out after dark and injuries due to leopards from the Sanjay Gandhi National Park within city boundaries.

To Do Activity
Study an area under habitat fragmentation due to mining activities using Google Earth

Agricultural Activities

With the rising population, need of higher food production is critical. However, modern agricultural practices are becoming too mechanised (within polyhouses, using tractors and sprinklers) to help sustain wild biodiversity from the neighbouring ecosystems. Rampant use of pesticides and chemical fertilisers is destroying soil biodiversity, non-pest insects (the critical pollinators - bees) and other fauna linked with them (for instance, birds feeding on insects). Land from eco-sensitive areas being usurped for subsistence-level agro-practices is also frequently reported.

Fig.3.17: Habitat Fragmentation in Western Ghats for Agricultural Activities

An example one can see is of Oil Palm plantation which have cause severe impact to the ecology. The production of palm oil is done on large scale as palm is versatile in nature and can be used cooking oil, lubricant, biofuel, and as an additive in the food and cosmetic industries. The production of this crop is higher in Indonesia and Malaysia wherein massive forest land has been cleared for the cultivation. In Indonesia it has led to destruction of habitat of Orangutan (*Pongoabelii*) due to the plantation. In India, many community based forests have been cut for plantation of the crop.

Exploitation of Resources

Exploitation of bio resources before they can be naturally replenished has been a critical threat to biodiversity. Over-fishing and over-hunting have led to complete wiping out of species from the local ecosystem, and at times globally - the dodo being an example of the latter. Felling of trees for timber, illegal cutting of top soil, sand mining from riverbeds etc. are other examples of over-harvesting of natural resources.

Introducing Invasive Species

Species that have not originated from a given bio geographic region but are introduced there through deliberate or unintentional human agency are termed Exotic Species. Exotic species, once introduced into a foreign ecosystem can adopt two fates:

- succumb to unsuitable abiotic and biotic factors, or
- grow uncontrollably in the absence of natural predator or pathogen and become Invasive

Invasive species proliferate at the expense of native species, giving them tough reproductive competition, edging them out from their niche and gradually forcing them close to extinction. In the case of invasive floral species edging out a native floral species, an added disadvantage is the breakage of the delicate linkage between fauna species supported by them (birds nesting on trees, butterfly larvae feeding on specific leaves etc.).

For instance, trees such as eucalyptus (native to Australia), quickstick (native to Mexico and Central America), monkeypod (native to Mexico, Central America and South America), Ear leaf Acacia (native to Australia), Gulmohar (native to Madagascar), Tulip tree (native to Africa), White lead tree (native to Mexico and Central America) and Velvet Mesquite (native to Mexico and Central America) have been thoughtlessly introduced in our city avenue plantations, silviculture exercises, and unfortunately, even forest ecosystems. Shrubs such as lantana (native to) and herbs such as Congress grass (native to) have become serious challenges threatening many of the Indian forests. Indeed, wide swathes of lands covered in quickstick plantation may look seasonally appealing with its pink blossoms in the spring but hardly supports any secondary faunal diversity and leads to what may be called as 'silent jungles'.

The rock pigeon (*Columba livia*) is of European origin and was introduced as a game bird in several countries. It has now virtually taken over urban avian bird biodiversity in many Indian cities, having enjoyed high reproductive success.

Pollution

Species are at immense risk of mortality and morbidity due to pollution. Plastic discharge in our oceans has led to the formation of micro plastics, which carry harmful chemicals on their surfaces and get ingested by various species, leading to disease and death. Oil spills in oceans have led to swarms of whales and fish being killed and mangroves getting dried up. Pesticides and other toxic chemicals are discharged in water bodies, killing fish and other aquatic species, reaching birds through biomagnification

Fig.3.18: Bird Covered with Oil

To Do Activity

Make a report on recent accidents that let to pollution and their impact on the biodiversity.

Illegal Trading

The world has been a ground for illegal trade of wildlife since ancient time, which has threatened decades of conservational efforts. Wildlife trading has been a big business, having linkage all over the globe. The trading of animals and their parts is done just like drugs. According to an estimate

given by TRAFFIC, the trading runs up to a cost of billion dollars. Not all kind of trade are illegal, and many of the plants and animal species have been harvested since years for the purpose of food, ornamental plants, leather, pets, medicines, etc. Wildlife trade moved towards crisis when the harvesting level or norms increased in proportion and diverted towards unsustainability, further threatening survival of the species.

There has been poaching of elephants for ivory; tigers are traded for their bones and skin; marine turtles are harvested for shells. The trading varies from a small herb to large animals for their specific part. In South Africa there are about 80% of the world's total Rhino. It was found that between 2013 and 2017, each year nearly more than 1000 rhinos are killed.

Fig.3.19: Illegal Trading of Tiger and Leopard Skin

Fig.3.20: Illegal Trading of Ivory

Among other countries, India has also been a country when illegal trading has been a problem due to demands from Southeast Asia. The Wildlife Society of India, in 2014 reported 23 deaths of tiger due to poaching, death of seventeen leopards. In 2013, 38 elephants and 41 rhinos were poached.

Climate Change

The negative impact of the rapid anthropogenic climate change currently underway on biodiversity is undeniable and has substantial empirical proof. Despite the inherent sturdiness and adaptation capability of several species, a changing climate in conjugation of over-exploitation and pollution, is wreaking havoc on species survival. For instance, loss of permanent ice zone areas in the Arctic is a serious threat to the species adapted to survive therein. The impact of climate change-induced biodiversity loss on human well-being is also serious, with the threatened loss of several species on which we depend for food, medicines and other critical resources.

In the **Table 3.8** below, anthropogenic impacts on biodiversity have been collated:

Table 3.8: Summary of Impact and its Causes

Type of Impact	Causes
Terrestrial Impact	
Natural habitat fragmentation and destruction	Roads and urban built-up area, rampant release of pollutants such as human sewage, industrial effluents
Agricultural fields growing unsuitable for supporting biodiversity	Loss of traditional agricultural practices, mechanisation of agriculture, intensification of agriculture, excessive use of chemicals like pesticides and fertilisers
Air, water soil pollution	Rampant release of pollutants without adequate treatment – ranging from human sewage to toxic industrial chemicals and agricultural pesticides
Invasive and exotic species	Pet trade, mindless pursuit of fast-growing and ornamental flora species
Epidemics affecting wildlife	Climate changes favouring growth of novel types of pathogens, human agency in careless handling of potential infectious material
Climate change	Loss of green cover, release of greenhouse gases, unplanned urbanisation
Loss of wetlands, a rapidly declining groundwater level	Excessive use of groundwater
Tourism	Overuse of green open spaces and wild areas, little respect for nature, mountain biking and motor sports in fragile areas, dogs not on leash
Aquatic Impact	
Overfishing putting species at risk of extinction	Commercial fishing, overexploitation, callous disregard for by-catch fishes, consumption/loss of juvenile fish, consumption/loss of gravid females, aquaculture of one target species at the cost of others
Eutrophied water bodies	Agricultural run-off, sewage discharge from ships, industrial effluent discharge
Loss of benthic biodiversity, degradation of sea-bed and riverbed	Trawlers, mindless dredging, illegal sand mining
Invasive species	Escape of aquaculture species into the wild
Loss of planktonic and benthic biodiversity from the inter-tidal zone	Beach tourism activities such as bike riding, lighting, horse-riding, mechanised cleaning of beaches

3.4 Conservation on Biodiversity: Strategies

Biodiversity conservation protects the living organism, ecosystem, etc. due to which it plays a major role in providing several services to human. Also, anthropogenic activities have led to increase in the impact on biodiversity due to which it has been depleting at alarming rate. Hence, it has become important to conserve biodiversity. There are two methods in which biodiversity can be conserved, i.e., *in-situ* and *ex-situ* methods.

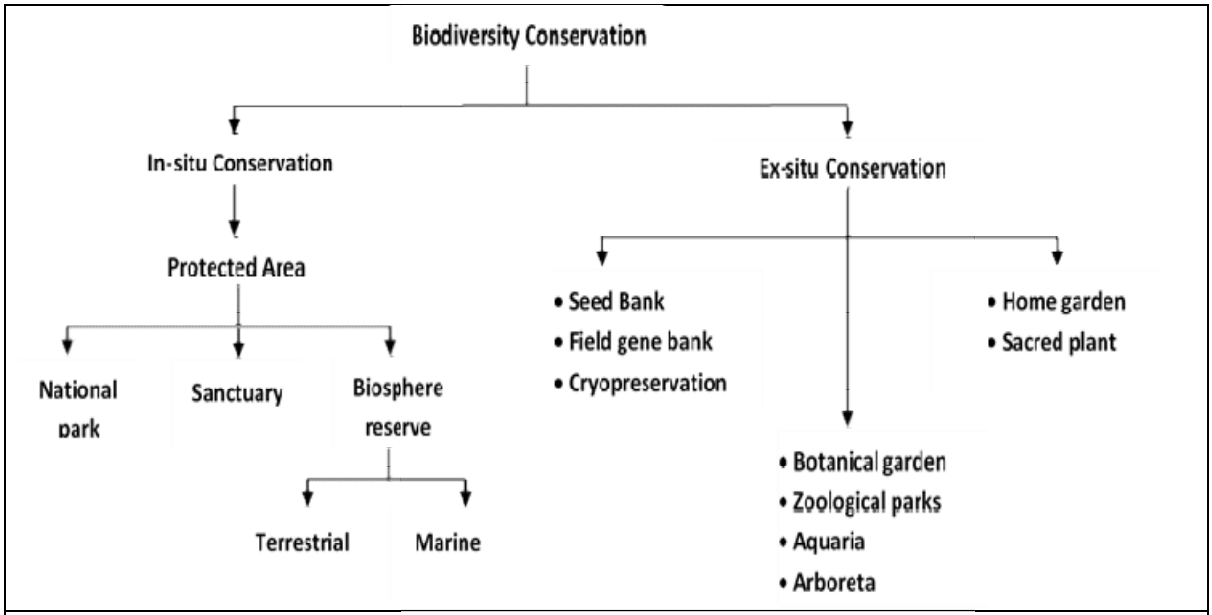


Fig.3.21: Techniques for Biodiversity Conservation

In-situ conservation

In in-situ conservation method, the conservation of the species is done on the same site in the species natural habitat, i.e., in its natural population. It is majorly used for protecting of endangered plants or animals in their habitat by conserving their habitats and protecting them from predators. In-situ conservation is done through various method such as declaring particular areas s Protected Areas (PAs) which are isolated from the outer surrounding. PAs receive protection due to their natural, ecological and cultural values. There are several PAs globally and the level of protection depends on the laws of any country. In India, the protected areas comprise of national parks, wildlife sanctuaries, conservation and community reserves. These all cover about 4.89% of the total geographical area of the country.

Table 3.9: Number of Protected Areas in India

Type of PA	Number	Area (km^2)	Geographical area of India (%)
National Parks	103	40500.13	1.23
Wildlife sanctuaries	537	118005.3	3.59
Conservation reserves	67	2349.38	0.07
Community reserves	26	46.93	0.001
Protected area	733	160901.74	4.89

(Source: Wildlife Institute of India, 2016)

National Park

National parks are areas of high ecological, floral, faunal or natural significance. National Parks are notified by the State Governments and are under the jurisdiction of the Forest Department. A plethora of Acts has provisions for national park management. These include:

- Wildlife (Protection) Act, 1972 & its amendments
- Indian Forest Act of 1927
- Forest (Protection) Act of 1980
- Biological Diversity Act, 2002
- Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006

In a National Park certain activities are prohibited for protection of the species. Destruction of habitat, encroachment, and hunting of wild animals, construction of tourist lodges and other such activities are prohibited. In national park, the conservation of only animals is done and no interference of human in form of harvesting timber, collection of forest resources, private ownership of land is allowed.

There are total 103 national parks in India. At 9 each, Madhya Pradesh and Andaman and Nicobar islands have the highest number of national parks. Kerala, Maharashtra Uttarakhand and West Bengal follow next with 6 each.

Wildlife Sanctuaries

Sanctuaries are similar to national park wherein conservation of animals is done with an exception that human activities such as harvesting timber, collection of forest resources, private ownership of land is allowed but without any interference with the conservation of the animal. Most of the provisions for national park and Sanctuary are same except the following:

- Livestock grazing is not permitted in a national park
- National parks have more sharply defined boundaries
- While a wildlife sanctuary can be upgraded to a national park, a national park cannot be downgraded
- Settlement of rights in a national park is stricter

There are total 537 sanctuaries in India. With 96, 41 and 29 WLS, Andaman and Nicobar Islands, Maharashtra and Tamil Nadu have the maximum number of wildlife sanctuaries in India.

To Do Activity

Make a case study of any Eco-tourism activity conducted in nearby area

Eco-tourism

Ecotourism is defined as 'responsible travel to natural areas that conserves the environment and improves the well-being of local people. Such tourism is low impact, educational, and conserves the environment while directly benefiting the economic development of local communities.

Ecotourism, when practiced correctly, is an important economic and educational activity.

Ecotourism is entirely different from conventional tourism, wherein the destination has to be a natural site, the tourist is primed with the humble desire to learn about nature and associated socio-cultural aspects, the focus is on relaxation and enjoyment coupled with a deeper desire to get more aware about our forgotten linkage with where life originated, eco-friendly actions form the key to tourism activities, local communities are benefitted from the tourism activities.

Eco-tourism is a more synergetic approach to tourism that tends to bind the tourist, local community and the environment. There are various advantages of eco-tourism:

- To protect the Ecosystem: Eco-tourism helps in maintaining the ecosystem where the ecotourism attraction is located. It helps in protecting and maintaining the wildlife species of the area, especially the endangered species. Through eco-tourism a harmony can be maintained between wildlife and people encouraging co-existence.
- Conservation of various resources: Eco-tourism helps in maintaining the quality of fresh water and marine resources. Waste discharge and contamination of the environment (water, soil and air) can be avoided, as waste is . It preserves local culture and history.
- • To aid infrastructure development: - Eco-tourism activities have often led to the development of infrastructural facilities in natural areas, as they are necessary to ensure tourism continues unhindered.
- • To help in balanced regional development: - Underdeveloped areas where industries may be few and agriculture may not be intensive, eco-tourism emerges as a source of income, helping these poorer areas to come higher up in economic ratings.
- • To help in generating employment: - The tourism industry is reputed to be a labor-intensive one with the capability of generating employment options for skilled, semi-skilled and unskilled laborers, as also small local businesses and local artistes.
- To maintain sustainable development: Ecotourism aids community development as it becomes an alternate, more sustainable source of income for the local community. Conservation of biodiversity and natural resources becomes mandatory, and the local communities become strong stakeholders of the same as their incomes depend on the same. Ecological experience to travelers, conservation of the ecological environment and gaining of economic benefit become the three-pronged benefits of eco-tourism.
- To help in maintaining peace and understanding: - Tourism plays an important role in promoting international goodwill. It creates awareness and appreciation of other countries' culture and nature.

Highlights:

- Identify and monitor important zones and activities – Use of GIS, remote sensing to demarcate tourist zones
- Assess carrying capacity of the area – Using the concepts of Physical Carrying Capacity, Real Carrying Capacity and Effective Permissible Carrying Capacity
- Baseline data collection of ecology and biodiversity features – checklist of flora and fauna, plant association secondary data, ecological association studies
- Baseline data collection of locally available eco-tourism features – to ensure no clashes with existing eco-tourism feature and to ensure at least local and preferably regional uniqueness of the eco-tourism features offered

- Social Survey – to understand expectations of potential eco-tourists
- Planning of Nature Interpretation Centre – to be constructed of eco-friendly material, to be rich in research material (a rich library, audio-visual unit, posters and standees)
- Management Plan for Tourists
- Solid & Liquid Waste Management Plan
- Marketing Plan for Enhanced Tourist Footfall

Caveat:
Eco-tourism sites must mimic nature as closely as possible, and emerge as an artificially created but natural-looking habitat; eco-tourism sites must necessarily be different from usual parks and gardens. Hence, following points may be considered

- It is randomness and unpredictability or inherent ecological associations that decide where flora species are observed in a natural ecosystem. Hence, various plantations in the eco-tourism site should be grown in a naturally random manner instead of specified orchid/moss/fern gardens and any flora-fauna associations should mimic those in nature
- Planned human interventions such as benches, handrails, plumbing, motors etc. should be kept to a bare minimum, and replaced by natural-looking features wherever possible; the essentials should be suitably concealed or camouflaged so that it does not clash with the natural features

Conservation and Community Reserves

Conservation and Community reserves are biodiversity-rich areas that fall in the buffer zones/connectors/wildlife migratory pathways of protected areas like wildlife sanctuaries and national parks; these areas are relatively less impacted by human activities and are owned by communities or privately.

The concept of Conservation and Community Reserves was introduced in the Wildlife (Protection) Amendment Act of 2002, which underscored the ecological significance of buffer zones and migratory corridors and recognised the fear of such land being put to non-ecofriendly usage by their private owners.

India's first Conservation reserve was KeshopurChambGurdaspur located in Punjab. In the year 2012, the Rajasthan government declared "JawaiBadh forest" as a conservation reserve. It is located in Pali village in close proximity to Kumbalgarh Sanctuary.
In 2007, KokkareBellur was declared a community reserve under Wildlife Protection Act, 1972. It is the only community protected sanctuary in Karnataka.

Biosphere Reserves

The Biosphere Reserves of India are equivalent to Category V of the IUCN and are often congruous with one or more national parks and national sanctuaries. There are 10 MAB areas in India.

- Nilgiri Biosphere Reserve
- Gulf of Mannar
- Sundarbans
- Nandadevi National Park and Biosphere Reserve

- Nokrek
- Pachmarhi Biosphere Reserve
- Similipal
- Achanakmar- Amarkantak
- Great Nicobar Island Biosphere Reserve
- Agasthyamalai Biosphere Reserve

The in-situ conservation tools described above have been planned in response to the categorisation of protected areas provided by IUCN. Detailed comparison has been provided in **Table 3.10.**

Table 3.10: Comparison of Protected Areas in India with IUCN Protected Area Categories

IUCN Category of Protected Areas	Salient Features	Corresponding Protected Area in India
Category Ia	Most strictly protected, with stricter control on human entry and natural resource usage	
Category Ib	Wildnerness area	
Category II	Less strictly protected with higher degree of human intervention permitted, aiming at conservation and sustainability	National Park
Category III	Natural monuments or features	
Category IV	Habitat or species management area focused on a	Wildlife Sanctuary
Category V	Protected landscape/seascape	Biosphere Reserves, Conservation Reserves
Category VI	Protected Area with sustainable use of natural resources	Community Reserves, Village Forests, Panchayat Forests

Biodiversity Research Campus/ Biodiversity Park – A modification of in-situ conservation
In the last decade or so, the concept of 'Biodiversity Parks' has begun to gain popularity. However, in the absence of very clear understanding of the term 'Biodiversity', lack of clear guidelines about the same, financial or site constraints, or even to use the novel term for tourism enhancement, a Biodiversity Park may end up being less than ideal.

In fact, the term 'Biodiversity Park' may itself be misguiding, as it tends to indicate that amusement and recreation are the chief purposes of the same. However, this very essential of green infrastructures in an urban area – where space is already limited and ecosystem disturbance already a challenge – should not be restricted to being an amusement park for children, a theme park for adults or just another recreation spot. Instead, it should be looked upon as an active attempt at ecological conservation – through scientific as well as social efforts. Hence, the alternative nomenclature of Biodiversity Research Campus appears more suitable.

To Do Activity
Make a report on Sacred groves in India and their associated cultural values

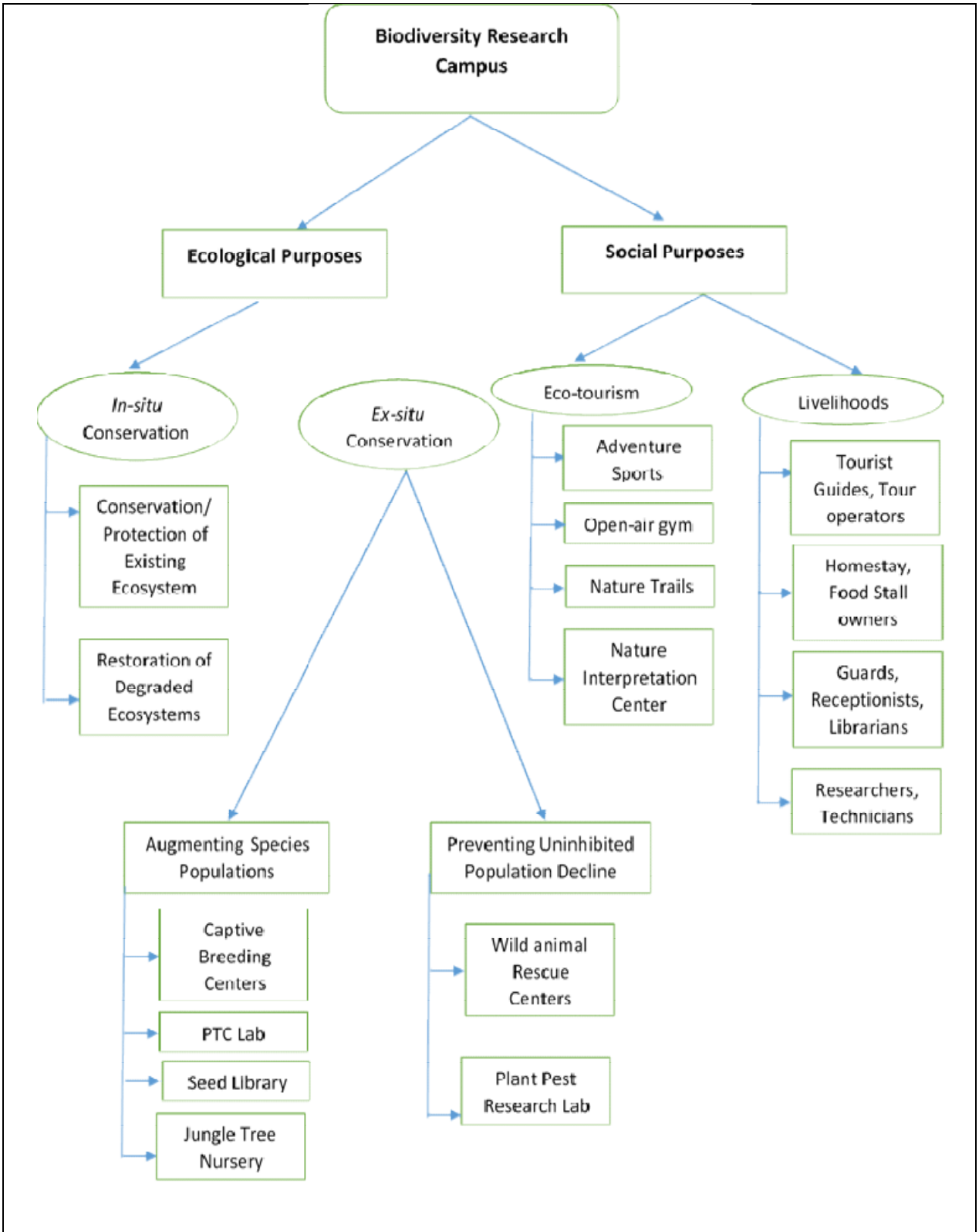


Fig.3.22: Benefits of Biological Research Camps in Conserving Native Biodiversity

Table 3.11: Biodiversity Parks in India

Sr. No.	Name	Location	Features	
			Ecological	*Social*
1.	Yamuna Biodiversity Park	Delhi	• Natural ecosystem rehabilitated and protected • Nursery of native saplings	Nature trail
2.	Kaziranga Orchid & Biodiversity Park	Assam	Located amidst the natural forests of Kaziranga Hot-house for orchids Seed library of local rice varieties	Children's play area Photograph gallery of orchids Local cultural display Local food and beverages Souvenir sale Livelihoods (managed by a local institution)
3.	Baramura Eco-Park, Tripura	Near Agartala, Tripura	Located amidst the Baramura Hills	Nature trails Souvenir shop Local food cafeteria
4.	Coastal & Marine Biodiversity Centre	Navi Mumbai, Maharashtra	Located along mangroves	A state-of-the-art interpretation centre Souvenir sale
5.	Mahim Nature Park	Mumbai, Maharashtra	Eco-restoration of a garbage dump Green lungs of an otherwise concretised jungle	Nature trails Library
6.	Pashan-Baner Biodiversity Park	Pune, Maharashtra	Local forest and hill patches protected	Nature trails
7.	UttamraoPatil Biodiversity Park, Karlekhind	Alibag, Maharashtra	Local forest and hill patches protected A dried stream rehabilitated	Children's play area Butterfly garden
7.	UttamraoPatil Biodiversity Park, Panchgani	Panchgani, Maharashtra	Local forest and hill patches protected	Nature trails

Advantages of in-situ conservation

- It is rather difficult to recreate a natural habitat artificially – hence, it is always more beneficial to conserve habitats as they are and go for in-situ conservation.
- In the absence of uncontrolled anthropogenic interference, flora and fauna species can thrive naturally.

- With the retention of natural ecosystems, the ecosystem goods and services associated with them also remain available for human benefit
- In-situ conservation is more cost-effective.
- The tribal folk residing within the protected area are also accorded protection

To Do Activity
Visit a Biodiversity Park

Ex-situ Conservation Technique

Ex-situ conservation is the preservation technique of biological components outside their natural ecosystem. This involves conservation of genetic resources, wild and cultivated species, parts or complete species have a diverse body of techniques and facilities. Ex-situ conservation techniques include botanical gardens, zoos, conservation strands and gene, pollen seed, seedling, tissue culture and DNA banks, tissue culture, seedling, pollen seed, conservation strands and gene, botanical gardens and zoos.

Seed gene bank

Seed bank are cold storages where seeds are kept under controlled temperature and humidity for storage and it is and easiest way to store the germ plasma of plants at low temperature. Seeds preserved under this technique can be stored for longer duration.

Field Gene Bank

In this preservation technique, plants are planted for conservation of genes. For this plantation, an artificial ecosystem is created. Plant studies and species-specific research can be conducted in such facilities, though they require more land, adequate soil, weather, etc.

"Annapoorna" is North East India's first indigenous seed saving library", it is established to collect and promote cultivation of heirloom rice land races of the region. The farmers come and deposit the seeds, which are sown by a volunteer. The yield are borrowed by other farmers. The farmers are introduced to different properties and characteristics on basis of which they make a choice.

Recognizing the importance of preserving genetic diversity among agricultural crops, and the threat of lab-prepared high yielding crop varieties fast replacing the unique and sturdy native

*Cryopreservation*overnment of Indian conferred the prestigious Padma Shri award to farmer and seed conservationist Ranibai Soma Popere from Ahmednagar, Maharashtra in 2020. She has been given the nom de plume of 'Seed Mother.'

This technique aims to preserve biological specimens. Individual cells and biological tissues may be cryopreserved in a living state of suspended cellular metabolism at the temperature of liquid nitrogen (-196°C). This practice is crucial for biomedical research, clinical medicine, zoology, botany, and biotechnology. When frozen and kept properly, specimens may remain in a state of suspended cellular metabolism indefinitely and can be thawed as needed.

Botanical Gardens

Botanical gardens may be defined as "public gardens which maintain collections of live plants mainly for study, scientific research, conservation and education." Botanical gardens help preserve rare plant specimens, providing useful information about them including their scientific names, distinctive features, phenology, socio-cultural importance, ecological importance, habitat, distribution range and spot where the particular specimen was collected from

According to Chakravarthy and Mukhopadhyay (1990), a botanical garden can broadly be called a "living repository" or "refugia" of plants where floral species are arranged, classified, labelled and maintained on a scientific basis, and opened for public viewing to help enhance awareness and empathy for conservation.

Few botanical gardens in India are as follows:

- Indian Botanic Garden, Kolkata
- Botanical Garden, Saharanpur
- LalbaghBotanical Garden, Bangalore
- Jawaharlal Nehru Botanical Garden, Gangtok

Zoological Gardens

Zoological garden or zoological park are places where wild animals and to an extent domesticated animals are exhibited in captivity. In such establishments animals are given personal and more intense care than the one in natural ecosystem. Mostly zoos exhibit primates, big cats, reptiles, tropical birds, or waterfowl, etc. Zoos also display the animals to public for entertainment purpose.
In India, the first zoo was established in Barrackpore in the year 1800.

Few zoological gardens in India are as follows:

- Arignar Anna Zoological Park Vandalur Zoo, Chennai, Tamil Nadu
- Assam State Zoo-cum-Botanical Garden, Guwahati, Assam
- Bannerghatta National Park, near Bengaluru, Karnataka
- Gorewada Zoo, Nagpur, Maharashtra
- Gopalpur Zoo, Gopalpur, Himachal Pradesh
- Indira Gandhi Zoological Park, Visakhapatnam, Andhra Pradesh

Aquaria

Aquaria is just like zoo, but here aquatic animals are kept in glass enclosures for public display. Taraporwala Aquarium is one of the famous aquariums in Mumbai.

Arboreta

An arboretum is generally a botanical collection of trees. Mostly they contain living woody plants and are used for scientific study. Udhagamandalam is one of the Arboreta established in Ooty.

Home gardens

Home garden is an integrated system with a variety of food and agricultural produce including staple crops, medicinal plants, etc. Home gardens emerge as a reservoir of biological diversity with the individual playing a key role. Home gardens are constructed in small area but are characterised by a structural complexity and multi-functionality.

Sacred Groves

In India, nature has been worshiped since ancient times and many religious and cultural practices are linked with nature. Some patches of forest are considered holy and are kept untouched because of social importance. These type of plants are called sacred groves and they are conserved by the local communities.

Advantages of Ex-situ Conservation:

- When only a few individuals of an endangered species are left, this may be the only option.

- Threatened species can be bred in captivity, keeping them safe from predation and infection and using the best of scientific technologies available, and then rehabilitated in their natural habitats.
- With the help of ex-situ conservation techniques, wild animal observation becomes an added advantage.
- Ex-situ conservation labs offer unique opportunities for research and development studies.

To Do Activity
Study the Pygmy hog captive breeding and rehabilitation project in Assam

3.5 Measuring Biodiversity

Baseline studies have been carried out on vegetation with reference to species composition, diversity, abundance and distribution of the species in the study areas. To select the locations, firstly, major habitat types were observed (i.e., wetlands, ponds, riverside, semi-dried streams, natural flora growths, rocky outcrops, open scrubs); in addition, disturbed sites were also observed. In these locations, accessibility was checked for, and in areas easily accessible, transects and quadrats were laid. Quadrat method was used for analysis in approachable areas. In the selected locations, quadrats of size 10 m x 10m were laid and qualitative and quantitative analysis of plants in the quadrat was carried out. Data of plant species, and number of individual species were recorded for herbs and shrubs while for trees, a checklist was prepared. Every parameter was listed according to the observation and various attributes were calculated such as density, frequency, abundance, important value index, Simpson's (D) and Shannon's (H) indices to ascertain species diversity and evenness.

IVI formula

Simpson's index (D): Species richness as a measure on its own takes no account of the number of individuals of each species present. It gives equal weight to those species with very few individuals and those with many individuals. The Simpson index is a dominance index because it gives more weight to common or dominant species. In this case, a few rare species with only a few representatives will not affect the value of the diversity index. Species richness appears to be influenced by temperature, tidal amplitude, rainfall, catchment area, freshwater seepage, and frequency of cyclonees.

Shannon's index (H'): The **Shannon index** is an information statistic index, which means it assumes all species are represented in a sample and that they are randomly sampled. The diversity of species has always been a fundamental area of inquiry in ecology. Species biodiversity may be used to indicate the 'biological health' of a particular habitat. Some habitats are stressful and so few organisms are adapted for life there, but, those that do, may well be unique or, indeed, rare. Such habitats are important even if there is little biodiversity. Pollution is also one of the reasons that lead to change in species biodiversity. Species biodiversity depends on the its habitat and it thrives only in conditions which are suitable to it. Any change in physiochemical or biological environment can affect the species.

$$H' = -\sum_{i=1}^{S} \frac{n_i}{N} \ln \frac{n_i}{N}$$

ni = number of individuals
N = Total number of specices

$$D = 1 - \frac{\sum_{i=1}^{S} n_i(n_i - 1)}{N(N-1)}$$

Floral survey was carried out using Quadrat method. Even selection of the site was done for accurate results. Sites were selected in which quadrats were laid; their geographical co-ordinates

Faunal Survey:

I. **Direct observation/Visual Encounter:** In this method, the species of animals observed visually were noted. Also, a count of each species observed was recorded.

II. **Searching for signs:** Signs such as scat, feeding signs, pug marks, burrows and dens are evidence of the presence of mammals. For proper accuracy, the burrows and dens should be checked, whether they are active or abandoned. Birds can be recognised by their unique songs and calls. Notable behaviors of the bird such as feeding, nesting, or breeding and the associated habitats should also be observed and accordingly the records are to be made.

III. **Identification and Listing**: Field identification was on the basis of experience, and wherever required, standard field guides and identification keys were made use of (a list of these field guides has been provided under the heading of References). Fauna was checked for their IUCN status (International union for Conservation of nature) and also their status in the Schedules of Wildlife Protection Act, 1972.

Fauna Survey Locations: Survey was conducted according to line transect and point transect method in which around 18 routes and 5 points were selected. The GPS locations of start and end point of respective line transect and point location of point transect

Large-bottle-type samplers have been found to be slightly more efficient for phytoplankton sampling (Kuparinen et. al.2009). The sampling protocol followed was as per USEPA (LG400), with the significant difference that instead of a rosette sampler, a large bottle type sampler was used. Briefly, composite samples were collected at each point till the euphotic depth. Samples were mixed. Sample preservation was with Lugol's iodine (final concentration 1% v/v). Samples were stored in the dark and refrigerated. Phytoplankton was viewed under a 40X lens in a compound microscope.

Zooplankton species is a heterogeneous assemblage of animals covering many taxonomic groups, largely composed of lower invertebrates like copepods, amphipods, rotifers, cladocerans and larvae of fish, prawn, shrimp, crabs etc. (Varghese and Krishnan 2009). Zooplankton was sampled using a standard zooplankton net. The net was dipped slowly in water and raised. It was rinsed thoroughly and the sample was concentrated. It was fixed first with 4-5% formalin (1 part formalin and 9 parts sample). Few drops of Rose Bengal solution was used for sample staining. This protocol was as per NIO Field manual (2004). Zooplankton was viewed under a 20X lens in a stereo microscope.

Benthic invertebrates were sampled using a Van Veen Grab Sampler. The procedure used for sampling and preservation of sample was as per USEPA protocol (LG406). Briefly, the sediment sampler was lowered slowly through the water column, being allowed to fall freely towards the end. Post that, it was pulled up, and the contents lowered into a tub. The sediment was then mixed with water to have a slurry-like consistency. This was then filtered through a mesh of size 500µm after thorough but low pressure rinsing to ensure sample concentration. Residue was fixed with 4% (v/v)

formalin (final volume of formalin 5-10% v/v of sample). Benthic biodiversity was viewed using a hand-held lens as well as under a 20X lens in a stereo microscope.

Table3.12: Methodology for Biodiversity Assessment

Sr. No.	Method	Brief Details
The biological environment information will be collected using transect method for fauna; quadrats will be laid along transects for flora.		
1.	Quadrat-based survey for shrubs & climbers and herbs	Qualitative and quantitative analysis of flora using systematic quadrat plots laid along ecosystem gradient. Trees, shrubs, climbers and herbs will be surveyed through quadrat-based approach (10m by 10m quadrats for trees, 5m by 5m quadrat size for shrubs and climbers and 1m by 1m quadrat size for herbs). **Note: Size of quadrats may change based on field conditions**
2.	Transect for Fauna	Location for laying the transects and quadrats shallbedependentonthetypeofnaturalorsemi-naturalhabitatsobservedintheregion, anthropogenicdisturbances(ifany),accessibility,andsocialissues(ifany)
3.	Visual Encounter Survey	Visual encounter survey for fauna through direct observation is a simple and quick survey method. Birds,mammals,amphibiansandreptileswillonlybeobservedandrecordedbutnottrapped.
4.	Indirect Indicators of Fauna Diversity	In terms of scat, droppings, pugmarks, bird calls, nests, roosting sites, amphibian calls, road-kills, feathers, bones, burrows, etc.
5.	Chance Sightings	Chance sightings outside the usual transect period will also be noted.
6.	Listing (Fauna)	IUCN, 3.1 Enlisted species as Near Threatened, Vulnerable, Endangered, Critically Endangered and Rare. Also, checking of any Schedule of species as per Wildlife protection Act, 1972.
Sensitiveareaswillbedefinedfromthespeciescompositioninformationforbothfloraand fauna.		
Aquatic Biodiversity:		
1.	Phytoplankton	Large-bottle-type samplers have been found to be slightly more efficient for phytoplankton sampling (Kuparinen et. al.2009). The sampling protocol followed will be as per USEPA (LG400), with the significant difference that instead of a rosette sampler, a large bottle type sampler will be used. Briefly, composite samples will be collected at each point till the euphotic depth. Euphotic depth is the depth till which light penetrates in the water body, and is determined using a Secchi Disk. Samples will be mixed. Sample preservation will be with Lugol's iodine (final concentration 1% v/v). Microscopic analysis under a40X lens of a compound microscope
2.	Zooplankton	Zooplankton will be sampled using a standard zooplankton net. The net will be dipped slowly in water and raised. The sample will be rinsed thoroughly and concentrated. It will be further fixed with 4-5% formalin (1 part formalin and 9 parts sample) first and then few drops of Rose Bengal solution will be added for sample staining. This protocol

		is as per NIO Field manual (2004). Microscopic analysis under a20X lens of Stereo-microscope
3.	Benthos	Benthic invertebrates will be sampled using a Van Veen Grab Sampler. The procedure used for sampling and preservation of sample is as per USEPA protocol (LG406). Briefly, the sediment sampler will be lowered slowly through the water column, being allowed to fall freely towards the end. Post that, it was pulled up, and the contents will be lowered into a tub. The sediment will then be mixed with water to have a slurry-like consistency. Later it will be filtered through a mesh of size 500µm thorough but low pressure rinsing to ensure sample concentration. Residue will be fixed with 4% (v/v) formalin (final volume of formalin 5-10% v/v of sample). Microscopic analysis under a20X lens of Stereo-microscope as well as hand-held lens.
4.	Ichthyofauna	Fish catch data from fishermen and survey of local fish markets will be conducted
Secondary Data Collection:		
1.	Research Publications	All published research papers related to the area will be studied and any information found will be noted.
2.	Government Organisations	Data of flora and fauna found in the region will be collected from government organisations
3.	Social Survey	One-to-one interaction, focus group studies for fauna sightings and fish catch. Data related to the important plants in the area and their uses. Information on use of river water and resources from the surrounding ecosystem.

Summary

The chapter introduces to several fundamental concepts of biodiversity, inter-linkages and its types. It provides a description of biodiversity in India and its uniqueness and importance. Various methodologies have been provided through which one can qualitatively and quantitatively estimate biodiversity. As human activities have impacted the biodiversity, several threats have been highlighted in the chapter and an overview of different conservation methods has been provided at the end.

Model Questions

- What is the importance of ecosystem diversity?
- What are the types of direct values provided by the biodiversity?
- What are the types of indirect values provided by the biodiversity?
- Write a short description on “value of a tree”.
- Write a brief description about biodiversity in India and give some examples.
- Describe some of the places in India known for its rich aesthetic Biodiversity.
- What are the threats to Biodiversity?
- What are the natural causes for habitat destruction?
- How does poaching affect the environment?
- What is man-wildlife conflict? Give one example.
- Why it is important to conserve biodiversity?
- Describe in-situ and ex-situ conservation methods for biodiversity.

- Have you come across any practical manifestation of in-situ conservation of biodiversity? Share your experience.
- State some pros and cons of ex-situ biodiversity conservation.

References

- Biodiversity Hotspots,Ministry of Environment, Forest & Climate Change, Retrieved on 23rd December 2019 from http://www.indiaenvironmentportal.org.in/files/file/Biodiversity%20hotspots.pdf
- Botanical Survey of India, Biodiversity hotspots in India, retrieved on 29th December 2019 from http://bsienvis.nic.in/files/Biodiversity%20Hotspots%20in%20India.pdf
- Distefano, E. (2005). Human-Wildlife Conflict worldwide: collection of case studies, analysis of management strategies and good practices. Food and Agricultural Organization of the United Nations (FAO), Sustainable Agriculture and Rural Development Initiative (SARDI), Rome, Italy.
- Ecozones of India, C.P.R. Environmental Education Centre,Retrieved on 28th December 2019 from http://www.cpreec.org/pubbook-ecozone.htm
- Foster, S. A. (1999). The geography of behaviour: an evolutionary perspective. Trends in Ecology & Evolution, 14(5), 190-195.
- Foster, S. A., & Endler, J. A. (Eds.). (1999). Geographic variation in behavior: perspectives on evolutionary mechanisms. Oxford University Press on Demand.
- Jones, T. B., & Barnes, J. I. (2006). Human Wildlife Conflict Study. Namibian Case Study.
- Mora, C., Tittensor, D. P., Adl, S., Simpson, A. G., & Worm, B. (2011). How many species are there on Earth and in the ocean?. PLoS biology, 9(8).
- Mora, C., Tittensor, D. P., Adl, S., Simpson, A. G., & Worm, B. (2011). How many species are there on Earth and in the ocean?. PLoS biology, 9(8).
- Mudappa, D. I. V. Y. A., & Raman, T. S. (2007). Rainforest restoration and wildlife conservation on private lands in the Western Ghats. Making conservation work, 210-240
- Mudappa, D., Noon, B. R., Kumar, A., & Chellam, R. (2007). Responses of small carnivores to rainforest fragmentation in the southern Western Ghats, India. Small Carnivore Conservation, 36, 18-26.
- Nature Trust British Columbia, Threats too Biodiversity, Retrieved on 21st December 2019, from https://www.naturetrust.bc.ca/conserving-land/threats-to-biodiversity
- Ogada, M. O., Woodroffe, R., Oguge, N. O., & Frank, L. G. (2003). Limiting depredation by African carnivores: the role of livestock husbandry. Conservation biology, 17(6), 1521-1530.
- Pooja Mondal, Conservations of Biodiversity: In-Situ Conservation and Ex-Situ Conservation, Your article library, Retrieved on 24th December 2019 from http://www.yourarticlelibrary.com/biodiversity/conservations-of-biodiversity-in-situ-conservation-and-ex-situ-conservation/30144
- Quijas, S., Schmid, B., & Balvanera, P. (2010). Plant diversity enhances provision of ecosystem services: a new synthesis. Basic and Applied Ecology, 11(7), 582-593.
- Raole, V. M., & Desai, R. J. (2012). Priority for Biodiversity Conservation. Phytotechnology: Emerging Trends, 29.
- Schellnhuber, H. J. (2001). World in Transition: Conservation and Sustainable use of the Biosphere (Vol. 1). Earthscan. http://www.biodiv.be/biodiversity/threats
- Threats to Biodiversity, WWF, Retrieved on 22nd December 2019, from https://wwf.panda.org/knowledge_hub/where_we_work/altai_sayan_mountain/altaisayan_threats/

Chapter 4 Environmental Pollution

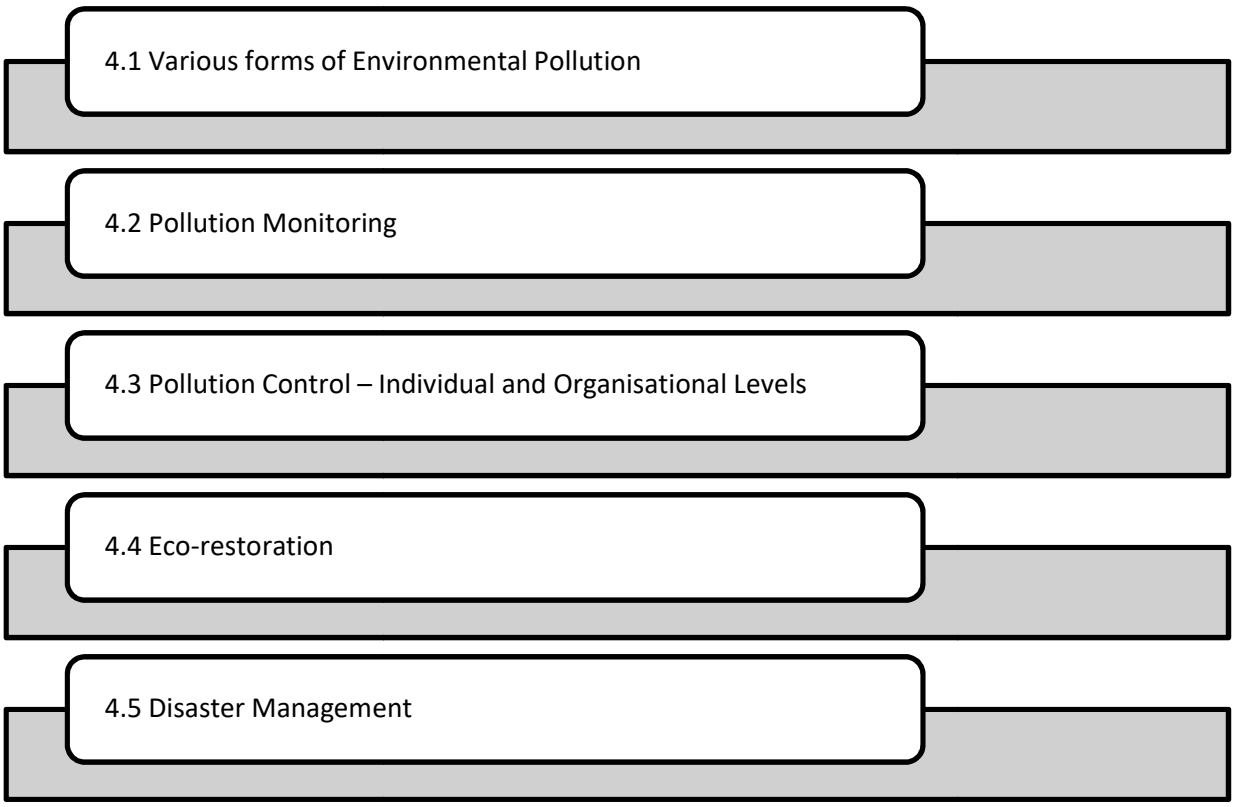
Introduction

In the first section of this chapter, various types of pollution (air, water, land, noise, light and nuclear) have been described, along with case studies. In the section, pollution monitoring methodologies have been outlined. The third section deals with various pollution control technologies and behavioural aspects that are useful for tackling pollution. The fourth section describes various aspects of eco-restoration, while in the fifth section, keeping in mind the rising trend of environmental disasters, basics of disaster management have been outlined.

Objectives

- To provide insights on environmental pollution, how dangerously all-pervading it is for the environment
- To explain on pollution monitoring, which is critical for quantifying and measuring exactly how good, bad or ugly the environmental pollution situation is
- To provide insight on pollution control and treatment, which is a solution-oriented approach towards the challenge of pollution
- To comprehend on eco-restoration
- To provide insights on environmental disaster management, which may well be critical to one's existence

Structure



4.1 Various forms of Environmental Pollution

Pollution

Pollution may be defined as either

a) The introduction of toxic substances into the environment

or

b) The abnormal increase in the level of naturally-occurring substances, leading to deleterious effects

Hence, while the release of chloro-fluoro carbons into the air can be termed as pollution, rise in carbon dioxide levels leading to global warming is also a manifestation of pollution.

Air Pollution

Air normally contains 78% nitrogen, 21% oxygen, 0.9% argon, 0.04% carbon dioxide and negligible amounts of some other gases, apart from varying proportions of water vapour. However, pollutants such as carbon monoxide, sulphur oxides, nitrogen oxides, ozone, particulate matter and lead spoil the quality of air, rendering it unhealthy and making it a source of multiple diseases.

Anthropogenic pollutants come in the air as a result of burning fossil fuel, manufacturing processes, burning of waste, smoke and soot from vehicular exhaust etc. Certain natural causes such as volcano eruptions also pollute the air by emitting copious amounts of sulphur, dust and gases such as carbon dioxide, carbon monoxide, hydrogen sulphide, sulphur dioxide and hydrochloric acid. Weather patterns can transfer pollutants, both human-made and natural, over long distances and across regions.

Air pollution emerges as a problem at two levels –

- Ambient or outdoor air pollution
- Indoor air pollution

Ambient air pollution

Ambient air pollution is a problem of gigantic proportions, afflicting the health of billions.

Asian countries like China and India have consistently shown poor to very poor air quality in the last few years.

In some cities in Asia, air quality has become 20 times worse than the WHO guidelines.

Indoor pollution

Burning of solid fuels for household cooking, heating and lighting is a major cause of household or indoor air pollution. Indoor air pollution puts nearly 3 billion people worldwide at risk of ill health and early death. Indoor pollutants include particulate matter (PM10 and PM2.5), mould, dust mites and bacteria, as well as chemicals and Volatile Organic Compounds (such as formaldehyde and benzene) from paints, personal care products and building materials.

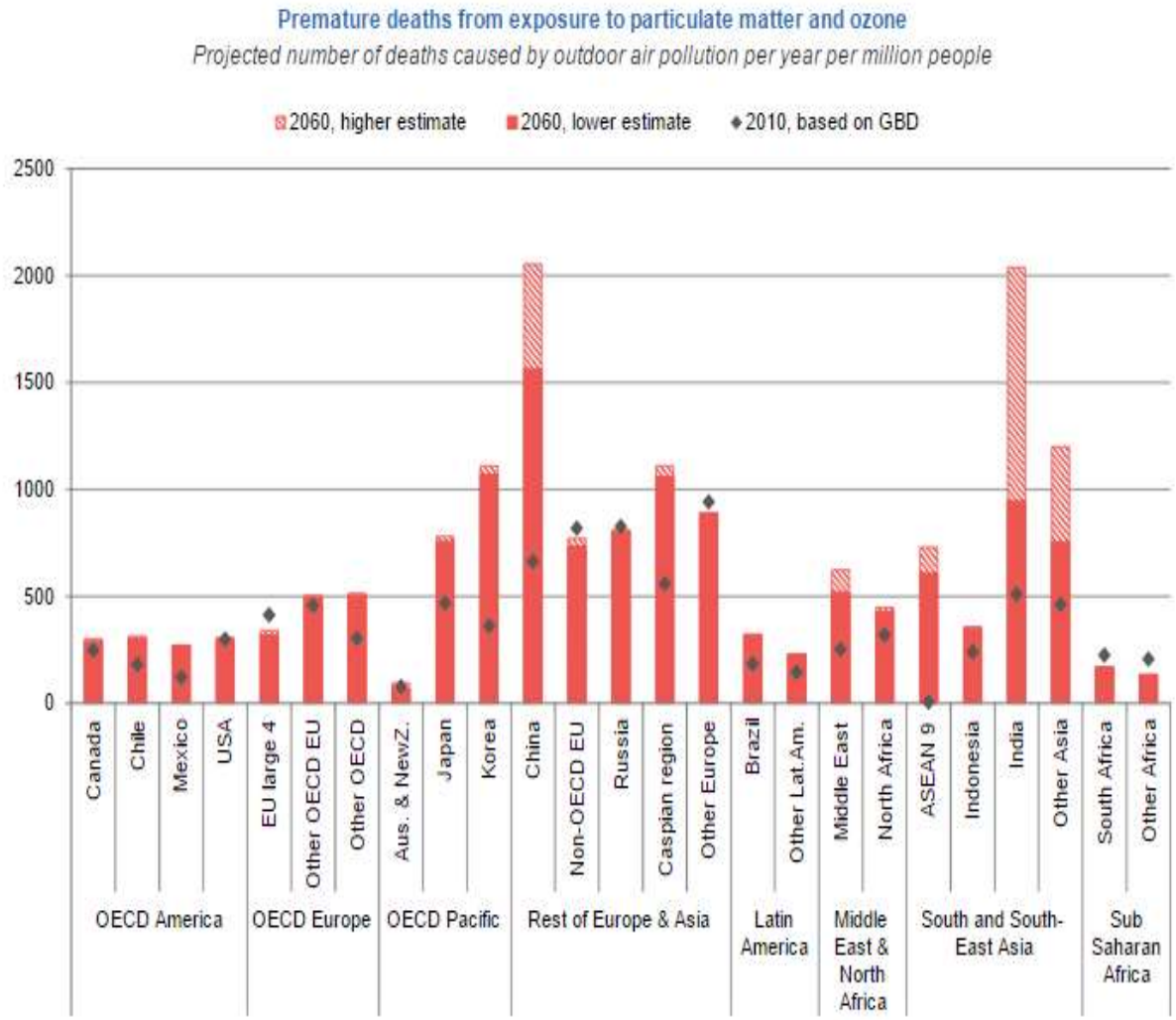


Fig.4.1: Premature Deaths from Exposure to Particulate Matter and Ozone
(Source: https://www.weforum.org/agenda/2016/08/air-pollution-deaths-oecd/)

As per some findings, indoor pollution is a bigger risk for infants and children than ambient air pollution, especially in the countries of Africa and Asia. In as many as 18 out of the 19 countries where the use of solid fuel for cooking is common, are in sub-Saharan Africa. At equal risk is the Indian population where more than 60% of the population cooks using solid fuels – as many as 100,000 child deaths were associated with indoor air pollution in 2012.

In the year 2012, air pollution was found to be the cause of 1 out of every 8 deaths around the globe – this translated into around 7 million people. As many as 600,000 of these fatalities were children under 5 years old. As per another report, more than half of pneumonia-related deaths of children per year are attrihuted to air pollution.
(https://www.unicef.org/publications/files/UNICEF_Clear_the_Air_for_Children_30_Oct_2016.pdf)

Table 4.1: Sources of Air Pollution

Type of Pollutant	Detail
Particular Matter$_{10}$	PM_{10} is rather tiny, only about one-seventh the diameter of a normal human hair. Dust is a major component of PM_{10} though it also consists of soot, sulphate, nitrates, ammonia, sodium chloride etc.
Particular Matter$_{2.5}$	$PM_{2.5}$ is more dangerous than PM_{10} due to its smaller size (about 1/30th the average width of a human hair) causing it to penetrate deeper into the lung tissue and even the bloodstream. $PM_{2.5}$ is attributed to fossil fuel combustion, vehicular exhaust, manufacturing processes and emissions from power plants. Dust and volcanic activity are natural sources of $PM_{2.5}$.
Ozone (O_3)	Ozone is formed as a result of photolysis of oxygen and the subsequent combination of a free oxygen atom with an oxygen molecule. Ozone causes lung inflammation, chest ache, breath shortness, coughing-wheezing, and complications in pneumonia and asthma.
Nitrogen oxides (NOx)	Fossil fuel combustion leads to emission of various oxides of nitrogen referred to as NOx. Areas near vehicular exhaust, industrial emission or cooking area show high NOx concentrations. NOx causes lung function reduction and complications in pneumonia, asthma, and bronchitis.
Polycyclic aromatic hydrocarbons (PAHs)	They are produced when burning of fossil fuels is incomplete, and often associated with diesel engines and black carbon. Prenatal exposure to PAHs has been shown to increase the risk of infection, coughing, breathing difficulties and 'nasal symptoms' in infants.
Sulphur dioxide (SO_2)	It is a colourless gas with a very sharp odour. It is formed when sulphur-based coal and oil is burned, or during the smelting of mineral ores that contain sulphur. SO_2 ails the respiratory system, and leads to coughing and copious mucus secretion. It also aggravates asthma and chronic bronchitis.
Carbon monoxide (CO)	This highly toxic, colourless, odourless gas produced due to combustion of carbon in the presence of less-than-required quantity of oxygen is a potent air pollutant
Volatile organic compounds (VOCs)	They are emitted as gases from certain solids or liquids contained in a number of indoor sources varying from paints to cosmetics, dry cleaning fluids, and automotive products
Ammonia (NH_3)	It is a naturally occurring substance characterised as a colourless alkaline gas with pungent smell. It is hazardous in concentrated forms.

(Source:https://www.unicef.org/publications/files/UNICEF_Clear_the_Air_for_Children_30_Oct_2016.pdf)

Air Pollution- Case Study

A large number of studies in Delhi have examined the effect of air pollution on respiratory functions and the associated morbidity. The most comprehensive study among them was the one conducted by the Central Pollution Control Board in 2008, which identified significant associations with all relevant adverse health outcomes. The findings were compared with a rural control population in

West Bengal. It was found that Delhi had 1.7-times higher prevalence of respiratory symptoms (in the past 3 months) compared with rural controls (P< 0.001); the odds ratio of upper respiratory symptoms in the past 3 months in Delhi was 1.59 (95% CI 1.32-1.91) and for lower respiratory symptoms (dry cough, wheeze, breathlessness, chest discomfort) was 1.67 (95% CI 1.32-1.93). (Rizwan S. et al,2013)

Fig.4.2: Air Pollution – Delhi

Water Pollution

Water resources in most developing countries are being polluted beyond their capacity to sustain traditional uses because of high population growth rates. Increasing urbanisation and industrialisation have exacerbated the situation by creating very large point sources of pollution. Water pollution is can be categorised into two parts, i.e., point source pollution and non-point source pollution, characteristics of point and non-point source pollution is given in table below.

Table 4.2: Characteristics of Water Pollution

Point Sources	Nonpoint Sources
• Wastewater effluent (municipal and industrial) • Runoff and leachate from waste disposal sites • Runoff and infiltration from animal feedlots • Runoff from mines, oil fields, unsewered industrial sites • Storm sewer outfalls from cities with a population >100,000 • Overflows of combined storm and sanitary sewers • Runoff from construction sites >2 ha	• Runoff from agriculture (including return flow from irrigated agriculture) • Runoff from pasture and range • Urban runoff unsewered and sewered areas with a population <100,000 • Septic tank leachate and runoff from failed septic systems • Runoff from construction sites • Runoff from abandoned mines • Atmospheric deposition over a water surface • Activities on land that generate contaminants, such as logging, wetland conversion, construction, and development of land or waterways.

(Source: Singh et al, 2017)

Major cities and villages are the sources of domestic effluent and sewage, while industrial effluent emerges from the manufacturing areas on the outskirts of cities. Agricultural waste rich in fertilisers and pesticides enters water bodies from non-point sources.

Various sources of pollution are given in the table below.

Table4.3: Sources of Water Pollution

Source	Description
Pesticides and fertilisers	These chemicals are obtained largely from various non-point sources of agricultural run-off from rural fields, and to a much lesser extent, from urban gardens where urea, potash, sulpha and other such chemical fertilisers are applied to encourage the growth of agricultural and ornamental species, respectively.
Oil, gasoline and additive	Oil spills, leakage of oil, fuel and fluid from vehicles or from the fuel station filling point, and from industrial areas introduce the element of oil & grease to polluted waters
Mining	Mine tailings, or the waste obtained from mining excavations are often rich in harmful pollutants earlier locked away inside the bowels of the earth but now exposed to the leaching caused by rainfall, due to which they enter the nearby surface water
Chemical and industrial processes	Industrial processes are of particular importance, given that they release waste particularly rich in recalcitrant or difficult to degrade compounds; although industries are supposed to be under strict control of the respective Pollution Control Board and cannot wilfully discharge untreated waste, unfortunate accidents and unsuitable/ill-maintained treatment plants contribute to the challenge
Sewage	As per Central Pollution Control Board's 2015-16 annual report on solid waste generation in the country, 1,35,198 tons per day (TPD) municipal solid waste is generated, of which a mere 25,572 (TPD) is treated.
Leachate	Leachate from unlined dumping grounds is a particularly difficult to treat effluent that can seep into the layers of the soil and pollute the groundwater reserves

To Do Activity
Visit to a nearby water body and make a note of sources of pollution and propose mitigation measures for the same.

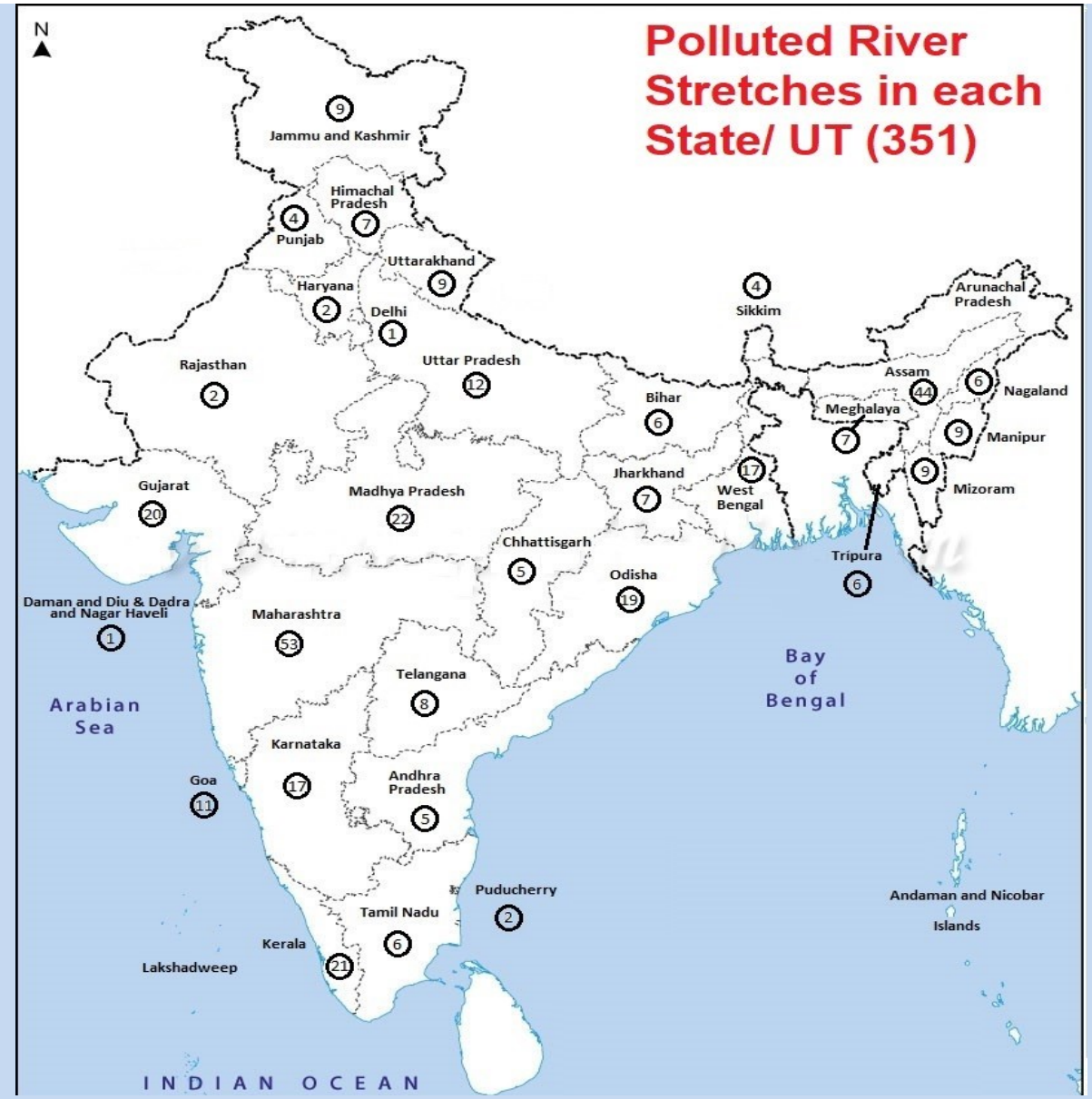


Fig.4.3: Polluted River Stretches in each State/ Union Territory

(Source: CPCB, 2018)

The Polluted Yamuna River- A Case Study

The Yamuna, which is one of the most critical tributaries of the Ganges and a significant river of North India, has earned the dubious credential of being one of the most polluted rivers of India. With agricultural pollutants such as pesticides and fertilisers from Haryana and sewage and industrial effluents from Delhi and Uttar Pradesh, Yamuna is fairly choking with pollutants. As per a report, 19 storm water drains (carrying sewage) and 22, 42 and 17 large industrial units in Haryana, Delhi and Uttar Pradesh, respectively, apart from numerous non-point sources of agricultural effluent and sewage drain into Yamuna. Hence, Delhi region is the biggest contributor of pollution in Yamuna.

Land Pollution

The degradation of land surfaces are caused directly or indirectly by human (anthropogenic) activities. It is possible to mention several reasons temporally or permanently changing the land structure and so causing land pollution. However, three main reasons are generally identified as industrialisation, overpopulation, and urbanisation, and the others are counted as the reasons

stemming from these main reasons. Some of them are as follows: improper waste disposal (agricultural/domestic/industrial/solid/radioactive waste) littering; mining polluting the land through removing the topsoil which forms the fertile layer of soil, or leaving behind waste products and the chemicals used for the process; misuse of land (deforestation, land conversion, desertification); soil pollution (pollution on the topmost layer of the land); soil erosion (loss of the upper (the most fertile) layer of the soil); and the chemicals (pesticides, insecticides, and fertilisers) applied for crop enhancement on the lands.

Land pollution may be described as the deposition of solid or liquid waste on the surface of land or below ground such that it contaminates the soil and groundwater. The degradation of land surfaces are caused directly or indirectly by human (anthropogenic) activities. It is possible to mention several reasons temporally or permanently changing the land structure and so causing land pollution. However, three main reasons are generally identified as industrialisation, overpopulation, and urbanisation, and the others are counted as the reasons stemming from these main reasons. Some of them are as follows: improper waste disposal (agricultural/domestic/industrial/solid/radioactive waste) littering; mining polluting the land through removing the topsoil, which forms the fertile layer of soil, or leaving behind waste products and the chemicals used for the process; misuse of land (deforestation, land conversion, desertification); soil pollution (pollution on the topmost layer of the land); soil erosion (loss of the upper (the most fertile) layer of the soil); and the chemicals (pesticides, insecticides, and fertilisers) applied for crop enhancement on the lands.

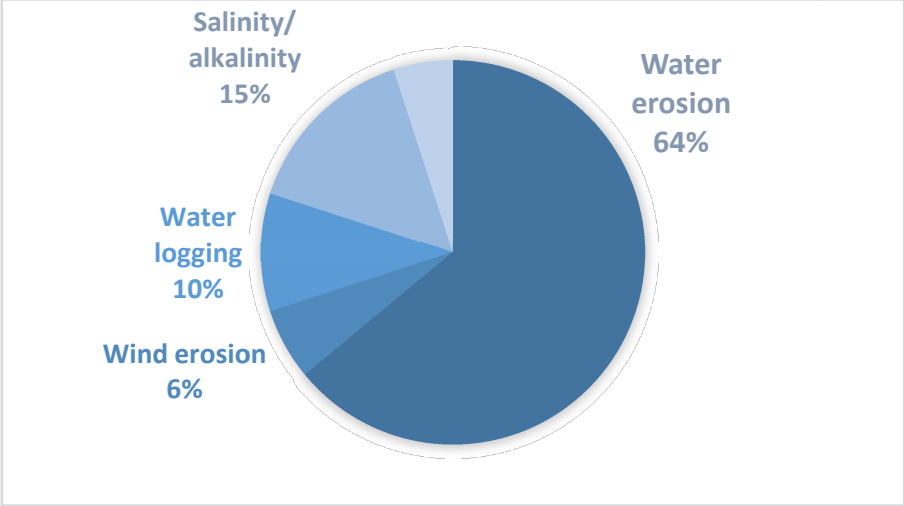


Fig.4.4: Causes of Land Degradation

(Source: https://link.springer.com/chapter/10.1007/978-3-319-19168-3_15)

Light Pollution

Artificial outdoor lighting that can interfere with the vital life processes of other species occurring during the night can be termed as Light Pollution. Even minimal lighting is capable of disrupting nocturnal natural activities - whereas human activities involve immensely wasteful artificial lighting during gala events, at tourist places and city hotspots. Lights emitted from artificial sources undergo secondary reflection due to the moisture and pollutants in the atmosphere, forming sky glow. Sky glow is visible from a long distance and has harmful impacts on natural processes.

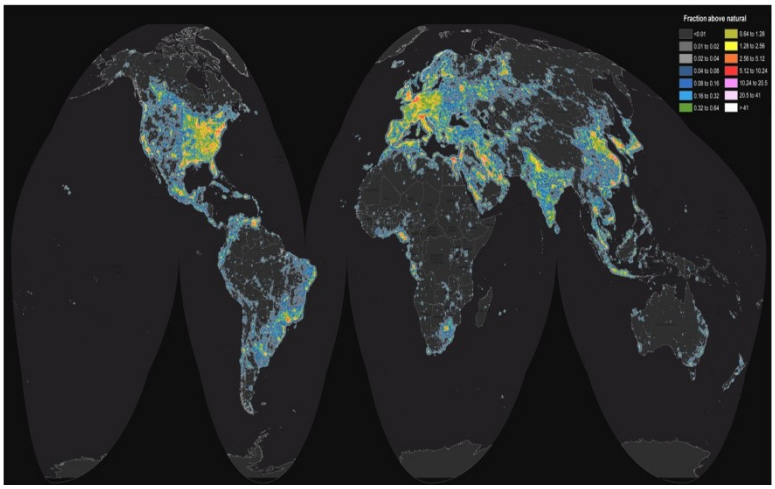


Fig.4.5: Wold's Light Pollution Map
(Source: Falchi et al, 2016)

Impact of light pollution on turtles- Case Study
Marine turtle conservation is heavily impacted by light pollution, gravid turtle females are guided to the coastline by moonlight. A study conducted by Kamrowski in 2012, it was found that more than a third of nesting WA logger heads and 43.9% of the eastern Australian loggerheads were potentially exposed to light pollution. Also, through a study conducted by Wildlife Institute of India in, it was found that the probability of hatchling disorientation was found to be highest at the location closest to the lighthouse though this was only about 18%. It was also observed that hatchling disorientation declined with increasing distance from the lighthouse, and beyond the 500 m location it was relatively negligible.

To Do Activity
Make a detailed study of how light pollution impacts mammals

Noise Pollution
Noise can be described as a loud or unpleasant sound causing disturbance. When the level of this disturbing sound reaches levels that it begins to impact human well-being or interferes with the vital activities like mating or feeding of other species, it is termed as noise pollution. Unfortunately, most of the pollution mitigation efforts are directed at air, water or land pollution and little attention is paid to noise pollution. With ever-rising population, increasing urbanisation, enhanced road, rai and air transportation and more and more use of machines in our lives, noise pollution is on a continual rise. Health impairments caused by noise are immense, ranging from interference with communication, sleep and concentration loss, headache and psychological disorders.
Ambient Air Quality Standards with respect to noise is given in **Table 4.4**

Table 4.4: Ambient Air Quality Standards for Noise

Category of Area/ Zone	Limit in dB(A) Leq*	
	Day Time	Night Time
Industrial Area	75	70
Commercial Area	65	55
Residential Area	55	45
Silent zone	50	40

(Source: CPCB,2000)

As per a 2011 study conducted by the Centre of Science and Environment (CSE), New Delhi emerged as the loudest city in India. Noise levels more than 100 decibels were reported, which is much higher than the prescribed limits.

To Do Activity
Map all the noise pollution locations in your surrounding area and their peak time. Also, mention the sources and reason for pollution.

Nuclear Pollution

Nuclear pollution may be described as the release of radioactive elements or radiations into the biosphere. Nuclear pollution can be caused in areas where ores of radioactive elements are naturally found, due to accidental discharge of radioactive material from nuclear power plants or industries using radioactive isotopes, or due to wilful usage/disposal. The sources of nuclear pollution have been described in detail in the **Table 4.5** below.

Radioactive waste can be found in materials such as Uranium ore tailings, spent fuel rod, radioactivity infected items

Table 4.5: Sources of Nuclear Pollution

Source	Description
Accidents in atomic energy plants and industries using radioactive isotopes	Being a highly potent source of energy, several atomic energy plants have been set up – even in developing countries like India. Also, certain industrial procedures rely on radioactive isotope usage. However, the strict requirement of safety concerns and the high risk associated with leakage/malfunction make this extremely high risk operation in highly populated developing nations.
Nuclear warfare	The victims of Hiroshima and Nagasaki stand as mute victims of the devastation that can be caused by the use of nuclear bombs as weapons of mass destruction; instantaneous deaths apart, these bombings afflicted children, unborn foetuses and generations to come.
Mining	Uranium, thorium, plutonium, radon, potassium, carbon and phosphorus are highly radioactive (or have radioactive isotopes). They are mined from regions where they naturally occur – however, villagers living in areas nearby these mines suffer immensely from the negative impact of these harmful radiations. The case study of Jadugoda village in Jharkhand, which has uranium reserves, can be followed to understand the ill-effects associated with radioactive ore mining.
Spillage/Disposal of radioactive chemicals	Rampant disposal of radioactive waste in the oceans by the developed countries during the world war and cold war period has released several radioactive isotopes in the marine environment – and thought the sea has immense capacity to dilute radioactivity, the isotopes may have moved up in the food chain

Following **Table 4.6** gives few examples of nuclear accidents

Table 4.6: Examples of few Nuclear Accidents

Date	Location	Reason
4th May, 1987	Kalpakkam, India	A refuelling accident at the Fast Breeder Test Reactor at Kalpakkam involved the rupturing of the reactor core, causing the plant to shut down for a couple of years
10th September 1989	Tarapur, Maharashtra	Radioactive ioding leakage at more than 700 times the prescribed limit was observed at the Tarapur Atomic Power Station. It took more than a year to repair the reactor
13th May 1992	Tarapur, Maharashtra	The Tarapur Atomic Power Station released 12 curies of radioactivity because of a faulty tube
31st March 1993	Bulandshahr, Uttar Pradesh	The Narora Atomic Power Station almost faced a risk of meltdown because of two fire incidents at its steam turbine blades, which damaged the heavy water reactor
2nd February 1995	Kota, India	The Rajasthan Atomic Power Station leaked radioactive helium and heavy water into the RanaPratapSagar River, necessitating a two-year shut down for repairs
22nd October 2002	Kalpakkam, India	Almost 100 kg radioactive sodium at a fast breeder reactor leaks into a purification cabin, ruining a number of valves and operating systems

To Do Activity
Visit to a nearby factory and on basis of its production process make a detailed study on type of pollutants related and their management.

4.2 Pollution Monitoring

Environmental monitoring is the process of assessing and quantifying the various parameters of environmental quality for the multiple purposes of:

- Identifying the baseline status

- As a part of Environment Impact Assessment (EIA) studies
- Research & development in the field of environment pollution treatment; confirming the success of the pollution control measures
- Risk assessment and to create environmental regulations
- Help in taking informed decisions about potential public health risks and corrective actions
- Co-relating with a suspected source of contamination
- Estimate the changes in levels of the pollutants in the environment if historic data is available.

Environmental monitoring must aim at protecting the public and the environment from toxic contaminants and pathogens. Environmental monitoring must encompass the measurement of all the different biotic and abiotic components of the environment. Hence, it requires a team of multi-skilled experts, ranging from ecology and biodiversity surveys to solid waste audits and air and water monitoring. Environmental monitoring data is a critical part of Environment Impact Assessment (EIA) studies. As per the Environment Impact Assessment Notification, 2006, baseline environmental data, and post project environmental audit are mandatory.

Typical environmental monitoring steps are given in **Figure 4.6.**

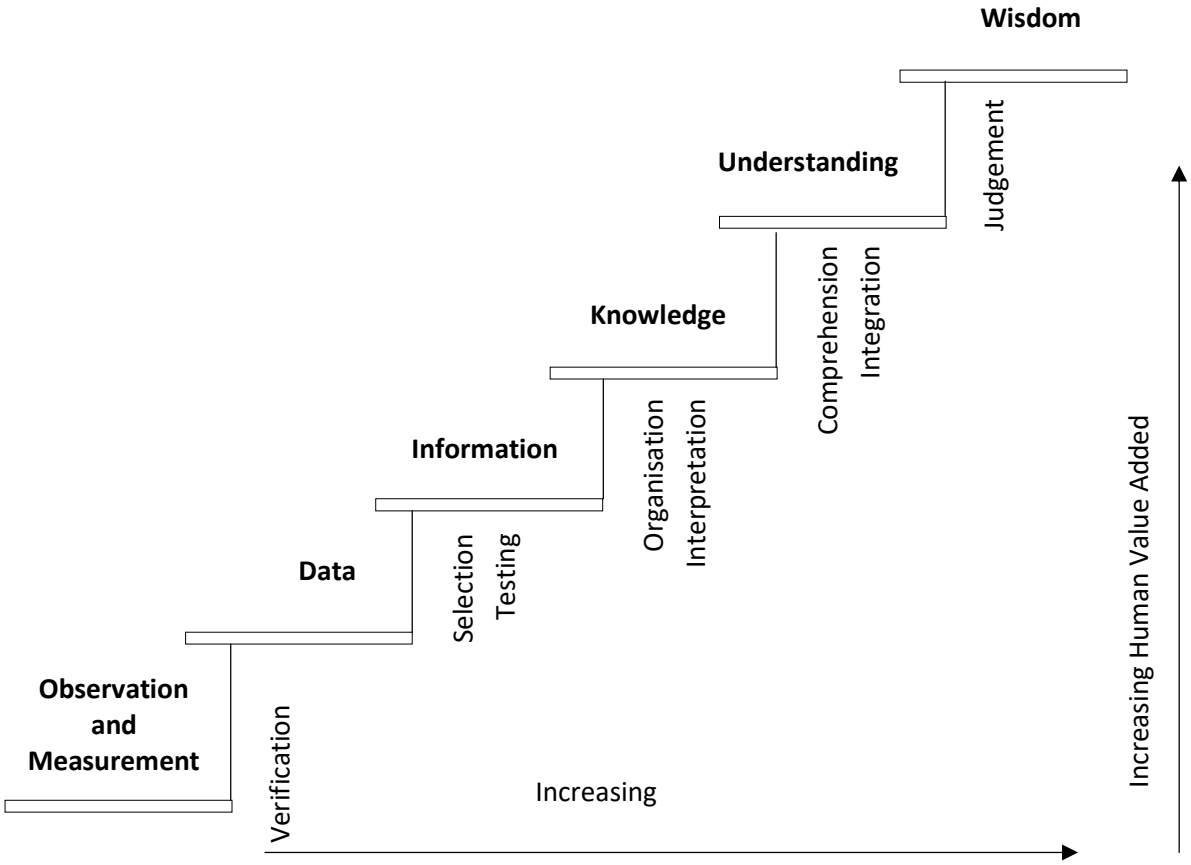


Fig.4.6: Stages in Environmental Monitoring

Selection of parameters of the environment to monitor must ensure the existence of national and international standards against which the findings can be compared. Methods used for environmental monitoring must adhere to national and international standards.

It must be understood that environmental monitoring is an expensive affair and involves critical aspects such as travel to and fro the site, sampling gear, laboratory charges, and skilled manpower. Hence, environmental monitoring exercises must be well-planned and in accordance with the set goals and practices.

Purposes of Environmental Monitoring

Baseline monitoring

It is the measurement of environmental parameters during a period before a particular source of pollution begins to impact – in other words, baseline monitoring aims at establishing pre-project environmental conditions. Baseline data, therefore, helps set reference points against which future changes – be it for the better or the worse – can be measured. Hence, baseline monitoring is the assessment of the possible (additional available) assimilative capacity of the environmental components during the pre-project period with respect to the standard or target level.

Effects monitoring

This is the monitoring of the environmental parameters during the execution stage of the project.

This helps serve three purposes –

a) To confirm the predictive accuracy of the pre-project reports
b) To prevent environmental damage during project execution by checking one's actions at the right time
c) To tweak the pre-formulated mitigation program if required

Compliance Monitoring

Compliance monitoring is the environmental monitoring undertaken for regulatory purposes, to confirm to the concerned authorities that a project or a manufacturing process is going as per pro-environment norms. The compliance monitoring is undertaken according to a pre-decided monitoring program.

Tools and Techniques in Environmental Monitoring

Baseline Data Collection

The overall purpose of a baseline is to measure key conditions (indicators) before a project begins, which can then be used to monitor and evaluate the project's progress. Baseline data for various environmental parameters is given in Table 4.7.

Table 4.7: Baseline Data for Environmental Monitoring

Sr. No.	Parameter	Details
1	Climatic variables	• Rainfall patterns – mean, mode, seasonality. Temperature patterns. • Extreme events. • Climate change projections. • Prevailing wind - direction, speed, anomalies. Relative humidity. • Stability conditions and mixing height, etc.
2	Topography	• Slope form. • Landform and terrain analysis. • Specific landform types, etc.
3	Drainage	• Surface hydrology. • Natural drainage pattern and network. • Rainfall runoff relationships. • Hydrogeology. • Groundwater characteristics – springs, etc.
4	Soil	• Type and characteristics. • Porosity and permeability. • Sub-soil permeability. • Run-off rate. • Infiltration capacity. • Effective depth (inches/centimetres). • Inherent fertility. • Suitability for method of sewage disposal, etc.
5	Geology	• Underlying rock type, texture. • Surgical material. • Geologic structures (faults, shear zones, etc.). • Geologic resources (minerals, etc.) , etc.
6	Water	• Raw water availability. • Water quality. Surface water (rivers, lakes, ponds, gullies) – quality, water depths, flooding areas, etc. • Ground water – water table, local aquifer storage capacity, specific yield, specific retention, water level depths and fluctuations, etc. • Coastal. • Floodplains. • Wastewater discharges. • Thermal discharges. • Waste discharges, etc.
7	Air	• Ambient. • Respirable. • Airshed importance. • Odour levels, etc.

Sr. No.	Parameter	Details
8	Noise	• Identifying sources of noise • Noise due to traffic/transportation of vehicles • Noise due to heavy equipment operations • Duration and variations in noise over time, etc.
9	Coastal dynamics and morphology	• Wave patterns • Currents • Shoreline morphology – near shore, foreshore • Sediment – characteristics and transport, etc.
10	Biological	• Species composition of flora and fauna • Flora – type, density, exploitation, etc. • Fauna – distribution, abundance, rarity, migratory, species diversity, habitat requirements, habitat resilience, economic significance, commercial value, etc. • Fisheries – migratory species, species with commercial/ recreational value, etc.
11	Land use	• Land use pattern, etc.

Note: parameters may change depending upon purpose of the monitoring exercise

Factors Considered for Environmental Monitoring

Type of Sampling: Grab and Composite Sampling

A Grab sample is a sample collected once within a given time-frame; it is collected in a short time-span and hence, yields quicker results. In contrast, a composite sample is an amalgamation of several discrete grab samples collected at a pre-determined frequency within a given time-frame, for instance, once every two hours within a 24-hour period.

While a grab sample is simple, cost-effective and quicker, it may not yield a representative sample if the population is heterogeneous, and the sampling frequency will have to be enhanced to ensure *statistically-credible sampling.*

Sampling equipment used

The sampling equipment to be used will be decided on the following criteria –

- Physical state of the hazardous waste (solid, liquid, semi-solid)
- Chemical nature of the hazardous waste (flammable, corrosive, reactive, toxic)
- How the hazardous waste has been stored (open pile, drum container, lagoon). Alternately, how accessible the site is

Important considerations are:

- No contamination

- No sample loss

No change in the physical or chemical characteristics or concentration of the sample in the period between sample collection and sample analysis

Sample Site Selection

This normally means that for designing a monitoring program in a study area which might have an impact, several monitoring stations are needed for characterizing the baseline conditions of the impacted area. When considering the location of individual samplers, it is essential that the data collected are representative for the location and type of area without the undue influence from the immediate surroundings. In any measurement point in the study area the total ambient concentration is the representative of:

- natural background concentration
- regional background
- impact of existing large regional sources such as industrial emissions and other power plants

To obtain the information about the importance of these different contributions it is, therefore, necessary to locate monitoring stations so that they are representative of different impacts. In addition to the ambient pollution data, one would often need other data governing the variations such as meteorological data for air pollution, to identify and quantify the sources contributing to the measurements. When considering the location of individual samplers, it is essential that the data collected are representative for the location and type of area without undue influence from the immediate surroundings.

Infrastructure

In addition to devising a monitoring network design and monitoring plans/program, it is also necessary to ensure adequate resources in terms of staffing and skills, equipment, training, budget, etc., for its implementation. Besides assigning institutional responsibility, reporting requirements, QA/QC plans and its enforcement capability are essential. A monitoring program that does not have an infrastructural support and QA/QC component will have little chance of success.

Magnitude of Activity

This is in direct proportion to the purpose of monitoring and the associated project costs.

Time and Frequency of monitoring

Time and frequency of monitoring is given in **Table 4.8**.

Table 4.8: Time and Frequency of Monitoring

Environmental Pollution/ Hazard	Environmental Performance Indicator (EPI)	Sampling Location	Monitoring Parameter	Period & Frequency
Resource Management				
Resource Requirements	Material Consumption	Site	Consumption rate	Monthly
	Total chemical Consumption	Site	Consumption rate	Monthly
	Water Consumption	Site	Consumption rate	Monthly
	Energy and Power	Site	Consumption rate	Monthly
	Fuel Consumption	Site	Consumption rate	Monthly
Liquid Effluent (Waste Water)				
Waste effluent	Quality effluent.	Inlet and outlet	pH, temp., COD, DO, TSS,TDS, Chloride	Daily
			MLSS,MLVSS, Colour,OG	Monthly
Ground Water				
Ground Water	Quality of bore well water	Bore wells	pH, TDS, TSS, Chloride, silica, sulphate, COD, Alkalinity	Once in a six month
Air				
Air Emissions	Gaseous Pollutant emission	All stacks	SPM, SO2 & NOX Visual observation	Monthly/ Whenever required
Ambient Air Quality	Ambient Air	Two location inside plant	PM10, SO2, NOx	Quarterly
Noise Emission	Noise Emissions from machineries &equipments	Near Sources	Noise Pressure Level in dB	Monthly
ETP sludge	Characterises	Waste storage area	As per consent of SPCB	Quarterly
	Quantity		Disposal quantity	Monthly
Soil				
Soil	Quality	Around premises	pH, permeability, conductivity & CEC	Yearly

To Do Activity
Prepare an environmental monitoring plan for a commercial and industrial area.

Reporting
It is the chronological documentation of paper trail, which is maintained to ensure the sequence of collection, transport, processing, treatment and disposal of hazardous waste.

A crucial aspect of chain of custody is sample labelling, which must be

- Legibly written or printed
- Gummed using adequate adhesive/tied securely
- Contain accurate description of the sample number, date, time & location of sample collection, and finally, name of the personnel who did the collection

The logbook or notebook used by the sampling personnel during sample collection should be further rich in information, including

- Purpose of sampling
- Number and volume of samples
- Details of sampling point location (as from the label, such information cannot be obtained in much detail), including its brief description
- Name and contact details of the field contact
- Name and contact details of the waste producer
- Sampling and sample preservation methodology
- If possible, some details of the process producing the waste to be sampled
- Physical state of the waste
- If possible, the estimated waste composition
- Sample number key (so that the sample number mentioned on the label can be further correlated with other factors)
- General field observations (if anything worthy of note)

The logbook must also contain name and signature of the field

A second document that needs to be prepared is a Sample Analysis Request Sheet, which the sampling personnel fills to provide the laboratory personnel with necessary field information such as sample description, sample identification and the requested analysis.

From the field, post collection, the sample should reach the laboratory for analysis. If the transport of the sample is not being managed by the same personnel who did the sample collection, the next link in the chain of custody becomes the personnel who will transport the waste to the laboratory.

Handing over the samples and the sample analysis request sheet to the laboratory is the next link in the chain of custody. Here, the necessary data that must go on record includes:

- Name and designation of the laboratory personnel receiving the sample
- Laboratory Sample Number
- Date and time of sample receipt
- Sample allocation
- Analyses to be conducted

The hierarchy of reporting differs from project to project and must be pre-decided.

Standard Protocols and Monitoring Instruments
Each aspect of environmental monitoring is diverse, and with every parameter the standard protocol and associated equipment differ.

Also, for certain parameters, standard protocols have been set and accord no confusion (for instance, APHA guidelines for water monitoring), whereas for other parameters there may be plenty of flexibility in deciding the methods on field (for instance, for ecology & biodiversity, field conditions help finalise the methods selected).

Table 4.9: Protocols for Monitoring

Sr. No	Components	Parameter	Instrument	
1	Ambient Air Quality	• PM_{10} • $PM_{2.5}$ • SO_2 • NO_X	• Gas sampler • Dust Sampler	 Aimbient Air monitoring Setup
2	Water Quality	• pH value • Colour • Odour • Turbidity • Conductivity • Calcium(as Ca) • Magnesium (as Mg) • Sodium (as Na) • Potassium (K) • Total Hardness as $CaCO_3$ • Alkalinity (as Ca CO_3) • Nitrate (NO_3) • Chloride (as Cl) • Sulphate (as SO_4) • Orthophosphate (H_3PO_4) • Chromium (Cr) • Lead (as Pb) • Cadmium (as Cd) • Copper (as Cu) • Total dissolve solid (TDS) • Total suspended solid (TSS) • BOD • COD • Total Coliform E. coli	• pH Meter • Conductivity Meter • Spectrophotmeter • Atomic absorption Sprectroscopy • Titrimetric Appartus	 Atomic Absorption Spectrophotometer  Spectrophotometer

Sr. No	Components	Parameter	Instrument	
3	Soil	• pH value • Conductivity • Soil Texture • Colour • Water Holding Capacity • Bulk Density • Chloride as (Cl) • Calcium(as Ca) • Sodium (as Na) • Potassium (as K) • Organic Matter • Magnesium (as Mg) • Available Nitrogen (as N) • Available Phosphorus • Zinc (as Zn) • Manganese (as Mn) • Chromium (Cr) • Lead (as Pb) • Cadmium (as Cd) • Copper (as Cu)	• pH Meter • Conductivity Meter • Spectrophotmeter • Titrimetric Apparatus	 pH Meter  Titration

4.3 Pollution Control – Individual and Organisational Levels

Environment protection has been the most burning issue in the last half century. In order to tackle the pollution menace, urgent steps have to be taken at global, national, regional and most critically at the local level. The role of individuals in pollution control and prevention is of immense importance, because it is the individuals that form the backbone of a community or country. Effort by each individual at his or her level can have a significant effect that ultimately reflects on the global level.

Pollution Control at Individual Level

Aware and inspired individuals are the strongest tools to help tackle pollution. An aware individual not only reduces the burden on the government but also helps tackle the problem of pollution more effectively, being more familiar with problems persisting at the local level. Also, an individual is the best judge of how he or she can best reduce their carbon and water footprint. The most effective way to prevent pollution is by educating individuals. Individuals should be encouraged to modify their lifestyle and living habits if that are not healthy from the perspective of the environment.

Solid Waste Management

Disposal of garbage in landfills is a common practice in many countries around the world and it is done by burying it in the ground. Needless to say, this is an environmental hazard since most of the waste is non-biodegradable, that is, it can take thousands of years to disintegrate. Landfill leachate trickles into ground and pollutes the groundwater. This leads to concentration of waste in the landfill, ultimately degrading the land and water bodies. Landfills and incinerators release carbon dioxide, methane and other greenhouse gases that contribute to local and global air pollution.

The first step one can do to reduce waste is segregate it into different types of waste based on similar characteristics. A typical waste management technique is given in Fig. This techniques helps in recovery of resources and reduced burden on landfills where waste is ultimately disposed.

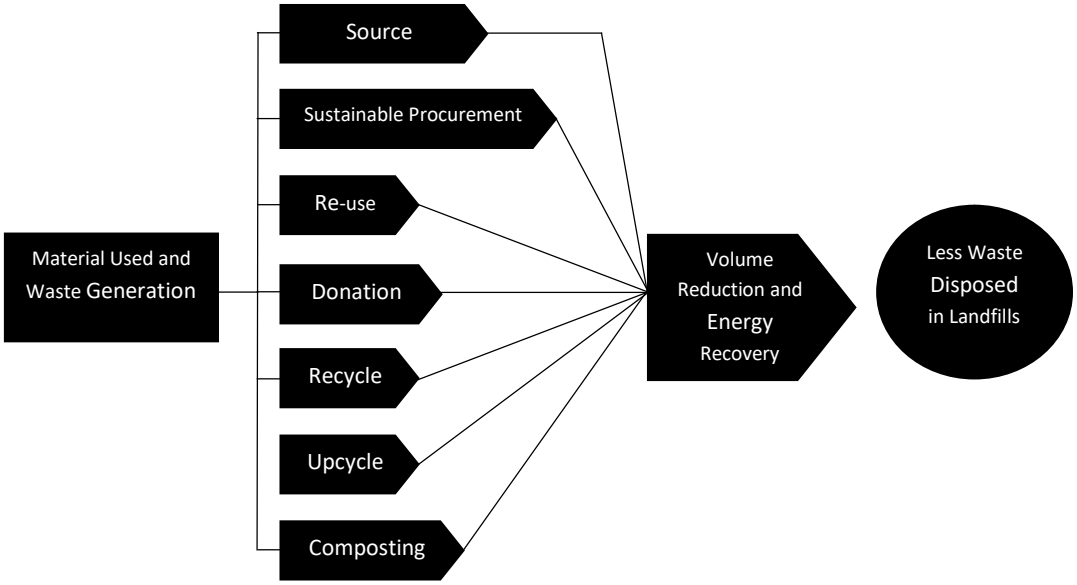


Fig.4.7: Waste Management Practices at Individual Level

E-waste belongs to hazardous waste category and hence has to be disposed separately and not with the municipal waste. In the event of careless e-waste disposal in landfills, these chemicals can seep into the ground water with disastrous effects.

Reduced Use of Toxin

Mercury, a bio accumulating toxin that affects the brain and neurological health, can be found in electrical switches, fluorescent bulbs, thermometers, thermostats and older batteries. Bioaccumulation is a process in which mercury, or any other persistent pollutant, accumulates in fatty tissues of animals and plants and increases in concentration as the food chain progresses. To prevent mercury pollution, choose mercury-free products, like digital thermometers, or use products that contain little mercury. Check with local waste management services about the best method for disposing of mercury-containing products.

Reduced Energy Consumption and Use of Clean Energy

Unplugging electronics when they are not in use and turning off unnecessary lights are examples of reducing energy consumption. Energy conservation does not require significant sacrifices. Purchasing energy-efficient and water-efficient appliances, electronics and plumbing devices reduces not only energy consumption but also your electric and water bills.

To Do Activity

Make a list of alternative that can be used to reduce solid waste generation at individual level.

Mindful Transportation

As the serious impact of vehicular pollution on environment has become a worldwide challenge for the researcher and scientists, various measures are being used at different levels to control it. To reduce the harmful impact of vehicular pollution on the environment the use of alternate fuels is considered to be a useful to a great extent.

Use of alternate fuel

At present Compressed Natural Gas (CNG) is used widely as an alternative to gasoline and diesel. CNG is a clean fuel for vehicles with remarkable potential to reduce fine particles from the vehicular emission. The use of CNG leads to reduction in emission of greenhouse gases by 12% than those from diesel engines. It has been also found that one CNG bus leads to reduction in emission equivalent to removal 85 to 94 cars from the road. Table highlights the percentage reduction in different pollution parameters due to use of CNG as an alternative fuels. (Kumar el al, 2014).

Table 4.10: Decrease in Level of Pollutant due to Use of CNG

Fuel	**Pollution Parameter**		
	CO	**NO_X**	**PM**
Diesel	2.4 gm/km	21gm/km	0.38 gm/km
CNG	0.4 gm/km	8.9 gm/km	0.012 gm/km
% Reduction	**84**	**58**	**97**

Use of Alternative source for travel

The congestion of traffic is also responsible for vehicular pollution. Generally, all big urban cities are crowded. So, any addition of the motor vehicle to the existing crowded area leads to increase in travel time for rest of the passengers and increase in traffic congestion results in decrement of the average speed of all vehicles below the eco- friendly speed leading to the rise in rate of emissions per kilometre. This can be avoided by using either public transport for travel or carpooling. C**arpooling** (also car-sharing, ride-sharing and lift-sharing) is the sharing of car journeys so that more than one person travels in a car, and prevents the need for others to have to drive to a location using different vehicle.

Use of Battery Operated Vehicles

The problem of pollution by vehicular emission is also being eliminating by using batteries and solar panels as the source of power in motor vehicles. In such vehicles the emission is zero. Solar panels fitted with photo voltaic cells are also being used according to the aerodynamic design of the vehicle.

Fig.4.8: Battery Operated Auto in Howrah, India

To Do Activity
Arrange "no-vehicle day" in your campus and calculate the amount of carbon footprint decreased.

Support Government Rules and Regulation
Support amendments, initiatives and laws that prevent pollution. Vote to encourage green infrastructure and low-impact development, improve waste reduction, decrease air pollution emissions and groundwater pollution, and limit pesticide use. Look for opportunities to support alternative energy sources. Local electric companies may offer wind or solar power alternatives.

Pollution Control at Organisational Level
The strong stance of regional and local governments provided the impetus for the development of environmental pollution control measures. Since environmental pollution is generally a localised phenomenon, pollution strategies at the local level are most important. In practice, however, controlling pollution proved difficult, because regional and local governments did not have the power to enforce pollution controls and because harsh penalties for exceeding the national government's lax regulation criteria was considered unlawful. (Source: https://www.researchgate.net/publication/236179607_Strategies_for_Prevention_and_Control_of_Air_Pollution_in_India)

Community-based Solid Waste Management
Community-based solid waste management is a complex process that requires inputs from the public, private formal and informal sectors, the community and civil society organisations. CBSWM is "a waste management system that recognises the community as the active role player in cleaning up their neighbourhoods and/or to earning an income from solid waste." The CBSWM approach is based on the principle of Kurt Lewin that states that "people are likely to modify their own behaviour when they participate in problem solving." Thus, CBSWM gives people control over their environment to participate, maintain and improve its aesthetic value. (Sinthumule et al, 2019).

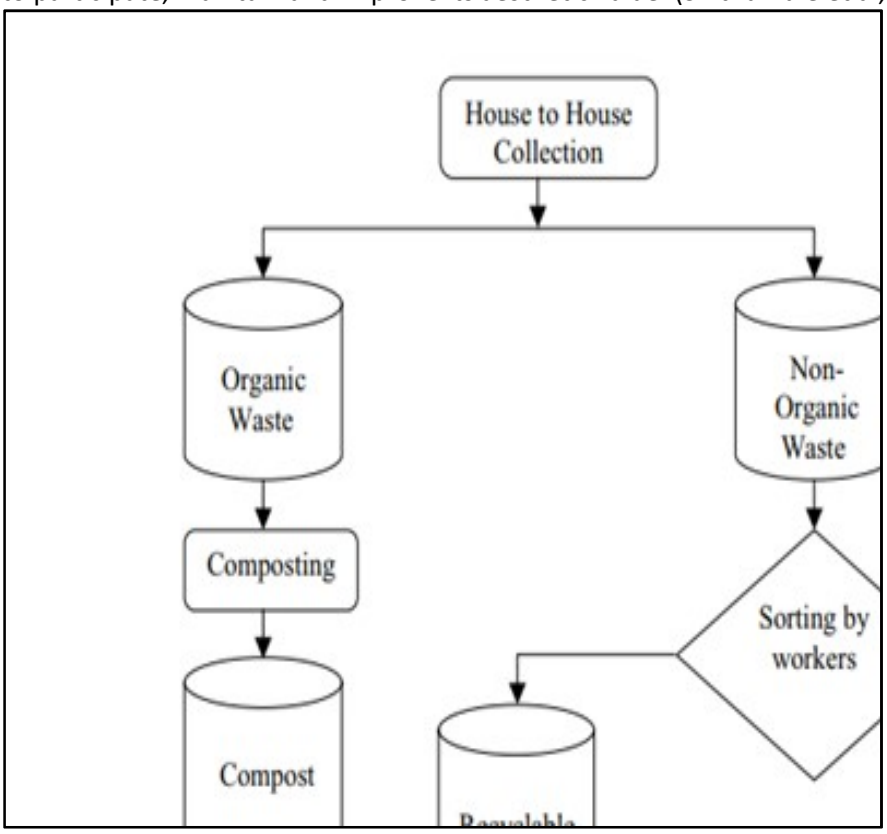


Fig.4.9: Optimal Waste Management Strategy at Community Level

Activities such as door-to-door collection will lead to efficient collection of waste; waste can be segregated at source and the wet waste generated can be used for composting. Community participation in waste management based on the principle of cooperation and partnership amongst Community Based Organisations (CBOs), Non-Governmental Organisations (NGOs) and the government body for managing civic services at the local level can help in waste management. A local committee can be established which will look after the smooth functioning of the system with respect to the planning and implementation. Rag pickers organised and trained by NGOs can collect waste and sort them out further; process biodegradable waste and sell the recyclable material. The government body can be approached for technical help in construction of composting pits in these areas In this scheme NGOs also play a very important role by organising rag pickers and giving them necessary training for collecting and composting waste (Rathi S., 2007).

To Do Activity
Set up a composting unit in your college. To understand the capacity of the unit make a study of the quantity of waste generated in the college.

Installation of Sewage Treatment Plant and Eco-friendly Septic Tanks
Waste water and solid waste can be managed through installation of S Eco-friendly septic tanks. Treated wastewater once released from the system can be further used for beneficial purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing, and replenishing a ground water basin.

The septic tank is the most common small-scale decentralised treatment unit for grey water and blackwater from cistern or pour-flush toilets. It is basically a sedimentation tank. Its shape can be rectangular or cylindrical.

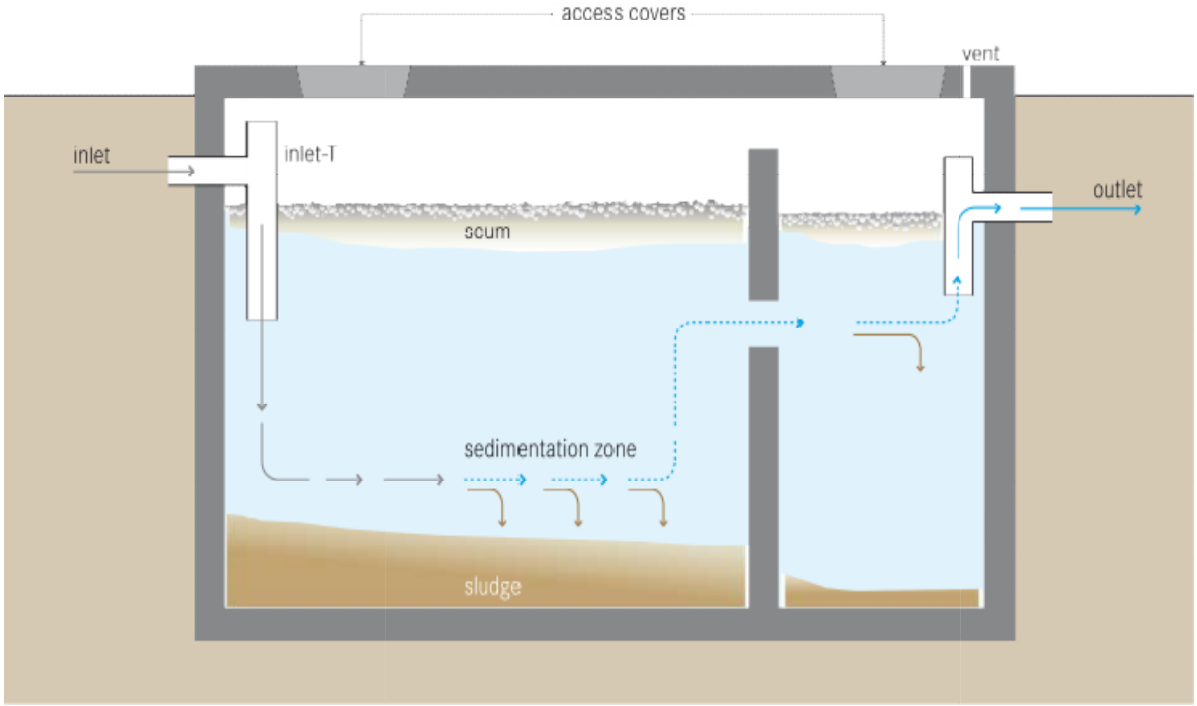


Fig.4.10: Schematic Representation of Septic Tank

Septic tanks are used for wastewater with a high content of settle able solids, typically for effluent from domestic sources, but they are also suitable for other wastewater of similar properties (SASSE 1998). Liquid flows through the tank and heavy particles sink to the bottom, while scum (mostly oil

and grease) floats to the top. Over time, the solids that settle to the bottom are degraded anaerobically. However, the rate of accumulation is faster than the rate of decomposition, and the accumulated sludge and scum must be periodically removed. The effluent of the septic tank must be dispersed by using a Soak Pit, evapo-transpiration mound or Leach Field, or transported to another treatment technology via a Solids-Free Sewer, simplified sewer or solids-free sewer. For secondary treatment e.g. surface flow, horizontal or vertical flow constructed wetlands) are suitable. Sludge must be emptied regularly (see also human-powered or motorised emptying) and treated for safe disposal or reuse. It can be dried in planted or unplanted drying beds, settling or thickening ponds. If the sludge is dried or composted, it can be applied in agriculture as valuable nutrient-rich soil amendment (see also application of pit humus and compost or application of sludge). There exist also several new processes to produce fertiliser from sludge.

Rain Water Harvesting

Over the years, it has been observed that the necessity for the exploitation of groundwater resources for various everyday needs, like toileting, bathing, cleaning, agriculture, and drinking water, industrial and ever-changing lifestyles with modernisation is leading towards tremendous water wastage. Also, storm water runoff is a major source of water pollution. As the runoff moves, it picks up and carries away pollutants such as sediment, chemicals and toxics and deposits them into nearby surface waters. In this context, adopting rainwater harvesting and recharging groundwater is one of the simplest and best measures in conserving water globally and avoiding its wastage. A typical rain water harvesting system is given in Fig. below. Such rain water harvesting can be done in housing societies and communities, business parks, etc. After collection, the water can be sourced for used.

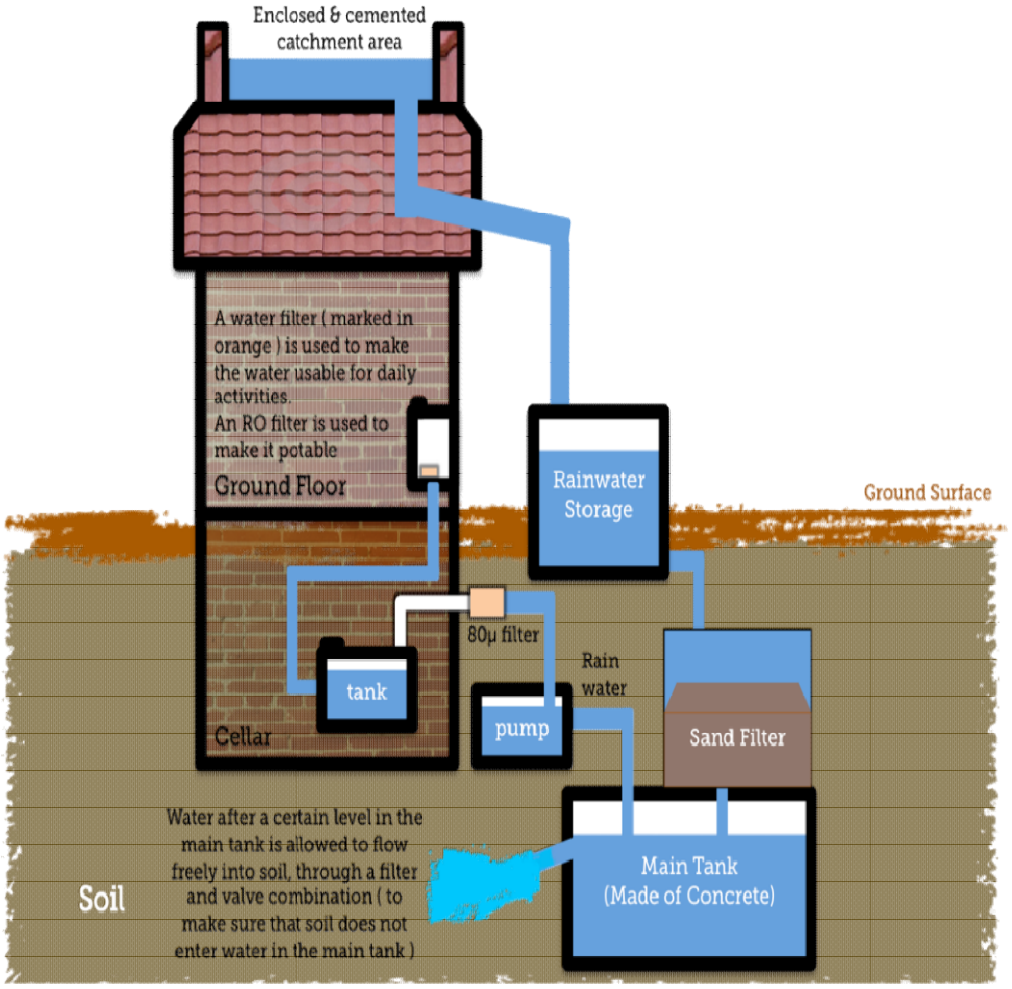


Fig.4.11: Rainwater Harvesting Technique

Use of Clean Energy Sources

Renewable sources of energy such as solar panels can used to reduce the release of greenhouse gases. When considering installing solar PV arrays, it is extremely important that robust and comprehensive data are available. This will allow users to produce detailed solar, energy demand and consumption profiles to design an optimal renewable energy system. Solar energy can also be used to source electricity to street lights.

The Shivshakti Society in a Mumbai suburb installed a rooftop solar system in May; the power generated takes care of 80% of its requirement. It has got a 9.135 kilowatt (kW) peak power rooftop solar system installed, which lights the lifts and the building's common areas. The building is home to 76 families. Spread across 1,100 square feet, the system consists of 29 solar panels that generate 14,600 kilowatt hour (kWh) solar energy as compared to 60,000 kWh, the annual electricity consumption of the society. The residents hope to save Rs 1.65 lakh in electricity bills annually.

(Source: https://www.hindustantimes.com/mumbai-news/ghatkopar-building-goes-solar-to-save-rs1-65-lakh-on-power-bills/story-5BgDSbQ6F6IOkeTDQIGjLO.html)

Fig.4.12 : Residents of Shivshakti Society and Rooftop Installed Solar Panel

Vegetation for Air Pollution Control

Filtration is an effective method for improving indoor air quality. Urban vegetation including green roofs or walls can decrease air pollution by slightly, particularly in highly polluted cities through deposition on leaf surfaces and reduced need for air conditioning due to the cooling effect provided by the soil layer and building shade. Vegetation along the side of a busy road can reduce air pollution behind the vegetative barrier by less than 40%, although results vary greatly by wind direction and study. Off-site, solid or vegetative noise barriers along highways can decrease the amount of air pollution reaching neighbourhoods. Native trees can be used for filtration of pollutants and maintain the overall air quality of the region. Such trees are said to have a high Air Pollution Tolerance Index (APTI). As per Singh et al. (1991), Air Pollution Tolerance Index (APTI) is an empirical relation which

evaluates the tolerance level of plant species towards air pollution from leaf biochemical parameters such as Leaf extract pH, relative water content of the leaf, ascorbic acid and total chlorophyll.
APTI= [A (T+P) + R] / 10. Where: A=Ascorbic acid content (mg/gm), T=Total chlorophyll (mg/gm), P=pH of the leaf extract, R=Relative water content of leaf (%).

Fig.4.13: Trees Surrounding a Locality- Barrier to the External Environment

Plants of tree habit have the tendency to absorb and dissipate sound energy and hence, act as buffer zone. Trees are planted along highways and other noisy places to mitigate the hazard of noise pollution. Certain trees are found very effective in reduction of noise pollution. *Polyalthialongifolia* of Annonaceae family is the best example of such type of tree species. The other suitable tree species are *Azadirachtaindica* (Meliaceae), *Tamarindusindicus* (Fabaceae), *Aeglemarmelos* (Rutaceae) etc.

4.4 Eco-restoration

Understanding the process

As per the Society for Ecological Restoration, the term ecological restoration may be defined as an "intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability".

Thus, an eco-restoration process would involve:

a) Data collection about the pristine environmental conditions and original habitat quality of the ecosystem
b) Assessment of existing environmental conditions
c) Understanding the reasons behind the deterioration of the environmental quality
d) Restoration of the habitat to its pristine conditions by avoidance/mitigation of the disturbances
e) Restoration of as many of the missing native species

Therefore, one of the most critical elements for successful eco-restoration would be the baseline date of the pristine ecosystem. Unfortunately, such data is very rarely available in a well-documented, peer-reviewed format and has to be sourced from:

- Social interactions with the oldest residents in the neighbourhood

- A study of ancient texts available for potential clues about the prevalent trees and wildlife species as well as air and water quality

An interesting example of this is the famous books 'Chandrakanta' and 'ChandrakantaSantati' penned by BabuDevkinandanKhatri, who roamed the dense jungles of Naugadh and Chakia in eastern Uttar Pradesh and the Gaya region of Bihar. In the course of his story, he mentions the main tree species present in the forests, and mentions the wild animals as well. Currently, the Chandraprabha Wildlife Sanctuary is the only remnant of the dense forests of the late 19th century. Also, in the course of the tale, the characters have been shown consuming water from the streams and rivers, and the air of certain valleys has been described as being pure enough to restore the health of the ailing.

However, the availability of such information can hardly be guaranteed for every area. In this case, to fix the reference parameters for the eco-restoration process, one has to scout the nearby area for the closest possible undisturbed ecosystem that can serve as a model. For instance, sacred groves have been protected with religious fervor in many parts of India and have been maintained virtually undisturbed for even centuries, where it is considered a taboo to cut the trees or destroy the ecosystem. Such sacred groves can serve as reference points for eco-restoration.
Hence, the process of eco-restoration can be summarised as:

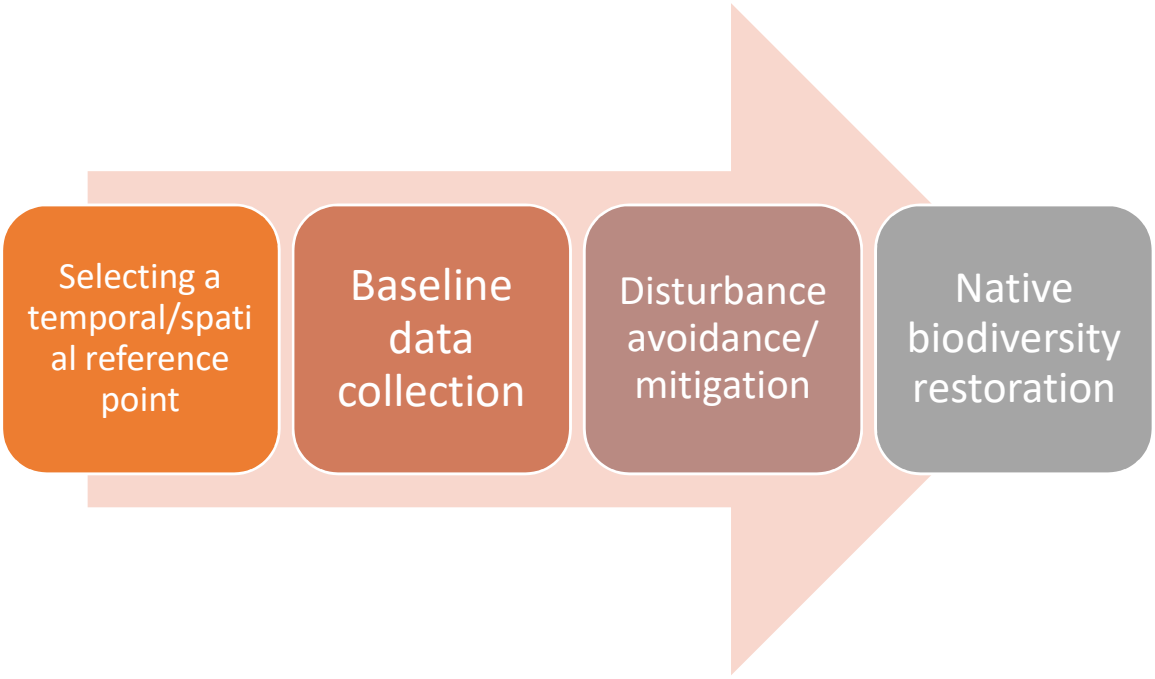


Fig.4.14: Outline of an Eco-restoration Process

1. Eco-restoration of a eutrophied Water Body

Lentic water bodies such as lakes and ponds, be it in the urban area or rural, are under severe anthropogenic stress. The most severe threats are:

- With haphazard built-up in the watershed area of the lake/pond, the natural input of water is interrupted and the water body gradually dries up
- Instead of good quality water input of yore, agricultural run-off, untreated sewage and industrial effluent inputs begin to build up, which lead to eutrophication, water hyacinth over-growth (as sewage/agricultural run-off are rich nutrient sources), fish kill and massive reduction in bird biodiversity

- Introduction of invasive species of fish and weeds further destroys native biodiversity of macrophytes, fish and birds

Hence, there is a reduction in quantity as well as quality of water, and the ecosystem is gradually destroyed.

The following write-up takes up the approach for Mumbai-based Powai Lake eco-restoration.

Powai Lake
Powai Lake was said to be populated by 37 species of fish (Kulkarni, 1947); Amore (1955) has listed 32 species in the lake while Singh Kohli (1991) has listed 10 main species i.e., *Catlacatla, Cirrhinusmrigala, Tor khudree, Labeorohita, Labeocalbasu, Osphronemusgoramy, Hypophthalmichthysmolitrix, CyprinusCarpio, Tilapia mossambica, Ctenopharyngodonidella* in the lake.

Also, Powai Lake supports a rich population of crocodiles.

Original Area	520 acres	Original Depth	10 ft at periphery, 40ft at deepest point (1891)
Area in 1986	365 acres	Depth in 1986	2 ft at periphery, 20 ft at deepest point

Table 4.11 given below provides information about the pristine habitat quality of the Powai Lake

Table 4.11: The Pristine Habitat Quality of the Powai Lake

Sr. No.	Variable	Year			
		1963[1]	**1992[2]**	**1996[3]**	**2001[4]**
1	pH	7.5	7.2	7.13	7.9
2	Total Alkalinity (mg/l)	NA*	11.6	81.25	169
3	Conductivity (µ mho/l)	NA*	NA*	NA*	280
4	Dissolved Oxygen (mg/l)	5.3	8	3.30	5.1
5	Soluble Phosphate (mg/l)	0.02	0.04	0.665	0.26
6	Nitrate (mg/l)	NA*	1.13	0.12	0.52
7	Chlorophyll-a (mg/m^3)	NA*	95	NA*	154
8	Nitrate Nitrogen (mg/l)	NA*	NA*	0.168	0.002
9	Hardness (mg $CaCo_3$/l)	79.3	105	104	56

*NA – Data not available, 1. Thakhare, 1969 2.Adak et.al. 1992 3.MSAA, 1996 4.Chandra and Mahajan, 2001; **courtesy Dr. P. B. Salaskar**

The area, depth and quality of the lake water have undergone severe degradation in the past few years. The area has reportedly shrunk to 365 acres (Maharashtra State Gazetteers, 1986) and 223 acres as per a more recent MCGM report. Another problem is the reduction in the dissolved oxygen level of the water, which at the bottom of lake has gone as low as 0.71 mg/L, and at the top it is 4.11mg/L (CSE,undated).

Eco-rejuvenation of water bodies is a complex, long-term, multi-expertise (water chemistry, hydrology, environmental engineering, ecology, biodiversity and sociology) requiring process and has multiple steps and approaches. Careful selection of technology needs to be undertaken for better restoration of the ecosystem.
Eco-rejuvenations can be done through implementation of following technologies:

1. Floating Wetlands

Floating treatment wetlands (FTWs) are currently gaining popularity as an in-situ phytoremediation technology for water-based ecosystems. FTWs mimic nature's floating wetlands and employ emergent aquatic plants such as Canna, Typha sp., Scripus, etc.

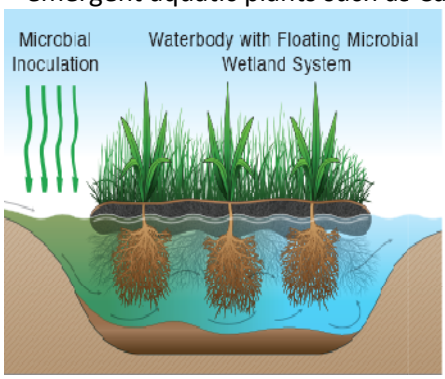


Fig. 4.15 & 4.16 : Floating Wetlands

It is a green treatment concept that employs rooted, emergent macrophytes growing in the floating mat on the surface of the water rather than rooted in the sediments. The plant roots beneath the floating mat provide an extensive surface area for the attached biofilm growth and entrapment of suspended particulate matter. Since the plants are not rooted in the soils like subsurface flow constructed wetlands, they are forced to acquire their nutrition directly from the water column, which may enhance rates of nutrient and element uptake into biomass. Not only do they serves as a contaminant removal system but serve the ecological role of bird perches and fish-laying sites.

2. Aerators

Aeration is used extensively for the biological oxidation of both domestic and industrial organic wastes. In wastewater treatment, the function of aeration is to introduce air into the water through the most effective and least costly methods that will increase oxygen transfer (dissolved oxygen) in the wastewater. Diffused aerators can be used in eco-rejuvenation of the lake.

In diffused aerators, a submerged devices release air or oxygen into the wastewater. As bubbles rise through the wastewater, oxygen is transferred from a gaseous state to a liquid state – thus adding Dissolved oxygen (DO) to the water and they keep the microorganisms suspended, so they do not settle out. The longer these particles are suspended and maintain contact with the DO, the more waste solids they can consume and break down.

3. Bio-cultures

In this method, microorganisms, especially bacteria are employed to treat waste water. Microbes have a tendency to biodegrade the pollutants in the water to obtain energy. They rapidly multiply and colonise in the polluted water restoring the biological health and efficiency. Hence, contributing in increasing the quality of water. Non biological methods can be effectively combined with biological methods to enhance degradation of recalcitrant pollutants. These bio-cultures help in reducing BOD / COD, increase in MLSS, breaks down fat & grease build up, controls odour and greatly reduces labour time and cost

Fig. 4.17: Diffused Aerators

Fig.4.18: Bioculture

Restoration of Shahadra Lake- Case Study

The ShahdaraJheel area is located in the Shahdara area (28° 40' 0" N, 77° 19' 0" E) of north-east Delhi. It is spread across 35 acres, of which an area of 10-16 acres used to be maintained as a lake, the remainder for sundry recreational purposes. The Lake initially had a fountain, sitting area, an old "dargah," footpaths, a nursery for green plants some light poles, seating parks, etc. are located in the southern side of the lake and several tree species. The lake was eco-restored by providing a simple, low energy, eco-friendly and cost-effective technology, for treatment of waste water flowing in the drains and reuse the treated water for recharge of Shahdaralake. Also, improving the lake bed surface and in-situ treatment combined with comprehensive and integrated landscape plan for sustainable and efficient use of the place in order to restore the natural beauty.

To Do Activity

Considering Environmental and Social aspects propose an eco-restoration plan for a nearby polluted water body.

Eco-restoration of a Degraded Forest

Forest eco-restoration is a particularly difficult task, considering the multitude of stakeholders involved, particularly longer time taken, and the high costs involved. Elliott et al. (2013) define forest restoration as "actions to re-instate ecological processes, which accelerate recovery of forest structure, ecological functioning and biodiversity levels towards those typical of climax forest." A climax forest has the stablest species structure and maximal biomass that can be achieved given the local climatic and edaphic factors.

Interestingly, on several occasions, planting of trees is not essential to forest eco-restoration. All it may be needed is to check and control the destructive anthropogenic interferences, and allow natural regeneration of the forest. For instance, mangrove forests require regular tidal influx – several times, unscrupulous elements deliberately destroy mangroves by disrupting tidal flow. In this case, merely reinstating the tidal flux is sufficient to aid mangrove regeneration, as mangrove seeds are transported via tidal currents.

Forest eco-restoration has immense potential to:

- Improve ecosystem goods and services
- Enhance the scope of forest-based livelihood
- Rehabilitate biodiversity

Jungle Flora Nursery

One of the most critical elements of successful forest eco-restoration is having access to the saplings of the right species. This is a particularly difficult challenge, as most of the native jungle flora species are:

a) Have long seed dormancy periods
b) Require seed pre-treatments (such as sun-drying, soaking in water, irradiation etc.)
c) Are slow-growers

To make matters worse, specific protocols about individual species are not available and dedicated research in this field is meagre.

To Do Activity

Identify locations in your locality where Eco-restoration is needed and detail the factors to be considered for the same associated with place.

Ecological Associations

When carrying out reforestation/afforestation it is critical to understand that the distribution of floral species in an area is not random. It is in fact determined through unique and delicate ecological interactions. Plant species form definite and recognizable strands, with a definite community structure. Hence, such factors must also be studied minutely before undertaking a successful and ecologically meaningful forest eco-restoration.

Case Study of Attapaddy Forest Eco-restoration, Kerala

Kumar et al. (2015) describe a successful case study of forests in the Attapaddy area of the Western Ghats in Kerala.

The four-pronged strategy included

- participatory management by involving the locals as well as forestry experts
- scientific afforestation/reforestation
- biomass conservation
- elements of agro-forestry

2. Eco-restoration of an Open-cast Mine/Quarry

Quarry Restoration is a process that involves creation of appropriate landform to support any envisaged post mineral extraction after-use, and creation of appropriate surfaces for the establishment of vegetation.

Quarry restoration is in the purview of the mining agency, and hence, has a clear stakeholder.

Need for restoration:

- Restore the chemical and structural health of the soils.
- Restore the health of vegetation in order to enhance biodiversity.
- Create a safe environment in and around a quarry.
- Improve the visual and aesthetic qualities.
- Preserve geological features, wildlife, and plant habitats.
- Most importantly, improve human health by reducing harmful particulate matter in the air.

Factors Affecting Quarry Eco-restoration Process

- The intended after use of the site
- Geological survey
- The character of the surrounding landscape
- The cost of using any particular technique
- Availability of topsoil
- Availability of fill material
- Selection of native trees

Approach

- Selecting the appropriate fill material and its application (artificial soil, organic amendments)
- Selecting the most suitable species – pioneer species that can exist in the degraded, stark surroundings
- Ensuring natural water body creation/maintenance of existing ones
- Regular overseeing in the subsequent years

While water bodies (including wetlands), forests and wildlife are protected by strict regulations in India, the protection accorded to grassland ecosystems may well be called a by-product of legislations such as Wildlife Protection Act, 1972, Indian Forest Act, 1927, Forest Conservation Act, 1980, Biological Diversity Act, 2002 and Forest Rights Act, 2006.

Indeed, it is not the breath-taking grasslands of Velavadar, Gir or Kaziranga that we are protecting – we are protecting the lions, the blackbucks and the one-horned rhinoceros! This detracts from common knowledge the fact that grassland ecosystems are:

a) Adept at carbon sequestration
b) Support their own special biodiversity
c) Are the climax ecosystems in their regions (based on soil and climate factors) that will not naturally lead to the growth of trees
d) Provide their own unique set of livelihood options to dependent populations

Hence, it is ecologically incorrect to cover grasslands under mass tree plantation drives to meet administrative and political targets.

Therefore, grassland eco-restoration processes come with their own set of challenges and require stricter protection given the lack of a focussed protection policy. For instance, availability of seeds of the required wild, native grass species is very poor.

Recognizing the significance of grassland ecosystems, the Gir forest department is planning a project to convert barren tracts of land into grasslands.

The Case Study of Basalt Quarry Restoration, Timba, Gujarat

Timba is located about 110 km south-east from the Gujarat capital city of Ahmedabad. Here existed a 15-20m deep old basalt quarry spread across 41 ha. Starting in the year 1975, the eco-restoration of this quarry took 8 years. The restoration process first attempted humus formation, enhancing soil moisture trapping and providing suitable situation for green cover growth with indigenous herbaceous species. After two years, once the green cover had appreciably established itself, native trees were planted and maintained for the next one year. By the fourth year, the green cover had begun to sustain itself, with natural vegetation taking over apart from the planted species. In one small part of the quarry, surface rainwater harvesting efforts were engineered to create a water body for the newly created ecosystem. This water body was stocked with fish.

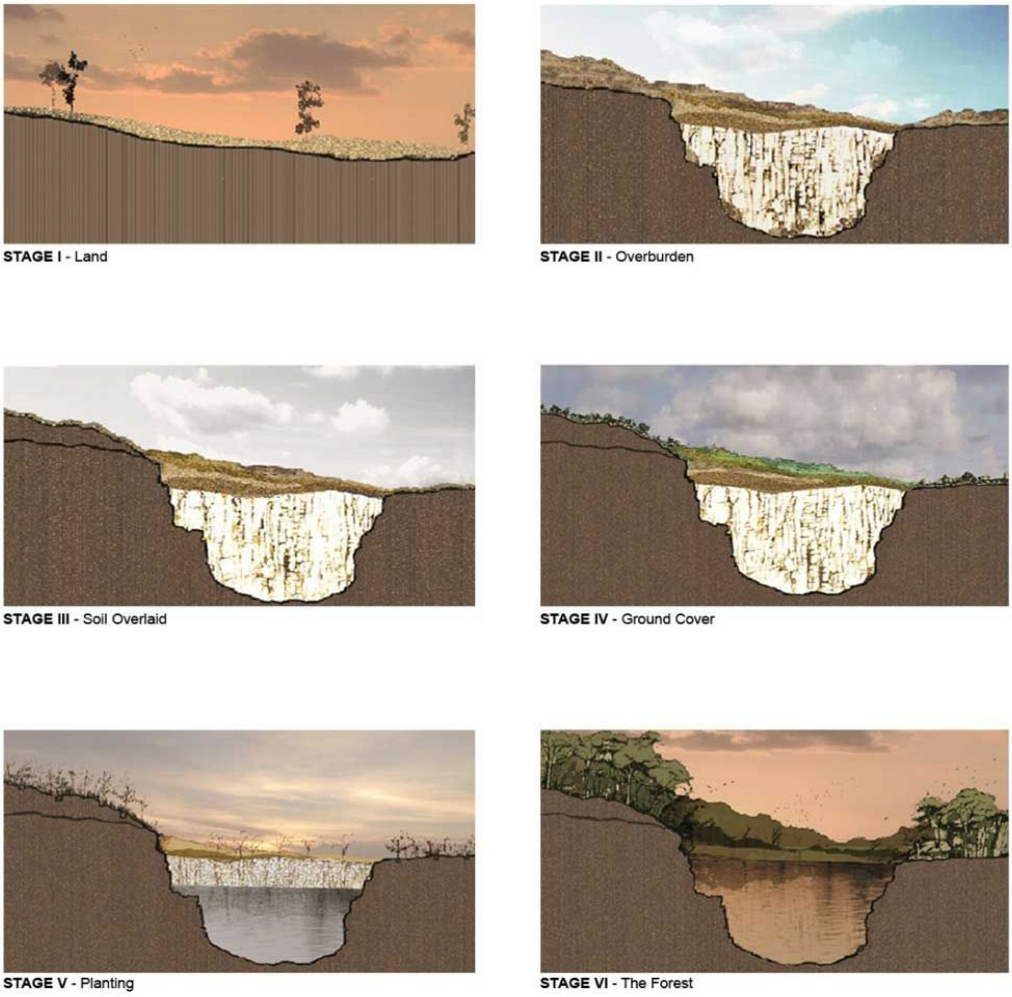


Fig.4.19: Quarry Restoration in Timba, Gujarat
Source: Rao (2014)

4.5 Disaster Management

Understanding Natural Disasters

Phenomena leading to injury or loss of life, property damage and environmental loss, and socio-economic disruption and livelihood impairment, are termed as natural disasters. It is a sudden, calamitous event bringing immense damage, loss, destruction and devastation to life and property.

A disaster is, therefore,

- difficult to predict accurately (thus, has a degree of uncertainty)
- occurs in a short time period (thus, has an element of speed and urgency)
- highly damage-inducing (thus, has an element of threat)
- likely to have a substantial number of victims (thus, has an element of vulnerability)

Depending on whether their origins lie in natural or anthropogenic agencies, disasters may be categorised as natural or man-made. Natural disasters include floods, landslides, cyclones, tsunamis, earthquakes, wildfires etc. Depending on their scale, disasters may be major or minor. Fig. 4.20 attempts to classify the various types of disaster.

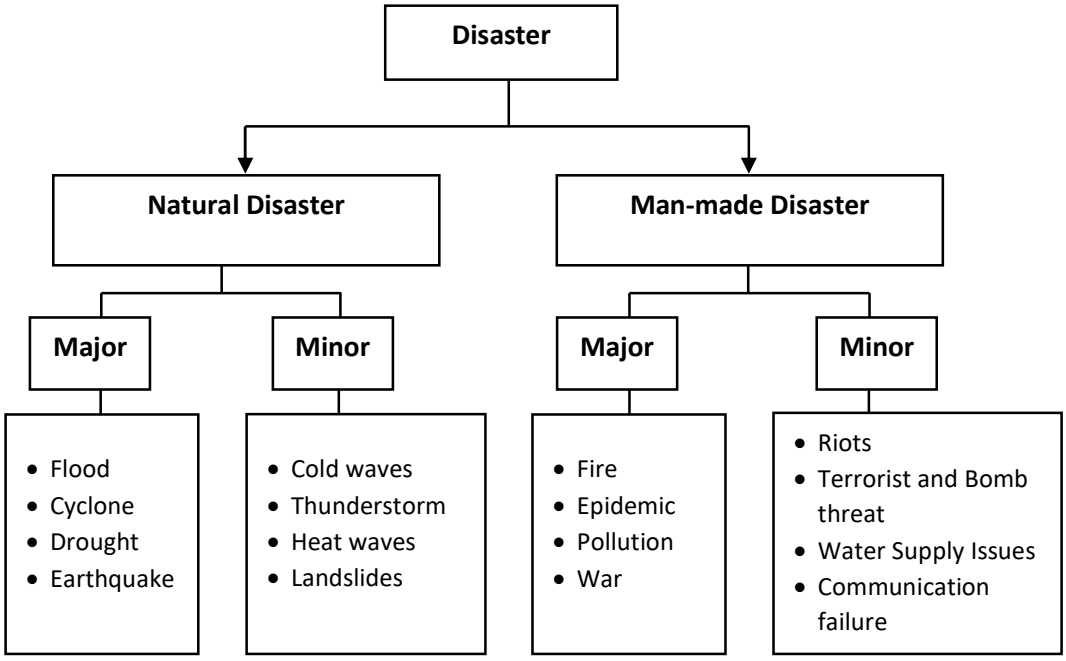


Fig.4.20: Different Categories of Disaster

The damage caused by disasters is difficult to measure accurately and varies with the geographical location, climate, and the degree of vulnerability of the populace affected.

To Do Activity
Make a list of natural and man-made disasters that occurred in your district and their causes.

Disaster Management Plan

To combat the serious impacts of disaster, disaster management planning is the approved course of action. A Disaster Management Plan (DMP) coordinates and integrates "all activities necessary to build, sustain, and improve the capability to mitigate against, prepare for, respond to, and recover from threatened or actual natural disasters, acts of terrorism, or other man-made disasters." A DMP is the outcome of multi-disciplinary effort with inputs being drawn from mathematics, science and technology to social science.

The key elements of a DMP are:

- Prevention
- Preparedness
- Response
- Recovery
- Mitigation

Fig.4.21: Elements of a Disaster Management Plan

Prevention

Risk and Vulnerability Assessment

Risk assessment is initiated with the assessment of potential disasters by delving into hazard mapping and vulnerability analysis. Risk assessment is carried out by:

- Understanding the type of hazard – every element of a disaster management plan differs with the type of hazard. Predictability of different types of disasters differs. For instance, an earthquake is almost impossible to predict accurately while a flood is comparatively more predictable. The type of emergency response plan required for a wildfire will be very different from that of a flash flood.
- Mapping the hazard – different geographic regions are at different degrees of risk from a given disaster. The hazard mapping exercise identifies the areas at high, medium and low risk
- Assessing the frequency of occurrence
- Determining the duration of the hazard in an area

All this requires in-depth analysis of previous databases, studying the patterns and trends in occurrences, and based on robust statistics, arrive at conclusions and predictions.

Risk Analysis

Risk analysis comprises of the following steps:

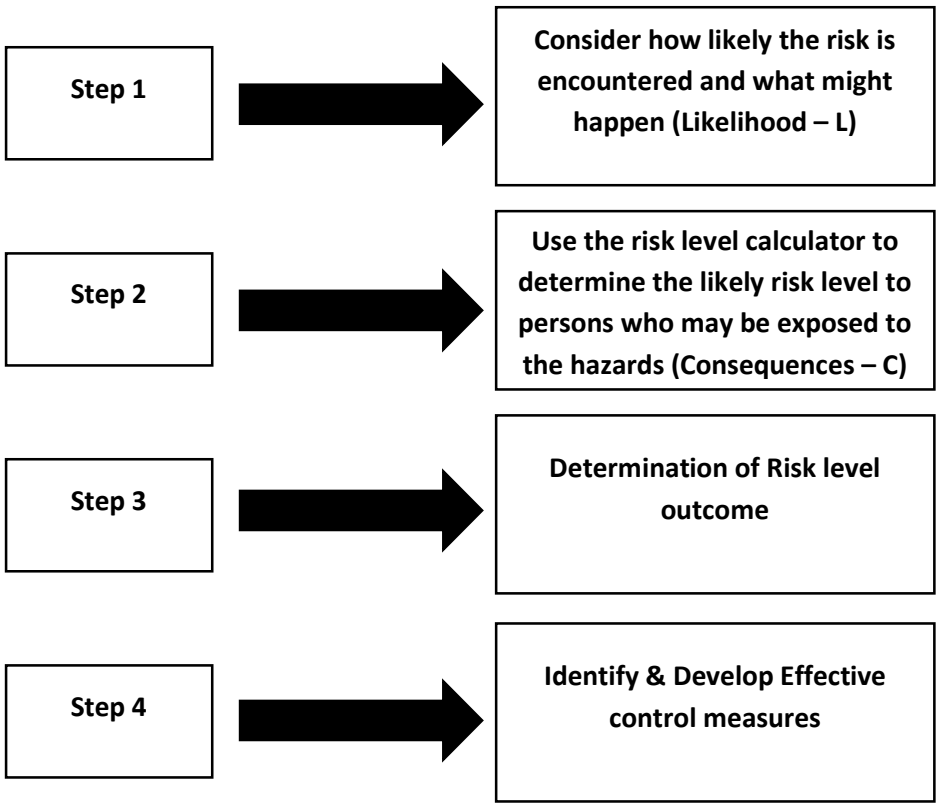


Fig.4.22: Risk Analysis

Preparedness

A Preparedness Plan for disasters must be prepared as per the relevant Environmental Emergency plan formulated at the national level and OSHA guidelines. As per these guidelines, an EEP must include:

- Initial Drill – raising sufficient awareness about the type of hazard, the warning system, the point of congregation during emergency, emergency contact numbers, and the first set of actions for containing the hazard
- Setting up of a team of local volunteers and building up their capacity as an emergency response team – this team of volunteers to be trained in –
    - Raising alarm
    - Contacting the assigned agencies
    - First set of actions to contain the hazard
    - Basic first aid
- Discovery – depending on the type of hazard, geographical area and social situation, an indicator can be pre-decided – this must be an indicator unquestionably linked to the said disaster; also, the indicator must occur just prior to the disaster or early enough during the disaster to allow sufficient time for the response plan to take off. Based on weather monitoring, meteorological and other sophisticated mechanisms, it has become easier to predict cyclones, floods and droughts. A set of traditional warning systems has been described in the **Table 4.12**.

Table 4.12: Indigenous Early Warning Indicators of Cyclones: Potential Application in Coastal Bangladesh.

Weather Patterns	Sky turns gloomy and overcast # Black rolls of cloud Weather unusually hot and humid/hot spells after rain # Strong wind blows from the south/south-east # East wind blows at full moon
Sea/River Patterns	Big waves/dark rolls of water 'Goroomgoroom' noise in the river Smokey or cloudy shapes in the sea Pond and river water becomes hot *
Animal Behaviour	Cattle become restless and stop eating grass *** # Cattle/dogs wail continuously/at night *** # Ants climb trees with eggs on their backs # Bees move around in clusters Kurpals (type of gull) fly high and cry Birds fly without destination Increased number of flies and mosquitoes # Insects attack cattle ** Fish jump in the rivers and ponds Crows/cockerels call/fly at night Frogs call constantly Foxes bark during the day Crabs come into the house and courtyard ****
Other	Bending trees Water hyacinth in the canal Leaves of the mandar and cotton tree turn upside down; new leaves of trees fall to the ground Muddy smell on the wind *

* Up to one day before ***3 – 7 days before
1 – 2 days before ** 10 - 12 days before
Most commonly mentioned across all four chars

- Alarm raising/Signal system – this can be a red flag, a siren or a loudspeaker warning, but it needs to be sufficiently visible/audible to each individual
- Rapid notification to assigned agencies – emergency contact numbers to be shared with the emergency response team
- Containment – first set of actions for containment of the hazard vary with the type of disaster. The local volunteers team must be duly trained in the same
- Measures to check

It is important to prepare Standard Operating Procedures (SOPs) to deal with the disaster to which a given area is prone to and to distribute the same among the likely-to-be-affected population and the local volunteers.

Relevant equipment (such as fire extinguisher, first aid kit, inflatable boats, personal protection equipment) to help tackle the emergency must be kept available.

Response

- By the victims
  - Raising the alarm for public issuance of warning/Being alert to the pre-decided alarm system
  - Contacting the local emergency response team
  - Taking the critical first steps to limit the disaster

- Helping each other to escape immediate danger

- By the Emergency Response Team

Rescue Team

- Instant evacuation to ensure least possible exposure of both the victims and the response team to the disaster
- Rescue of animals (livestock and wild animals)

Supplies Team

- Emergency shelters – these can be existing schools and government office premises put to use as shelter homes; else, in disaster-prone areas, permanent shelter homes have been built
- Provision of safe drinking water, or providing portable water filters/water purification tablets is of high importance
- Basic subsistence food packages must be prepared and distributed at regular intervals
- Baby food
- Fodder for livestock

Medical Aid Team

- Emergency medicines
- Especial care for the elderly, infants, physically disabled, injured and ailing ones
- Curbing the risk of infection spread, which is high in densely inhabited shelter homes

Information Dissemination Team

A critical element of disaster management is information dissemination, with stress on:

- Right information display at the right time, at the right place and to the right people so that timely and correct action is taken
- Coordinating among the other teams at work on the ground
- Avoiding panic among the general populace
- Relaying accurate information to the outside world so that required aid flows in, and friends/relatives of the disaster victims do not panic

Response Team

The tentative structure of a Response Team has been provided in **Fig.4.23** below:

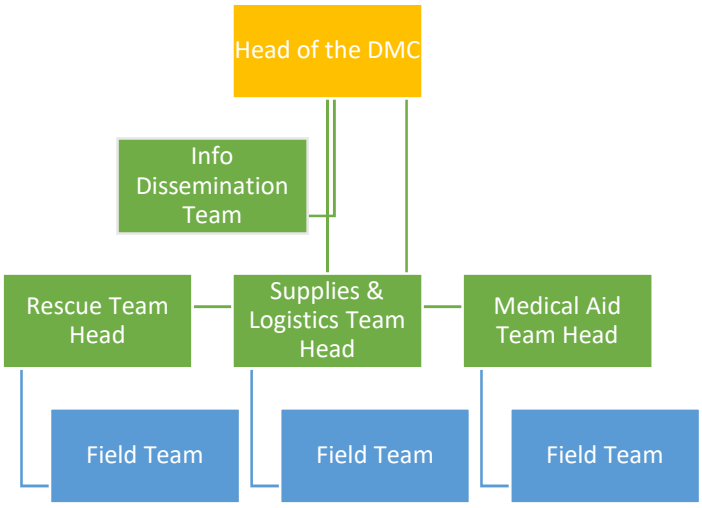


Fig.4.23: Structure of a Disaster Management Cell

In India, the rescue team is usually the Indian army, the logistics and information dissemination teams are formed by the local government officials while the government medical officers form the medical aid team. While field teams for rescue and medical aid are composed of trained professionals, local volunteers aid the supplies and logistics team.

Recovery

A disaster recovery plan is a process of setting up of procedures for recovery of the impacts such as disruption of normal life, loss of live and property, enormous suffering, spread of disease, etc. The recovery phase is a difficult and long term phase. The actions on any recovery phase depends on several factors such as the type of disaster, location of the disaster, gap between pre and post disaster conditions, potential of the impact. It is moreover impossible to exactly anticipate a recovery plan for any disaster. The two major essential focus during the recovery stage is capacity building and financial arrangement. The capacity building involves strengthening the stakeholders at all levels and providing sufficient information and training for immediate actions. Financial arrangement is crucial in recovery phase as the complete process and its efficiency depends on the fund allocated for recovery.

The concept of 'Build Back Better' is the mantra on which a disaster recovery plan should be based. BBB is not restricted to physical construction – it extends to environmental inputs, strengthened local economy, and societal capacity building.

Mitigation

A Mitigation plan comes into action after the emergency response has tackled the immediate challenges and the recovery phase is in process or near-completion. The purpose of the mitigation plan is to avoid and minimise the calamitous impact, and finally, to compensate for the same.
Mitigation alternatives are decided on the basis of cost-effectiveness, and technical and social feasibility.

To Do Activity
Prepare a disaster management plan for your college

Elements of a mitigation plan

Compensation payment

Understanding and addressing the root cause – for instance, one of the main causes of the recent spate of urban flooding incidents in India have been the clogging of drains because of plastic. Hence, state-level single-use plastic ban in some Indian states and stress on raising awareness about avoidance of plastic use during the Swachh Bharat Mission IEC activities are significant for mitigating urban flooding incidents.

Long-term remediation – Mangrove plantations have been known to reduce the risk to coastal populations in the event of cyclones, and hence, undertaking mangrove plantation would be an effective long-term mitigation plan. Similarly, plantation of trees along slopes in areas prone to landslides would be a feasible long-term mitigation plan.

Social aspects – A well-informed community that has been made fully aware of the details of their hazard-prone area, and drilled about the activities that they must/must not undertake to improve/aggravate the situation, goes a long way towards effective prevention of disasters.

Table 4.13: A Brief Comparison of Various Types of Natural Disasters

Type of Disaster/Parameter	High Risk Areas	Early Indicators	Immediate Response	Basic Emergency Equipment Required	Complications	Recovery Plan Highlights	Mitigation Plan Highlights
Earthquake	Zone 5 areas have the highest seismicity, For eg. Guwahahti (Assam) and Jammu Kashmir are Zone 5 areas, which faces deadly earthquakes.	No early indicator, however changes in animals' behaviour has been observed.	Slight onset of tremors can give us the time to take cover under a strong surface such as table.	Water, food, flashlight, first aid kit.	No fool-proof early indicator	Debris removal	Building earthquake-resistant structures Possible permanent evacuation of tectonically unstable areas
Wildfire	Forest areas are highly prone for wildfire. North East areas in India are highly susceptible to wild fires because of slash-burn (jhoom)cultivation in forest.	Local weather modification, rise in Temperature and Heat	The steeper the slope, the faster the fire travels. If living on a hill, immediate evacuation is necessary; sprinkling of water, manually or otherwise	Map marked with at least two evacuation routes. Three-day supply of non-perishable food and three gallons of water per person.	Spreads extremely quickly, most of the times too quickly for manual response to start in time before substantial damage is done	Water sprinkling on a large scale, rescue operations for human beings and wildlife, prevention of further spread of wildfire by removing flammables as much as possible, acting on weather forecasts if	Understanding the root cause – for instance, it may be burning of waste, or festival celebration (like *holikadahan*) or careless disposal of cigarette butt – hence, raising awareness is the key

						they indicate weather conditions that can further stoke the wildfire	
Floods	River floodplains and coastal areas are the most susceptible to flooding. The major flood prone regions in India include Punjab, Haryana, most of the Gangetic plains, including Uttar Pradesh, North Bihar and West Bengal, the Brahmaputra valley, coastal Andhra Pradesh and Orissa, and southern Gujarat.	intense rainfall, dam or levee failure as well as other events such as slow moving tropical storms and early snow melt can all contribute to flooding, whether one lives in a flood zone or not.	Move to higher ground immediately. Stay out of floodwaters. Avoid driving through flooded areas. Stay away from power lines and electrical wires.	Water - drinking and sanitation. Food - at least a three-day supply of non-perishable food. Battery-powered radio with tone alert. Inflatable rafts. Flashlight. First aid kit. Extra batteries.	Spread of infectious, waterborne diseases	Boats for evacuating those stranded in flood; provision of emergency food and medicine kit, dewatering, restoration of electricity	Understanding the root cause – in urban areas this may be the clogging of drains due to plastic waste; evacuation of folks from flood-prone areas
Cyclone/Tornado	More cyclones occur in the Bay of Bengal than the Arabian Sea and the ratio is approximately	Modern Technology such as Satellites, weather radars,	Stay indoor under a heavy object or take shelter in a basement.	Water, food, flashlight/candles first aid kit, portable charger, radio.	High wind speeds are particularly devastating	Evacuation, provision of emergency food and medicines, restoration	Efficient monitoring and early warning system; cyclone-

	4:1. Four states - Andhra Pradesh, Odisha, Tamil Nadu and West Bengal and one Union Territory - Pondicherry on the East Coast are most vulnerable to cyclone disasters.	computers can track cyclone, usual signs are barometer reading fall, harsh winds, ocean swell upto 13 ft, large mass of white cirrus clouds.				of electricity, removal of animal carcasses, prevention of infection spread with chlorination	resistant infrastructure; planting more mangroves to enhance coastal integrity
Tsunami	Tsunamis struck majorly in all low-lying coastal areas.	a strong earthquake that causes difficulty standing; a rapid rise or fall of the water along the coast; a load ocean roar.	Drop, Cover, then Hold On. Get to high ground as far inland as possible.	Water, food, flashlight/candles first aid kit, portable charger, radio.	Very high and speedy waves destroy lives and property	Evacuation, provision of emergency food and medicines, restoration of electricity, removal of animal carcasses, prevention of infection spread with chlorination	Having an efficient monitoring and warning system in place; planting more mangroves
Landslide	Heavy rain and steep mountains are a potentially disastrous combination for	Springs, seeps or saturated ground in areas that	If indoor, find cover in the section of the building that is furthest away	Emergency food and drinking water, flashlights, radios, first-aid	Can occur very suddenly	Immediate aerial evacuation, debris removal,	Slope stabilisation, evacuation from landslide-

	landslide .Coarse soil, deforested land in mountains also accounts for landslides. The major landslide prone areas in India include the Western Ghats and Konkan Hills (Tamil Nadu, Kerala, Karnataka, Goa and Maharashtra), Eastern Ghats (Araku region in Andhra Pradesh), North-East Himalayas (Darjeeling and Sikkim) and North West Himalayas (Uttarakhand, Himachal Pradesh, Jammu and Kashmir).	are not usually wet. New cracks or unusual bulges in the ground, street or sidewalks.	from the approaching landslide. If outdoor, move quickly away from its likely path, keeping clear of embankments, trees, power lines and poles.	supplies, sanitation supplies, blankets, warm clothes		provision of emergency food and medicines, restoration of electricity, removal of animal carcasses	prone areas, more tree plantation on slopes, prevention of quarrying and mining in sensitive areas
Snowstorm	In India, snow storms occur in the north and mountainous areas	High-altitude cirrus clouds indicate precipitation within the next 24 to 36	Stay indoors, keep warm with appropriate clothing, look for signs of	Working heater, tank filled with gas, Water bottles, warm food like soups and stews,	Burial under snow, car accidents, frostbite, hypothermia, etc.	Preventing loss of life from hypothermia and frostbite	Early warning system

		hours, as does a ring around the moon or a sudden drop in the cloud deck	frostbite and hypothermia, take immediate precautions.	packaged items.			
Volcanic eruption	Sixty percent of all active volcanoes occur at the boundaries between tectonic plates.	Before the onset of volcanoes there can be tremors, smoke generation, volcanic rocks are thrown away. Gases such as carbon dioxide and hydrogen sulfide, a gas that smells like eggs gone bad, frequently are present and escape in seams along the mountain.	Follow evacuation, avoid areas downstream of the volcanic eruption.	Cloth to cover mouth and nose from the fly ash, goggles to protect eyes, water, food, first aid kit	Burial under lava, burns, poisonous gas intake, harmful for eyes and skin	Immediate evacuation; avoiding areas downstream to the volcanic eruption	Early warning system, evacuation room immediate vicinity

The Disaster Management Act, 2005

The Disaster management Act was drafted in the year 2005 and received assent on 9th January 2006 from the President of India. It has 11 chapters and 79 sections. It extends to the whole of India. The Act was enacted for the effective management of disasters occurring in the country and for matters connected with incidents. Under the act a three tier disaster management structure was proposed. The disaster management structure is given in Fig.

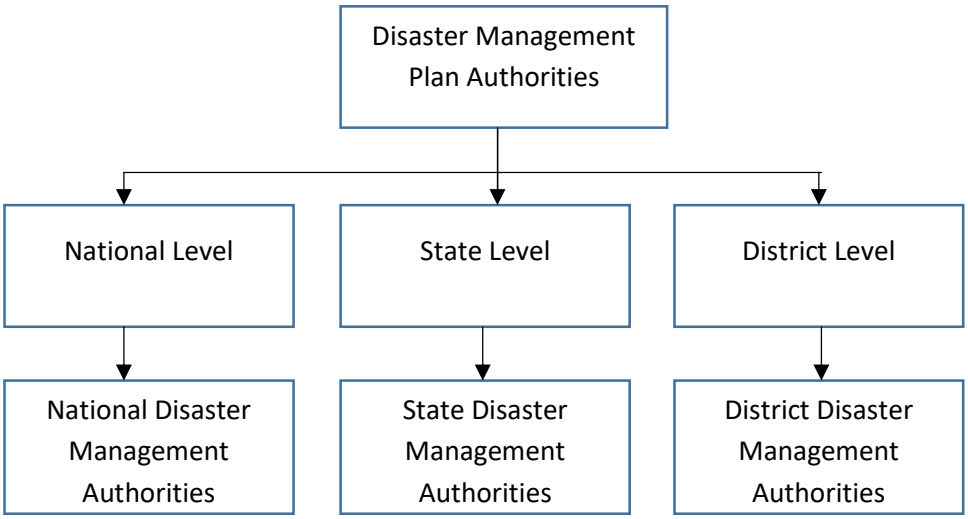


Fig.4.24: Disaster Management Structure

The National Disaster Management Authorities (NDMA) and State Disaster Management Authorities (SDMA) are headed by the Chief Minister whereas the District Disaster Management Authorities (DDMA). Two bodies, viz. National Institute of Disaster Management (NIDM) and the National Disaster Response Force (NDRF) were formed under NDMA.

To Do Activity

Study the disaster management plan of your district.

Summary

Developing urbanisation and industrialisation has led to several issues of pollution in the environment. This chapter puts forth the types of pollution that have occurred and its impact on the environment. Further, the chapter gives details of several pollution monitoring equipments that are critical for quantifying and measuring the present environment situation. The pollution can be controlled at individual and community level as the pollution is majorly caused locally, the chapter gives a basic detail of techniques to control pollution at individual and community level and an Eco-restoration plan enhance the value of degraded ecosystems. A environmental management plan is briefed at the end as its found to be critical for decreasing impact on human.

Model Questionnaire

- Give a brief description about the types of pollution
- What are the sources of pollution?
- What are the effects of pollution on Earth?
- State one rule and regulation you would like to put yourself for controlling any pollution.
- What is Environmental monitoring and its objective?
- What are environmental monitoring methods and types of monitoring?
- What are the common air pollutants around?

- Describe some of the models used to detect Air pollution.
- How pollution can be controlled in an individual and organisational level?
  What is Eco restoration and what is its purpose?
- What are the various eco system restoration approaches?
- With the help of a flowchart describe the process of ecological restoration.
- Describe some polluted places around you, and what you think you can do to restore it.
- What are the types of disasters?
- What are the phases of disaster management and disaster preparedness?
- Name some of the national and international level disaster management organisations.
- Give two examples of man-made and natural disasters in India with its causes and effects.
- Prepare a checklist of precautionary measures to be taken for any disaster outbreak.

References

- Elliott, M., Mander, L., Mazik, K., Simenstad, C., Valesini, F., Whitfield, A., & Wolanski, E. (2016). Ecoengineering with ecohydrology: successes and failures in estuarine restoration. Estuarine, Coastal and Shelf Science, 176, 12-35.
- Gargava, P., Sengupta, B., & Biswas, D. Strategies for Prevention and Control of Air Pollution in India.
- Kumar, A., & Tripathi, S. (2014, December). Study of Vehicular Pollution and its Mitigation Measures. In KIIT International Symposium on Advances in Automotive Technology.
- Kumar, R. S., Binu, N. K., Caballero, J., & Kundu, S. (2015). Rehabilitation of degraded mountain forests with an integrated eco restoration model-A case study of the Attappady Hills, Kerala, India. SAARC FORESTRY JOURNAL, 32.
- Rathi, S. (2007). Optimisation model for integrated municipal solid waste management in Mumbai, India. Environment and development economics, 12(1), 105-121.
- Singh, S. K., Rao, D. N., Agrawal, M., Pandey, J., & Naryan, D. (1991). Air pollution tolerance index of plants. Journal of Environmental Management, 32(1), 45-55.
- Sinthumule, N. I., & Mkumbuzi, S. H. (2019). Participation in community-based solid waste management in Nkulumane suburb, Bulawayo, Zimbabwe. Resources, 8(1), 30.
- Denix, Integrted Solid Waste mangement, retrieved on 5th January 2020, from https://www.denix.osd.mil/iswm/home/
- Department of environmental quality, How Your Community Can Prevent Pollution, retrieved on 3rd January, 2020 from https://www.deq.idaho.gov/pollution-prevention/p2-for-local-govts/how-to-implement-p2/
- Simon Upton (2016),World Economic Forum, retrieved n 6th January 2020, from https://www.weforum.org/agenda/2016/08/air-pollution-deaths-oecd/
- Nicholas Rees (2016), Clean the air for children, United Nations Children's Fund (UNICEF), retrieved on 7th January 2020, from https://www.unicef.org/publications/files/UNICEF_Clear_the_Air_for_Children_30_Oct_2016.pdf
- Badri Chatterjee (2016),Ghatkopar building goes solar, to save Rs1.65 lakh on power bills, Hindustan Times, retrieved on 2nd January, 2020 from https://www.hindustantimes.com/mumbai-news/ghatkopar-building-goes-solar-to-save-rs1-65-lakh-on-power-bills/story-5BgDSbQ6F6IOkeTDQIGjLO.html

Chapter 5 Social Issues and the Environment

Introduction

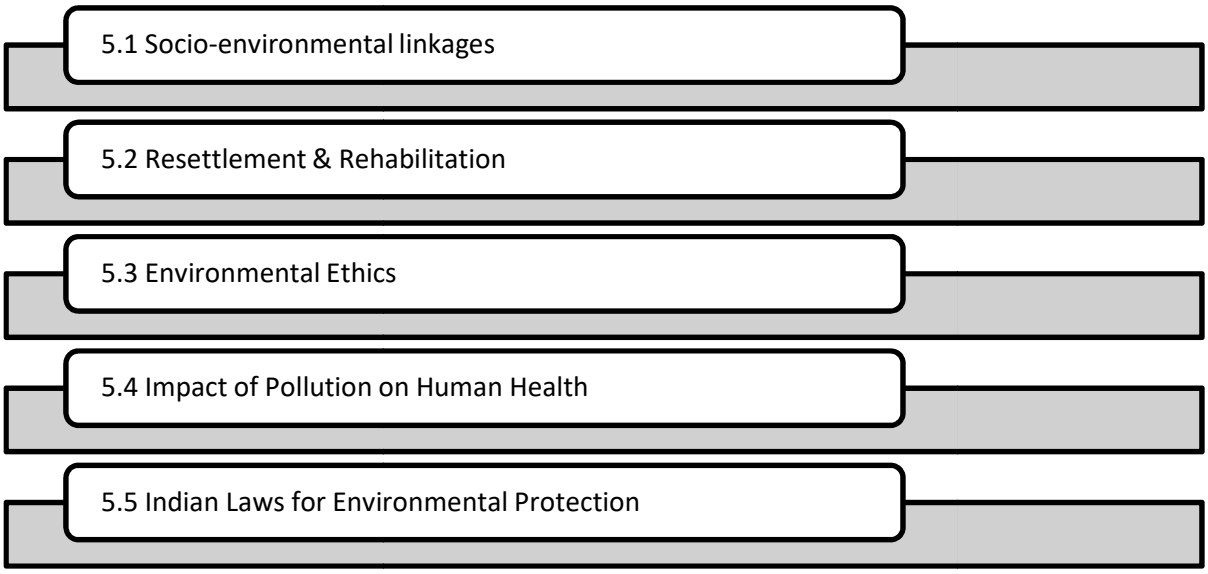
The link between the society and the environment is critical and must be studied in order to ensure a healthy biosphere. There is a heated debate between the developing and the developed communities as to the former's manner of growth – while the developed communities of yore polluted the environment to get rich, the developing communities are facing crippling sanctions to ensure that *their* growth is not at the expense of environmental resources. However, the critical queries raised by them are several. Is it possible to develop without over-utilizing natural resources? Is it possible to ensure profitability while taking care of the environment? What socio-technological interventions can ensure profit along with the planet?

In this unit, the first section deals with socio-environmental linkages, where various hypotheses and theories related to this complex, bi-directional relationship between society and the environment have been discussed. The complexities arising out of Resettlement and Rehabilitation have been discussed in the second section. In the third section, the philosophical branch of Environmental Ethics has been described, wherein another set of theories have been dealt with - especially those pertaining to eco-centrism, environmental racism, environmental justice and gender-basis to environmental issues have been included. The penultimate section deals with the impact of the environment on human health while the final section sums up the various laws pertaining to sustainable environmental management in India.

Objectives

- To provide insights on the bi-directional relationship between the environment and the society
- To provide an overview of the prevailing theories and hypotheses
- To assess approaches and case studies that offer a solution to the economic growth versus environmental degradation challenge

Structure



5.1 Socio-Environmental Linkages

Social factors have a strong impact on environmental management, causing issues with equitable resource sharing and leading to improper management of common natural areas.

Social factors are extremely critical to ensure sustainably successful environmental management, as social factors cause as well as help solve environmental problems. At the same time, environmental mismanagement can, in turn, lead to social issues. Thus, both social and environmental issues drive and shape each other.

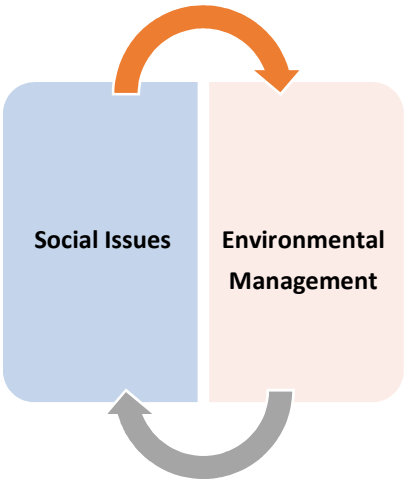


Fig.5.1: The Complicated Bi-directional Relation between Social Issues and Environmental Management

Environmental Social Science is at the juxtaposition of Environmental and Social studies, attempting to address the complex issues that arise out of the tug-of-war between varied social needs and limited natural resources. Core social science subjects such as anthropology, psychology, economics, history, political science and sociology have been integrated with the various branches of Environmental Sciences for Environmental Social Science to emerge as a distinct inter-disciplinary field of study.

To elucidate the social dimension of environmental problems, Buttel (1996) attempts to segregate human activities into two distinct categories – sub structurally-environmental and intentionally-environmental. Sub structurally-environmental practices are ordinary, everyday events like production and consumption at the individual or institutional levels that are indulged into during one's ordinary course of existence, without being aware about the environmental footprint involved. On the other hand, intentionally-environmental activities are those where individuals or institutions purposely take up environmental engagements such as participating in demonstrations, recycling activities, etc. The motivations behind these broadly different socio-environmental behaviours are the focus of studies by environmental social scientists.

Over-consumption and Under-investment: Understanding the Tragedy of the Commons

The concept of Tragedy of the Commons was introduced by Hardin (1968), an evolutionary biologist, in his iconic paper that was published in the *Science* magazine. Herein, the effect of over-population on limited resource availability was studied, wherein it was concluded that when limited resources had several consumers, over-consumption would result at the individual level.

Natural resources with multiple beneficiaries are said to suffer from the 'Tragedy of the Commons' given that the maintenance and renewal of such resources is expensive and it is rather difficult to discretely identify a payer. With demand gradually exceeding supply, over-consumption and

depletion of the resources ultimately results. Thus, the term Tragedy of the Commons basically indicates personal gain over-shadowing societal gain.

Tragedy of the Commons affects resources that are:

- Scarce
- Rivalrous (if consumed by one, resource will not be available for another)
- Non-excludable (non-payable resources which even non-paying consumers can access)

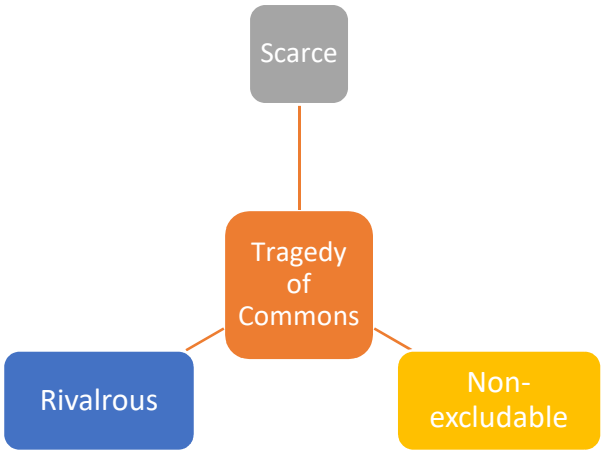


Fig.5.2: Tragedy of the Commons: Over-consumption and Mismanagement of Natural Common-Pool Resources

Species Extinction: An example of the Tragedy of the Commons

Species extinction may be defined as the death of the last individual of a species – locally or globally. While many species have undergone extinction due to natural causes, several anthropogenic reasons of species extinction have been pointed out:

- Over-consumption and hunting
- Habitat degradation and fragmentation
- Introduction of exotic species
- Natural disasters sparked by human intervention

Pink headed duck and Asiatic cheetah are the extinct species in India.

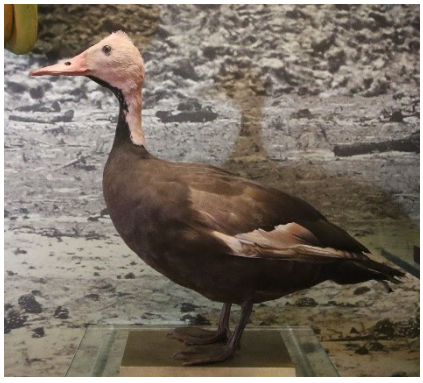


Fig. 5.3: Pink Headed Duck

Fig. 5.4: Asiatic Cheetah

Clearly, species extinction can be observed as a manifestation of the Tragedy of Commons – wild species that have not been domesticated have no clear owners, and little efforts were made to popularise their habitats or autecology studies.

To Do Activity
Make a case study of any 10 extinct animals and understand the reason for their extinction and the role they played in Ecosystem Management.

Over-consumption: The Neo-Malthusian Crisis
Malthus (1798) propounded a theory in his essay entitled 'An Essay on the Principle of Population' which raised an alarm that while human population is rising exponentially, agricultural food supply is struggling to keep pace as its rise is only arithmetic. Thus, infinite population growth cannot be supported. Thus, Malthus proposed a twin approach towards keeping populations in check: preventive and positive. While the preventive approach ensures individual efforts to reduce population growth (abstinence, birth control), positive approach is nature's answer to population rise as in war or famine.

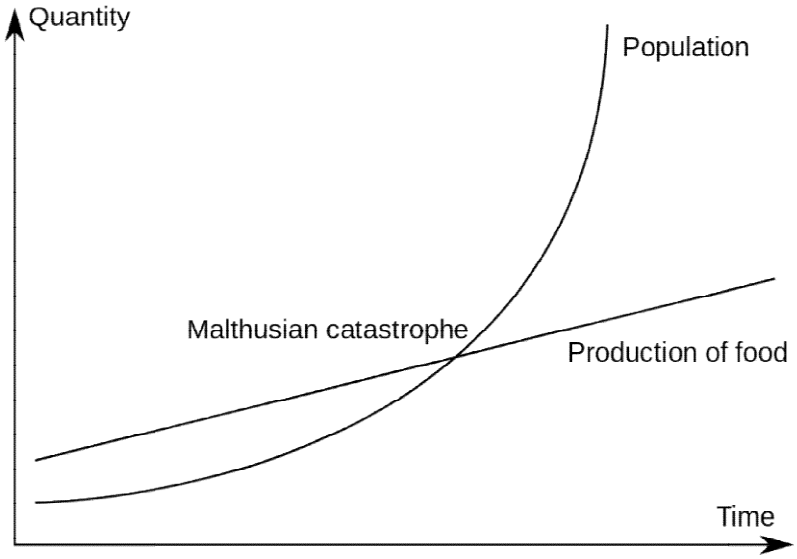


Fig.5.5: Malthusian Catastrophe

Neo-Malthusian theories retain the fundamental principle of limited supply versus unlimited demand, but extend it beyond mere agricultural supply to all natural resources and technological advances as well. Neo-Malthusianism followers express strong concern that the Earth's finite carrying capacity will soon be exceeded because of the exponentially rising population and even technological advances will fail to enhance resource supply indefinitely or check pollution and waste mismanagement. Neo-Malthusians further believe that in the absence of a check on population growth and continued resource consumption will lead to famine and war.

As per Schnaiberg (1980),the capitalist mind-set centred on profit-making is starkly in contrast with the principles of environmental conservation – as opined by several Environmental Social Scientists. The inherent competition among capitalists ensures that there is steady economic growth. Besides, steady economic growth is what governments aim at too, to ensure healthy tax input. These, in turn, lead to continuous resource extraction and pollution.

The Environmental Kuznets Curve hypothesis
Hypothesised earlier by Simon Kuznets in the 1950s, the Kuznets curve argued that in a developing economy, market forces shape economic inequalities in such a way that they initially rise, but then begin to reduce.

This theory was applied to the environmental pollution and degradation associated with industrial growth – with rising industrial growth, environmental degradation initially increases, but after growth in per capita income reaches a certain point, pollution begins to get checked. Hence,

environmental pollution is viewed as a product of poverty, and economic growth as a solution to pollution. Thus, this acknowledges the fact that to check environmental degradation and pollution control, the economic requirements are high and hence, raising per capita income through higher production is critical.

It has been argued that with rising income, after one's basic necessities are met with, the individual becomes better equipped for improved environmental services.

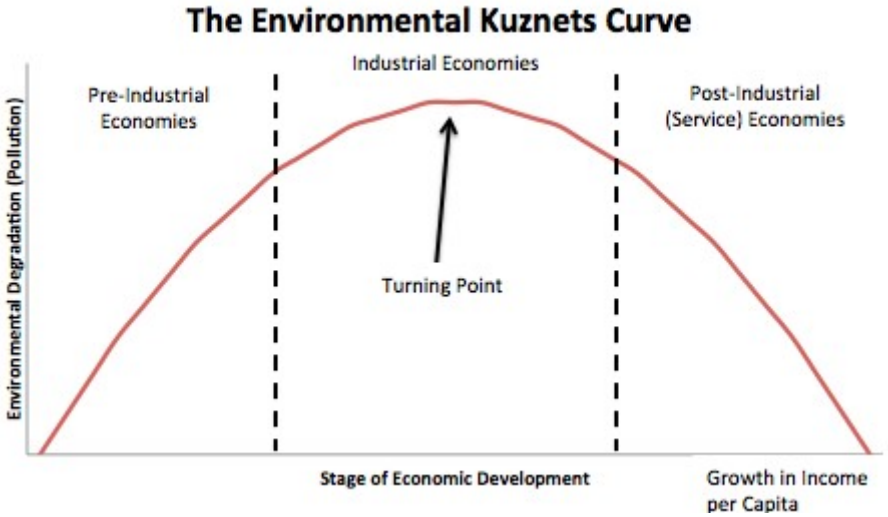


Fig.5.6: The Environmental Kuznets Curve

The Neo-Malthusian theory and the Environmental Kuznets Curve appear to flatly contradict each other. Critics against the Neo-Malthusian theory vest their faith in technological advances (such as solar and other renewable energy, green chemistry, green supply chain etc.) to avoid such a crisis. Other scholars point out the role played by policies and regulations that can generate artificial crisis and precipitate scarcity even in the face of plenty.

However, the Environmental Kuznets Curve has attracted heavier criticism of several scholars who point out that enhanced income cannot guarantee improved attitude towards the environment. Interestingly, a World Bank report states that more developed and industrialised nations produce more waste. In addition, another World Bank report showed that countries with the highest per capita income were also the top CO_2 generators in the world. Also, empirical evidence in the support of the Environmental Kuznets Curve could not disassociate the effect of rising income from the impact of appropriate policies and regulations from the government side. Also, to waste or not to waste is many a time an individual decision, and environmental ethics and spiritual ecology play a vital role in governing this disposition.

Community-based Ecosystem Management

Community based Ecosystem Management (CBEM) as a concept is becoming widely popular. It is indeed a paradigm shift in thought and policy. The beauty of this bottoms-up approach of ecosystem or natural resource management is that the actual resident in or around an ecosystem, the one who has been doing so for generations and holds immense traditional knowledge about this ecosystem or resource, is given the right to sustainably manage or conserve what had been rightfully his to conserve. Indeed, it appears to hold little sense on the face of it that a set of officials geographically and socio-culturally far removed from an ecosystem be expected to formulate management plans for the same ecosystem.

Effective ecosystem management plan can benefit from a point of discussion – ecosystem *conservation* versus ecosystem *preservation*. Ecosystem Conservation denotes an effort to sustain a space or resource for perpetual use. Preservation denotes a fortress-like approach to nature, walling off human influence in order to maintain pristine "wilderness". One of the best remembered examples of conservation versus preservation debates in India is that of completely preventing shepherds from allowing their livestock within the Bharatpur Bird Sanctuary in Rajasthan – a practice they had been wont to doing for years. BNHS reported that in the absence of the predation pressure of the livestock, the grasses overgrew that year, causing wetland shrinkage, fish depletion and a subsequent sharp reduction in the number of migratory birds that arrived (Vijayan 1987). Other studies have reported cattle as being a significant prey for the Asiatic lion in Gir (Dugan 1990) and the tiger in the Kanha National Park (Schaller 1967), thus, refuting the belief that grazing within sanctuary boundaries harms the ecosystem.

This discussion presented above essentially points out two things – a) ecosystems can be conserved and managed, instead of being preserved and regulated; b) ecosystems need to be conserved and managed by the local community inhabiting it traditionally and is armed with the wealth of years of traditional knowledge and not by the policymakers far removed from the ground truths.

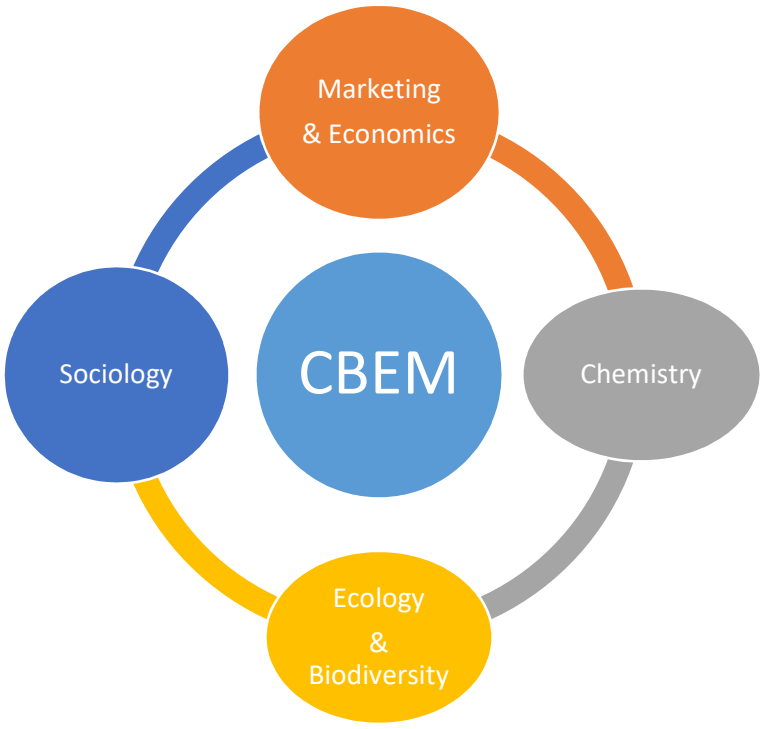


Fig. 5.7: Pictorial Representation of the Tenets of Community-based Ecosystem Management

However, the challenge with CBEM is:

a) The absence of technical expertise that is expensive and scarce in remote areas
b) The fragmented nature of CBEM and lack of connectivity between proponents of successful case studies.
c) Awareness levels of the local community are often low despite their usually high ecological literacy
d) At times, it is difficult to get the local community to participate without conflicts. It is unclear as to who is in the driving seat

e) Prevention of over-harvesting and exceeding the carrying capacity of an ecosystem is another challenge.
f) Also, it is difficult for the often uneducated, village-bred and village-bound population to envisage national and international markets.

To Do Activity
Prepare a community based ecosystem management plan for a beach which is influenced by tourism activity and over-fishing.

Circular Economy
With systems thinking at its core, a circular economy is based on the cradle-to-cradle approach – it uses renewable energy and raw materials and components are, to the extent possible, sourced from the waste products of other processes. The basic tenets are – to reduce wastage, and to reduce the pressure on natural resource by ensuring maximal reuse and recycling, both from the material and energy points of view. The circular economy takes inspiration directly from natural processes, where there is no waste and only by-products that are used up in other processes.

Benefits of a circular economy:

- Reduced cost of raw material, hence higher profitability
- Improved competitiveness due to higher profitability
- Strengthened societies due to higher profitability
- Fewer emissions, lesser waste, lower dependence on natural resources

The concept of circular economy is in direct contrast with that of Linear Economy, commonly referred to as a 'take---make---waste' economy. The future of sustainability lies in a swift and efficient shift from linear to circular economy.

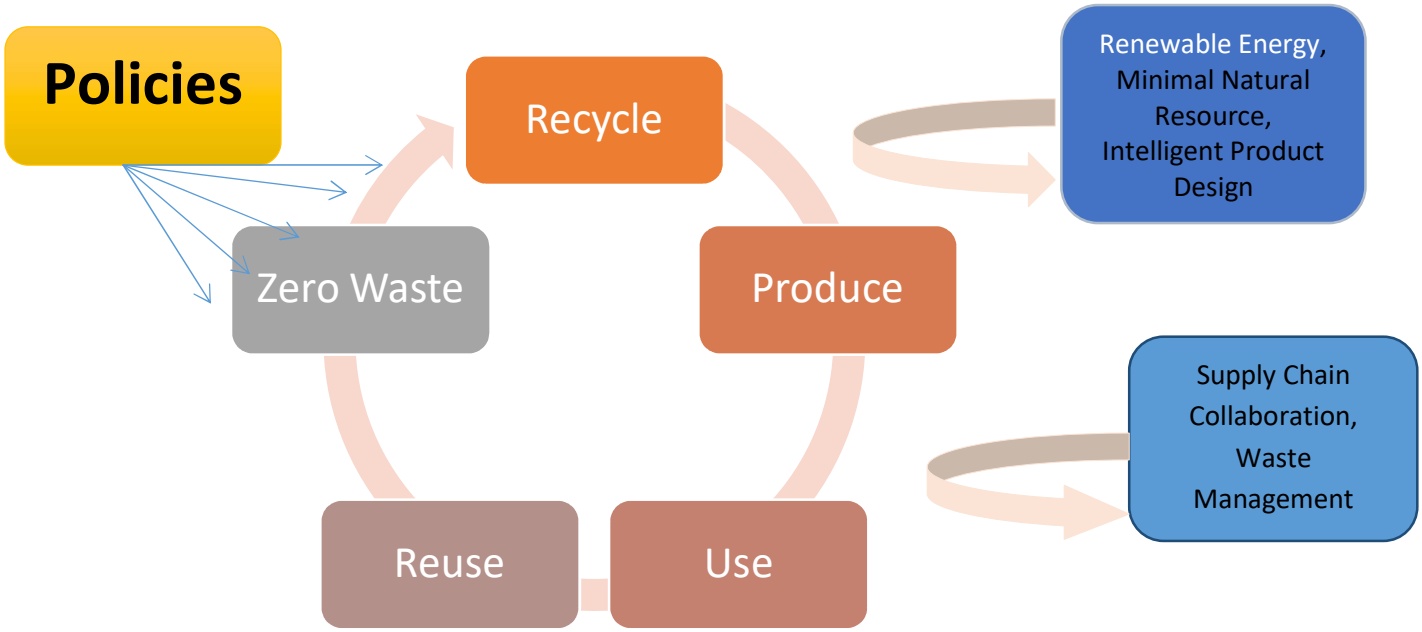


Fig.5.8: Circular Economy

Circular Economy as a practical concept is still in its nascent stage and yet to solidify. However, a few live examples of the same have been collated here.

The Kalundborg Symbiosis is an example of industrial symbiosis from Denmark. Initiated in the year 1972, this may be considered to be the first practical manifestation of the circular economy concept.

9 private and public manufacturing companies have joined hands such that the “a residue from one company becomes a resource at another, benefiting both the environment and the economy.”

The Kalundborg Symbiosis consists of: The Municipality of Kalundborg and seven privately held companies: Novo Nordisk, Novozymes, Statoil, DONG Energy, Saint-Gobain Gyproc, KalundborgForsyning, and Kara/Noveren. Schneider Electricisa France-based organisation that works in the field of energy management and automation. Currently, it employs 142,000 people in more than 100 countries, uses recycled content and recyclable materials in its products, and helps prolong product lifespan through leasing and pay-per-use. It has also introduced take-back schemes into its supply chain. The company has even won the Award for the Circular Economy Multinational.

Mangrove Ecosystem Management- a Case Study

Mangrove ecosystems represent natural capital capable of producing a wide range of products and resources for coastal environments and their related communities with society as a whole. In these value is determined by the markets through exchange and quantified in terms of price. Many of the wild species such as fishes, shellfishes, avian, reptilian, mammalian and planktonic diversity are supported by the nursery provided in Mangroves. Also, commercial fish and crustaceans are supported by mangrove ecosystems, sustaining the local abundance of fish and shellfish populations. The coastal water quality is maintained by Mangroves with the help of nutrient retention and cycling, and rhizo-filtration of pollutants, preventing their seaward flow.

Mangrove conservation and management cannot be a one-time activity – it has to be a continuous exercise. This, in turn, implies that there must be a continuous financial activity that must be linked with the ecosystem conservation and management activity so that the entire project becomes sustainable. The broad term “aquaculture” is the commercial breeding and rearing of aquatic flora and fauna species found in all types of water bodies including ponds, rivers, lakes and seas.

The species found in brackish water include mangrove crabs, shrimps, prawns, oysters, mussels, clams, mullet fish, cobia fish etc., which can be aqua-cultured to protect the existing mangroves on one hand and enhance the value of mangrove land by increasing the supply of seafood. One such activity can be the aquaculture of economically significant brackish water fauna. A few positive impacts of aquaculture on biodiversity are: cultured seafood can reduce pressure on overexploited wild stocks stocked organisms may enhance depleted stocks.

Mangrove protection by aqua-culturists is a win-win situation. It is possible to have sustainable aquaculture farms and sustainable mangrove ecosystem in the same vicinity through enlightened management methods and dedication by the aqua-culturists towards environmental stewardship. With this in background, the Mangrove Foundation of Maharashtra started a mangrove crab aquaculture farm at Vengurla, Sindhudurg, Maharashtra where local fishermen were trained to set up a farm of their own, in exchange of taking care of the mangrove ecosystem in their surroundings. Since 2015, the farm is providing livelihood option to several fishermen families in Vengurla.

Fig.5.9: Visit to the Mangrove Crab Aquaculture Pen of Mr.Sutar in Dec 2015

Hence, based on the above, the following tenets for successful, collective environmental management may be worked out:

Overcoming the Socio-Environmental Crisis: Tenets of Successful Natural Common Pool Resource/ Environmental Management

- Demarcating the boundaries of the resource to be managed
- Identifying the stakeholders and making them a part of the decision-making authority
- Effective ecosystem monitoring by individuals answerable to the stakeholders
- Accountability-based restrictions for stakeholders that fail to obey the community rules
- Effective and affordable conflict-resolution
- Minimal intervention by the government
- For larger common pool resources, multiple levels of nested enterprises with smaller base-level, local bodies are recommended
- Associating an income-generating activity to help fund restoration/management of resources (eco-tourism, sustainable harvest of one resource)

5.2 Resettlement & Rehabilitation

Resettlement & Rehabilitation, often referred to by the acronym R & R, consists of two distinct processes. Of these, Resettlement may be defined as a migration, often forced, of a group, often ethnically, culturally and socially related, for reasons that may be political, social, financial or environmental or caused by development projects coming up in that area. R&R has also been reported due to the demarcation of areas of rich wildlife and high conservation value as National Parks or Wildlife Sanctuaries. Rehabilitation, on the other hand, is the process of restoring someone to their former position in society.

In the present study, we have restricted ourselves to R & R motivated by development projects. After India's independence in the year 1947, several development projects such as multipurpose dams and river valley projects, transport projects, mining projects, and thermal power projects. As per a United Nations report as well as a Working Group on Human Rights (WGHR) report, India is globally at the top, with the largest number of migrants due to development projects.

There are several negative aspects of forced resettlement.

- Most critically, loss of immovable property stares in the face of the migrants
- If the resettlement is hurried, even movable property tends to be forfeited

- The place where resettlement has to take place may not be as ideal to the migrants as their previous place of residence
- Unsatisfactory rehabilitation leading to employment loss
- Insufficient and untimely provision of compensation
- Less than ideal usage of compensation amount for ensuring long-term welfare of the resettled population
- Neglect of vulnerable groups

To understand the volume of R&R in India, the following figures should suffice:

- A year 2007 study by The International Displacement Monitoring Centre revealed that 50 million people in India had to be provided with an R & R plan owing to development projects in the last 50 years (1947-1997)
- As per another estimate, this figure was 60 million for the period of 1947-2000 in only 6 Indian states (Fernandes, 2008; Negi&Ganguly, 2011)
- As per the findings of Indian Social Institute published by Lama (2000), there were 21.3 million internal displacements due to development projects. As per figures obtained from the Indian Social Institute, there were 21.3 million development-induced internally displaced persons. Of these as many as 16.4 million people had been forced to leave their native place due to major or minor dam project. Mining projects came second, displacing 2.55 millions. Industrial development (1.25 million) had also caused significant displacement. In addition, declaration of forests as wild life sanctuaries and national parks had caused a sizeable tribal population to relocate (0.6 million).

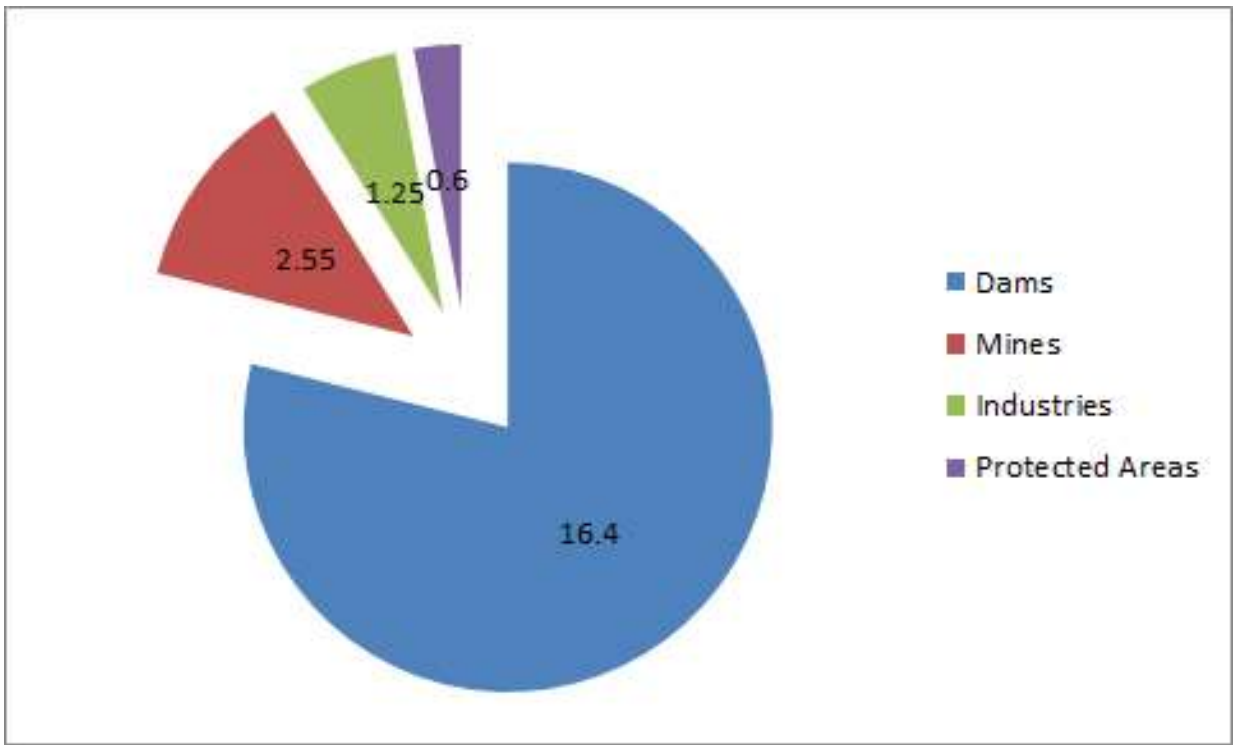


Fig.5.10: Causes of Displacement

Table 5.1: Number of Displaced Persons due to Dam Projects

Dam	Country	Number of people displaced
Already built		
Akosombo	Ghana	84,000
Aswan High	Egypt	100,000
Danjiangkou	China	383,000
Kainji	Nigeria	50,000
Kossou	Cote d'Ivoire	85,000
Mangla	Pakistan	90,000
Nangbeto	Togo & Benin	12,000
Portile de Fier	Romania & Yugoslavia	23,000
Saguling	Indonesia	65,000
Sobradinho	Brazil	65,000
Srisailam	India	100,000
Tarbela	Pakistan	86,000
Almatti	India	160,000
Itaparica	Brazil	40,000
Narayanpur (BasavaSagar Dam)	India	80,000
SardarSarovar	India	220,000
Shuikou	China	68,000
Yacyreta	Argentina	45,000
Casecnan	Philippines	4,000
Gandhi Sagar	India	100,000
Kalabagh	Pakistan	80,000
Soubre	Cote d'Ivoire	40,000
Swarnarekha Multipurpose Project (Chandil Dam &Icha Dam)	India	80,000
Three Gorges	China	1,30,000
Xiaolangdi	China	170,000
Projects Under design		
Karnali	Nepal	55,000

Concepts and Terms

- Project Affected Persons (PAPs) – individuals adversely affected by projects causing land acquisition, land use change or change in natural resource usage pattern, leading to relocation, loss of property or loss of income, are called the Project Affected Persons (PAPs). The term is sometimes replaced by the related term of Project Affected Families (PAFs).
- Displaced Person (DP) – an individual forced to flee his/her usual place of residence due to a oppression or natural/anthropogenic calamity.
- Development-Induced Development (DID) – resettlement/relocation caused by development projects.

- Social Impact Assessment (SIA) – this is the formal process of identifying the social impacts – whether positive or negative – that are associated with any development project. An SIA helps identify the tenets of the project-specific R&R plan.

To Do Activity
Considering one of the Dam project, prepare a case study on its R&R plan.

Social Aspects of R &R in India

The National Commission for Scheduled Castes and Scheduled Tribes had earlier indicated that as many as 40% of the Displaced Persons and the Project Affected Persons, were tribal folk. In a stark revelation made by the 'Tribal Health in India' report (2018) by the Union Ministry of Health and Family Welfare, more than 55% of the tribal population of India had been found to have been displaced. As per Mohanty (2005), this may be attributed to the fact that most of the resource-rich regions of India, where mining and infrastructural projects have attracted investors are inhabited by tribal folk.

Also, there are inherent gender issues associated with R &R, with women-folk bearing the brunt of income loss and greater challenges in executing household chores post the resettlement, as observed by authors such Ravindran and Mahapatra (2009), Ahmad and Lahiri-Dutt (2006), Mathur (2009) etc.

International Policies

Convention 107 (Indigenous and Tribal Populations Convention) of the International Labour Organisation (ILO) recognised forced resettlement in the year 1957, and underscored the importance of adequate compensation provision to the migrants. The Convention states that the indigenous or tribal migrants must be "provided with lands of quality at least equal to that of the lands previously occupied by them, suitable to provide for their present needs and future development." India ratified ILO's Convention 107 on September 29, 1958.

In the year 1989, ILO Convention 107 was revised and renamed the Indigenous and Tribal Peoples Convention, 1989 (No. 169), though India has not ratified this.

Indian Policies

The respective state governments are responsible for acquiring private land for a development project.

The Resettlement & Rehabilitation policy of India was drafted in the year 1985, but it took several years to take shape as the National Rehabilitation and Resettlement Policy.
As per the National Rehabilitation and Resettlement Policy (2007) of India, it is mandatory to conduct an SIA and census of the affected areas, and the involvement of the local governing bodies (Gram Panchayat or Municipality) is a must. The R&R benefits include:

- land for land
- compensation packages
- rehabilitation grants
- employment for at least one person per nuclear family

- vocational training, scholarships and other skill development opportunities
- allotment of outsourced contractual shops or other economic opportunities and labour work at the project site.

The National Rehabilitation and Resettlement Policy (2007) has special provisions to safeguard the socio-cultural heritage of tribal folk – it is critical that Scheduled tribe populations are relocated in similar socio-ecological areas.

Under the Forest Rights Act, 2006, if at all a resettlement is inevitable, it can only be done after due recognition of tribal rights on forest land and acceptance of the resettlement plan by the tribal folk. The purpose of this Act is "to recognise and vest the forest rights and occupation in forest land in forest dwelling Scheduled Tribes and other traditional forest dwellers who have been residing in such forests for generations but whose rights could not be recorded." In this, protected areas such as National Parks and Sanctuaries are included as well. The Act clearly defines that in case of inevitable eviction and resettlement of the forest-dwelling ST or other traditional forest-dwellers, their rights as per the FRA need to be adequately verified and duly recognised, and due acceptance of the resettlement package by the affected tribal-folk. This is aimed as a deterrent against diversion of forest land for other purposes, forced eviction and forced relocation.

The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 aims at providing just and fair compensation for voluntary land acquisition by the government for public utility and infrastructural services. The Act aims at providing an R&R plan that is participative and transparent. Also, the Act aims at providing such an R&R plan that it substantially improves the socio-economic status of the PAPs. The Act was a replacement for the archaic Land Acquisition Act, 1894, a colonial law more than a century old.

Also, the resettlement sites must have basic amenities and infrastructure such as roads, public transport, drainage, sanitation, safe drinking water, community ponds, grazing land, land for fodder, plantation (social forestry or agro forestry), Panchayatghars, Post Offices, provision for irrigation, electricity and health centres, child and mother supplemental nutritional services, children's playground, community centres, schools, institutional arrangements for training, places of worship, land for traditional tribal institutions, burial/cremation grounds and security arrangements.

The policy also provides for monitoring and reviewing the implementation of the R&R plan and also a mechanism for grievance redressal either by the Administrator for Resettlement and Rehabilitation or by an R&R Committee. It is also mandated that there should be an R&R Committee at even the state and district level. This Act has a section dedicated to ST resettlement and compensation. The first schedule of this Act details the procedure of compensation quantification. In Table 5.2, details of procedure for compensation package calculation have been provided.

Table 5.2: Components of Compensation Package in Respect of Land Acquired

Serial No.	Component of compensation package in respect of land acquired under the Act	Manner of determination of value	Date of determination of value
(1)	(2)	(3)	(4)
1.	Market value of land	The collector needs to adopt the following criteria in assessing and determining the market value of the land, namely: a) If any market value is specified in the Indian Stamp Act, 1989 (2 of 1989) for the registration of sale deeds or agreements to sell, as the case may be, in the area, where the land is situated; or b) It can be the average sale price for similar type of land located in the nearest village or nearest vicinity area; or c) Consented amount as compensation under sub-section (2) of section 2 to be paid in case of acquisition of lands for private companies or for public private partnership projects.	
2.	Factor by which the market value is to be multiplied in the case of urban areas	1.00 (one) to 2.00 (Two) based on the distance of project from urban area, as may be notified by the appropriate Government.	
3.	Factor by which the market value is to be multiplied in the case of urban areas	1(One)	
4.	Value of assets attached to land or building	1) For determination of the value of building and other immovable property or assets attached to the land acquired, should use the services of a competent engineer or any other specialist in the relevant field, as considered necessary by him. 2) For determination of Trees and plants value, attached to the land, the collector should use the services of experienced person in the field of agriculture, forestry, horticulture, sericulture, or any other field considered necessary by him. 3) For the purpose of assessing the value of the standing crops damaged during the process of land acquisition, the collector can use the services of experienced person in the field of agriculture as considered necessary by him.	

Serial No.	Component of compensation package in respect of land acquired under the Act	Manner of determination of value	Date of determination of value
5.	Solatium	Equivalent to one hundred per cent, of the market value of land mentioned against serial number 1 multiplied by the factor specified against serial number 2 for rural areas or serial number 3 for urban areas plus value of assets attached to land or building against serial number 4 under column(2)	
6.	Final award in rural areas	Market Value of land mentioned against serial number 1 multiplied by the factor specified against serial number 2 plus value of assets attached to land or building mentioned against serial number 4 under column (2) plus solatium mentioned against serial number 5 under column (2)	
7.	Final award in urban areas	Market Value of land mentioned against serial number 1 multiplied by the factor specified against serial number 3 plus value of assets attached to land or building mentioned against serial number 4 under column (2) plus solatium mentioned against serial number 5 under column (2)	
8.	Other component, if any, to be included		

The Environmental Impact Assessment Notification, 2006 ensures that an SIA is compulsorily conducted prior to the project commencement.

- Social Impact Assessment is conducted as a part of the EIA studies prior to a project
- Mandatory to note if local demographics and social infrastructure will change due to the project
- If proposed project will adversely affect local communities, sacred sites or cultural aspects, and to propose safeguards for the same
- Social impact assessment, public consultation and risk assessment are mandated under Additional Studies of an EIA document
- Post-project compliance monitoring report has to be submitted every 6 months under the EIA notification

An Ideal R&R Plan

An ideal R&R plan aims to achieve:

- Compensation as per prevailing rules; timely pay out
- Participation of the PAPs in the R&R plan preparation
- Income and livelihood restoration
- Socio-cultural integration
- Minimal demographic changes
- Encouraging participatory inputs
- Especial regard to socially vulnerable groups among the PAPs
- Sound advice on short and long-term financial investment

Case Studies

In compliance with the Schedule III of the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013, the National Hydroelectric Power Corporation Ltd aims to provide not just housing but several other infrastructural and socio-cultural facilities to the PAFs in the areas it is active in.

Fig.5.11: View of Resettlement Colony at Teesta-V Power Station, Sikkim

(Source: http://www.nhpcindia.com/Default.aspx?id=232&lg=eng&)

To-do-activity: Make a list of factors that has to be considered during an R&R plan.

5.3 Environmental Ethics

Environmental ethics may be looked upon as a branch of philosophy that addresses the interrelation between human beings and the environment and how ethical living helps shape this. Environmental ethics may be defined as the moral relationship between humans and the natural environment (Naess, 2011).

Shoreman Ouimet and Kopnina (2015) put forth a definition of environment ethics which has been quoted here as "a sub-discipline of philosophy that deals with the ethical problems surrounding the environment, in some cases providing ethical justification and moral motivation for the cause of environmental protection or for considerations of animal welfare".

As per the Stanford Encyclopaedia of Philosophy, Environmental ethics "is the discipline in philosophy that studies the moral relationship of human beings to, and also the value and moral status of, the environment and its non-human contents."

The working tenet of Environmental ethics is that humans are not the most supreme creatures on earth but are rather as much a part of the society as the other species on the earth and all natural resources need to be shared equitably between all. This relates closely with the concept of intrinsic value of the environment, wherein it is stated that the environment has a value higher and beyond what we humans assign to it. It is understood as per environmental ethics that estimating the true worth of the environment will always be beyond human capacity. To understand this better, consider the following:

Overconsumption, wastage and pollution are morally wrong –however, simply agreeing to this is not sufficient. Further, it is critical to comprehend it as morally wrong. Is it wrong because in the long run it would make the planet uninhabitable for us, and it is for the human race's own good to ensure a sustainable environment? Or, should our reasoning go beyond human existence and human welfare and transcend to the welfare of other species and the earth because the latter must exist for *their own* sake and not *our* sake!

Environmental Ethics is also akin to the theory of Spiritual Ecology, which attempts to include the concept of spirituality within the concept of conservation and sustainability. An interpolation of the concept of Environmental Ethics would be the prevention of Environmental Racism, to ensure the equitable sharing of natural resources among human beings of all caste, colour and social strata.

A further interpolation of the same would be the removal of gender bias in environmental management.

Fig. 5.12: Concept of Equitable Sharing of Natural Resources

To incorporate environmental ethics into one's way of life is a critical aspect of sustainable living, and is vital for prolonging and enriching human existence on earth.

Anthropocentrism versus Ecocentrism: The Central Dilemma

Anthropocentrism holds on to the core belief that the *Homo sapiens* is the single most significant species in the world and human values and standards can be used to assess the worth of other species, and environmental goods and services. The term itself can be broken into 'Anthropo' (of a human being) and 'centrism' (centre) to better understand the concept.

In a stark contrast, Ecocentrism opposes the concept of human superiority and professes a nature-centred system of beliefs and values. Herein, the *Homo sapiens* become a part of the intricate web of nature instead of rising above it. Ecocentrism, therefore, raises thought-provoking queries on bio spherical egalitarianism, animal rights, resource sharing and others. Ecocentrism is akin to Biocentrism.

The central dilemma of Environmental Ethics can be well-represented in **Fig. 5.13**

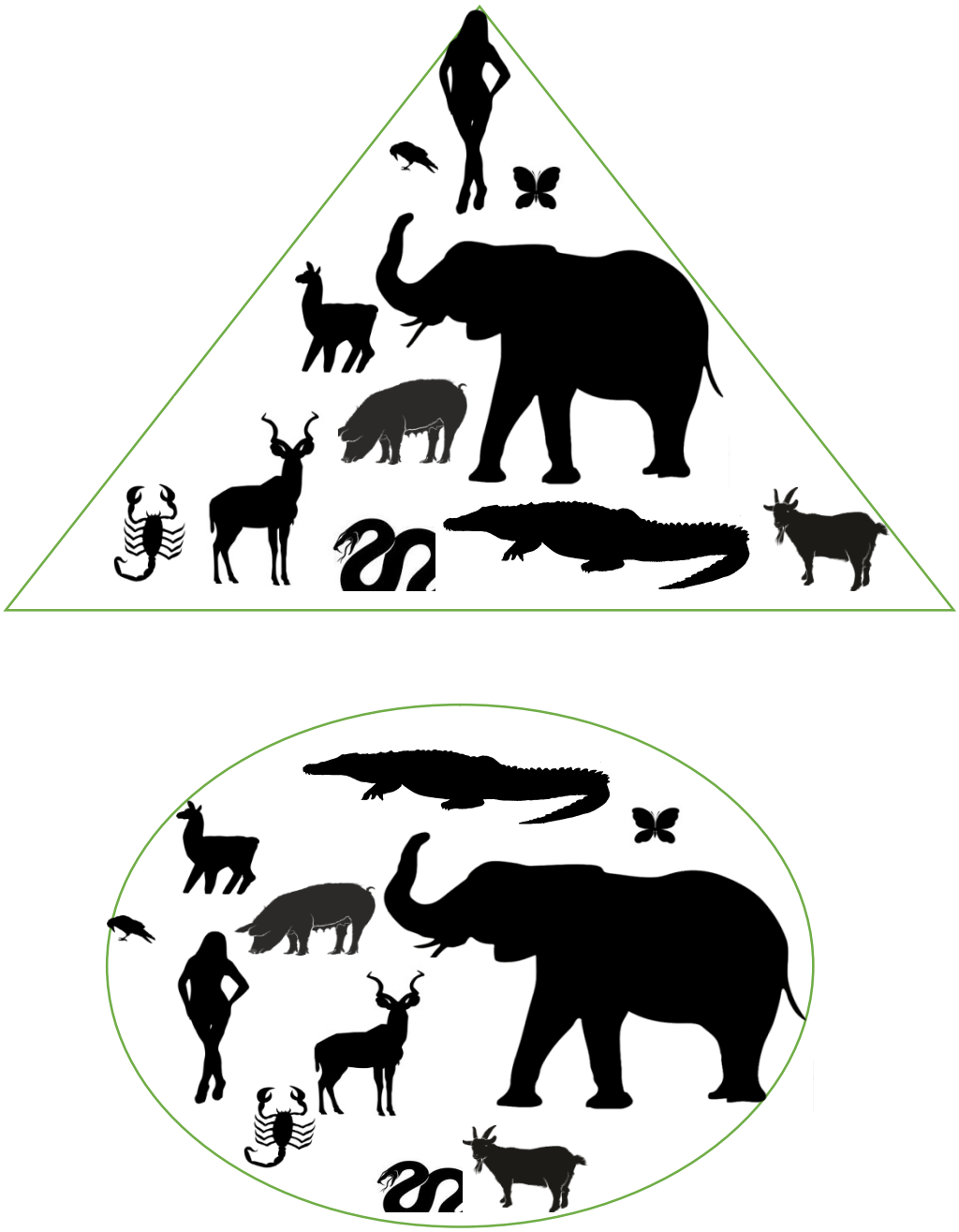


Fig. 5.13: Anthropocentrism vs. Ecocentrism

Gaia Hypothesis

The Gaia hypothesis (also known as Gaia Theory or Gaia Principle) has at its core the Greek Mythology wherein the Earth Goddess is known as Gaia. It was propounded by James Lovelock, a chemist and co-developed by Lynn Margulis, a microbiologist in the 1970s. The theory proposes that all species (biotic factors) interact with their inorganic surroundings on Earth (abiotic factors) to form a synergistic and self-regulating system that helps control, adjust and perpetuate the biosphere. Thus, this system is a complex one, with each biotic and abiotic factor playing its role in ensuring that it works and none of the contributing factors can be considered dispensable. Hence, species extinction, habitat loss, habitat degradation, resource depletion, if not checked, will inexorably take us closer towards a point of no return where the biosphere will not continue to exist as it was prior to disturbance.

Deep Ecology versus Shallow Ecology

Shallow Ecology aims at promoting ecological conservations strategies to check pollution and natural resource depletion. Deep Ecology, on the other hand, holds all this as important but also has "ecological wisdom" at its core, which takes into consideration the inherent value of all species. Thus, while both Shallow and Deep Ecology are pro-conservation concepts, the latter adopts a profounder, all-inclusive approach.

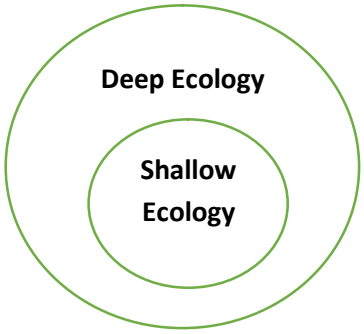


Fig.5.14: Understanding the Concept of Deep and Shallow Ecology

Environmental Racism

This term was coined by Benjamin Chavis, the then executive director of the United Church of Christ (UCC) Commission for Racial Justice. He defined the term as "Racial discrimination in environmental policy making, the enforcement of regulations and laws, the deliberate targeting of communities of colour for toxic waste facilities, the official sanctioning of the life-threatening presence of poisons and pollutants in our communities, and the history of excluding people of colour from leadership of the ecology movements."

As per Park (1998), Environmental Racism has four distinct causative factors, as outlined in **Fig. 5.15**below:

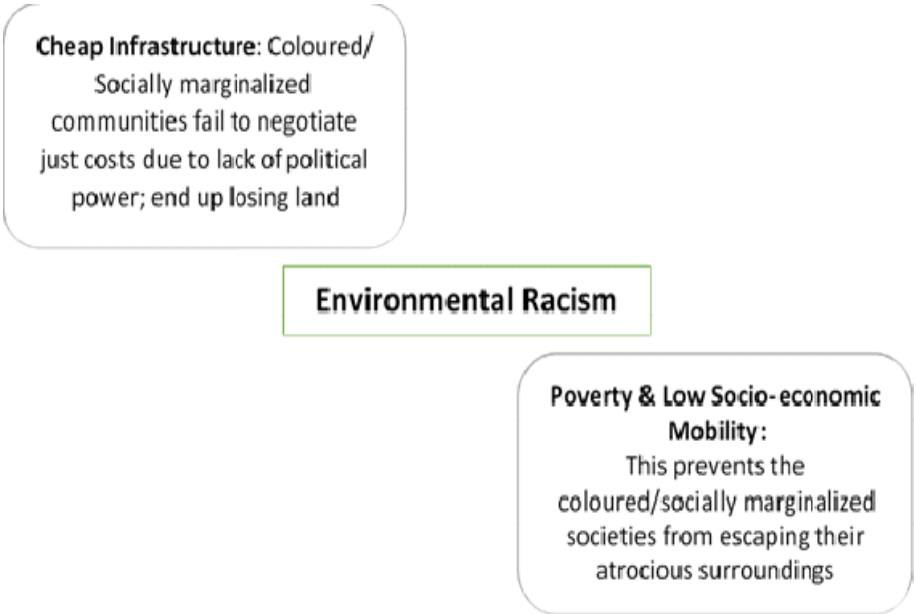


Fig. 5.15: Manifestation of Environmental Racism

Manifestations of Environmental Racism

Native Americans were subjected to intense cruelty, genocide and forced migration in one of the earliest incidents of Environmental Racism. The American Bison, a culturally significant animal for the Native Americans, was hunted to the extent of going nearly extinct by the US Army – the soldiers

were encouraged to hunt these massive beasts for the purpose of pushing off the Native Americans from their traditional lands. The Indian Removal Act, 1830 aimed at relocating the Native Americans living east of the Mississippi towards the west, away from their traditional lands. Unfortunately, their resettlement location was anything but congenial, being barren and dry and of low value for white Americans.

The Bhopal Gas Tragedy

Touted as the worst industrial disaster in the world, the Bhopal Gas Tragedy took more than 3500 lives and irrevocably harmed more than 5 lakh victims due to the accidental release of the highly toxic methyl isocyanate gas. Charges of environmental racism against Union Carbide Corporation, the owner of the pesticide manufacturing company behind this massive tragedy may be levelled on the following bases:

- A gas as lethal as methyl isocyanate should not have been stored in such large quantities in a densely populated area – it is argued that UCC went ahead and did so as environmental norms are relaxed in a third world country like India and it is a risk the company has been known to avoid in its other plants
- Methyl isocyanate needs to be stored at much lower temperatures than what it was being stored at in the Bhopal factory – reportedly costs involved in cooling were cut to increase profit margins
- Preventive maintenance staff were fewer in number than ideally required, and their numbers had been reduced to cut costs and enhance profit margins
- No formal Disaster Management Plan (DMP) had been prepared by the UCC for their Bhopal plant
- The compensation paid to the victims was substantially low by international standards (Schroeder et al. 2008)

To this day, the Bhopal Gas Tragedy remains a massive, unresolved, stark example of the apathy of first world capitalists for third world victims that has left lakhs of people injured in its wake, many among them scarred beyond human agency.

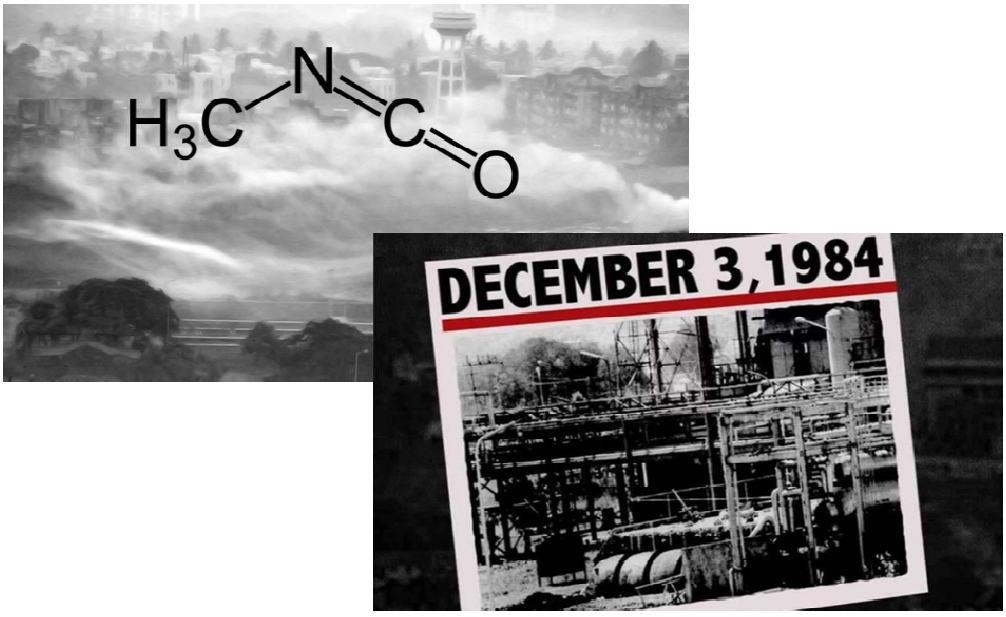


Fig.5.16:A Representation of the Bhopal Gas Tragedy

To Do Activity

Make a case study of an Environmental Tragedy that led to long term impact on humans.

International Toxic Waste Dumping

A rising trend in toxic or hazardous waste management is the import of the same by developing countries from developed countries. Indeed, the global waste trade may well be observed as a manifestation of environmental racism. Interestingly, a World Bank report states that more developed and industrialised nations produce more waste. However, a substantial bulk of this waste is shipped off to the third world countries to be dealt with, given their so-called advantages of cheap labour, lower land costs and relatively relaxed environmental laws.

While some support this view as providing a source of income to a developing country and boosts its economy (Johnson et al. 2007), several others point out the health risks faced by the waste handlers and the insufficiency of facilities to ensure that the hazardous waste is being managed in an environmentally sound manner (Sonak et al. 2008).

Gender & Environmental Ethics

Gender inequality is a critical facet of environmental ethics. It may be envisaged that women are critical elements of environmental conservation because they:

- Chiefly collect water, fuel, fodder and other NTFP (non-timber forest products) for household use
- Participate in agricultural activities

Several thinkers have opined that women have a unique instinct for nature and a holistic purview of environmental processes. To quote Vandana Shiva, a noted environmentalist observes, " (women produce) wealth in partnership with nature, have been experts in their own right of holistic and ecological knowledge of nature's processes".

Women have played critical roles in several environmental conservation activities. The ‘eco-feminist’ Chipko Movement of the 1970s will be remembered in history as a pro-active women-centred forest conservation movement where women from Uttarakhand (then Uttar Pradesh) came out to embrace trees to prevent their chopping down. Similarly, Professor WangariMaathai initiated Kenya's Green Belt movement in 1977 - which was a massive women-led rural plantation mission to help control desertification.

The Love Canal movement envisaged by Lois Gibbs in 1978 New York led to the safe evacuation of about 800 families who had been suffering multiple health and teratogenic impacts emanating from the toxins released by the dumpsite atop which the Love Canal township was built. Other major women-led pro-environment efforts include:

- Hawk Mountain Sanctuary run by Rosalie Edge
- Sylvia Earle’s Mission Blue for ocean conservation
- Urban gardens in and around Harlem, led by Bernadette Cozart
- Vandana Shiva’s BijaVidyapeeth

However, despite notable examples of women leading environmental conservation movements, at several societal levels the existing lacunae in gender equality accentuate the unequal distribution of environmental benefits between man and woman:

- Research shows that majority of the world’s poor are women
- Fewer women are in leadership roles
- Fewer women have access to formal healthcare, education and finance facilities
- Fewer women are formal asset owners

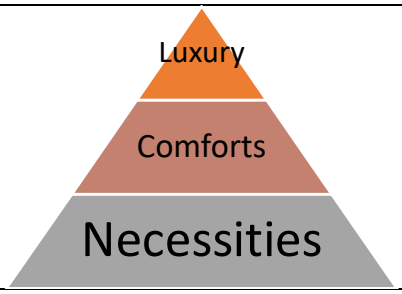
- More women are engaged in household chores and childcare, which does not help them earn incomes

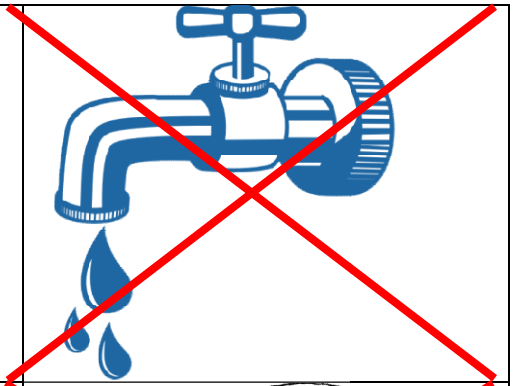
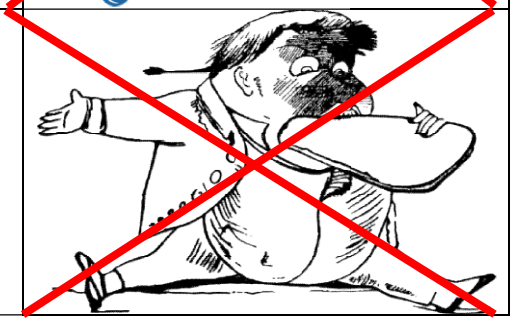
Authors such as Islam (2015), Agarwal (2007), Denton (2002) etc. stress on the importance of ensuring gender equality to ensure environmental sustainability.

Environmental Justice

Environmental Racism sprouts the related concept of Environmental Justice. Environmental Justice emerges as the juxtaposition of environmental facets and social justice. Shoreman-Ouimet and Kopnina(2015) describe Environmental Justice as "equity equality, and rights issues in relation to both social and ecological actors". Unequal distribution of resources creates environmental vulnerability for already marginalised classes, who are forced to bear the "environmental burdens" whereas the more privileged ones enjoy higher "environmental benefits."

Tenets of Environmental Ethics

The hierarchy of needs – comforts – luxury	
Environmental egalitarianism	
Back to Nature Worship	

Avoiding wastage	
Avoiding over-consumption	

James GustaveSpeth, who is the U.S.A. Advisor on climate change, famously said: "I used to think that top environmental problems were biodiversity loss, ecosystem collapse and climate change. I thought that thirty years of good science could address these problems. I was wrong. The top environmental problems are selfishness, greed and apathy, and to deal with these we need a cultural and spiritual transformation."

Box 5.1: James GustaveSpeth's quote on Solving Environmental Issues

5.4 Impact of Pollution on Human Health

Being Healthy: Morbidity versus Mortality

As per the World Health Organisation (WHO), "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 1948). Two related but different aspects of ill-health are Morbidity and Mortality.

Morbidity is the state of being unhealthy due to a disease or condition, whereas Mortality translates into the number of deaths due to a given cause of ill-health

Environmentally-caused Morbidity

Human health can be viewed from four different aspects of:

a) Nutrition
b) Psychology
c) Genetic
d) Biological

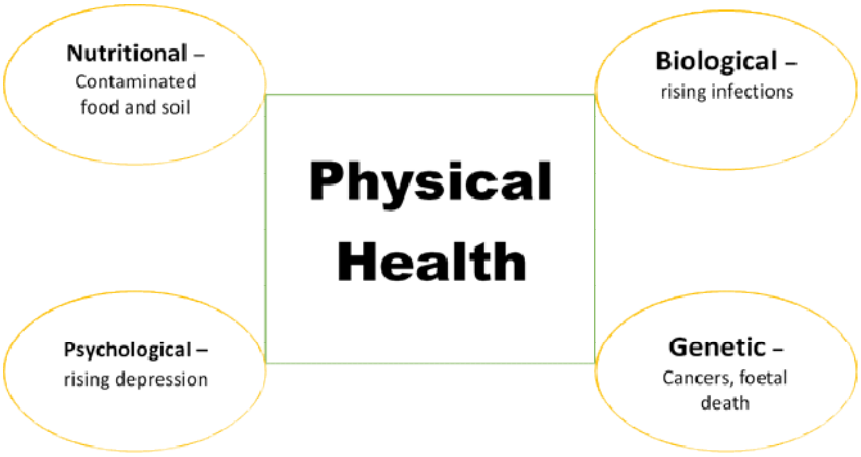


Fig.5.17: Various Aspects of Human Health Affected by Pollution

Table 5.3: Impact of Pollution on Physical Health

Aspects of Physical Health	Impact of Pollution
Nutritional - Sufficient nutrients as per age group - Uncontaminated food	- Excessive pesticide contaminates food, causes entry of potential carcinogens in the food chain - With mindless discharge of pollutants in water, harmful heavy metals and other chemicals lodge into the tissues of species later consumed as sea-food - With heavy usage of chemical fertiliser, arable land is becoming saline and unfit for agriculture, reducing productivity and threatening food security - Microplastics are polluting our oceans, exfoliating our fishes, and worse still, entering our bodies through the seafood consumed
Psychological - Emotional health, happiness, and self-esteem	- Particulate matter from polluted air cause inflammation and oxidative stress in the brain, precipitating depression - Rate of depression can be up to 2 times higher for each 10 $\mu g/m^3$ increase in the nitric oxide level - Depressive episodes leading to emergency OPD visits reportedly rise with an increase in PM10 concentration in the air - Rising PM 2.5 in the air leads to higher chances of depression
Genetic - No genetic disorders - No cancers due to mutagenesis	- Mutagenic pollutants such as polycyclic aromatic hydrocarbons (PAH) and heterocyclic amines form DNA adducts that can prove carcinogenic if they affect the somatic cells - Mutations in germ cells can lead to a variety of genetic diseases and fetal death - Reactive oxygen species generated by pollutants also induce the formation of DNA adducts.
Biological - Infections from various sources	- PM2.5 exposure leads to acute lower respiratory infection (ALRI) in young children - Respiratory tract infections such as influenza and pneumonia have also been reported in adults due to PM2.5 - With improper sewage management and open defecation, gastro-intestinal infections are on the rise - With the changing climate, several vector-borne diseases such as malaria, dengue, Zika virus and Lyme disease are also on the rise

Nutrional
Several chemical contaminants can reportedly lead to ill-health in humans, entering the system via drinking-water.

Psychological
Mental disorders, especially depression, has affectedas many as 300 million people globally. Alarmingly,morethan18% rise in mental disorders was was reported between 2005 and 2015.

Several research studies have linked an increase in the cases of depression and other mental disorders with rising air pollution.

A recent study in China reported that every 1 standard deviation rise in particulate matter over an average PM2.5 concentration enhances the risk of suffering from mental illness (including depression) by 6.67%.

Rate of depression can be up to 2 times higher for each 10 $\mu g/m^3$ increase in the nitric oxide level – as was proved by

Patients of depression faced up to 7.2% higher risk of emergency department visits for depression attacks when PM10 concentration rose by 19.4 $\mu g/m^3$.

Biological
Pollution contributes to several changes in the stable ecosystem leading to increase in parasitic activity, causing diseases. At lower temperatures, a small increase in temperature can greatly increase the risk of malaria transmission due to increased numbers of mosquitoes. Other environmental changes can also affect malaria transmission. Similarly, diseases like chikungunya and dengue may also be influenced by climate, as both are transmitted by the common vector *Aedesaegypti*.

Environmentally-caused Morbidity

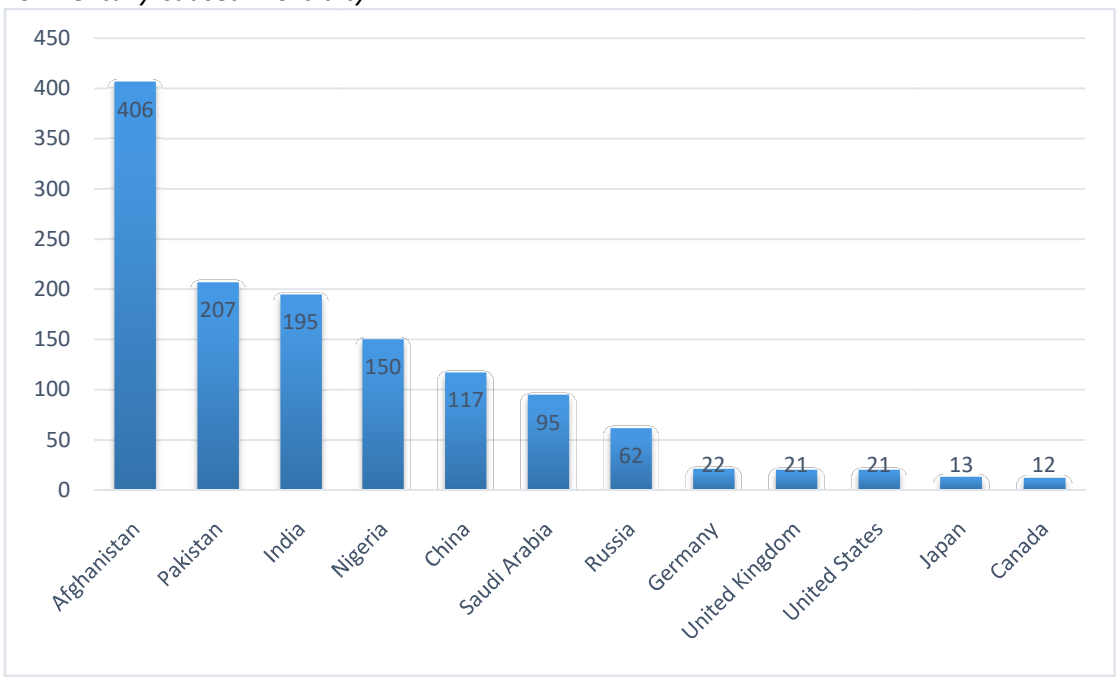


Fig.5.18: Mortality from Ambient Air Pollution (Source: WHO)

The World Health Organisation (WHO) reported that as many as 90% of the global population had to live in a polluted atmosphere, which caused up to 7 million deaths annually. As per WHO, ambient air pollution causes:

- 29% of all deaths and disease from lung cancer
- 17% of all deaths and disease from acute lower respiratory infection
- 24% of all deaths from stroke
- 25% of all deaths and disease from ischaemic heart disease
- 43% of all deaths and disease from chronic obstructive pulmonary disease

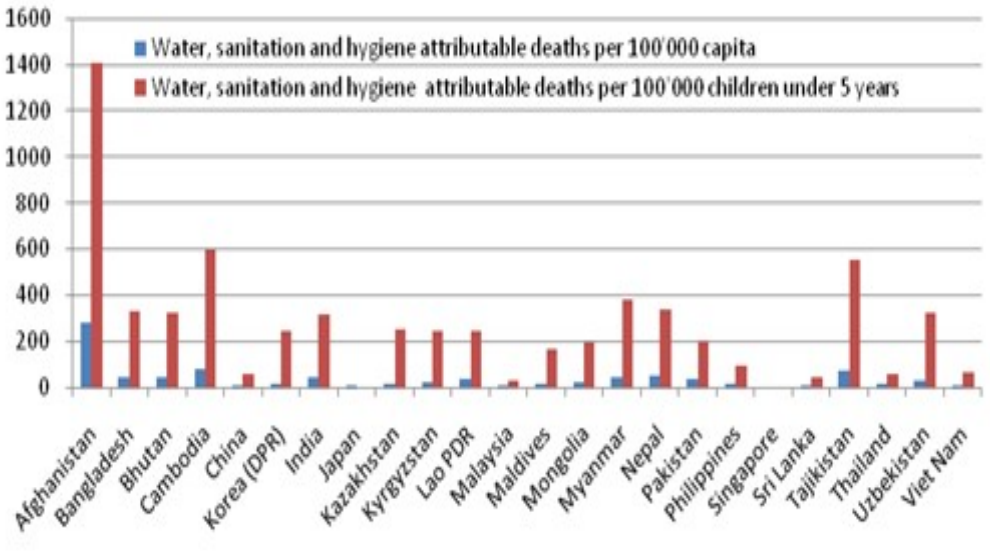


Fig.5.19: Mortality from Water Pollution (Source: Global Water Forum)

Social Epidemiology

Social epidemiology studies how socio-economic factors such as income, class, caste etc. determine one's health status and quality of life. The Centre for Disease Control and Prevention (CDC) describes social determinants of health as the "conditions in the places where people live, learn, work, and play ... that affect a wide range of health risks and outcomes". Now, the environment is which one exists can specifically impact the health of a certain socio-economic class, and such trends need to be researched. For instance, in densely populated areas with low quality housing, infectious diseases can spread much faster. Thus, Social Epidemiology provides common ground for health specialists, social scientists and environmental scientists to help ensure that poor social position does not lead to ill health due to environmental degradation.

Importantly, the Fifth European Ministerial Conference on Environment and Health, focussed on providing better low-income housing conditions and smart urban planning, health equity, and environmental justice policies to help children avoid environmental health risks.

The World Health Organisation (WHO) has prepared a Strategic Environmental Assessment (SEA) protocol in 2001 to conduct health impact assessments along with environmental impact assessment to help ensure better health among the lower socioeconomic strata.

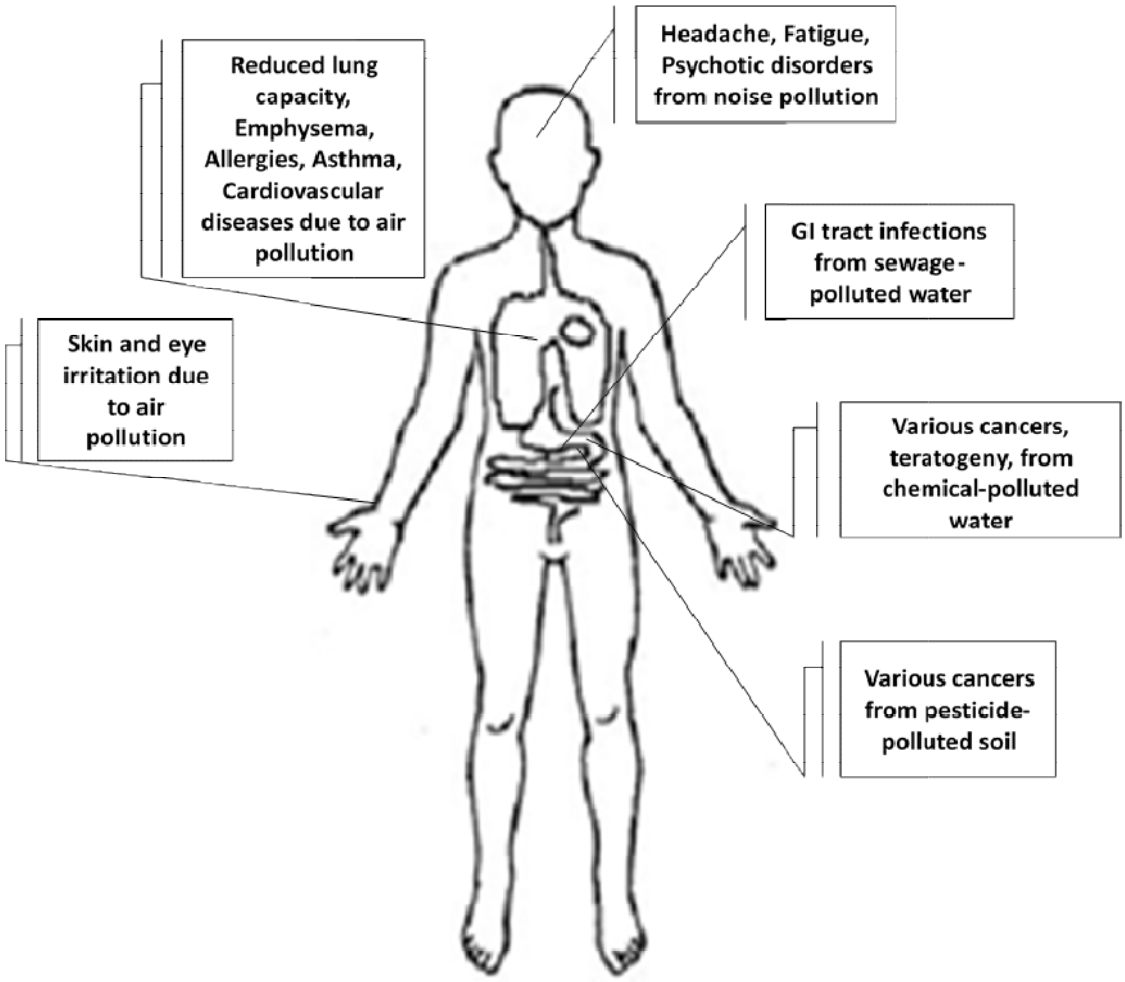


Fig.5.20: Health Impacts of Environmental Pollution

5.5 Indian Laws for Environmental Protection

Air (Prevention and Control of Pollution) Act, 1981 (amended 1987, 2018)

Air (Prevention and Control of Pollution) Act, 1981 (amended 1987 and 2018) is aimed at controlling air pollutants from chemical industries and ensuring healthy air quality.

Air pollutant can be defined as "any solid, liquid or gaseous substance (including noise) present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment." The regulation of emissions from industries to ensure adherence to this act is through the central and state-level pollution control boards.

Functions of the Central Pollution Control Board is:

- To provide advisory guidelines to the government regarding the monitoring, prevention, control, and reduction of air pollution.
- Synchronise the activities of the various state boards and resolve disputes, if any.
- Set ideal as well as realistic standards for the quality of air
- Collate, curate and publish technical and statistical data relating to air pollution and the measures devised for its effective prevention as well as control

Function of the State board is to inspect ,at all reasonable times, any control equipment, industrial plant or manufacturing process.

Types of air contaminants are aerosol, dust, fumes, smoke, mist, vapour, gas particles etc. Air sampling techniques for particulate pollutants can be done through sedimentation, filtration, impingement, precipitation, thermal percipitation, electrostatic precipitation. Sampling protocols for the gaseous pollutants include absorption, adsorption and condensation sampling.

Air Pollution control devices include electrostatic precipitators (ESPs), fabric filters(FF or baghouse), flue gas desulfurisation(FGD), and selective catalytic reduction(SCR). ESPs serve the purpose of fly ash emission reduction by creating an ionised field that attracts/repels and subsequently separates charged particles.

Air (Prevention and Control of Pollution) (Union Territories) Rules, 1983
This Act is administered by Central Pollution Control Board and State Pollution Control Boards. The Objective of the legislation is to control Air pollutants from chemical industries.

Water (Prevention and Control of Pollution) Act, 1974 amended 1988
The Water (Prevention and Control of Pollution) Act is the first enactment by the parliament in 1974 after the Stockholm conference in order to tackle Environmental problems.

This Act is administered by Central Pollution Control Board and State Pollution Control Boards. Objective of the legislation is the prevention and control of water pollution and also maintaining or restoring the wholesomeness of water.

The Water (prevention and pollution control) act 1974, provides the following:
1.Prevention and control of water pollution
2.Every polluter(industry/municipality) has to obtain consent from SPCBs/PCCs.
3. Ensuring the health and purity of water through preventive as well as restorative approaches
4.Establishment of a board for prevention and control of water pollution.

The Act has different sections concerned with the powers conferred to the board for entry and inspection, prohibition on irresponsible disposal of water, restriction on new outlets and discharge points, provision to manage the existing discharge of domestic/industrial effluent, which if not found satisfactory, refusal or withdrawal of consent by the state pollution control board and the procedures associated with charging penalties.

Water (Prevention and Control of Pollution) Rules, 1975
This Act is administered by Central Pollution Control Board and State Pollution Control Boards. Objective of the legislation is the prevention and control of water pollution and also maintaining or restoring the wholesomeness of water. The Water (Prevention and Control of Pollution) Rules, 1975 talks on rules related to the power of collecting samples.

Environmental (Protection) Rules, 1986
This Act is administered by Ministry of Environment and Forests, Central Pollution Control Board. The Objective of the legislation is protection and improvement of the Environment. The Environment Protection Act, 1986 came into effect from 19 nov,1986 by the central government.

1. The act to provide for protection and improvement of environment.
2. Prevention of hazards to the life and property of human beings and the existence of other species.
3. For prevention and control of Environmental pollution
4. Laying standards for quality of environment
5. Restriction of areas for location of industries.

6. Safeguards for handling hazardous substances
7. Research relating to environmental pollution

Hazardous Waste (Management and Handling) Rules, 1989 (amended 2000 and 2003)
The Hazardous Wastes (Management and Handling) Rules, 1989, notified under the Environmental Protection Act as amended in January 6, 2000 and May 21, 2003.
This Act is administered by MoEF, CPCB, SPCB, DGFT, Port Authority and Customs Authority. Objective of the legislation is Management & Handling of hazardous wastes in line with the Basel convention.

- Responsibility of State Pollution Control Board:
- Inventorisation of Hazardous Waste
- Grant and renewal of Authorisation
- Environmentally sound recycling, recovery or reuse facilities.
- Proper arrangement for end-to-end treatment and disposal of the waste.
- A valid registration from the CPCB and a proof of being an actual user, if required under these rules.

Manufacture Storage and Import of Hazardous Chemicals Rules, 1989 (amended 2000)
This Act is administered by Ministry of Environment &Forests. The objective of the legislation is regulating the manufacture, storage and import of hazardous chemicals, which have a direct impact on environmental quality and human health. The rules are based on safety reports and safety audits, preparation of onsite-offsite emergency plan, information on persons who are likely to be affected, provision of Material Safety Data Sheets (MSDS) and regulating the import of hazardous chemicals.

Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996
This Act is administered by CCG, SCG, DCG, LCG and MAH Units. The objective of the legislation is to ensure emergency planning, preparedness and adequate response to chemical accidents. It talks on the role of central government for the constitution of a central crisis group, crisis alert system and the functions of state government for the constitution of state-level crisis groups and setting up the district and local crisis groups. Some of the functions of the District Crisis Group are:

- Help prepare the district-level off-site emergency plan.
- Regulate and review the on-site emergency plans prepared
- Assist the district administration in the management of chemical accidents at a site lying within the district.
- Continuously monitor every chemical accident.

Environment (Protection) Act, 1986
The main objective of this Act is to ensure the protection and improvement of environment. It was enacted in the backdrop of the Bhopal Gas Tragedy of 1984.Herein, the Central government assumes power to prevent, control and abate environmental pollution. The Act empowers the government to appoint suitable officers to ensure prevention of environmental pollution. A plethora of rules have been formulated under this umbrella act, to ensure least adverse effects on the environment. The EPA 1986 sets environmental emission standards that must be met by industries. The empowered officers can enter premises, visit sites, take samples and analyze the same in environmental laboratories. Government analysts may be employed for the purpose as well. Non-compliance invokes heavy penalty. The objective of the Act is the prevention of environmental pollution.

It is the most powerful environmental protection legislation in India

It empowers the Central Government to take all necessary measures for environment protection.

-Coordinate the actions of State Governments
-Lay down standards of environment quality and pollutants.
-Execute nationwide programmes.
-Restriction of areas for industries, etc.
-Inspecting industrial premises,
-Preparation of manuals, codes or guides

A plethora of rules have been formulated under this act -it is hence, referred to as the Umbrella Act

- Environment Protection Rules, 1986
- Hazardous Waste Rules, 1989 (Now 2016)
- Bio Medical Waste Rules, 1998
- Municipal Solid Waste Rules, 2000
- Noise Pollution Rules, 2000
- Ozone Depleting Substances Rules, 2000
- Battery Waste Rules, 2001
- Plastic Waste Rules, 2011
- Electronic waste Rules, 2011

Environment Impact Assessment (EIA) Notification, 2006 under the EPA 1986
EIA Notification, 2006 is controlled by MoEF, SPCB. The objective of the legislation is the requirement of environmental clearance before establishment of or modernisation / expansion of certain type of industries/projects. EIA notification under the Environment (Protection) Act, 1986 mandates environmental and social due diligence prior to the commencement of projects categorised and listed in the notification document. Based on an EIA report prepared as per this notification, it is attempted to ensure that the negative impacts of a project are avoided, nullified or reduced.

The National Environment Tribunal Act, 1995
This Act aims at ensuring quick disposal of cases related to environmental accidents arising due to mishandling of hazardous chemicals, and the expeditious payment of just compensations. This Act was propounded in response to India's attendance of the 1992 Rio de Janeiro United National Conference on Environment and Development.

The National Green Tribunal Act, 2010
This Act provided for setting up the National Green Tribunal for the efficacious and quick assessment of cases related to environment resource conservation and protection of nature. This Act, too, was propounded in response to the Rio conference of 1992. As of October 2019, a total of 30,972 cases have been lodged before various benches of NGT since 2011; of this as many as 27,876 (up to 90%) had been disposed off.

Batteries (Management and Handling) Rules, 2001.
Batteries (Management and Handling) Rules, 2001 is controlled by SPCB, CPCB and MoEF. The objective of the legislation is to control the hazardous waste generation (lead waste) from used lead acid batteries. This applies “to every manufacturer, importer, re-conditioner, assembler, dealer, recycler, auctioneer, consumer and bulk consumer involved in manufacture, processing, sale, purchase and use of batteries or components thereof.” The handing and management rules comes with responsibilities of manufacturer, importer, assembler, re-conditioner dealer, consumer or bulk consumer and auctioner.

The dealer must ensure all possible attempts to prevent environmental damage during transportation. Also, it is the dealer's responsibility to create public awareness through various means such as posters/pamphlets/other forms of advertisements about:

- Lead and its associated hazards
- Return of used batteries either to the dealers or to pre-designated collection centres, this being the purview of the consumer.
- Provision of addresses of dealers and designated collection centres.
- Making the bulk consumer responsible for ensuring that used batteries are prevented from irresponsible disposal
- Instruction to bulk consumer to return the batteries to dealers, manufacturers, importers, assemblers, registered recyclers, re-conditioners or at the designated collection centres
- Instruction to bulk consumers or their user units to auction off the used batteries only to registered recyclers.

Public Liability Insurance Act, 1991 (amended 1992)

Public Liability Insurance Act, 1991 (amended 1992) aims to provide immediate relief to victims of hazardous chemical related accidents. The Act aims at establishing an Environmental Relief fund and an insurance policy to cover the liabilities subsequent to accidents/disasters related to 179 types of chemicals enlisted. This act tells about the duties of owner to take out insurance policies, verify and publish details of accidents, application for claim for relief, and the award of relief. The Act expounds upon rules related to establishment of administration of fund, extent of liability and the owner's financial inputs to environmental relief fund. The Act also confers powers such as power to call for information, power of entry and inspection, power of search and seizure, power to give directions, and power to make application to courts for restraining owner from handling hazardous substances.

Factories Act, 1948

In Great Britain, the second half of the 18th century, there was a rapid growth of industrial towns and factories. As it was started without planning, they employed the women as well as their children in factories who needed to work more than 12 hours a day. Some of the employees took initiative to implement labour legislations, Factories Act came into existence in 1819. After some modifications, the final amended of Factories Act took place in 1948. In industrial premises with at least ten people at work (if power is used), or twenty or more people are at work (if power is not used), in a manufacturing process is termed factory. Factories Act, 1948 is under the aegis of the Ministry of Labour. The objective of the legislation is to control workplace environment, and provide for good health and safety of workers. The Act is applicable to any place wherein manufacturing process is carried on with or without the aid of power. Factories Act majorly focuses on health, safety, welfare, working hours of adults, annual leave with wages.

In addition, there is a strong focus on reducing environmental pollution. For instance, a 'hazardous process' according to this Act is anything that can pollute the general environment. Also, such hazardous processes must be conducted with strict adhesion to the emission criteria mandated by the Air (prevention and control of pollution) Act, 1981 and the Water (prevention and control of pollution) Act, 1974.

The Explosives Acts, 1884 and The Explosive Rules, 1983 (amended 2008)

The Explosives Acts, 1884 and the Explosive Rules, 1983 has been propounded by Ministry of Commerce and Industry in order "to regulate the manufacture, possession, use, sale, transport, export and import of explosives with a view to prevent accidents." The 1983 Explosive rules are based on import and export of explosives, and transportation of explosive items. It also state rules

regarding manufacture of explosives, its possession, sale and use. It also states some rules on granting licences.

The Motor Vehicle Act, 1988

The Motor Vehicle Act, 1988 (amended in 2019) is under the aegis of the Ministry of Shipping, road transport and highways. The objective of the legislation, apart from preventing loss of life, includes prevention of damage to the environment and stoppage of pollution. Some of the key features from this Act that are relevant from the environment point of view are:

- The Act seeks support innovation by enhancing Central Government's flexibility of action to aid new technologies, inventions and innovations from the provisions of the principal Act to promote innovation.
- The Motor Vehicles Rules, 1989 makes it compulsory for all motor vehicle owners to obtain the Pollution Under Control (PUC) certificate and renew it periodically through checks conducted by authorised individuals
- Vehicles with engines or other parts causing environmental pollution can be recalled

The Energy Conservation (Amendment) Act 2010

The Energy Conservation Act enforces the government to set specific norms and stands for efficient energy utilisation by different industries. These norms and standards are also set for equipment, appliances, construction. A Bureau of Energy efficiency is established under the Act to carry energy audits and also specify certain qualifications and certification process for the auditors. The Act applies to commercial sectors with load more than 100kV.

Summary

This Chapter give a cumulative information on bi-directional relationship between the environment and the society. Also, an overview of the prevailing theories and hypotheses are detailed in the chapter. Several approaches and case studies that offer a solution to the economic growth versus environmental degradation challenge are highlighted in the chapter. The Chapter also gives a brief of several laws pertaining to environment.

Model Questions

- How environment and people are connected to each other?
- What are the components of Social environment?
- What is resettlement and rehabilitation?
- What are the causes for resettlement or rehabilitation?
- List down some movements in India who are actively working for rehabilitation.
- What are your views on the permission granted to hunt and kill Nilgai in several districts of Bihar, which is a poor, agriculture-dependent state where nilgai is a pest? Please give reasons for your answer. If not killing, what other feasible options may be suggested?
- What, in your view, will help one transition from being a Shallow Ecologist to a Deep Ecologist?
- Which tenet of Environmental Ethics can you as an individual most easily incorporate in your lifestyle? Which one would you find most difficult?
- Prepare a case study of environmental racism that you can observe in your surroundings.
- Prepare a case study of gender bias in environment management that you can observe in your surroundings.
- Keeping in mind the Gaia Theory, how would a fire in the Amazon or the Australian bushfires affect a resident of India?

- Describe the various aspects of human health affected by pollution.
- What are the effects of Land pollution on human health?
- Visit a nearby clinic or a hospital and find out the rate of people and diseases affected by air pollution
- List down some of the important Environmental laws in India
- Which Environmental law was first developed in India and what is its importance?
- When the law of Biodiversity was formed in India and state its importance?
- How environment and people are connected to each other?
- What are the components of Social environment?
- What is resettlement and rehabilitation?
- What are the causes for resettlement or rehabilitation?
- List down some movements in India who are actively working for rehabilitation.

References

- Agarwal, B. (2007). Gender inequality, cooperation and environmental sustainability. Inequality, cooperation and environmental sustainability. Princeton University Press, Princeton, Nesw Jersey, 274-313.
- Ahmad, N., & Lahiri-Dutt, K. (2006). Engendering mining communities: examining the missing gender concerns in coal mining displacement and rehabilitation in India. Gender, Technology and Development, 10(3), 313-339.
- Andheria, A. P., Karanth, K. U., & Kumar, N. S. (2007). Diet and prey profiles of three sympatric large carnivores in Bandipur Tiger Reserve, India. Journal of Zoology, 273(2), 169-175.
- Buttel, F. H. (1996). Environmental and resource sociology. ENVIRONMENTAL SOCIOLOGY SYLLABI AND INSTRUCTIONAL MATERIALS FIFTH EDITION COMPILED AND EDITED BY RIK SCARCE SKIDMORE COLLEGE, 169.
- Denton, F. (2002). Climate change vulnerability, impacts, and adaptation: Why does gender matter? Gender & Development, 10(2), 10-20.
- Dugan, Patrick, and Patrick J. Dugan, eds. Wetland conservation: A review of current issues and required action. IUCN, 1990.
- Ebong, G. A., Etuk, H. S., & Johnson, A. S. (2007). Heavy metals accumulation by Talinum triangulare grown on waste dumpsites in Uyo metropolis, Akwa Ibom State, Nigeria. Journal of Applied Sciences, 7(10), 1404-1409.
- Fernandes, W. (2008). India's forced displacement policy and practice: Is compensation up to its functions. Can compensation prevent impoverishment, 181-207.
- Hardin, G. (1968). The tragedy of the commons. science, 162(3859), 1243-1248.
- Islam, S. N. (2015). Inequality and environmental sustainability.
- Lama, M. P. (2000). Internal displacement in India: causes, protection and dilemmas. Forced Migration Review, 8, 24-26.
- Malthus, T. (1798). An essay on the principle of population. Printed for J. Johnson. St. Paul's Church-Yard, London, 1-126.
- Mathur, H. M. (2009). Tribal land issues in India: Communal management, rights, and displacement. Land and Cultural Survival.

- Mohanty, B. (2005). Displacement and rehabilitation of tribals. Economic and political Weekly, 1318-1320.
- Naess, A. (2011). The deep ecological movement: Some philosophical aspects. In Ecophilosophy in a World of Crisis (pp. 96-110). Routledge.
- NHPC Limited (2019),Resettlement & Rehabilitation (R&R) Initiatives, retrieved on 15th January 2019, from http://www.nhpcindia.com/Default.aspx?id=232&lg=eng&
- Park, L. S. H., & Pellow, D. N. (2004). Racial formation, environmental racism, and the emergence of Silicon Valley. Ethnicities, 4(3), 403-424.
- Ravindran, L. A. T. H. A., & Mahapatra, B. A. B. I. T. A. (2009). Gender issues in displacement: a study of irrigation projects in Southern Orissa. Beyond relocation, 240-274.
- Schnaiberg, A. (1980). The environment: From surplus to scarcity.
- Schroeder, R., Martin, K. S., Wilson, B., & Sen, D. (2008). Third world environmental justice. Society and Natural Resources, 21(7), 547-555.
- Shoreman-Ouimet, E., & Kopnina, H. (2015). Reconciling ecological and social justice to promote biodiversity conservation. Biological Conservation, 184, 320-326.
- Singh Negi, N., & Ganguly, S. (2011). Development projects vs. internally displaced populations in India: a literature based appraisal.
- Sonak, S., Sonak, M., & Giriyan, A. (2008). Shipping hazardous waste: implications for economically developing countries. International environmental agreements: politics, law and economics, 8(2), 143-159.

Editors' Profile

Dr W G Prasanna Kumar

Dr. W. G. Prasanna Kumar, PhD in Education with basic degree in Social Work and Master's Degrees in Sociology, Public Administration and Political Science has professional education in Environmental Economics, Public Relations, Communication and Training and Development. Presently Chairman, Mahatma Gandhi National Council of Rural Education (MGNCRE) under the Ministry of Human Resource Development, in Government of India strives to promote resilient rural India through Higher Education interventions. The national initiative of reviving Mahatma Gandhi's ideas of NaiTalim, spearheaded by Dr. W G Prasanna Kumar, has met unprecedented success at both national and state levels. The primary objective of this initiative is to promote Gandhiji's ideas on Experiential Learning, NaiTalim, Work Education and Community Engagement, and mainstreaming them in School Education and Teacher Education Curriculum & Pedagogy. As Professor and Head Centre for Climate Education and Disaster Management in Dr MCR HRD Institute, conducted several capacity building and action research programmes in climate education, disaster management and crowd management. He has handled many regional, national and international environmental education programmes and events including UN CoP11 to Convention on Biological Diversity and Media Information Management on Environmental Issues.

He was Director in National Green Corps in the State Government for over 11 years and Senior Social Scientist in State Pollution Control Board for 6 years. Conducted various curriculum and non-curriculum related training programmes in environmental education. He was a Resource Person for AP Judicial Academy, AP Police Academy, AP Forest Academy, EPTRI, Commissonerate of Higher Education and Intermediate Education, State Council for Educational Research and Training and National Council for Educational Research and Training New Delhi, CCRT, Bharathiya Vidyapeet University Pune, CPR Environmental Education Centre Chennai and Centre for Environment Education Ahmedabad. Dr W G Prasanna Kumar was trained in Community Consultation for Developmental Projects in EPA Victoria Australia in 1997 trained as State Chief Information Officer by IIM Ahmedabad and MCRHRDI Government of Andhra Pradesh in 2004 and trained in Environmental Education and Waste Management Technique by JICA, Japan in 2011.

He was awarded Best State Nodal Officer of National Green Corps Award from Centre for Science and Environment, New Delhi, 2008, Jal Mithra Award from Earthwatch Institute of India and Water Aid New Delhi, 2014 and Certificate of Commendation for the services in UN Conference of Parties to Convention for Biodiversity conducted at Hyderabad from 1-20 October 2012 by the Government of Andhra Pradesh 2012.

Dr K N Rekha

Dr K N Rekha, is a PhD Graduate from IIT Madras. She has 14 years of experience in training and education Industry. She works at Mahatma Gandhi National Council of Rural Education (MGNCRE), Hyderabad as Senior Faculty. She is involved in curriculum development on Rural Management and Waste Management. Prior to this, she worked as a researcher at Indian School of Business, Hyderabad, a short stint at Centre for Organisation Development (COD), Hyderabad. She has co-authored a book on "Introduction to Mentoring", written book chapters, peer reviewed research papers, book reviews, Case studies, and caselets in the area of HR/OB. She also presented papers in various national and international conferences. Her research areas include Mentoring, Leadership, Change Management, and Coaching. She was also invited as a guest speaker at prominent institutions like IIT Hyderabad.

Dr Deepti Sharma

Dr. Deepti Sharma is the Founder-Director of TerraNero Environmental Solutions Pvt. Ltd., a niche environmental research consultancy. Also, she is the Founder and Chief Editor of Poison Pen Enterprises, in which capacity she has edited and proofread PhD theses, dissertations and research publications from several elite research and academic institutes of India such as IIT-Bombay, NITIE, JNU, BHU, CSIR-NIO,CSIR-NEERI, JNCASR and NMIMS. She herself has several research publications in peer-reviewed journals. With a doctorate in the field of Biodiversity (Botany), Dr. Sharma has been recognized as a Category 'A' Functional Area Expert in the field of Ecology and Biodiversity by the Quality Council of India (QCI)- NABET. She was formerly associated with CSIR-NEERI, Mumbai Zonal Lab in the capacity of a Project Scientist. As a part of TerraNero and CSIR-NEERI, she has worked with several eminent organizations like IIT-Bombay, TCE Pvt. Ltd., ACC Ltd., AECOM Pvt. Ltd., MMR-EIS, various municipal bodies of Maharashtra and Karnataka, the Goa State Biodiversity Board, and the Maharashtra State Forest Dept among others. Dr. Sharma's tryst with solid and liquid waste management began when she was working with CSIR- NEERI, where she worked on preparing a microbial consortium for liquefying fecal sludge and designing floating treatment wetlands for impounded wastewater treatment. Her organization TerraNero has conducted various waste management-related projects in Maharashtra and Karnataka.

Mahatma Gandhi National Council of Rural Education

Department of Higher Education

Ministry of Human Resource Development, Government of India

सत्यमेव जयते

Where there is Rural Wellbeing there is Universal Prosperity

O40 - 2321 2120

admin@mgncre.in

www.mgncre.in

#5-10-174, Shakkar Bhavan, Fateh Maidan Lane

Band Colony, Basheer Bagh,

Hyderabad-500004