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# Environment and Ecology

Social Psychology (Central University of Haryana)



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# VAJIRAM & RAVI

# ENVIRONMENT AND ECOLOGY

## 2018

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# CHAPTER – 1
# INTRODUCTION TO ECOLOGY

## What is environmental science?

"Environmental science is the academic field that takes physical, biological and chemical sciences to study the environment and discover solutions to environmental problems."

Environmental science is the study of how living and non-living organisms interact with their surroundings. Modern-day technology and human actions are slowly ruining and draining the planet's ecosystem and natural resources. The study of environmental science helps to enlighten the world about **global issues**, such as **forest denudation** and **dynamite fishing**. Global **warming** is another impending issue that can only be addressed through environmental science. Applying knowledge gained through environmental science is the only way to solve these problems so that the environment can be preserved. The rapid urbanization of the environment needs to be studied constantly in order to avoid altering and damaging the environment significantly. Ultimately, environmental science is necessary to save the environment from destruction and all of its dependents from extinction.

## Need for public awareness

"Public awareness of the environment means the ability to emotionally understand the surrounding world, including the laws of the natural environment, sensitivity to all the changes occurring in the environment, understanding of cause-and-effect relationships between the quality of the environment and human behaviour, an understanding of how the environment works as a system, and a sense of responsibility for the common heritage of the Earth, such as natural resources - with the aim of preserving them for future generations."

Our environment is being increasingly deteriorated by our activities. It is evident that something needs to be done. It is the **prevention of environmental degradation** that must become a part of all our lives. Mass media such as newspapers, radio and television strongly influence public opinion. However, someone has to bring this about. If each of us feels strongly about the environment, the press and media will add to our efforts. Politicians in a democracy always respond positively to a strong publicly-supported movement. We are living on planet earth with a limited supply of resources. Each of us is responsible for spreading this message to as many people as possible. There are several Government and Non-Government Organizations working towards environmental protection in our country. They have created a growing interest in environmental protection and conservation of nature and natural resources.

## What is ecology?

"Branch of biology that attempts to understand the relationship between living organisms and their environment, and the associated energy-flows."

## Scope of Ecology

The solution of a particular ecological problem requires several lines of approach. None of this constitutes an end in itself but each one of these makes important contribution in making the picture complete. *These various lines of approach towards the ecological problem can be translated as:*

(a) **Biotic**: Biotic factors are the direct outcome of the various types of activities amongst the animals. A competition for food and shelter always exists amongst the members of a community. This competition demands various types of activity amongst the animals.



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(b) **Quantitative**: Quantitative study includes an assessment of the population density in a given area and also an estimation of the number of members present in different communities. Information of this kind is of immense value in solving many problems like food availability and movement within a particular colony.

(c) **Climatic** (both physical and chemical): Climatic factors include both physical and chemical conditions present in a habitat. These factors are ever changing in nature. Physical factors include mainly temperature, light and humidity. Chemical factors include acidity or salinity that are especially present in aquatic habitat. Some animals are so sensitive that a minute climatic change becomes fatal to them. Climatic factors play an important role in the distribution of animals.

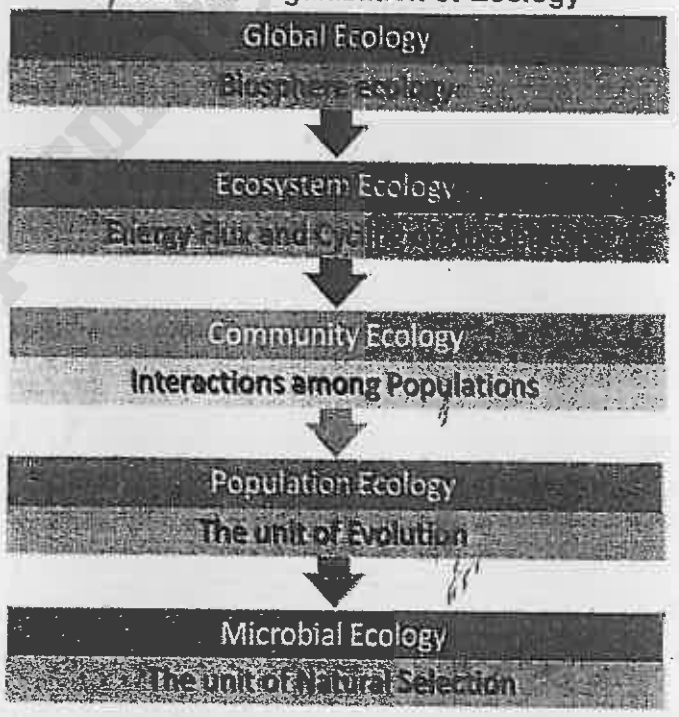
(d) **Taxonomic**: Taxonomy means classification, naming and description of organisms. A mere naming of a large number of animals of a given area, as was done earlier in ecological surveys, is meaningless without a consideration of the circumstances that enable them to live there. Thus a complementary observation of the various ecological factors together with taxonomy is emphasized in ecology.

(e) **Genetic** and **evolutionary**: The genetic and evolutionary aspects have taken a rightful place in ecological problems. In recent years the knowledge of heredity and the mechanism of the operation of Natural Selection have increased to a considerable extent.

## Branches of Ecology

1. **Habitat** ecology: It deals with ecological study of different habitats on planet earth and their effects on the organisms living there. According to the kind of habitat, ecology is subdivided into marine ecology (oceanography), estuarine ecology, fresh water ecology (limnology), and terrestrial ecology. The terrestrial ecology in turn is classified into forest ecology, cropland ecology, grassland ecology, desert ecology, etc., according to the kinds of study of its different habitats.
2. Community ecology: It deals with the study of the local distribution of animals in various habitats, the recognition and composition of community units, and succession.

Hierarchal Organization of Ecology




3. **Population ecology:** It deals with the study of the manner of growth, structure and regulation of population of organisms.
4. **Evolutionary ecology:** It deals with the problems of niche segregation and speciation.
5. **Taxonomic ecology:** It is concerned with the ecology of different taxonomic groups of living organisms and eventually includes following divisions of ecology: microbial ecology, mammalian ecology, avian ecology, insect ecology, parasitological, human ecology and so on.
6. **Human ecology:** It involves population ecology or man and man's relation to the environment, especially man's effects on the biosphere and the implication of these effects for men.



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7. **Applied ecology:** It deals with the application of ecological concepts to human needs and thus, it includes following applications of ecology: wild-life management, range management, forestry, conservation, insect control, epidemiology, animal husbandry, aquaculture, agriculture, horticulture, and land use and pollution ecology.
8. **Ecosystem dynamics:** It deals with the ecological study of the processes of soil formation, nutrient cycline energy flow, and productivity.
9. **Production ecology:** It deals with the gross and net production of different ecosystems like fresh water, sea water, agriculture, horticulture, etc., and tries to do proper management of these ecosystems so that maximum yield can be obtained from them.
10. **Ecological energetic:** It deals with energy conservation and its flow in the organisms within the ecosystem. In this thermodynamics has a significant contribution.
11. **Physiological ecology (ecophysiology):** The factors of environment have a direct bearing on the functional aspects of organisms. The ecophysiology deals with the survival of populations as a result of functional adjustments of organisms with different ecological conditions.
12. **Chemical ecology:** It concerns with the adaptations of animals or preferences of particular organisms like insects to particular chemical substances.
13. **Ecological genetics (genecology):** An ecologist recognized a kind of genetic spasticity in the case of every organism. In any environment only those organisms that are favoured by the environment can survive. Thus, genecology deals with the study of variations of species based upon their genetic potentialities.
14. Palaeo-ecology: It is the study of environmental conditions, and life of the past ages, to which palynology, palaeontology, and radioactive dating methods have made significant contribution.
15. Geographic **ecology:** It concentrates on the study of geographical distribution of animals (zoogeography) and plants (phytogeography), and also of palaeoecology and biomes.
16. **Space ecology:** It is a modern subdivision of ecology which is concerned with the development of partially or completely regenerating ecosystems for supporting life of man during long space flights or during extended exploration of extra-terrestrial environments.
17. **Pedology:** It is a branch of terrestrial ecology and it deals with the study of soils, in particular their acidity, alkalinity, humus contents, mineral contents, soil-types, etc., and their influence on the organisms.
18. **Radiation ecology:** It deals with the study of gross effects of radiations and radioactive substances over the environment and living organisms.
19. Ethology: It is the interpretation of animal behaviour under natural conditions. In it, often, detailed life history studies of particular species are amassed.
20. **Sociology:** It is the study of ecology and ethology of mankind.

## BRIEF HISTORY OF ECOLOGY

| Notable figure | Lifespan | Major contribution & citation |
|---|---|---|
| Antoni van Leeuwenhoek | 1632-1723 | First to develop concept of food chains |
| Carl Linnaeus | 1707–1778 | Influential naturalist, inventor of science on the economy of nature |

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| | | |
|---|---|---|
| Alexander Humboldt | 1769–1859 | First to describe ecological gradient of latitudinal biodiversity increase toward the tropics in 1807 |
| Charles Darwin | 1809-1882 | Founder of evolution by means of natural selection, founder of ecological studies of soils |
| Herbert Spencer | 1820–1903 | Early founder of social ecology, coined the phrase 'survival of the fittest' |
| Karl Mobius | 1825-1908 | First to develop concept of ecological community, biocenosis or living community. |
| Ernst Haeckel | 1834-1919 | Invented the term ecology, popularized research links between ecology and evolution |
| Victor Hansen | 1835-1924 | Invented term plankton, developed quantitative and statistical measures of productivity in the seas. |
| Eugenius Warming | 1841-1924 | Early founder of Ecological Plant Geography. |
| Ellen Swallow Richards | 1842–1911 | Pioneer and educator who linked urban ecology to human health |
| Stephen Forbes | 1844–1930 | Early founder of entomology and ecological concepts in 1887 |
| Vito Volterra | 1860-1940 | Independently pioneered mathematical populations' models around the same time as Alfred J. Lotka |
| Vladimir Vernadsky | 1869-1939 | Founded the biosphere concept |
| Henry C. Cowles | 1869-1939 | Pioneering studies and conceptual development in studies of ecological succession. |
| Jan Christian Smuts | 1870-1950 | Coined the term holism in a 1926 book *Holism and Evolution*. |
| Arthur G. Tensely | 1871–1955 | First to coin the term ecosystem in 1936 and a notable researcher. |
| Charles Christopher Adams | 1873-1955 | Animal ecologist, biogeographer, author of first American book on animal ecology in 1913, founded ecological energetics. |
| Friedrich Ratzel | 1844-1904 | German geographer who first coined the term biogeography in 1891. |
| Frederic Clements | 1874-1945 | Authored the first influential American ecology book in 1905. |
| Victor Shelford | 1877-1968 | Founded physiological ecology, pioneered food-web and biome concepts, and founded The Nature Conservancy. |
| Alfred J. Lotka | 1880-1949 | First to pioneer mathematical populations models explaining trophic (predator-prey) interactions using logistic equation |
| Henry Gleason | 1882-1975 | Early ecology pioneer, quantitative theorist, author, and founder of the individualistic concept of ecology. |
| Charles S. Elton | 1900-1991 | 'Father' of animal ecology, pioneered food-web & niche concepts |



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| | | |
|---|---|---|
| | | and authored influential *Animal Ecology* text. |
| G. Evelyn Hutchinson | 1903-1991 | Limnologist and conceptually advanced the niche concept. |
| Eugene P. Odum | 1913-2002 | Co-founder of ecosystem ecology and ecological thermodynamic concepts. |
| Howard T. Odum | 1924–2002 | Co-founder of ecosystem ecology and ecological thermodynamic concepts. |
| Robert MacArthur | 1930–1972 | Co-founder of Theory of Island Biogeography and innovator of ecological statistical methods |

## Ecology in India

**Ancient literature** is so full of references wherein landscapes and serene beauty has been eulogized in conditions of the wealth it provided and the visual pleasure it offered. It should be noted that the landscape was visualized not only in conditions of the economic and strategic significance but also its aesthetic value that was appreciated.

Early **Vedic literature** mentions the expansion of human settlement from the north-western India towards the Ganga-Yamuna Doab. A shift from the semiarid region to more wet regions of Ganga-Yamuna Doab and the nomad character of the new settlers necessitated movement towards a greener region. With the advent of 'iron revolution' in the densely forested region became a reality. Slowly the agriculture spread, forests shrank, and empires began to take form. Monarchies were concentrated in the Ganga plain, perhaps due to the information, that it was easier to clear the wooded low-lying hills than the marshy jungles of the plain. It also suggests that there had been continuous interaction flanked by the settled agriculture and the adjoining forest regions, information substantiated through Kautilya. He visualized forests and mountains as providing effective barrier against the enemies. He also supported management of forests to generate revenue as well. Thus, forests and mountains were perceived in conditions of their economic and strategic significance.

In the ***ancient Tamil poetry***, love of man and woman is taken as the ideal expression of inner self as well as outer world. The moods of separation and union are described through borrowing attributes from the wider natural world and placed within the rituals of poetry. There are some types of lay; each is presided through a deity and named for a flower or tree feature of the region:

- **Mullai** – a diversity of jasmine, stands for the forests overseen through *Mayon*, the dark-bodied god of herdsmen.
- **Kunnci** – (pronounced *Kuriñji*): a mountain flower, for the mountains overseen through *Murukan*, the red-speared god of war, youth and beauty.
- **Marutam** – (pronounced *Marudam*), a tree with red flowers rising closeto the water, for the rustic region, overseen through *Vendan*, the raingod.
- **Neytal** – (pronounced *Neydal*)a water flower for the sandy sea shore overseen through the Wind God.
- **Palai** – is given no specific site, for it is said that any mountain or forest may be parched to a waste land in the heat of summer. It is named for *Palai*, supposedly an ever-green tree unaffected through drought. Information in relation to the landscape is also available for the medieval era.



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**Medieval era:** A secure examination of the Persian sources of the **medieval era** reveals that the region of Ganga-Yamuna Doab then had a dissimilar landscape. Throughout Alauddin's reign, the region flanked by Delhi and Badaun was densely forested unlike the vast expanse of agriculture spanning the region today with only sparsely wooded regions. Alauddin had given orders for clearing the forest to make the passage safe for the merchants and travellers. It appears that the vanishing of the forests here began in the thirteenth century. Munhta Nainsi, the seventeenth century courtier of the Marwar state, while describing the mountains of Mewar region specially mentions the availability of water on mountains. Likewise, we have information on the political boundary of states defined beside the courses of rivers. In the medieval era the territory flanked by the two warring states of Mewar and Marwar were defined just as to the farming of specific trees. The *anwla* plantation was seen as demarcating the Mewar region whereas Marwar was recognized with the *babool* tree, suggesting a broad division of the territory in conditions of the semi-arid and wet regions. Landscape was visualized not only in conditions of the type of agriculture it could sustain, but also in conditions of the animal the region could harbour. Historical works of ancient, medieval, and even British era carry enough references to suggest that sure landscapes were defined in conditions of the wild animals established there. The landscape experienced change with the beginning of the colonial era.

| | |
|---|---|
| 02 February | World Wetland Day |
| 28 February | National Science days |
| 21 March | World forestry day |
| 22 March | World water day |
| 18 April | World heritage day |
| 22 April | Earth day |
| 22 May | International Biodiversity day |
| 05 June | World Environment day |
| 11 July | World Population day |
| 16 September | World ozone day |
| 28 September | Green Consumer day |
| 03 October | World Habitat day |
| 1-7 October | Wildlife Week |
| 04 October | Animal Welfare day |
| 02 December | Bhopal Tragedy day |

India's biological diversity was scientifically documented through the British. Demand of timbre, initially for the ship-industry and later on for creation of sleepers for the fast expanding railways, forced an unmanageable demand on wood. Interior landscapes were penetrated to secure wood. When the impact of this reckless act became imminent, the cutting of diversified natural forests was compensated through the farming of monoculture of commercially viable species. This penetration and promotion of commercial diversities changed the whole landscape of the region. Likewise, propagation of plantation economy in the southern and north-eastern part of the country led to extinction of natural forest cover replaced again through the monoculture of the commercial plants. Creation of canal networks in parts of upper India and eastern India led to drastic change in the landscape of these regions.



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# CHAPTER – 2
# INSTITUTIONS IN ENVIRONMENT

Among the large number of institutions that deal with environmental protection and conservation, a few well-known organizations include government organizations like the Ministry of Environment, Forest and Climate Change, Pollution Control Boards and Zoological Survey of India, and NGOs like the BNHS, WWF-I and others.

**Ministry of Environment, Forest and Climate Change (MoEFCC)**

The MoEFCC is primarily concerned with the planning, promotion and coordination of the implementation of India's environmental and forestry policies and programmes. The primary concern of the Ministry lies in the implementation of policies and programmes relating to the conservation of the country's natural resources including lakes and rivers, its biodiversity, forests and wildlife, ensuring the welfare of its animals and prevention and abatement of pollution. These objectives are well supported by a set of legislative and regulatory measures, aimed at the preservation, conservation and protection of the environment. The Ministry also serves as the nodal agency in the country for the United Nations Environment Programme (UNEP), South Asia Cooperative Environment Programme (SACEP), International Centre of Integrated Mountain Development (ICIMOD) and for the follow-up of the United Nations' Conference on Environment and Development (UNCED). The Ministry is entrusted with issues relating to multilateral bodies such as the Commission on Sustainable Development (CSD), Global Environment Facility (GEF) and of regional bodies like the Economic and Social Council for Asia and Pacific (ESCAP) and South Asian Association for Regional Cooperation (SAARC) on matters relating to the environment. As a part of the MoEFCC's planning of environmental policies, the Environmental Information System (ENVIS) was established in 1982 by the Government of India. The focus of ENVIS is to provide environmental information to decision makers, policy planners, scientists, engineers and research workers all over the country. ENVIS is a decentralised system with a network of distributed subject-oriented centres ensuring integration of national efforts in environment information collection, collation, storage, retrieval and dissemination to all concerned. A large number of nodes, known as ENVIS centres, have been established in the network to cover the broad subject areas of environment with a focal point in the MoEFCC. These centres have been set up on areas such as pollution control, toxic chemicals, central and offshore ecology, environmentally sound and appropriate technology, biodegradation of waste and environment management.

**Central Pollution Control Board (CPCB) & State Pollution Control Boards (SPCBs)**

It is a statutory organisation which was constituted in 1974 under the Water (Prevention and Control of Pollution) Act, 1974 and under the Air (Prevention and Control of Pollution) Act, 1981 to prevent and control pollution to improve the quality of India's environment. A large number of activities and programmes have been started such as the development of source-specific pollution control norms and guidelines based on available scientific understanding, setting up of ambient air and water quality criteria, monitoring of ambient air and water quality, auto fuel quality and emission norms for controlling vehicular pollution and planning for environmentally sound industrial development. There are 22 State Pollution Control Boards. Pollution Control Committees which are responsible for regulating and implementing environmental protection and pollution control within the state. These State Pollution Boards are **autonomous statutory** bodies which are bound to report to the CPCB for any critical matter.



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**Zoological Survey of India (ZSI)**

The ZSI was established in 1916. Its mandate was to do a systematic survey of the fauna in India. It has over the years collected 'type specimens' on the basis of which our animal life has been studied. Its origins were collections based at the Indian Museum at Calcutta, which was established in 1875. The older collections of the Asiatic Society of Bengal, which were made between 1814 and 1875, as well as those of the Indian Museum, made between 1875 and 1916, were then transferred to the ZSI. Today, it has over a million specimen. This makes it one of the largest collections in Asia. It has done an enormous amount of work on taxonomy and ecology. It currently operates from 16 regional centres.

**Bombay Natural History Society (BNHS), Mumbai**

The BNHS began as a small society of six members in 1883. It grew from a group of shikaris and people from all walks of life into an important research organisation that substantially influences conservation policy in the country. Its influence on wildlife policy building, research, popular publications and peoples' action has been a unique feature of the multifaceted society. Undoubtedly its major contribution has been in the field of wildlife research. It is India's **oldest conservation research-based NGO** and one that has been at the forefront of the battle for preservation of species and ecosystems. The BNHS publishes a popular magazine called the **Horn bill** and also an internationally well-known Journal on Natural History. One of its greatest scientists was Salim Ali, whose ornithological work on the birds of the Indian subcontinent is world famous. The BNHS has over the years helped the Government to frame wildlife-related laws and has taken up battles such as the 'Save the Silent Valley' campaign.

**World Wide Fund for Nature-India (WWF-I), New Delhi**

First established in Mumbai in 1969, the headquarters were shifted to Delhi with several branch offices all over India. The early years focused attention on wildlife education and awareness. It runs several programmes, including the Nature Clubs of India programme for school children and works as a think-tank and lobby force for environmental and developmental issues.

**Botanical Survey of India (BSI)**

The BSI was established in 1890 at the Royal Botanic Gardens, Calcutta. However it closed down for several years after 1939. After reorganisation, with the development and establishment of different regional centres, the aims and objectives of the Survey were redefined by the Programme Implementation and Evaluation Committee in 1976 with a view to encourage taxonomic research and to accelerate scientific expertise for the preparation of a comprehensive list of the flora of the country, under the 'Flora of India' project, ethnobotanical study, modernisation and maintenance of herbaria and museums, and creating interests among botanists and the public in general. In a recent review (1987), the aims and objectives of Botanical Survey remained unchanged except that activities like the survey and exploration of plant resources, listing of endangered species, publication of national flora, preparation of national data bank on herbarium and live collection, plant distribution and nomenclature were prioritized.

**Centre for Science and Environment (CSE), New Delhi**

The activities of this centre include organising campaigns, holding workshops and conferences, and producing environment-related publications. It has published a major document on the State of India's Environment, the first of its kind to be produced as a Citizen's Report on the Environment. The CSE also publishes a popular magazine, **Down to Earth**, which is a science and environment fortnightly. It is involved in the publication of material in the form of books, posters and video films and also conducts workshops and seminars on biodiversity-related issues.



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**CPR Environmental Education Centre (CPR-EEC), Chennai**

This was set up in 1988. It conducts a variety of programs to spread environmental - awareness and create an interest in conservation among the general public. It focuses attention on NGOs, teachers, women, youth and children, to generally promote conservation of nature and natural resources. Its programmes include components on wildlife and biodiversity issues. CPR-EEC also produces a large number of publications.

**Centre for Environment Education (CEE), Ahmedabad**

This was initiated in 1989. It has a wide range of programmes on environment and produces a variety of educational material, for various target groups.

**Madras Crocodile Bank Trust (MCBT)**

MCBT, the first crocodile conservation breeding centre in Asia was founded in 1976 to conserve Indian crocodiles and establish a programme for the conservation and propagation of other species of endangered reptiles. Over the years, over 1500 crocodiles and several hundred eggs have been supplied to various State Forest Departments for restocking programmes in the wild and for setting up breeding facilities in other states of India and neighbouring countries. MCBT started the first sea turtle survey and conservation programme in India, including a sea turtle hatchery. The Crocodile Bank is the site of the Irula Snake Catchers' Cooperative Society, which is an Adivasi self-help project and supplies all of India's snake and scorpion venom needed for the production of anti-venom and for medical use.

**State Department of Environment**

It is present in every state of India. It is responsible for improving the overall environmental quality within that state. The Department actively engages in environmental assessment, monitoring, protection and awareness amongst people in the state.

**Salim Ali Centre for Ornithology and Natural History (SACON), Coimbatore**

This institution was Salim Ali's dream, which became a reality only after his demise. Initially conceived as being a wing of the BNHS, it later evolved into an independent organisation based at Coimbatore in 1990. It has instituted a variety of field programmes that have added to the country's information on our threatened biodiversity.

**Wildlife Institute of India (WII), Dehradun**

This institution was established in 1982, as a major training establishment for Forest Officials and for research in Wildlife Management. Its most significant publication has been Planning a Wildlife Protected Area Network for India (Rodgers and Panwar, 1988). The organisation has over the years added an enormous amount of information on India's biological wealth. It has trained a large number of Forest Department officials and staff as Wildlife Managers. Its MSc Program has trained excellent wildlife scientists. It also has an Environment Impact Assessment (ETA) cell. It trains personnel in ecodevelopment, wildlife biology habitat management and nature interpretation.



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# CHAPTER – 3
# BIOSPHERE

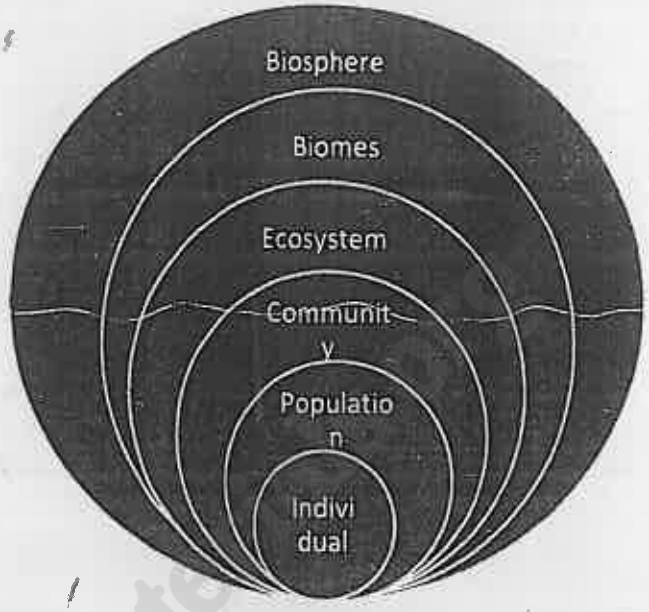
**What's Biosphere?**

"The part of the earth's crust, waters, and atmosphere that supports life."

**How does it support life?**

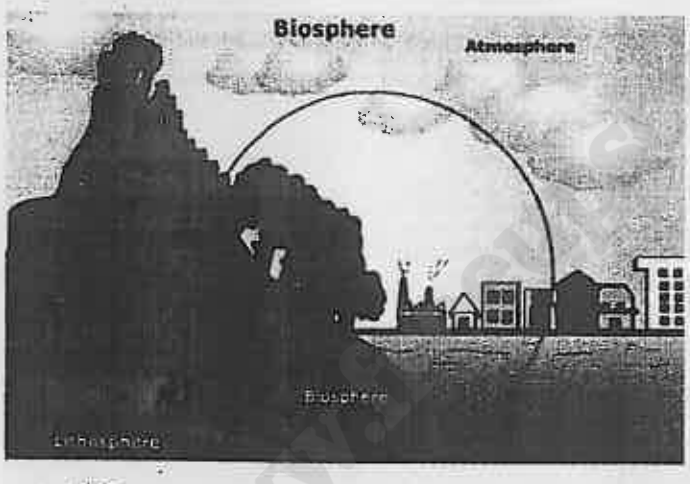
- It provides the support system for life on earth.
- It provides us humans and other organisms with a wide range of essential goods.

At the ***global level,*** the surface of the earth supporting the life forms is called biosphere



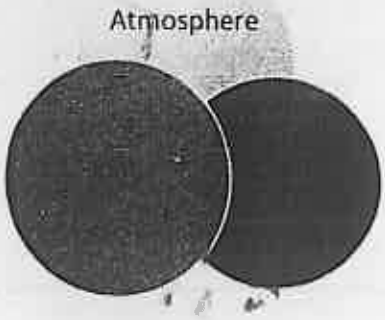

**How is Biosphere formed?**

It is formed through the *interaction of Atmosphere, Lithosphere and Hydrosphere.*




The area of contact and interaction between these three components are the basic requirement for the Biosphere to exist.

Atmosphere, Lithosphere and Hydrosphere are the three main subdivisions of Biosphere. Living organisms are mostly confined to the area prevalent in sunlight and oxygen; this includes atmosphere, the surface of land, the few metres of soil and the upper layer water of oceans, lakes and rivers. In simple words, biosphere can be viewed as the part of the earth consisting of oceans and the surface of the continents, together with the adjacent atmosphere. The three components of Biosphere can further be elaborated as follows:




**Atmosphere**

Although atmosphere is approximately 1000 KMs in width, but the layer which we are concerned for the study of ecosystem is only 10-15 KMs thick, i.e. ***Troposphere.***

| Some of the gases in the air are elements: | |
|---|---|
| ❖ Nitrogen, $N_2$ | 78% |
| ❖ Oxygen, $O_2$ | 21% |
| ❖ Argon, Ar | 0.9% |

Some are compounds, including:
- ❖ Carbon dioxide, $CO_2$
- ❖ Water vapour, $H_2O$



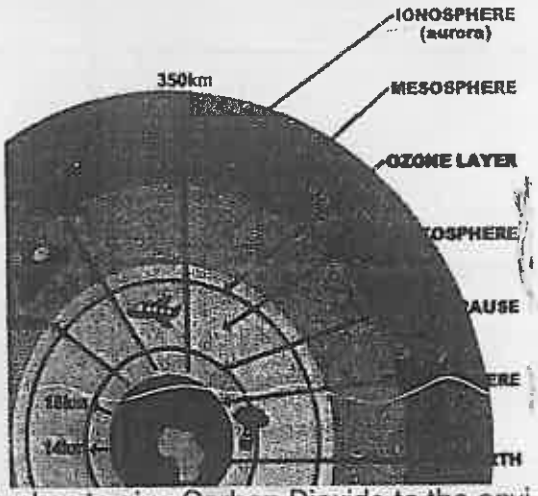
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- Plants and animals undergo Photosynthesis and respiration with the help of gases of the Troposphere.
- The sunlight prevalent through Atmosphere, acts as catalysing energy for living things of the earth.
- The green plants incorporate a variety of inorganic (that do not contain carbon-hydrogen bonds) elements and compounds.

**Layers of the Atmosphere**

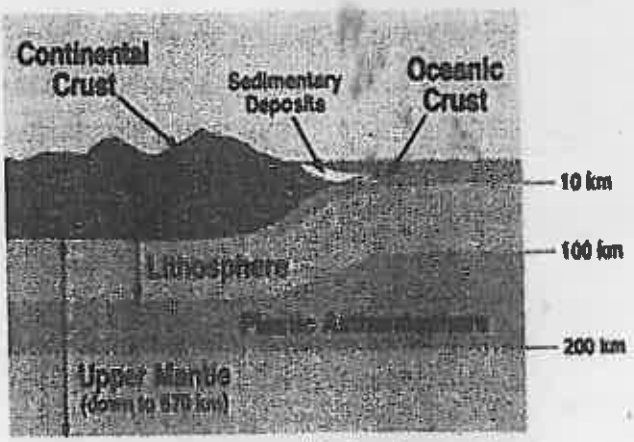



- **Carbon dioxide:** During the process of converting solar energy into chemical energy, atmospheric carbon dioxide enters the living world as the basic constituent of all organic compounds. Carbon dioxide along with water is used by all plants in their photosynthetic process to produce organic substances such as glucose, a vital molecule in living things, and Oxygen. Similarly in respiration, the food (glucose) is broken to give Carbon Dioxide to the environment. Carbon dioxide of the atmosphere is replenished not only through the process of respiration or biological oxidation but also through combustion of fuels and volcanic eruptions. The other important constituent in this cycle is water.
- **Oxygen**: The Oxygen is another very important constituent of atmosphere, necessary for the survival of ecosystem. Oxygen enters the living world through respiration which is a familiar process in both plants and animals including through it, glucose molecules are converted into energy needed for various activities. In fact, the level of Oxygen depicts the health of any ecosystem on this planet.
- **Nitrogen** is also an essential component of living systems. It is required by organisms for the synthesis of proteins, nucleic acids, and other nitrogenous compounds. In nature, **atmospheric nitrogen** is fixed by specialized organisms. There are industrial processes to convert atmospheric nitrogen into fertilizers.

### Lithosphere

Geologically, Lithosphere refers to the combination of earth's Crust and outer Mantle. It provides the platform and habitat to the biotic elements of the ecosystem.

**Lithosphere = Earth's Crust + Outer Mantle**




*Lithosphere has two main functions with reference to the biosphere:*

1. It provides salt or platforms for terrestrial, transitionary and aquatic plants and
2. It is the source of nutrients and minerals vital for the growth and survival of ecosystem.

### Hydrosphere

Hydrosphere refers to the water bodies like lakes, ponds, rivers, oceans etc. on the earth surface. Water is considered to be the most important constituent of biotic elements. In fact,

- Almost all of the organisms have more than half of their constituent as water.
- Water is inevitably required for the metabolism of living things.



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❖ Plants also require it for the distribution of nutrients throughout its body.

The surface of planet earth is occupied by more than 71% water. On a large scale, water is cycled through, evaporation-cloud formation-precipitation-run off, whereas, water when consumed by biotic elements is partially used for metabolic activities and is partially excreted as waste in the environment in various forms.

## BIOMES

### What are biomes?

Biomes are the major *subdivisions* of the biosphere

### How are biomes differentiated?

Cardinal feature of each biome is that they are recognizable by the characteristic structure of its dominant vegetation. The earth's biomes are spread over millions of square miles and span entire continents. Each has unique climates; the average weather conditions in a given region determine the boundaries of a biome and the abundance of plants and animals found in each one.

"Although a biome can be considered a very large ecosystem, it differs from ecosystem such as a pond or a patch of woodland in its complexity and internal variations. For example, the coniferous taiga biome contains lakes, bog, and other ecosystems within itself, in addition to the overall evergreen forest ecosystem. The evergreen forest itself varies considerably from one locality to the next within the biome."

Biomes pertaining to the land are called Terrestrial Biomes and that related to ocean and water is called Aquatic Biomes. **There is not much marked difference between an ecosystem and a biome except their spatial expansion.** Hence terrestrial and aquatic biomes can also be called as terrestrial and aquatic ecosystems.

## BIOGEOGRAPHIC REALMS

Biosphere has also been divided in different Bio-geographical Realms at sub-global levels. Bio-geographic realms are large spatial regions within which ecosystems share a broadly similar biological evolutionary history. Assessing biodiversity at the level of bio-geographic realms is important because the realms display substantial variation in the extent of change, they face different drivers of change, and there may be differences in the options for mitigating or managing the drivers. Terrestrial bio-geographic realms reflect freshwater biodiversity patterns reasonably well, but marine bio-geographic realms are poorly known and largely undefined.

Realm divisions are based on three basic patterns:

1. Nearly all taxon are endemic or restricted to particular areas.
   (Taxon is a group of one or more populations of an organism or organisms seen by taxonomists to form a unit.)
2. Certain kinds of organisms tend to occur together providing a basis for dividing the earth into regions.
3. Similar kinds of morphology in plants and animals occur in widely separate regions (i.e., unrelated animals and plants evolve to look alike). These animals share different evolutionary histories but have evolved similar adaptations (convergence or convergent evolution). **Adaptation the process of change by which an organism or species becomes better suited to its environment.**

The English naturalist Alfred Russell Wallace (1823-1913), contributed greatly to biogeography with his book "The Geographic Distribution of Animals" in 1876.



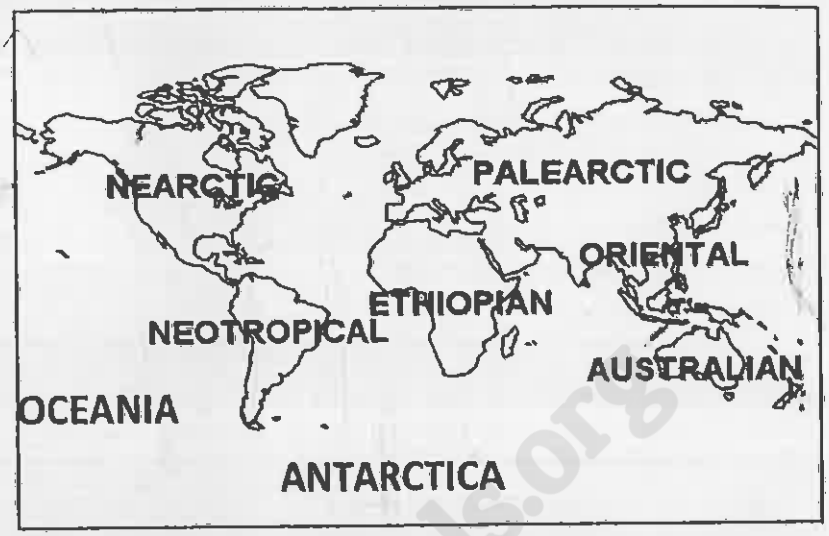
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Originally, six regions were identified: Palearctic (Europe and Asia), Nearctic (North America), Neotropical (Mexico, Central and South America), Ethiopian (Africa), Oriental (Southeast Asia, Indonesia) and Australian (Australia and New Guinea). Currently, eight are recognised since the addition of Oceania (Polynesia, Fiji and Micronesia) and Antarctica.



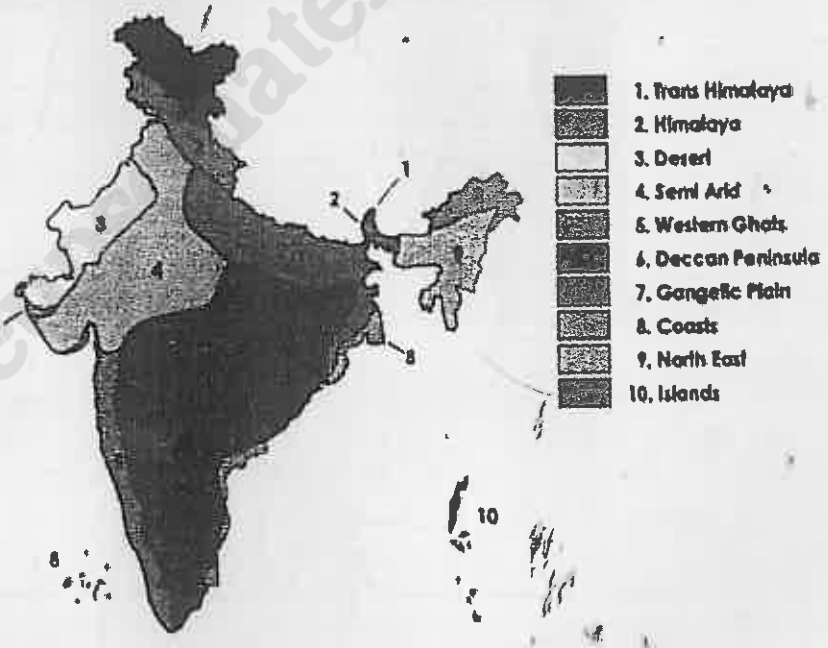

## BIO-GEOGRAPHIC REGIONS

At a further decentralised level, the distribution has been named as Bio-geographic regions. **However, except its localised classifications, it does not have any distinct** feature **which separates it from the Bio-geographic Realms. It is generally done at national or state level.**

Bio-geographers have classified India into following ten bio-geographic zones with each zone having characteristic **climate, soil and biodiversity.**

**Trans-Himalayas:**

The Trans-Himalayas is an extension to the Tibetan plateau. This region comprises of the high-altitude cold desert in Ladakh (Jammu and Kashmir) and Lahaul Spiti (Himachal Pradesh). It accounts for 5.7% of the country's landmass.




**Himalayas:**

The Himalayas are the northern boundaries of India. The entire mountain chain is running from Kashmir in the North-west to Assam in the north-east. The Himalayas comprise of a diverse range of biotic provinces and biomes. The Himalayas cover 7.2% of the country's landmass.

**Desert:**

The extremely dry area west of the Aravalli hill range comprises both the salty desert of Gujarat and the sandy desert of Rajasthan. Deserts occupy around 6.9% of the country's land mass. The kinds of deserts found in India are:

1. The desert of western Rajasthan
2. The desert of Gujarat
3. The high-altitude cold desert of Jammu & Kashmir and Himachal Pradesh.

The Indian deserts have more diversified fauna.



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**Semi-arid:**

This zone lies between the desert and the Deccan plateau. It includes the Aravalli hill range. It covers approximately 15.6% of the country's landmass.

**Western Ghats:**

The Western Ghats are a mountain range that runs along the western cost of India. They are a range extending north-south from southern tip of Gujarat in the north to Kanyakumari in the south. The mountains cover an area of about 160,000 sq. km. This Ghat section covers an extremely diverse range of biotic provinces and biomes. It covers about 5.8% of the country's land mass.

**Deccan Peninsula:**

It is a large triangular plateau south of the Narmada valley. Three sides of the plateau are covered by mountains slopes towards east. Satpura Mountains cover the north while Western Ghats cover the west side and Eastern Ghats cover the eastern side of the plateau. It is the one of largest zones covering the southern and south-central plateau with mostly deciduous trees. It covers 4.3% of the country's land mass.

**Gangetic plain:**

This plain covers the area between the south Himalayas to the tropic of cancer. These plains were formed by the Ganges river system and are relatively homogeneous. This region experience 600 mm rainfall annually. Sunderbans forests are located in this region and it covers 11% of the country's land mass.

**Coasts:**

India has a large coastline distributed both to the east and west with distinct differences between the two. The Lakshadweep islands are included in this but the area of these islands is negligible.

**North-east India:**

These are pains and non-Himalayan ranges of north eastern India and have a wide variety of vegetation. It covers around 5.2% of the country's land mass.

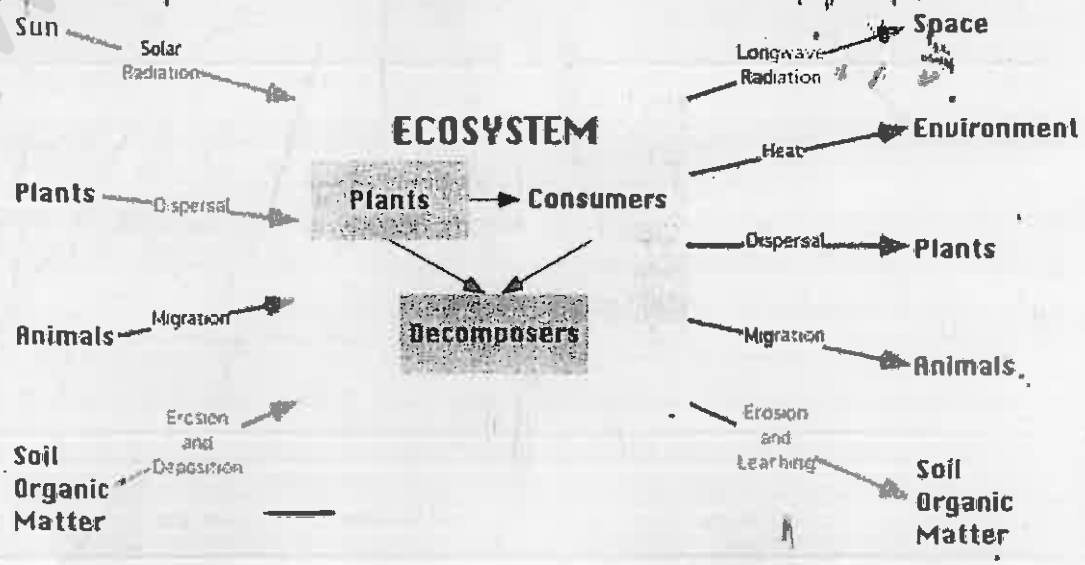
**Islands:**

The Andaman and Nicobar Islands in the Bay of Bengal has almost 300 big and small islands. Among these, only five islands are inhabited. Only tribes are found in the island of Nicobar. These islands have a highly diverse set of biomes and occupy 0.03% of the country's biomass.

At even more level, each area have several structurally and functionally identifiable ecosystems, such as different types of forests, grass lands, river catchments, swamps, seashores, islands etc. to give only a few examples. Here too each of these forms a habitat for specific plants and animals.

## ECOSYSTEMS

An ecosystem is a community of plants, animals and smaller organisms that




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live, feed, reproduce and interact in the same area or environment. **The ecosystem is a core concept in Biology and Ecology, serving as the level of biological organization in which organisms interact simultaneously with each other and with their environment.** As such, ecosystems are a level above that of the ecological community, but are at a level below, or equal to, biomes and the biosphere. Essentially, biomes are regional ecosystems, and the biosphere is the largest of all possible ecosystems.

Ecosystems include living organisms, the dead organic matter produced by them, the abiotic environment within which the organisms live and exchange elements (soils, water, atmosphere), and the interactions between these components. Ecosystems embody the concept that living organisms continually interact with each other and with the environment to produce complex systems with emergent properties, such that "the whole is greater than the sum of its parts" and "everything is connected."

The spatial boundaries, component organisms and the matter and energy content and flux within ecosystems may be defined and measured. **However, unlike organisms or energy, ecosystems are inherently conceptual, in that different observers may legitimately define their boundaries and components differently. For example, a single patch of trees together with the soil, organisms and atmosphere interacting with them may define a forest ecosystem, yet the entirety of all organisms, their environment, and their interactions across an entire forested region in the Amazon might also be defined as a single forest ecosystem.**

"Some have even called the interacting system of organisms that live within the guts of most animals as an ecosystem, despite their residence within a single organism, which violates the levels of organization definition of ecosystems. Moreover, interactions between ecosystem components are as much a part of the definition of ecosystems as their constituent organisms, matter and energy."

## COMMUNITY

Community is when organisms of different species interacting with each other. Community refers to all the populations in a specific area or region at a certain time. Its structure involves many types of interactions among species. Some of these involve the acquisition and use of food, space, or other environmental resources. Others involve nutrient cycling through all members of the community and mutual regulation of population sizes. In all of these cases, the structured interactions of populations lead to situations in which individuals are thrown into life or death struggles.

In general, ecologists believe that a community that has a high diversity is more complex and stable than a community that has a low diversity. This theory is founded on the observation that the food webs of communities of high diversity are more interconnected. Greater interconnectivity causes these systems to be more resilient to disturbance. If a species is removed, those species that relied on it for food have the option to switch to many other species that occupy a similar role in that ecosystem. In a low diversity ecosystem, possible substitutes for food may be non-existent or limited in abundance. Communities in most instances are named after the dominant plant form (species). For example – A grassland community is dominated by grasses, though it may contain herbs, shrubs, and trees, along with associated animals of different species

### Community Structure

Ecologists use three characteristics to describe a biological community:

(1) Physical appearance: the relative sizes, stratification, and distribution of its populations and species.



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(2) Species diversity: a combination of numbers of different species (richness) and abundance if individuals within each species (species evenness).

(3) Niche structure: the number of ecological niches, their resemblance or difference from each other, and interaction of species with each other.

## POPULATION

Population is a group of individuals of the same species inhabiting the same area. Populations can be defined at various spatial scales. Local populations can occupy very small habitat patches like a puddle. A set of local populations connected by dispersing individuals is called A set of local populations connected by dispersing individuals is called a Meta-population. Populations can be considered at a scale of regions, islands, continents or seas. Even the entire species can be viewed as a population.

Populations differ in their stability. Some of them are stable for thousands of years. Other populations persist only because of continuous immigration from other areas. On small islands, populations often get extinct, but then these islands can be re-colonized. Finally, there are temporary populations that consist of organisms at a particular stage in their life cycle. For example, larvae of dragonflies live in the water and form a Hemi-population.

## INDIVIDUAL

Any organism is referred to as individual when it has the capability of sustaining independently. An individual is any living thing or organism, which can act and function independently in course of its life. Individuals do not breed with individuals from other groups. Animals, unlike plants, tend to be very definite with this term because some plants can cross-breed with other fertile plants.

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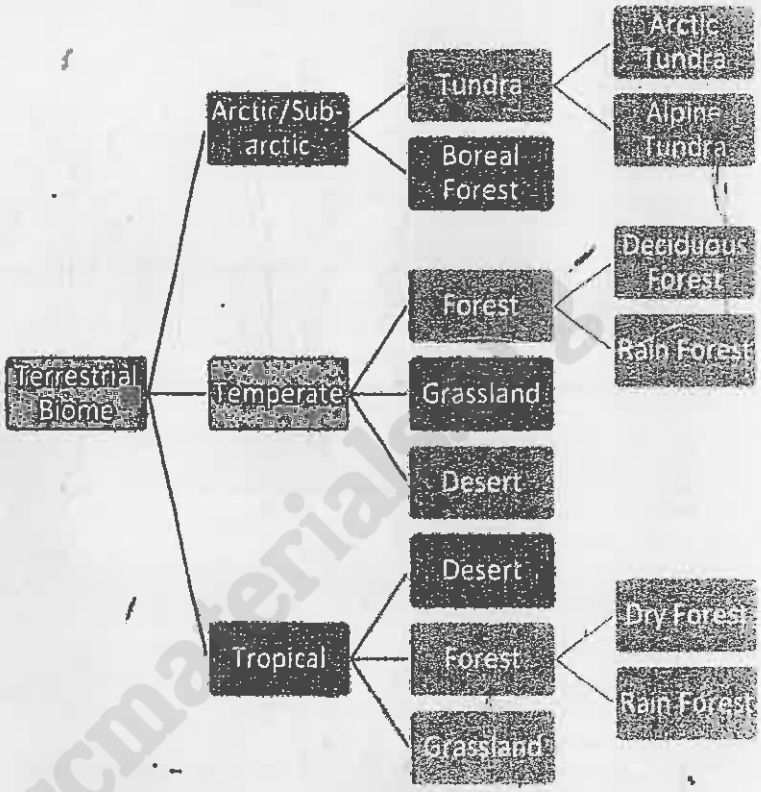


# CHAPTER – 4
# TERRESTRIAL BIOMES

### What is a Terrestrial Biome?

Terrestrial biomes are major regions in the Earth that share the same climate despite being in different geographical locations.

The world has been divided into Terrestrial Biome Types as shown in the figure on the right side.



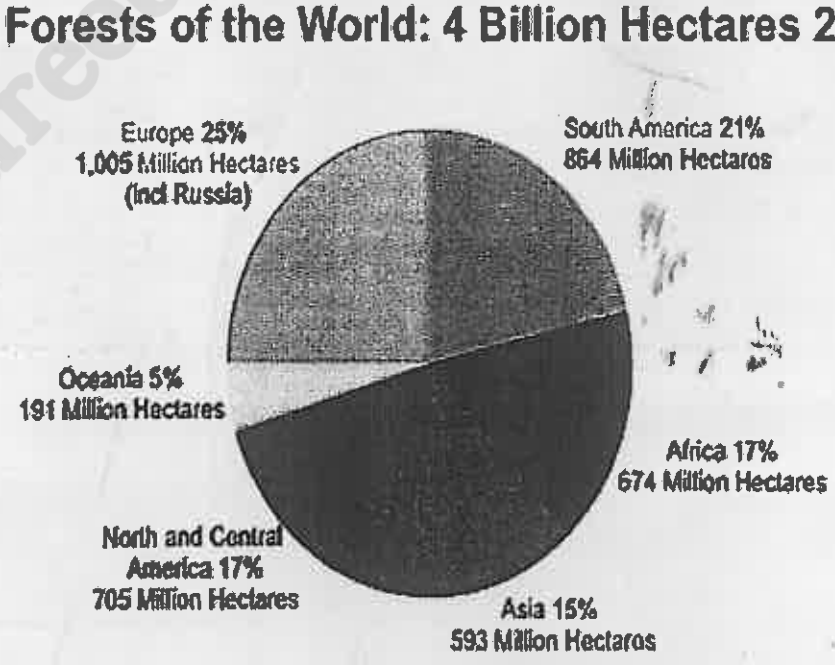

Characteristics of terrestrial biomes:

- *Most of the classified biomes are identified by the dominant plants found in their communities.*
- *The diversity of animal life and subdominant plant forms characteristic of each biome is generally controlled by abiotic environmental conditions and the productivity of the dominant vegetation.*
- *Adaptation and niche specialization are nicely demonstrated in the biome concept.*

### FORESTS

About forest biomes:

- Forest Biomes represent the largest and most ecologically complex systems.
- They contain a wide assortment of trees, plants, mammals, reptiles, amphibians, invertebrates, insects and micro-organisms which vary depending on the zone's climates.



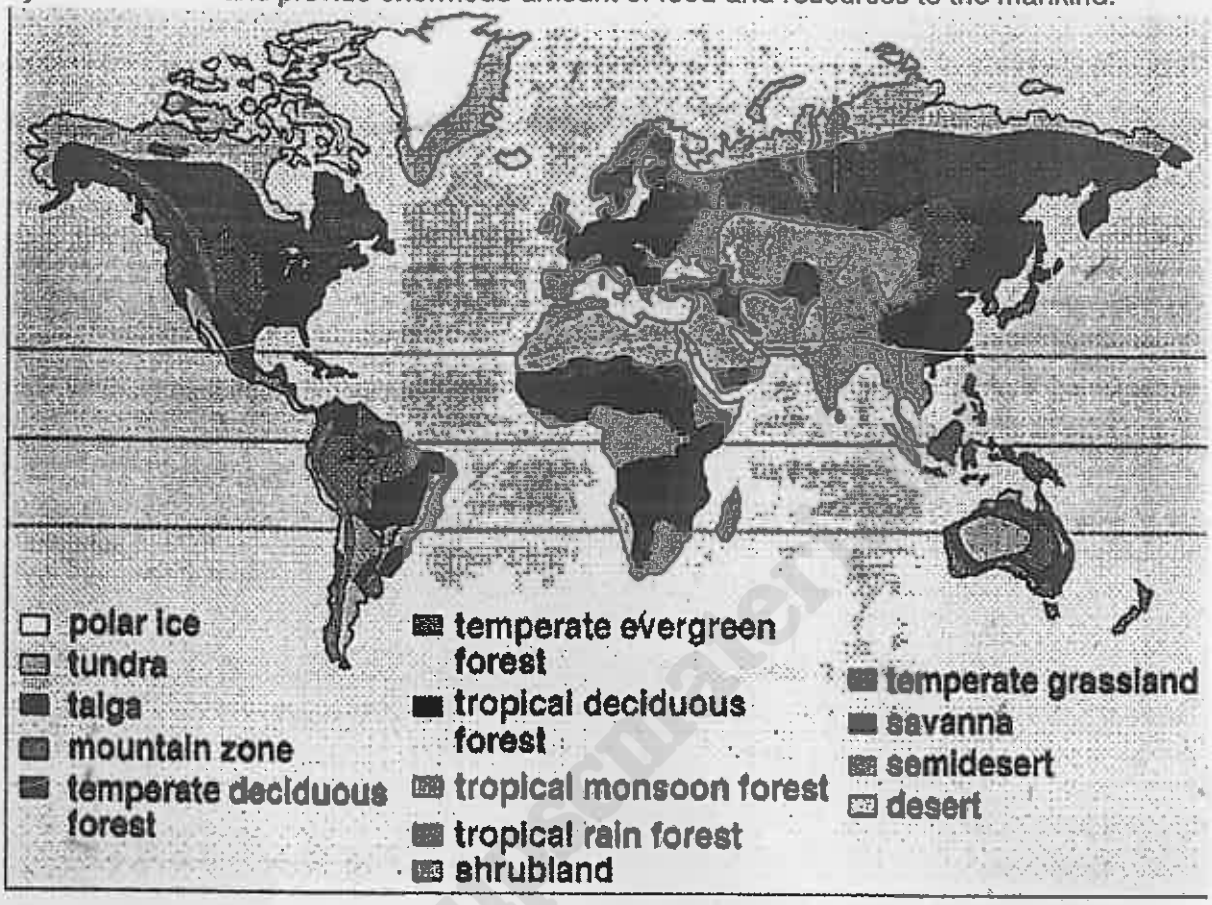



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- Forests occupy approximately one-third of Earth's land area, account for over two-thirds of the leaf area of land plants, and contain about 70% of carbon present in living things. They are the major carbon sink and provide enormous amount of food and resources to the mankind.



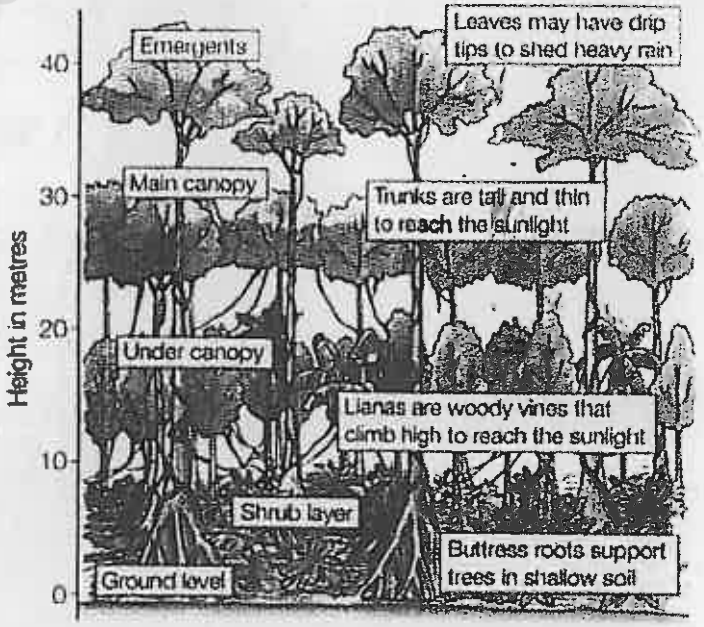

## GEOGRAPHICAL DISTRIBUTION OF FORESTS

***Forests have further been divided into following four types:***

*1. Equatorial Rain Forest–*

***Where?***

Found in and around equator regions, characterised by ample heat and heavy rainfall throughout the year. The major areas containing such forests are - Congo Basin, Cameroon highlands, Rainforests of the Amazon and Orinoco, Central America, Malaysia, Borneo and Indonesia.




a) The trees are very tall and of a great variety of species.

b) The vegetation is so dense that little light reaches the forest floor.

c) Most of the plants are evergreen, not deciduous.



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d) The branches of the trees are hung with vines and epiphytes.

**Characteristic features of Equatorial Rain Forest**

- The most outstanding feature is its great uniformity of temperature throughout the year to be around 28°C with very little variation. There is no winter.
- Cloudiness and heavy precipitation help to moderate the daily temperature, so that even at the equator, climate is not unbearable.
- The diurnal as well as annual range of temperature is very small.
- Well distributed annual rainfall of 150-250 cm having no distinct dry season, but having April and October as the maximum rainfall month.
- Growing and flourishing season of trees in the forests are all round the year without any climatic extremities and hence no fixed pattern of seeding, flowering, fruiting and decaying of trees.
- Biodiversity is at its best in equatorial rain forests having ample varieties of flora and fauna. This is the reason for difficulty in commercial exploitation of timber.
- Climbing plants, Epiphytes and parasites.
- A distinct layered arrangement with thick canopy at the top as all the trees and plants struggle for sunlight.
- The smaller trees beneath form the next layer and the ground is rooted with ferns and herbaceous plants which can tolerate shades.
- The hot, wet climate which stimulates rapid plant growth also encourages the growth of insects and pets thereby inflicting many diseases and crop damage.
- Soils of the equatorial rain forest are fairly fertile due to thick layer of humus. But once the humus is used and the natural vegetative cover is removed, the torrential downpours soon washout most of the soil nutrients (leaching), making it useless for the agricultural purposes.

The lushness of the tropical rain forest suggests a high net productivity, but this is illusory as the high rainfall leaches soil minerals below the reach of plant roots and the warmth and moisture cause rapid decay so little humus is added to the soil.

2. *Tropical Deciduous Forest–*

**Characteristic features of Tropical** Deciduous Forests

- Such types of forests are found in the areas having distinct dry season and heavy concentration of rainfall within few months.
- The areas have typical seasonality ranging from cool winters, hot and dry summer to rainy season.
- Trees are normally deciduous, because of the marked dry period, during which they shed their leaves to withstand the drought.
- The forests are more open and less luxuriant than the equatorial forests and there are far fewer species.
- Tropical deciduous forests yield valuable timber and are prized for their durable hardwood. For example – Teak, Sal, Acacia etc.
- Bamboo thickets are other typical characteristics of such forests.
- Areas of lesser rainfall exhibit Savannah and scrubland like features with scattered trees and tall grass.
- Majority of the forests have been cleared for agriculture to support excessive populations.



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**Where?**

These are found in the areas characterised by **distinct dry and heavy wet seasons.**

a) The trees of Tropical Deciduous forests lose all of their leaves in summer season **to prevent loss of water.** These forests have a **more open and dwarfish (not tall) composition.**

b) In the dry season trees shed their leaves and the forest gives the appearance of vast grassland with naked trees, dispersed all over the region.

c) These forests are a mixture of trees and grasses.

d) Summer heat is very intense in such forests which burns the dry grass and kills seeds of weeds.

Major species of trees: **Teak, Sal, Bamboo, Sandalwood** etc.

*Tropical Deciduous Forest* are highly commercial and have been exploited heavily. Tropical Deciduous Forest is mainly found in Indian subcontinent and is also called ***Monsoon forests.***

3. *Temperate Forest–*

**Where?**

These are found in areas with a milder, shorter winter season. This biome occupies the

**Characteristic features of Temperate Forests**

- The climate in the Temperate Forest varies, and the plant and animal life there must adapt. For example, when the weather gets cold most animals put on an extra layer of fat to keep warm.
- The average temperature in this biome is 15oC in the daytime and in the night time it can get below freezing.
- In every month of the year the Temperate Forest sees some rainfall. The rainfall ranges from 40 cm to 150 cm per year. Once in a while there are severe storms in this biome, and in some parts of the Temperate Forest it snows in winter months. In the Temperate Forest there are generally warm summers, and short, cold and silent winters.
- Trees and plants in temperate forests have special adaptations to survive in this biome. Deciduous trees are trees with leaves rather than pine needles, and they dominate temperate forests. As the seasons change each year, so do the leaves. Each year deciduous trees lose their leaves, and grow them back. In the summer their broad green leaves capture sunlight and help the trees make food through photosynthesis. As temperatures cool in the fall, the chlorophyll (green pigment in leaves) breaks down, causing the beautiful red, yellow and orange leaf colours of fall. In the cold winter, deciduous trees and plants go into dormancy, kind of like sleep. It is too cold for them to protect their leaves from the damage of freezing in the winter, so they simply loose them and seal up the places where the leaves attach to the branch. The warmer spring days signal to the trees that they can grow new leaves again, and restart the cycle.
- The Temperate Forest is full of various plants and trees. There are Pine Fir, Hemlock, Spruce, and Sequoias just to name a few.
- Some plants are used to make medicines for people. Many plants flourish in this environment because of the rich soil that the Temperate Forest has.
- The Temperate Forest has many different species of animals. There are bobcats, snow leopards, white tailed deer, raccoons, mice, and many types of birds just to name a few. Animals in the Temperate Forest depend upon one another in a complex food chain. The soil in the Temperate Forest is very rocky, sandy, and is known to be mostly poor quality.



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eastern half of the United States and a large portion of Europe. It is characterized by hardwood trees (e.g., beech, maple, oak, hickory) which are deciduous; that is, shed their leaves in the autumn. Canopy is moderately dense and allows light to penetrate, resulting in well-developed and richly diversified understory vegetation and stratification of animals. The number of different species is far more limited than in the tropical and equatorial regions. Large stands dominated by a single species are common. Deer, raccoons, and salamanders are characteristic inhabitants. During the growing season, this biome can be quite productive in both natural and agricultural ecosystems.

4. *Boreal forests (Taiga)* –

**Where?**

Occurring between 50° and 60° north latitudes, these can be found in the broad belt of Eurasia and North America: two-thirds in Siberia with the rest in Scandinavia, Alaska, and Canada.

- **Evergreen habit – retention of foliage allows plants to photosynthesize as soon as temperatures permit in spring, rather than having to waste time in the short growing season merely growing leaves.**
- **Dark colour – the dark green of spruce and fir needles helps the foliage absorb maximum heat from the sun and begin photosynthesis as early as possible.**

Seasons are divided into short, moist, and moderately warm summers and long, cold, and dry winters. Boreal Forests are dominated by conifers, especially spruces and firs. It is populated by an even more limited variety of plants and animals than is the temperate deciduous forest. Before the long, snowy winter sets in, many of the mammals hibernate, and many of the birds migrate south. Although the long days of summer permit plants to grow luxuriantly, net productivity is low.

Boreal Forests are dotted with lakes, bogs and marshes.

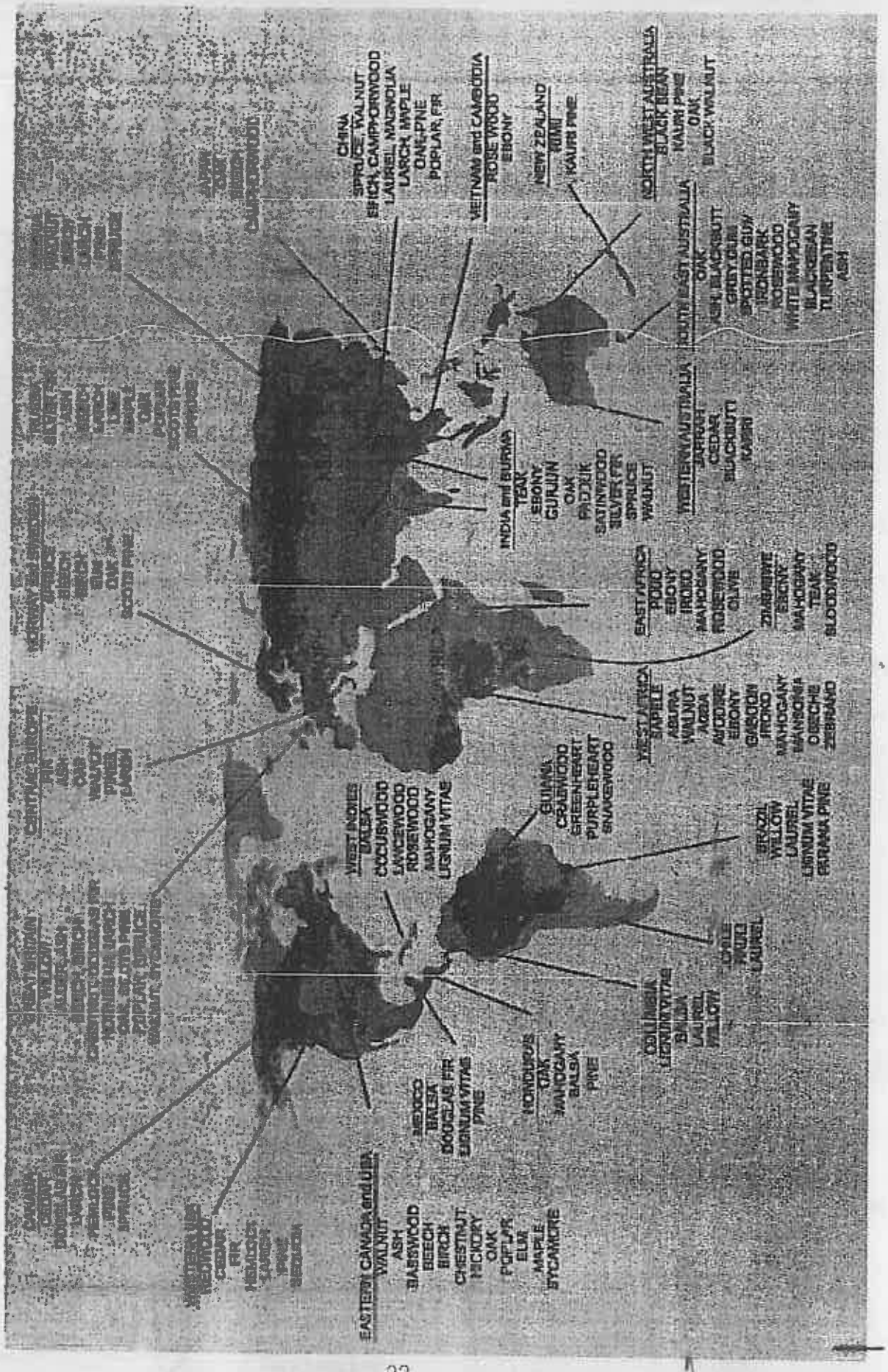
**Characteristics features of Boreal Forests:**

- The Boreal Forest is named after Boreas, the Greek god of the North wind.
- The Boreal forest corresponds with regions of subarctic and cold continental climate.
- There are long, severe winters (up to six months with mean temperatures below freezing) and short summers (50 to 100 frost-free days), as is a wide range of temperatures between the lows of winter and highs of summer.
- There is little rainfall in the boreal biome. Precipitation comes in the form of fog and snow, with a little rain during the summer months.
- Mean annual precipitation is 40 cm to 50cm but low evaporation rates make this a humid climate.
- Broadleaf deciduous trees and shrubs are members of early successional stages of both primary and secondary succession. Most common are alder birch, and aspen.
- This type of forest supports very poor in biodiversity supporting only handful species of flora and fauna.
- The trees of the boreal forest tend to have shallow roots, due to the thin soils.
- Logging has played its role on the boreal forest, with large swaths of Siberia's taiga harvested for lumber.
- The soils of the boreal forest are often acidic, due to falling pine needles, and low on nutrients since the cold temperatures do not allow much foliage to rot and turn into dirt.

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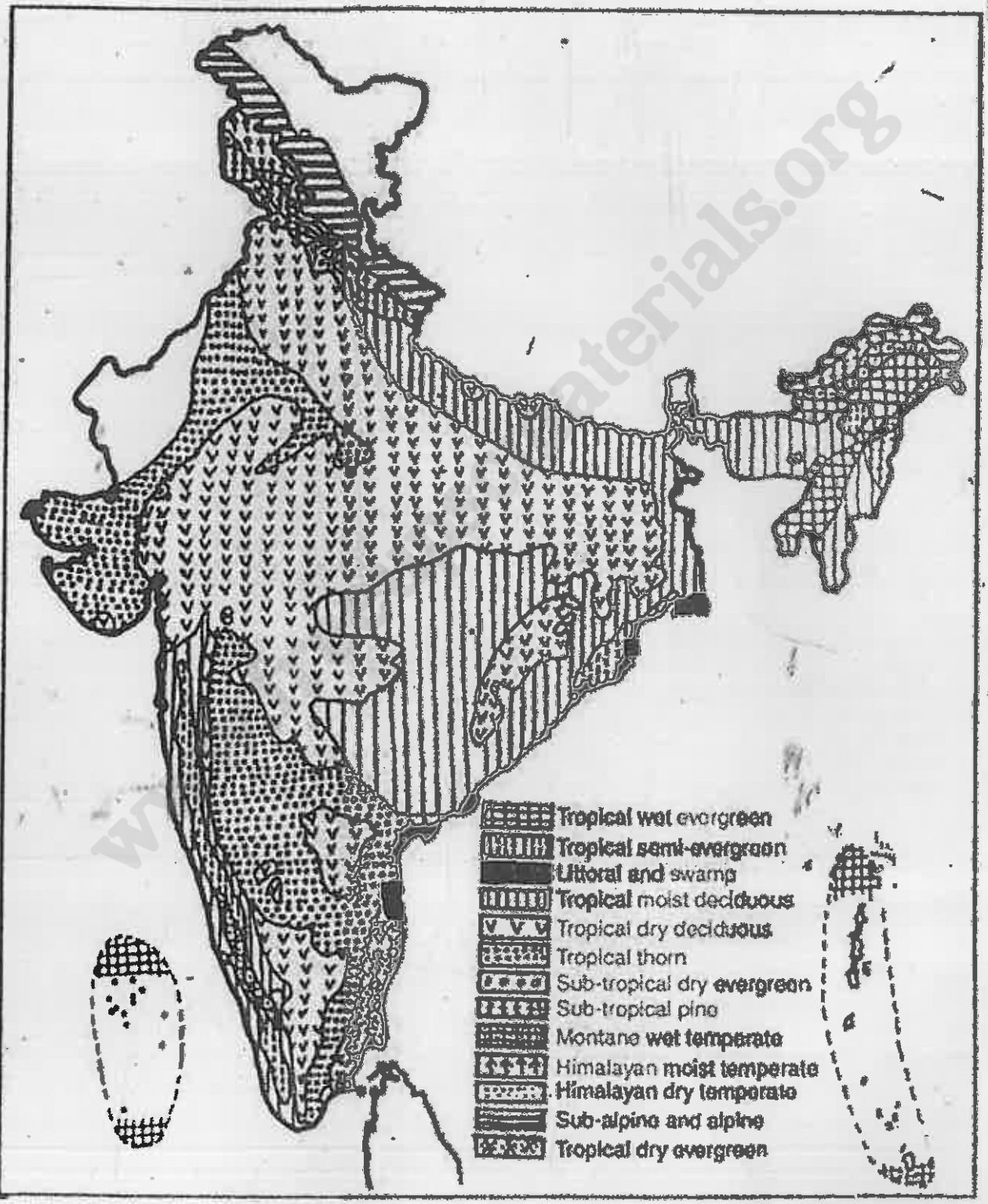
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## Plant Hardiness Zone

A hardiness zone is a geographically defined area in which a specific category of plant life is capable of growing, as defined by climatic conditions, including its ability to withstand the minimum temperatures of the zone (see the scale on the right or the table below). For example, a plant that is described as "hardy to zone 10" means that the plant can withstand a minimum temperature of –1 °C (30 °F). A more resilient plant that is "hardy to zone 9" can tolerate a minimum temperature of –7 °C (19 °F).






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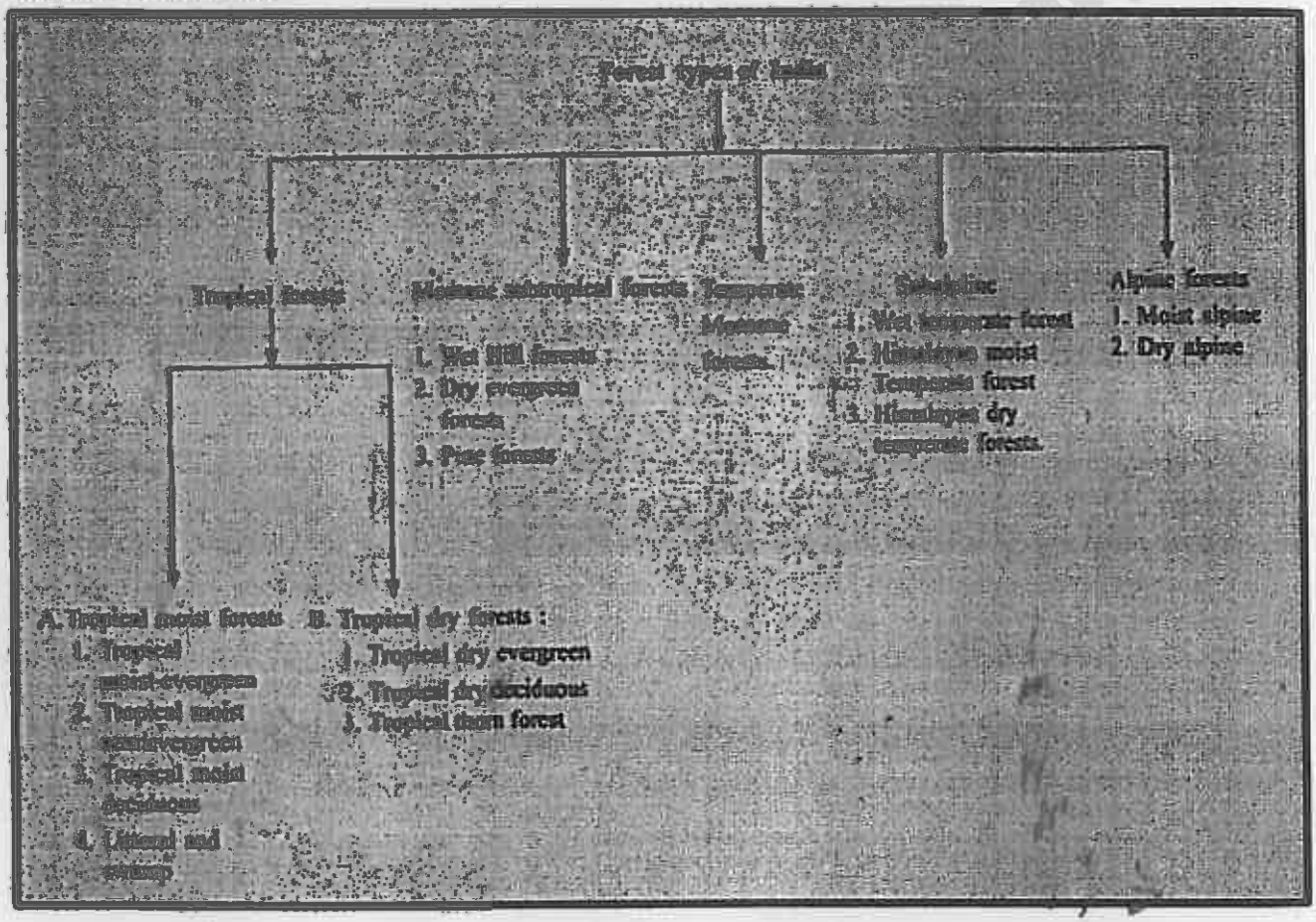


India has a diverse range of forests as can be seen from the map in the previous page: from the rain-forest of Kerala in the south to the alpine pastures of Ladakh in the north, from the deserts of Rajasthan in the west to the evergreen forests in the north-east. Climate, soil type, topography, and elevation are the main factors that determine the type of forest. Forests are classified according to their nature and composition, the type of climate in which they thrive, and its relationship with the surrounding environment.

**UPSC Prelims:**
If you travel through the Himalayas, you are Likely to see which of the following plants naturally growing there?
1. Oak 2. Rhododendron 3. Sandalwood
Select the correct answer using the codes given below:
(a) 1 and 2 only (b) 3 only (c) 1 and 3 only
(d) 1, 2 and 3

Solution (a)

**Indian forests can be divided into broad types, with a number of sub types. :**




### 1. Moist Tropical –

≠ *Wet evergreen forests* - These are found in the south along the Western Ghats and the Nicobar and Andaman Islands and all along the north-eastern region. It is characterized by tall, straight evergreen trees that have a buttressed trunk or root on three sides like a tripod that helps to keep a tree upright during a storm. These trees often rise to a great height before they open out like a cauliflower. Such forests found in regions with rainfall over 250cm per annum. The more common trees that are found here are the Jackfruit, Betel nut palm, Jamun, Mango, and Hollock. The trees in this forest form a tier pattern: shrubs cover the layer closer to the ground, followed by the short structured trees and then the tall variety. Beautiful fern of various colours and different varieties of orchids grow on the trunks of the trees.



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≠ *Semi-evergreen forests* – These are found along the Western Ghats adjoining wet ever green forests i.e., in Assam and lower attitudes of Eastern Himalayas, Orissa, Malabar Coast and Andaman's. Rainfall varies from 200-250 cm. Such forests have a mixture of the wet evergreen trees and the moist deciduous trees. The forest is dense and is filled with a large variety of trees of both types.

≠ *Littoral and swamp forests* – Such type of forests are found along the Andaman and Nicobar Islands and the delta area of the Ganga and the Brahmaputra. It consists mainly of Whistling pines, Mangrove, Palms, and Bulletwood. They have roots that consist of soft tissue so that the plant can breathe in the water. The littoral forests occur all along the sea coasts and along the sandy bars of deltas of the larger rivers, whereas, the tidal swamp forests are further divided into 5 types: (i) Mangrove scrub, (ii) Mangrove forests, (iii) Salt water mixed forests, (iv) Brackish water mixed forests and (v) Palm Swamp. The Sunderbans (W.B.) and the Bhitarkanika (Orissa) mangrove forests come under this category.

≠ *Moist deciduous forests* – These forests are found throughout India in the regions of typical rainfall range of 150-200 cm annually except in the western and the north-western regions. The trees have broad trunks, are tall and have branching trunks and roots to hold them firmly to the ground. Some of the taller trees shed their leaves in the dry season. There is a layer of shorter trees and evergreen shrubs in the undergrowth. These forests are dominated by Sal and Teak, along with Mango, Bamboo, and Rosewood.

**2. Dry tropical forests –**

A. Dry deciduous forests – These forests are found throughout the northern part of the country except in the North-East. It is also found in Madhya Pradesh, Gujarat, Andhra Pradesh, Karnataka, and Tamil Nadu. All the forests of North India i.e., Bihar, U.P., Punjab, Haryana of non-teak, and teak bearing types come under this. The canopy of the trees does not normally exceed 25 metres. The common trees are the Sal, a variety of Acacia, and Bamboo.

B. Thorn Forests - This type is found in areas with black soil: North, West, Central, and South India having 25-75 cm of rainfall every year. The trees do not grow beyond 10 metres. Spurge, caper, and cactus are typical of this region.

C. Dry evergreens – These are found along the Andhra Pradesh and Karnataka coast. It has mainly hard-leaved evergreen trees with fragrant flowers, along with a few deciduous trees. These are dense forests of curvaceous leaved evergreen forests.

**3. Montane Sub-Tropical forests –**

A. *Dry evergreen forests* - These normally have a prolonged hot and dry season and a cold winter. It generally has evergreen trees with shining leaves that have a varnished look. Some of the more common ones are the pomegranate, olive, and oleander. These forests are found in the Shivalik Hills and foothills of the Himalayas up to a height of 1000 metres.

B. *Pine forests* – These are found in the steep dry slopes of the Shivalik Hills, Western and Central Himalayas, Khasi, Naga, and Manipur Hills. The trees predominantly found in these areas are the Chir, Oak, Rhododendron, and pine. In the lower regions Sal, sandal, Amla, and Laburnum are found.

**4. Montane temperate forests –**

A. *Wet Montane temperate forests* - These occur in the North and the South. In the North, it is found in the region to the east of Nepal into Arunachal Pradesh, at a height of 1800–3000 metres, receiving a minimum rainfall of 200 cm. In the South, it is found in parts of the Niligiri Hills, the higher reaches of Kerala. The forests in the northern region are denser than in the South. This is because over time the original trees have been replaced by fast-growing varieties such as the

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Eucalyptus. Rhododendrons and a variety of ground flora can be found here. In the North, there are three layers of forests: the higher layer has mainly coniferous, the middle layer has deciduous trees such as the oak and the lowest layer is covered by Rhododendron and Champa.

B. *Moist Montane temperate forests* - This type spreads from the Western Himalayas to the Eastern Himalayas. The trees found in the western section are broad-leaved oak, brown oak, Walnut, Rhododendron, etc. In the Eastern Himalayas, the rainfall is much heavier and therefore the vegetation is also more lush and dense. There are a large variety of broad-leaved trees, ferns, and bamboo. Coniferous trees are also found here, some of the varieties being different from the ones found in the South.

C. *Himalayan Dry Temperate Forests* – This type of forest is found mainly in Lahaul, Kinnaur, Sikkim, and other parts of the Himalayas. There are predominantly coniferous trees that are not too tall, along with broad-leaved trees such as the oak, maple, and ash. At higher elevation, Fir, Juniper, Deodar, and chilgoza can be found.

5. Sub-alpine forests –

These extend from Kashmir to Arunachal Pradesh between 2900 to 3500 metres. In the Western Himalayas, the vegetation consists mainly of Juniper, Rhododendron, Willow, and Black Currant. In the eastern parts, Red fir, Black Juniper, Birch, and Larch are the common trees. Due to heavy rainfall and high humidity the timberline in this part is higher than that in the West. Rhododendron of many species covers the hills in these parts

6. **Alpine** forests –

A. Moist alpines - These are found all along the Himalayas and on the higher hills near the Myanmar border. It has a low scrub, dense evergreen forest, consisting mainly of rhododendron and birch. Mosses and ferns cover the ground in patches. This region receives heavy snowfall.

B. Dry alpines – These are found from about 3000 metres to about 4900 metres. Dwarf plants predominate, mainly the black juniper, the drooping juniper, honeysuckle, and willow.

## IMPORTANCE OF FORESTS

The importance of forests can be enlisted as follows:

- Forests are commonly referred to as **lungs of the earth**. It is primarily because of the presence of variety of plants which due to their high density produce massive amount of Oxygen which enables other organisms to breathe. Forest of one acre provides over 6 tons of Oxygen every year.
- Forests provide home to diverse animal and plant species, which not only provide bio-diversity on earth, but each species has the important role in the ecosystem.
- About 25% of all the medicines that are produced originate from rainforest plants. For example Curare (toxic plant) comes from a tropical vine, and is used as an anaesthetic and to relax muscles during surgery. Similarly **Quinine** is derived from the 'Cinchona Tree' which is used to treat Malaria.
- Forest provide timber, which is used for building house, furniture etc.
- Forests are the most important components of earth's ecosystem as it prevents soil erosion, maintains water cycle, check global warming etc. Without all these roles performed by forests, the earth would be uninhabitable.
- Wildlife tourism generates lots of capital, which in turn increases the revenue of the government.
- Forests still harbour various species of living organisms which are still being discovered. Each animal insects and plants contain its individual genetic material that has been evolving for thou-



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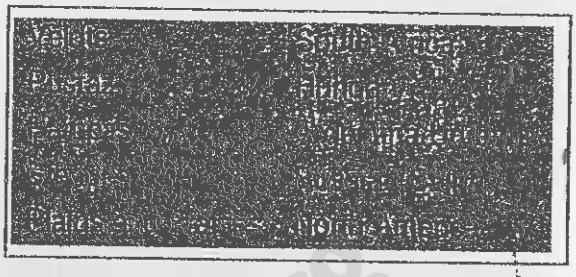
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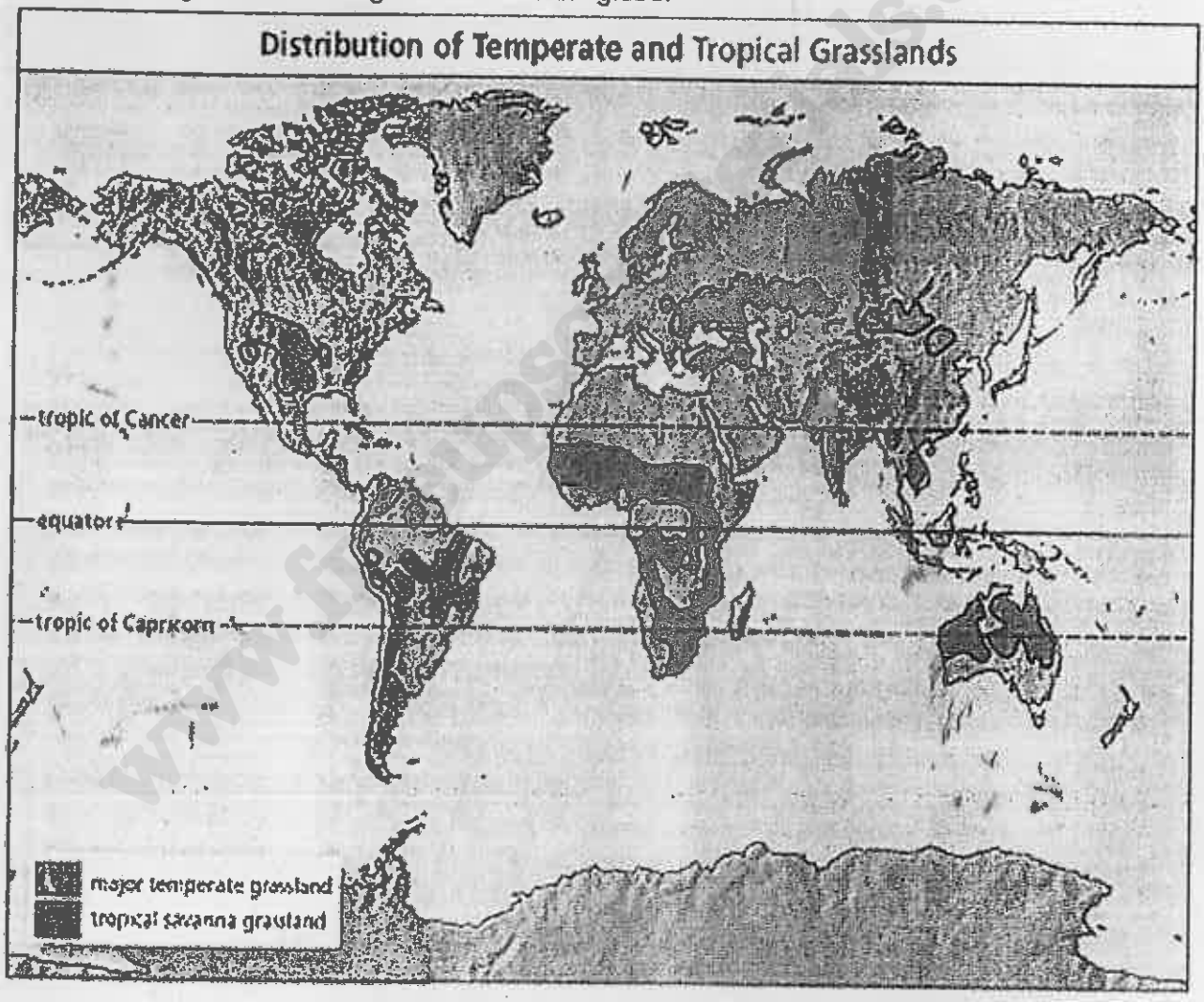


sands of years. Protecting the forests not only preserves a process of life that started billions of years ago but it also gives us missing clues to various riddled aspects of life itself.

## GRASSLANDS



Grassland biomes are unaltered areas of land where grass is the dominant plant life, as opposed to other terrestrial biomes where trees occupy most of the land surface. Grassland are found around the globe and have served as grazing areas for a large number of animals, and have been exploited as farming grounds or plantations by humans. They occupy about one quarter of the Earth's land area. Grasslands are considered the transitional biome and are usually found between deserts and forests. The box on the right shows the major regional expressions of grasslands recognized around the globe.




***They have been divided into following two parts:***

| Savannah | Temperate Grassland |
|---|---|
| Characteristic Features: | Characteristics Features: |
| ≠ The savannah stays pretty warm all year. It | ≠ Due to their location in interiors of con- |



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cools down some during the dry season, but stays warm and humid during the rainy season.

≠ Savannas have two distinct seasons in regards to precipitation. There is a rainy season in the summer with around 40 cm to 80cm of rainfall and a dry season in the winter when less than 10 cm of rain may fall.

≠ The majority of the savannah is covered in different types of grasses including lemon grass, Rhodes grass, star grass, and Bermuda grass.

≠ There are also lots of trees scattered about the savannah. Some of these trees include the acacia tree, the baobab tree, and the jackalberry tree.

≠ The plants need to be able to survive the dry season and drought in the savannah. Some store water and energy in their roots, bulbs, or trunks. Others have roots that go deep into the ground to reach the low water table

≠ Fires are an important part of the savannah. During the dry season fires clear out old dead grass and make way for new growth. Most of the plants will survive because they have extensive root systems that allow them to grow back quickly after a fire. The trees have thick bark which helps them to survive. The animals generally can run to escape the fire. Some animals burrow deep into the ground to survive. Insects generally die by the millions in a fire, but this provides a feast to many birds and animals.

≠ There are many herbivores in the savannah biome which also bring many carnivores. Herbivores have developed traits which help them escape predators such as being fast, being large, or being tall.

≠ Although there are various types of soil in the savannah biome, it is not suitable for farming.

tinents, the annual range of temperature is huge ranging from -20°C to 20°C respectively in the winter and summer

≠ Rainfall is generally less in temperate grasslands than in tropical savannas, falling usually in temperate grasslands in the late spring and early summer. There is an average of 50 – 80cm of rainfall a year.

≠ Unlike savannas that can have trees and shrubs scattered throughout, temperate grasslands have trees and shrubs absent.

≠ Grasses of this area have adapted to cold temperatures, drought, and occasional fires.

≠ These grasses have deep, massive root systems that take hold in the soil. This allows the grasses to remain firmly rooted in the ground to reduce erosion and to conserve water.

≠ The dominant vertebrates in grasslands are herbivorous or plant-eating grazers called ungulates. Ungulates are mammals with hoofs, like horses and deer. Their long legs help them run fast to escape grassland predators. The temperate grassland does not have much animal diversity, especially compared to the Savannah. Some animals that inhabit temperate grasslands in North America are bison, antelope, birds, gophers, prairie dogs, coyotes, and insects.

≠ Temperate grassland soil has fertile upper layers, created from fires and the decay of deep grass roots, which makes it ideal for farming and grazing.

## DESERTS

Deserts cover about **one fifth** of our planet, and are caused by extremely low rainfall over an area. Theses biomes are nonetheless home for many plants and animals which have through the course of their evolution adapted to this dry environment. Most deserts have a considerable amount of specialized vegetation, as well as specialized vertebrate and invertebrate animals. Soils often have abundant nutrients because they need only water to become very productive and have little or no organic matter. Disturbances are common in the form of occasional fires or cold weather,



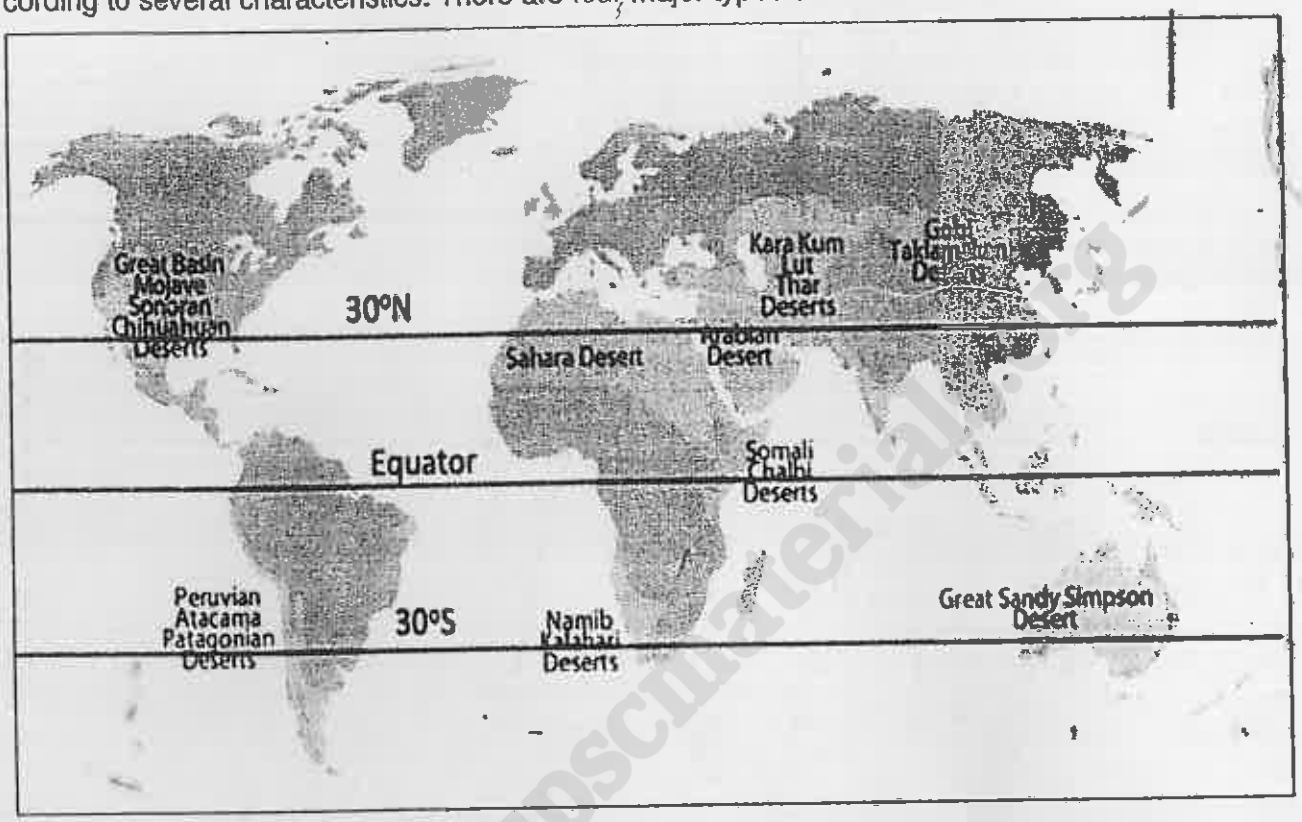
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and sudden, infrequent, but intense rains that cause flooding. There are relatively few large mammals in deserts because most are not capable of storing sufficient water and withstanding the heat. Deserts often provide little shelter from the sun for large animals. The dominant animals of warm deserts are non-mammalian vertebrates, such as reptiles. Desert biomes can be classified according to several characteristics. There are four major types of deserts:




**1. Hot and Arid Desert** – These generally occur at low latitudes, and can be found in Sahara, South western North-America, South-America, Australia, and middle east. Seasons in the arid desert are generally dry and hot, with few occurrences of rain during the winter. The heat peaks to extremes during the daytime because there are no clouds to shield the earth from the sun's rays. When it rains, it is not uncommon for the rain to evaporate before hitting the ground. The soil is usually either sand or coarse, and rocky.

Vegetation **consists mainly of shrubs and small trees of which the leaves have evolved to retain water.**

Most desert life forms have followed this train of evolution, with animal species being mostly active at night (nocturnal).

***Where?***

Although most deserts, such as the Sahara of North Africa and the deserts of the southwestern U.S., Mexico, and Australia, occur at low latitudes, another kind of desert, cold deserts, occur in the basin and range area of Utah and Nevada and in parts of western Asia.

**2. Cold Desert** - Perhaps the strangest of all desert biomes is the cold desert, as our perception of the desert is usually associated with the heat of the sun. But even if there is a moderately high amount of snow and rainfall during the wintertime, the soil is too heavy and alkaline. Alluvial fans pull some of the salt through the porous soil, so plant life can survive, but then again, as with its arid counterparts, the cold desert offers less than ideal conditions for sustaining delicate plants and animals. Most of the animals in the cold desert are burrowers, even the carnivores and reptiles which even though cold-blooded, have made their homes in the cold desert.

**Characteristic Features of Cold Desert**



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- These deserts are characterized by cold winters with snowfall and high overall rainfall throughout the winter and occasionally over the summer.
- They have short, moist, and moderately warm summers with fairly long, cold winters. Mean winter temperature is between -2 to 4° C and the mean summer temperature is between 21-26° C.
- The winters receive quite a bit of snow. The mean annual precipitation ranges from 15-26 cm. Annual precipitation has reached a maximum of 46 cm and a minimum of 9 cm.
- The plants are widely scattered. In areas of shad scale, about 10 percent of the ground is covered, but in some areas of sage bush, it approaches 85 percent. Plant heights vary between 15 cm and 122 cm. The main plants are deciduous, most having spiny leaves.
- Widely distributed animals are jack rabbits, kangaroo rats, kangaroo mice, pocket mice, grasshopper mice, and antelope ground squirrels. All except the jack rabbits are burrowers. The burrowing habit also applies to carnivores like the badger, kit fox, and coyote. Several lizards do some burrowing and moving of soil. Deer are found only in the winter.
- The soil is heavy, silty, and salty. It contains alluvial fans where soil is relatively porous and drainage is good so that most of the salt has been leached out.

## TUNDRA

Tundra, the "ice desert", "frozen prairie", the cold plains of the Far North get their name from the Finnish word "tunturia", which means treeless land. The tundra biome is the coldest of all terrestrial eco-systems, and also the most chaotic. Still, the tundra is host to a surprising number of plants and animals, and represents a fascinating testament to nature's adaptability, and cruel beauty.

**Characteristics of tundra include:**

(1) Extremely cold climate
(2) Low biotic diversity
(3) Simple vegetation structure
(4) Limitation of drainage
(5) Short season of growth and reproduction
(6) Energy and nutrients in the form of dead organic material
(7) Large population oscillations

Although of uniform nature, but they have been divided in two parts: 1. Arctic, and 2. Alpine.

**1. Arctic Tundra** - The arctic tundra occupies earth's Northern hemisphere, cling the North Pole all the way down to the ergreen forests of the boreal biomes. The soil of

**Characteristic Features of Arctic Tundra:**

- The arctic is known for its cold-desert like conditions.
- The growing season ranges from 50 to 60 days.
- The average winter temperature is -34° C), but the average summer temperature is 3-12° C, which enables this biome to sustain life.
- Rainfall may vary in different regions of the arctic. Annual precipitation, including melting snow, is 15 to 25 cm.
- All of the plants are adapted to sweeping winds and disturbances of the soil.
- Plants are short and group together to resist the cold temperatures and are protected by the snow during the winter. They can carry out photosynthesis at low temperatures and low light intensities. The growing seasons are short and most plants reproduce by budding and division rather than sexually by flowering.
- Animals are adapted to handle long, cold winters and to breed and raise young quickly in the summer. Animals such as mammals and birds also have additional insulation from fat. Many animals hibernate during the winter because food is not abundant. Another alternative is to migrate south in the winter, like birds do. Reptiles and amphibians are few or absent because of the extremely cold temperatures. Because of constant immigration and emigration, the population continually oscillates.
- Soil is formed slowly. A layer of permanently frozen subsoil called permafrost exists, consisting mostly of gravel and finer material. When water saturates the upper surface, bogs and ponds may form, providing moisture for plants. There are no deep root systems in the vegetation of the Arctic Tundra; however, there are still a wide variety of plants that are able to resist the cold climate.

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the Arctic Tundra is poor in nutrients, which accounts for the low amount of vegetation. There is an under-layer of soil called permafrost which remains completely frozen at all times, allowing little room for deep rooting plants and trees. The plants that do survive the frozen landscapes are extremely resilient, and their roots are close to the surface of the hard soil, as to intake what little water falls upon the ground; most of the arctic tundra's plant life consists of shrubbery, lichen, moss, and flowers. Birds of the tundra migrate south during the winter months, causing constant change in the animal population.

**2. Alpine Tundra** - The Alpine Tundra biome exists on rocky mountaintops and is very similar to the Arctic Tundra except for a conspicuous lack of trees. Because trees cannot grow at this high altitude, most of the Alpine Tundra's plant life consists of shrubbery and small leafy plants such as alpine bluegrass which is consumed by a variety of grazing animals such as bighorn sheep and mountain goats.

**Characteristic Features of Alpine tundra:**

- They are usually at an altitude of about 10,000 feet or more. The Alpine biome lies just below the snow line of a mountain.
- In the summer average temperatures range from 10o to 15oC. In the winter the temperatures are below freezing. The winter season can last from October to May. The summer season may last from June to September. The temperatures in the Alpine biome can also change from warm to freezing in one day.
- At high altitudes there is very little CO2, which plants need to carry on photosynthesis.
- Because of the cold and wind, most plants are small perennial groundcover plants which grow and reproduce slowly. They protect themselves from the cold and wind by hugging the ground. Taller plants or trees would soon get blown over and freeze.
- When plants die they don't decompose very quickly because of the cold. This makes for poor soil conditions.
- Most Alpine plants can grow in sandy and rocky soil. Plants have also adapted to the dry conditions of the Alpine biome.
- Alpine animals have to deal with two types of problems: the cold and too much high UV wavelengths. This is because there are fewer atmospheres to filter UV rays from the sun. There are only warm blooded animals in the Alpine biome, although there are insects.
- Alpine animals adapt to the cold by hibernating, migrating to lower, warmer areas, or insulating their bodies with layers of fat. Animals will also tend to have shorter legs, tails, and ears, in order to reduce heat loss. Alpine animals also have larger lungs, more blood cells and haemoglobin because of the increase of pressure and lack of oxygen at higher altitudes. This is also true for people who have lived on mountains for a long time, like the Indians of the Andes Mountains in South America and the Sherpas of the Himalayas in Asia.



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# CHAPTER – 5
# AQUATIC BIOMES

## Introduction

Water covers about 75% of our planet. Without water, most life forms would be unable to sustain themselves and the Earth would be a barren, desert-like place. Although water temperatures can vary widely, aquatic areas tend to be cooler.

*Life forms in water depend on the abiotic factors such as sunlight entering the waters, temperature, pressure, salt content and so on. Water biomes with lots of light tend to have more flora diversity and the growth of algae and plankton is more. Small water bodies that freeze during the cold seasons, or dry out in the dry and hot seasons tend to have less diversity. Examples of animals found in marine biomes include star fishes, sharks and tuna and sea birds. Examples of animals in freshwater biomes include salmon, tilapia worms, water-surface insects and crabs. Aquatic biomes also form the basis of the water cycle and help with atmospheric moisture, cloud formation and precipitation.*

## What are Aquatic biomes?

Aquatic biomes (ecosystem) are a group of interacting organisms dependent on one another and their water environment for nutrients (e.g., nitrogen and phosphorus) and shelter. Familiar examples are ponds, lakes and rivers, but aquatic ecosystems also include areas such as floodplains and wetlands, which are flooded with water for all or only parts of the year. Seemingly inhospitable aquatic ecosystems can sustain life. Thermal springs, for instance, support algae and some insect species at water temperatures near the boiling point; tiny worms live year-round on the ice fields; and some highly polluted waters can support large populations of bacteria. Even a drop of water is an aquatic ecosystem, since it contains or can support living organisms. In fact, ecologists often study drops of water -- taken from lakes and rivers -- in the lab to understand how these larger aquatic ecosystems work.

NOTE: Main concepts of terrestrial primary succession can be applied to aquatic ecosystems except for oceans. Over time, most aquatic ecosystems are replaced by terrestrial ecosystems as aquatic ecosystems receive continuous input of soil particles and organic matters. As sediment increases, water depth decreases and types of organisms inhabiting the ecosystem also change.

Aquatic Biomes are three-dimensional environments that can be divided into distinct zones based on characteristics such as

1. **Depth**
2. **Tidal flow**
3. **Temperature**
4. **Proximity to landmasses.**

On these parameters, they

**I. Fresh water:** Very small proportion of earth's area that is only 0.8 percent of the earth's surface is covered by them. Primary production in a fresh-water ecosystem is controlled by light and nutrient availability. Fresh water can be defined as the water that contains a relatively small amount of dissolved chemical compounds. It includes: Standing Water- lakes and ponds and Moving Water - Rivers & streams. Freshwater is defined as having a low salt concentration - usually less than 1%.

**II. Transitional Communities:** They act as ecotone between terrestrial and aquatic ecosystems, as they lay between the regions of water and landmass hence their inhabitants have to adapt accordingly. They have further been divided as Estuaries and Wetlands.

**III. Marine Ecosystem:** About 71% of the earth's surface is covered by marine ecosystem. Marine ecosystem involves: Shorelines, Coral Reefs and Open Ocean.



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can be divided into following three parts, which can further be divided in to various sub parts.

## FRESH WATER ECOSYSTEMS

They are closely linked to soils and biotic components of terrestrial biomes through which they pass. Their characteristics are influenced by patterns and speed of water flow and climate of area in which it is located. Plants and animals in freshwater regions are adjusted to the low salt content and would not be able to survive in areas of high salt concentration (i.e. ocean). The fresh water ecosystem is limited by solar radiation and temperature. Their nutrient limitations are common to that of marine ecosystems, but phosphorus is usually limiting nutrient (rather than nitrogen as in oceans), hence there has been a shift in late 1970's to phosphate-free detergents.

Freshwater regions have been divided in two categories - standing (lentic) bodies of water, which includes lakes, ponds etc. and moving (lotic) bodies of water, i.e. rivers, streams etc.

**1. Ponds and Lakes** - These regions range in size from just a few square meters to thousands of square kilometres. Ponds and lakes may have limited species diversity since they are often isolated from one another and from other water sources like rivers and oceans. Lakes are large, natural bodies of standing fresh water, formed when precipitation, runoff, groundwater seepage fills depressions in earth's surface. These depressions can be formed by glaciation (Great Lakes, NA), crustal displacement (Lake Nyasa, East Africa) and volcanic activity (Crater Lake, Oregon). The size of lake may vary from as small as a pond to as big as small seas. Large lakes may have many of same characteristics as oceans.

Lakes are often classified according to their production of organic matter. Alternatively, Lakes have been classified in following three categories on the basis of their nutrient content or productivity.

- **Oligotrophic** – A newly formed lake generally has a small supply of plant nutrients and is called an Oligotrophic lake, i.e. poorly nourished. This type of lake is deep, cold having steep banks and small surface area relative to its depth. This lake is nutrient-poor and hence phytoplanktons are sparse. Such a lakes are not very productive and hence do not contain much life. Waters of Oligotrophic Lake are often very clear and have low sediments in decomposable organic matter. Such lakes are generally found in undisturbed regions free from any human interference, for example Lake Baikal in Siberia.
- **Eutrophic** – Over time, sediments, organic material and inorganic nutrients wash into most oligotrophic lakes giving impetus to the growth of flora and fauna. These when decompose form bottom sediments in benthos. A lake with a large or excessive supply of nutrients (mostly nitrates and phosphates) needed by producers is called a Eutrophic (well nourished) lake. These lakes typically are shallow and have murky brown or green water with poor visibility. Excessive organic matter content in Benthos leads to high decomposition rates and potentially low oxygen. Because of human activity, there can be large input of nutrients into the lakes resulting into eutrophication (called cultural eutrophication).
- **Mesotrophic** – Many lakes fall somewhere between two extremes of nutrients enrichment and therefore are called Mesotrophic lakes. They have moderate nutrient content and moderate amount of phytoplankton, reasonably productive. Such types of lakes can be considered as a transition phase from Oligotrophic to Eutrophic.



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## Productivity of Lakes

Lakes' productivity is determined by several factors, i.e. temperature, depth, nutrient content and dissolved oxygen content. Areas having lesser temperature have very low productivity. Similarly, areas containing plethora of nutrients (generally in littoral zones) have high productivity. Depth is a parameter measuring sunlight and warmth of the lake regions, which in turn influences the productivity. Dissolved oxygen content is extremely vital for the process of respiration and photosynthesis. Oxygen enters water from air, released as result of photosynthesis and also as mixing from wave action. Dissolved oxygen content determines types of organisms that can inhabit a lake. Moreover, decomposition of organic matter by bacteria and fungi also requires oxygen (as they perform respiration) thereby diminishing the amount of dissolved Oxygen.

Biochemical oxygen demand (BOD) is the amount of oxygen used by decomposers to break down a specific amount of organic matter. Greater amount of organic matter (or influx of nutrients) increases BOD and decreases amount of Oxygen available in water.

Lakes and ponds are divided into three different "zones" which are usually determined by depth and distance from the shoreline. They have been divided in 4 zones:

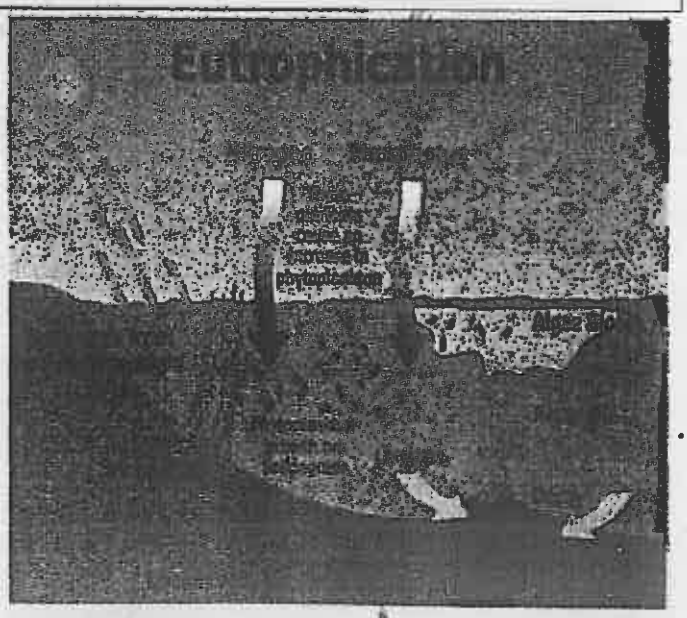
- Littoral zone - The topmost zone near the shore of a lake or pond is the Littoral zone. This zone is the warmest since it is shallow, well lit and can absorb more of the Sun's heat. It sustains a fairly diverse community, which can include several species of algae, rooted and floating aquatic plants, grazing snails, clams, insects, crustaceans, fishes, and amphibians.
- Limnetic zone - The near-surface open water surrounded by the littoral zone is the limnetic zone. This zone is well-lit open surface water and farther from the shore, extending to depth penetrated by light. This zone is occupied by phytoplankton, zooplankton, higher animals and produces food and oxygen that supports most of lake's consumers.
- Profundal zone - The deepest zone of the lake is the Profundal zone. This zone is much colder and denser than the other two. Little light penetrates all the way through the limnetic zone into the Profundal zone. It consists of deep, aphotic regions, lacking in oxygen and which are too dark for photosynthesis. This zone is inhabited by fish adapted to cool dark waters.
- Benthic zone – This zone is actually bottom of lake, inhabited by organisms that can tolerate cool temperatures and low oxygen levels. Mostly decomposers, detritus feeders and fish that swim from one zone to other inhabit this zone. It is nourished mainly by dead matter that falls from the littoral and limnetic zone and by sediments washing into lakes.

## Threats to Lake Ecology

### *Eutrophication*

***What is it?***

*'Eutrophication' refers to natural or artificial addition of nutrients to bodies of water and to the effects of the added nutrient. When the effects are undesirable, eutrophication may be considered a form of pollution. Alternatively, the enrichment of bodies of fresh water by inorganic plant nutrients (e.g. nitrate, phosphate) is called Eutrophication."*




It may occur **naturally** but can also be the result of human activity (cultural eutrophication from fertilizer runoff and sewage discharge) and is particularly evident in slow-



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moving rivers and shallow lakes. Increased sediment deposition can eventually raise the level of the lake or river bed, allowing land plants to colonize the edges, and eventually converting the area to dry land. Eutrophication occurs naturally over centuries as lakes age and are filled in with sediments However, human activities have accelerated the rate and extent of eutrophication through both point-source discharges and non-point loadings of limiting nutrients, such as nitrogen and phosphorus, into aquatic ecosystems.

Eutrophication was first recognized as a pollution problem in European and North American lakes and reservoirs in the mid-20th century. Runoff from agriculture and development, pollution from septic systems and sewers, and other human-related activities which increased the flux of both inorganic nutrients and organic substances into lakes were established as causes enhancing eutrophication.

The main **causes of eutrophication are:**

- Natural run-off of nutrients from the soil and the weathering of rocks
- Run-off of inorganic fertilizer (containing nitrates and phosphates)
- Run-off of manure from farms (containing nitrates, phosphates and ammonia)
- Run-off from erosion (following mining, construction work or poor land use)
- Discharge of detergents (containing phosphates)
- Discharge of partially treated or untreated sewage (containing nitrates and phosphates)

**Effects of Eutrophication:**

***Algal Blooms –***

*"An algal bloom or marine bloom or water bloom is a rapid increase in the population of algae in an aquatic system."*

ALGAL BLOOMS MAY OCCUR IN FRESHWATER AS WELL AS MA-RINE,ENVIRONMENTS.

*Typically only one or a few phytoplankton species are involved and some blooms may be recognized by discoloration of the water resulting from the high density of pigmented cells. Although there is no officially recognized threshold level, algae can be considered to be blooming at concentrations of hundreds to thousands of cells per millilitre, depending on the causative species. Algal bloom concentrations may reach millions of cells per millilitre. Colours observed are green, yellowish-brown, or red. Bright green blooms may also occur. These are a result of blue-green algae, which are actually bacteria (cyanobacteria).*

Some algal blooms are the result of an excess of nutrients (particularly phosphorus and nitrogen) into waters and higher concentrations of these nutrients in water cause increased growth of algae and green plants. As more algae and plants grow, others die. This dead organic matter becomes food for bacteria that decompose it. With more food available, the bacteria increase in number and use up the dissolved oxygen in the water. When the dissolved oxygen content decreases, many fish and aquatic insects cannot survive. This results in a dead area. Algal blooms may also be of concern as some species of algae produce **neurotoxins.**

At the high cell concentrations reached during some blooms, these toxins may have severe biological impacts on wildlife. Algal blooms composed of Phytoplankton known to naturally produce bio-toxins are often called Harmful Algal Blooms, or HABs.

Not all HABs are toxic. Only forty or so species are believed to produce such potent toxins. Some species are merely unpalatable to other marine life because of gelatinous envelopes or other characteristics and they exact their harmful effects by essentially "starving" the food chain.

**Harmful Algal Blooms (HABs)** - While single species blooms can turn the water surface red, brown, yellow, green or white, they are often generically referred to as **"red tides"** and are often associated with harmful or toxic effects. When the blooming microalgae have properties that are deemed harmful to humans



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or other life, the blooms are called Harmful Algal Blooms, or HABs. In recent years, there has been growing alarm over what appears to be an "epidemic" of HABs worldwide. In many regions, HABs are occurring more frequently occurring over larger areas and lasting longer. HABs are also being recorded in areas where previously they were not known. In other cases, algal species previously benign, or even unknown, have suddenly emerged to become problematic.

- HABs can kill marine life and cause losses to aquaculture operations.
- A number of species release powerful toxins that can make their way through the food web to affect seabirds, marine mammals and humans, sometimes fatally.
- Some toxic species can cause a variety of human ailments, contracted either through inhaling airborne toxins, skin contact or, more commonly, eating contaminated shellfish.
- These toxins may cause amnesia, stomach cramps, nausea, memory loss, paralysis and even death. Other species can cause physical damage, as the blooms of species which contain barbs that lodge among gill tissues of fish, causing death.
- Such blooms can cause a great deal of financial damage by killing farmed fish, which are grown in crowded aquaculture pens.
- Some blooms of algae are not inherently harmful but may result in severe environmental impacts. For instance, low oxygen conditions may result from the decay of excessive amounts of algal growth caused by nutrient pollution.

**Other effects of Eutrophication –**

- Fishes and various aquatic organisms die on large scale.
- The water can have a bad taste, colour and odour which have a negative impact on the environment and surroundings.
- It also reduces the biodiversity caused by loss of species.
- Some phytoplankton species produce toxins that cause severe symptoms such as diarrhoea, memory loss, paralysis and in severe cases death.

**Hypoxia** - Hypoxia is reduced dissolved oxygen content of a body of water. The algae may keep out the light and when they eventually die, they are decomposed by bacteria which consume oxygen in this process so that the water may become temporarily anoxic (hypoxia) which may be toxic to aquatic life.

**CAUSES**

Although there are some scientists who believe the increase in reports of HABs is a function of increased awareness and monitoring, others have provided compelling evidence that, for some regions, human activities play an important role. The primary human contribution to HABs is thought to be nutrient pollution -- from, amongst other things, agriculture, sewage outfalls and mining -- creating a more favourable, nutrient-rich environment in coastal waters in which certain groups of phytoplankton can thrive. Climate change may also be making some coastal environments more hospitable to harmful phytoplankton species. Many species of phytoplankton are also transported around the world in ships' ballast water and discharged in areas where they did not previously occur. Others are distributed accidentally through the transfer of shellfish for aquaculture.

**2. Streams and Rivers** - These are bodies of flowing water moving in one direction. Streams and rivers can be found everywhere—they get their starts at headwaters, which may be springs, snowmelt or even lakes, and then travel all the way to their mouths, usually another water channel or the ocean. The characteristics of a river or stream change during the journey from the source to the mouth. The temperature is cooler at the source than it is at the mouth. The water is also clearer, has higher oxygen levels, and freshwater fish and heterotrophs can be found there. Towards the



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middle part of the stream/river, the width increases, as does species diversity—numerous aquatic green plants and algae can be found. Towards the mouth of the river/stream, the water becomes murky from all the sediments that it has picked up upstream, decreasing the amount of light that can penetrate through the water. Since there is less light, there is less diversity of flora, and because of the lower oxygen levels, fish that require less oxygen, such as catfish and carp, can be found. The nutrient content of river/stream is largely determined by the terrain & vegetation of the area through which it flows. The input of nutrients is through adjacent and overhanging vegetation, weathering of rock, soil erosion and human activities.

Streams and Rivers can be separated into following three zones –

A. **Source zone** – It contains headwaters (headwater streams) and often begins as springs or snowmelt. The water in this zone is cold, clear and carries little sediment or relatively few nutrients. Channels are usually narrow, current is swift and substrate is rocky.

B. **Transition** Zone – This zone contains wider and lower elevation streams. The streams here join to form tributaries. The water of this zone is relatively warmer, less clear and carries more sediment or more nutrients. Channels are usually wider, current is slower and substrate begins to accumulate silt.

C. Floodplain zone – Rivers get fragmented to form distributaries, which empty into oceans at estuaries. The water of this zone is relatively warmer, murky and carries substantially more sediments or more nutrients. Channels are wider, river mouths are also wider, current is relatively slow and substrate becomes silty from deposition of sediments.

## TRANSITIONAL COMMUNITIES

This type of Biome or ecosystem lay somewhere between freshwater and marine ecosystems. The flora and fauna of such ecosystems are adapted to brackish and acidic water. More about these can be studied by dividing them in following two categories -

### 1. Wetlands

*Ramsar Convention on* ***Wetlands define wetlands*** *as: "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"*

Plant species adapted to the very moist and humid conditions are called **Hydrophytes**. These include pond lilies, cattails, sedges, tamarack, and black spruce. Marsh flora also includes such species as cypress and gum. Wetlands have the highest species diversity of all ecosystems. Many species of amphibians, reptiles, birds (such as ducks and waders), and furbearers can be found in the wetlands. Wetlands are not considered freshwater ecosystems as there are some, such as salt marshes, that have high salt concentrations—these support different species of animals, such as shrimp, shellfish, and various grasses.

**Types of Wetlands:**

Wetlands are highly variable and dynamic: they are water bodies but also include land. They are freshwater, brackish or saline, inland or coastal, seasonal or permanent, natural or man-made. Wetlands include mangroves, (peat) swamps and marshes, rivers, lakes, floodplains and flooded forests, rice-fields, and even coral reefs. Wetlands are one of the world's most important environmental assets, containing a disproportionately high number of plant and animal species compared to other areas of the world.

Wetlands have generally been divided under following headings:



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**buffering climate change impacts:**

- Wetlands act as significant carbon sinks – the destruction of wetlands will release carbon dioxide, a greenhouse gas.
- Wetlands will play a further role as the frontline defenders of coastal and inland areas as countries deal with the full effects of climate change: increasing frequency of storms, changing rainfall patterns, rising sea-levels and sea surface temperatures.

**10. Natural transport infrastructure**

**11. Aesthetic and educational value, support for tourism** – the natural beauty of many wetlands makes them ideal locations for recreation, education and tourism.

**12. Food for animals** – cattle and duck graze on some types of wetlands; wetland vegetation may be used as an addition to forage, etc.

***Protection of Wetlands***

These amazingly productive and diverse wetlands that stand between upland and open water are vanishing at such a quick rate in some parts of the country that within our lifetime they may just be a memory. It has become inevitable and imperative to protect this ecosystem, otherwise it may cost dearly to human beings. Following can be some of the measures to protect our wetlands –

- ❖ Not to engage in land use changes or hydrologic modifications.
- ❖ Encourage and support local laws to protect and regulate wetlands.
- ❖ Seek non-wetland sites for development and protect wetlands during construction
- ❖ Increase awareness and education about the vitality of wetlands.
- ❖ Avoid mining and construction activities in the vicinity of wetlands
- ❖ Proper implementation of EIA
- ❖ Prohibit the direct and untreated discharge from industries.
- ❖ Afforestation
- ❖ Removal of encroachments

**1) National Wetland Conservation Programme (NWCP) –**

Government of India operationalized National Wetland Conservation Programme (NWCP) in closed collaboration with concerned State Government during the year 1985/86. Under the programme 115 wetlands have been identified till now by the Ministry which requires urgent conservation and management initiatives. The scheme was initiated with the following objectives:-

- To lay down policy guidelines for conservation and management of wetlands in the country;
- To undertake intensive conservation measures in priority wetlands;

**Ramsar Sites of India (decreasing Area wise)**

1. Vembanad-kol wetland (Kerala)
2. Chilika Lake (Odisha)
3. Kolleru Lake (Andhra Pradesh)
4. Bhitarkanika Mangroves (Odisha)
5. Ashtamudi Wetland (Kerala)
6. Point Calimere Wildlife And Bird Sanctuary (Tamilnadu)
7. Loktak Lake (Manipur)
8. Upper Ganga River (Uttar Pradesh)
9. Sambhar Lake (Rajasthan)
10. Wular Lake (Jammu and Kashmir)
11. Pong Dam Lake (Himachal Pradesh)
12. East Calcutta Wetlands (West Bengal)
13. Nalsarovar (Gujarat)
14. Tsomoriri (Jammu and Kashmir)
15. Harike Lake (Punjab)
16. Deepor Beel (Assam)
17. Bhoj Wetland (Madhya Pradesh)
18. Keoladeo National Park (Rajasthan)
19. Hokera Wetland (Jammu and Kashmir)
20. Ropar (Punjab)
21. Sasthamkotta Lake (Kerala)
22. Surinsar-Mansar Lakes (Jammu and Kashmir)
23. Rudrasagar Lake (Tripura)
24. Kanjli (Punjab)
25. Chandertal Wetland (Himachal Pradesh)
26. Renuka Wetland (Himachal Pradesh)



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- To monitor implementation of the programme
- To prepare an inventory of Indian wetlands.

**2) Ramsar Convention on Wetlands**

The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. Ramsar Convention is the only global environment treaty dealing with a particular ecosystem. The Ramsar Convention on Wetlands was developed as a means to call international attention to the rate at which wetland habitats were disappearing, in part due to a lack of understanding of their important functions, values, goods and services. Governments that join the Convention are expressing their willingness to make a commitment to helping to reverse that history of wetland loss and degradation. Under the "three pillars" of the Convention, the Contracting Parties commit to:

1. Work towards the wise use of all their wetlands;
2. Designate suitable wetlands for the list of Wetlands of International Importance (the "Ramsar List") and ensure their effective management;
3. Cooperate internationally on trans-boundary wetlands, shared wetland systems and shared species.

Major **obligations** of countries which are party to the Convention are:

- Designate wetlands for inclusion in the List of Wetlands of International Importance.
- Promote, as far as possible, the wise use of wetlands in their territory.
- Promote international cooperation especially with regard to trans-boundary wetlands, shared water systems, and shared species.
- Create wetland reserves.

**2. Estuaries**

An estuary is a partially enclosed body of water formed where freshwater from the land meets and mixes with saltwater from the ocean. This mixing of waters with such different salt concentrations creates a very interesting and unique ecosystem. In fresh water the concentration of salts, or salinity, is nearly zero. The salinity of water in the ocean averages about 35 parts per thousand. The mixture of seawater and fresh water in estuaries is called brackish water and its salinity can range from 0.5 to 35 ppt. The salinity of estuarine water varies from estuary to estuary, and can change from one day to the next depending on the tides, weather, or other factors.

Estuaries support a wide variety of flora and fauna. Micro flora like algae, and Macro flora, such as seaweeds, marsh grasses, and Mangrove trees (only in the tropics), can be found here. **Mangroves are various large and extensive types of trees up to medium height and shrubs that grow in saline coastal sediment habitats in the tropics and subtropics – mainly between latitudes 25° N and 25° S.** Estuaries support a diverse fauna, including a variety of worms, oysters, crabs, and waterfowl. Estuaries vary in size and can also be termed bays, lagoons, harbours, inlets, sounds, wetlands and swamps. Estuaries are unique environments to which plants and animals have specially adapted. They are a type of transition from land to sea and fresh water to salt water. Estuaries are protected from ocean forces by reefs, barrier islands, headlands and deltas. Estuaries transport and trap nutrients and sediment through the combined action of freshwater flow, wind, waves and tidal action.

Characteristic features

- Estuaries and the lands surrounding them are places of transition from land to sea and freshwater to salt water.



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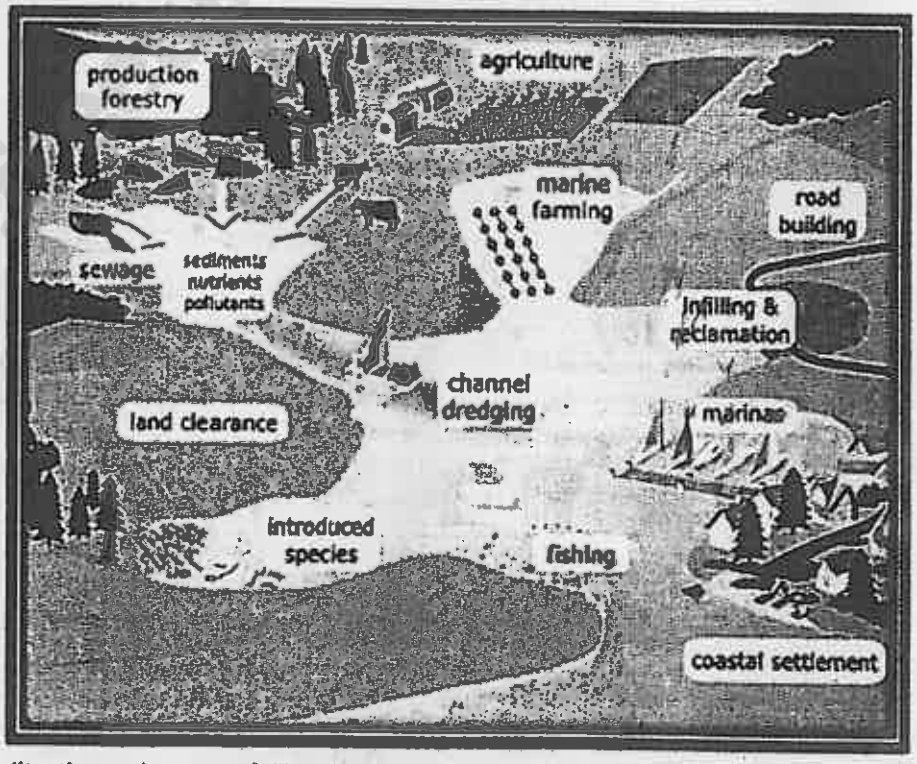
- Estuarine environments are among the most productive on earth, creating more organic matter each year than comparably-sized areas of forest, grassland, or agricultural land.
- The tidal, sheltered waters of estuaries also support unique communities of plants and animals especially adapted for life at the margin of the sea.
- Estuaries provide a calm refuge from the open sea for millions of plants and animals.
- The diversity of habitats enclosed in estuaries supports enormous abundance and diversity of species e.g. fish, shellfish, lobsters, marine worms, reeds, sea-grasses, mangroves, algae, and phytoplankton.
- The margins of the estuary contain the food webs important producers e.g. algae, eelgrass, rushes and mangroves providing a huge amount of organic matter. Marshes and mangroves produce up to ten tones of plant detritus per hectare per year – considered organic factories.
- Micro-organisms decompose complex organic compounds into useable forms – ammonia, nitrates and phosphates. This becomes the basic food for primary consumers like crabs, shellfish, snails, and marine worms. These burrowing invertebrates – especially sediment feeders continually turn over the deposited material.
- Visiting animals from land, sea and fresh water use the estuary for feeding, breeding, spawning and as nurseries for their young. Food is abundant and easy to access because of the shallow water attracting many types of birds including gulls, ducks and wading birds.

***Importance of Estuaries:***

- Estuaries provide us with a suite of resources, benefits, and services.
- Estuaries provide places for recreational activities, scientific study, and aesthetic enjoyment.

*Habitats associated with estuaries include salt marshes, mangrove forests, mud flats, tidal streams, rocky intertidal shores, reefs, and barrier beaches.*

- Thousands of species of birds, mammals, fish, and other wildlife depend on estuarine habitats as places to live, feed, and reproduce. And many marine organisms, including most commercially-important species of fish, depend on estuaries at some point during their development.




- Because they are biologically productive, estuaries provide ideal areas for migratory birds to rest and re-fuel during their long journeys.
- They maintain water quality through natural filtration as microbes break down organic matter and sediments bind pollutants. Wetlands that fringe many estuaries also have other valuable functions. Water draining from the land carries sediments, nutrients, and other pollutants. Much



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of the sediments and pollutants are filtered out as the water flows through these fringing marshes. This creates cleaner and clearer water, which benefits both people and marine life. Wetland soils and plants like mangroves, sea grasses and reeds also act as a natural buffer between the land and ocean, absorbing floodwaters from land and storm surges from the ocean.

≠ Salt marsh grasses and other estuarine plants also help prevent erosion and stabilize shorelines.

### *Estuarine Habitats*

A rich array of habitats surrounds estuaries. The type of habitat is usually determined by the local geology and climate.

### Salt Marshes

Salt marshes are a mosaic of snaking channels called tidal creeks that fill with seawater during high tides and drain during low tides. Salt marshes are covered with salt-tolerant plants, or halophytes, like salt hay, black rush, and smooth cordgrass. Salt marshes are salty because they are flooded by seawater every day. They are marshy because their ground is composed of peat. Because salt marshes are waterlogged and contain lots of decomposing plant material, oxygen levels in the peat are extremely low—a condition called hypoxia. Hypoxia promotes the growth of bacteria which produce the rotten-egg smell that is attributed to marshes and mud flats.

***Adaptations to life in the estuary***

- *Mangrove trees and blue crabs are some of the estuarine species that have adapted to unique environmental conditions. In almost all estuaries the salinity of the water changes constantly over the tidal cycle. To survive in these conditions, plants and animals living in estuaries must be able to respond quickly to drastic changes in salinity.*
- *Plants and animals that can tolerate only slight changes in salinity are called Stenohaline. These organisms usually live in either freshwater or saltwater environments. Most stenohaline organisms cannot tolerate the rapid changes in salinity that occurs during each tidal cycle in an estuary.*
- *Plants and animals that can tolerate a wide range of salinities are called Euryhaline. These are the plants and animals most often found in the brackish waters of estuaries. There are far fewer euryhaline than stenohaline organisms because it requires a lot of energy to adapt to constantly changing salinities. Organisms that can do this are rare and special. Some organisms have evolved special physical structures to cope with changing salinity. The smooth cordgrass found in salt marshes, for example, has special filters on its roots to remove salts from the water it absorbs. This plant also expels excess salt through its leaves.*
- *Unlike plants, which typically live their whole lives rooted to one spot, many animals that live in estuaries must change their behaviour according to the surrounding waters' salinity in order to survive. Oysters and blue crabs are good examples of animals that do this.*

### *Disturbances to Estuaries*

Estuaries are fragile ecosystems that are very susceptible to disturbances. Natural disturbances are caused by the forces of nature, while anthropogenic disturbances are caused by people. Natural disturbances include winds, tidal currents, waves, and ice. Anthropogenic disturbances include pollution, coastal development, and the introduction of non-native species to an area.

| *Natural Disturbances* | *Anthropogenic Disturbances* |
|---|---|
| • The most prominent natural disturbance is the continual pounding of ocean waves. | • The greatest threat to estuaries is, by far, their large-scale conversion by draining, fill- |



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Waves can also dislodge plants and animals, or bury them with sediments, while objects carried by the water can crush them. Large storms are especially destructive to estuaries.

- A common disturbance to estuaries in non-tropical regions is winter ice. Ice can freeze on an estuary's shoreline, or float freely in the water. When slabs of free-floating ice make contact with the shore, they have a scouring effect, dislodging and killing the plants and shoreline animals that lie in their path. When sheets of ice form on the shore, especially in salt marshes, they can trap plants and grass stalks inside them.
- Another natural disturbance in salt marshes is the burial of vegetation by rafts of dead floating plant material, called wrack. Wracks can be quite large—up to hundreds of square meters, and up to 30 cm thick. The spring high tides often move these wracks into the high marsh, where they become stranded.

ing, damming or dredging. These activities result in the immediate destruction and loss of estuarine habitats.

- Estuarine areas are seriously degraded by pollution. People have historically viewed estuaries and waterways as places to discard the unwanted by-products of civilization. Pollution is probably the most important threat to water quality in estuaries. Poor water quality affects most estuarine organisms, including commercially important fish and shellfish.
- The pollutants that have the greatest impact on the health of estuaries include toxic substances like chemicals and heavy metals, nutrient pollution (or eutrophication), and pathogens such as bacteria or viruses.
- Another, less widely discussed human-caused disturbance is the introduction of non-native or invasive species into estuarine environments.

## MANGROVES

Mangrove forests or Mangals grow at tropical and sub-tropical latitudes near the equator where the sea surface temperatures never fall below 16°C. Mangroves lie in about two-thirds of the coastlines in tropical areas of the world.

A unique mix of marine and terrestrial species lives in Mangrove ecosystems. The still, sheltered waters among the mangrove roots provide protective breeding, feeding, and nursery areas for snapper, tarpon, oysters, crabs, shrimp and other species important to commercial and recreational fisheries. Herons, brown pelicans, and spoonbills all make their nests in the upper branches of mangrove trees. Mangrove trees have become specialized to survive in the extreme conditions of estuaries. Two key adaptations they have are the ability to survive in water-logged and anoxic (no oxygen) soil, and the ability to tolerate brackish waters. All mangrove species have laterally spreading roots with attached vertical anchor roots. These roots are very shallow. Because the soil in shallow areas of mangrove forests is typically flooded during high tides, many species of mangrove trees have aerial roots, called pneumatophores that take up oxygen from the air for the roots. Some species also have prop roots or stilt roots extending from the trunk or other roots that help them withstand the destructive action of tides, waves, and storm surges.

There are about 80 species of mangrove trees, all of which grow in hypoxic (oxygen poor) soils where slow-moving waters allow fine sediments to accumulate). Many mangrove forests can be recognized by their dense tangle of prop roots that make the trees appear to be standing on stilts above the water. This tangle of roots helps to slow the movement of tidal waters, causing even more sediments to settle out of the water and build up the muddy bottom. Mangrove forests stabilize the coastline, reducing erosion from storm surges, currents, waves and tides.



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Just like the high and low areas of salt marshes where specific types of grasses are found, Mangroves have distinct zones characterized by the species of mangrove tree that grows there. Where a species of mangrove tree exists depends on its tolerance for tidal flooding, soil salinity, and the availability of nutrients. Generally, there are three dominant species of mangrove trees. The red mangrove (Rhizophora Mangle) colonizes the seaward side of the Mangrove, so it receives the greatest amount of tidal flooding. Further inland and at a slightly higher elevation, black mangroves (Avicennia Germinanas) grow. The zone in which black mangrove trees are found is only shallowly flooded during high tides. White mangrove (Laguncularia Racemosa) and buttonwood trees (Conocarpus Erectus), a non-mangrove species, face inland and dominate the highest parts of the Mangrove. The zone where white mangrove and buttonwood trees grow is almost never flooded by tidal waters.

Many mangrove trees also have a unique method of reproduction. Instead of forming seeds that fall to the soil below and begin growing, mangrove seeds begin growing while still attached to the parent plant. These seedlings, called Propagules, even grow roots. After a period of growth, these seedlings drop to the water below and float upright until they reach water that is shallow enough for their roots to take hold in the mud.

### Threats to Mangrove ecosystem

Large demographic pressure is exerting tremendous stress on the coastal environment. The main culprit in the destruction of mangroves is man. To achieve harmful supremacy over nature, human have destroyed this magnificent ecosystem almost irreparably. Land reclamations and industrial effluents are the major causes of mangroves degradation. Systematic dumping of all kinds of waste and debris in the mangrove areas destroys them. Land reclamations and industrial effluents are the major causes of mangroves degradation. This waste/debris creates a barrier preventing the sea water from entering the mangroves and eventually kills the mangroves. In many instances, this is done intentionally to reclaim land for construction activity. There is an urgent need to stop this systematic degradation of mangroves. To summarise, major threats are:

≠ Land reclamations for construction activity, aquaculture, agriculture, tourism
≠ Industrial and domestic pollution, Port development
≠ Dumping of all kinds of waste and debris
≠ Deforestation for fuel wood, Over harvesting of marine resources

Which one of the following is the correct sequence of ecosystems in the order of decreasing productivity? (UPSC 2013)
(a) Oceans, lakes, grasslands, mangroves
(b) Mangroves, oceans, grasslands, lakes
(c) Mangroves, grasslands, lakes, oceans
(d) Oceans, mangroves, lakes, grasslands

**Importance of Mangroves**

- Buffer Zone between the land and sea.
- Stabilize the coastline, reducing erosion from storm surges, currents, waves, and tides.
- Play an invaluable role as nature's shield against cyclones, ecological disasters and as protector of shorelines.
- Breeding and nursery grounds for a variety of marine animals.
- Harbour a variety of life forms like invertebrates, fish, amphibians, reptiles, birds and even mammals like tigers.
- Good source of timber, fuel and fodder.
- Main source of income generation for shoreline communities like fisherfolk.
- Save the marine diversity, which is fast diminishing.
- Purify the water by absorbing impurities and harmful heavy metals and help us to breathe a clean air by absorbing pollutants in the air.
- Potential source for recreation and tourism.
- The intricate root system of mangroves also makes these forests attractive to fish and other organisms seeking food and shelter from predators.



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## MANGROVES IN INDIA

Mangrove in India is world famous for its rich variety of flora and fauna and also for its huge area. The Sundarbans comprise the principal portion of Mangrove in India. The Sundarban mangroves occupy a huge area followed by the Andaman-Nicobar Islands and Gulf of Kachchh in Gujarat. Compared to the Sunderbans, the rest of the mangrove ecosystems are comparatively smaller. The Mangrove in India is home to a large number of over 1600 plant and 3700 animal species. Mangrove in India is found in tropical and sub-tropical tidal areas, and in the areas that have a high degree of salinity.




Mangrove in India includes numerous species that helps maintaining the balance of ecosystem in India. There are several places where Mangrove in India is found including the Godavari-Krishna and Sundarbans. Mangrove occurs on islands in the Indian Ocean, Arabian Sea, Bay of Bengal, in India and the Sundarbans is considered as the largest mangrove forest in the world. Sunderbans is located in the Ganges delta in the state of West Bengal, India. Apart from that, major mangals can also be found in the Andaman and Nicobar Islands and the Gulf of Kutch in Gujarat. Some of the other significant mangals found in India, include the Bhitarkanika Mangroves and Godavari-Krishna mangroves. The second largest mangrove forest in the world, the Pichavaram Mangrove Forest is situated near Chidambaram in South India and it is home to a large variety of birds. The birds include the local resident, migratory resident and the pure migratory birds and the forest is separated from the Bay of Bengal by a lovely beach. It is also one of those rare mangrove forests, which has actually increased by 90% between the years of 1986 and 2002.

### *Sunderban Mangrove Delta Complex*

Sundarbans, a cluster of 102 miracle islands, form the largest mangrove delta complex on the globe in the estuarine phase of the Ganges and Brahmaputra Rivers, constitute a unique Biosphere Reserve in the coastal Bay of Bengal and host landmark ancient heritage of mythological and historical events bestowed with wide bio-diversity of mangrove flora and fauna, magnificent scenic beauty and natural resources of immense scientific, anthropological and archaeological interests. This region is one of the world's most remotely challenged geographical regions with a population density of more than 1100 person per sq. km. "Sunderban" literally means "beautiful jungle or forest" in Bengali language. The name Sundarbans may also have been derived from the



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Sundari trees that are omnipresent in Sundarbans. Other possible explanations can be a derivation from "Samudra Ban" (Sea Forest) or "Chandra-bandhe" (name of a primitive tribe). However, the generally accepted view is attributed to Sundari trees.

***Bhitarkanika Mangroves***

Bhitarkanika Mangroves is India's second largest forest, located in the state of Odisha. Bhitarkanika is created by the two river deltas of Brahmani and Baitarani River and one of the important Ramsar Wetland in India. It is also home of salt-water crocodiles and nesting beach olive ridley sea turtle.

***Godavari-Krishna Mangroves***

The Godavari-Krishna mangroves lies in the delta of the Godavari and Krishna rivers in the state of Andhra Pradesh. Mangroves ecoregion is under protection for Calimere Wildlife and Pulicat Lake Bird Sanctuary.

***Pichavaram Mangroves***

Pichavaram mangrove is one of the largest mangrove in India, situated at Pichavaram near Chidambaram in the state of Tamil Nadu. Pichavaram ranks among one of the most exquisite scenic spots in Tamil Nadu and home of many species of aquatic birds.

***Baratang Island Mangroves***

Baratang Island Mangroves is a swamp, located at Great Andaman and Nicobar Islands.

| Rank | States/UTs | Mangrove grove-cover (Sq. km) | Mangrove areas |
|---|---|---|---|
| 1. | West Bengal | 2097 | Sunderbans |
| 2. | Gujarat | 1103 | Gulf of Kutchh, Gulf of Khambhat |
| 3. | A and N Islands | 604 | North Andamans, Nicobar |
| 4. | Andhra Pradesh | 352 | Coringa, East Godavari, Krishna |
| 5. | Odisha | 213 | Bhitarkanika, Mahanadi, Subarnarekha, Devi-Kauda, Dhamra, Mangrove Genetic Resources Centre, Chilka |
| 6. | Maharashtra | 186 | Achra- Ratnagiri, Devgarh-Vijaydurg, Veldur, Kandalika-Revdanda, Mumbra-Diva, Vikhroli, Shreevardhan, Vaitarna, Vasai-Monori, Malvan |
| 7. | Tamil Nadu | 39 | Pichavaram, Muthupet, Ramnad, Pulicat, Kaznuveli |
| 8. | Goa | 22 | Goa |
| 9. | Kerala | 6 | Vembanad, Kannur |
| 10. | Karnataka | 3 | Coondapur, Dakshin Kannada/ Hannavar, Karwar, Mangalore Forest Division |

## MANGROVES FOR THE FUTURE (MFF)

Mangroves for the Future (MFF) is a unique multi- country, multi sectoral, partner- led initiative which builds on the long history of coastal management interventions and lessons learned during the course of post- tsunami reconstruction and rehabilitation. The initiative is founded on a vision for a more healthy, prosperous and secures future for all Indian Ocean Coastal communities, where all the ecosystems are conserved and managed sustainably and seeks to promote investment and action in ecosystem conservation for sustainable coastal development. Co-chaired by IUCN and UNDP, MFF provides a platform for collaboration among the many different agencies, sectors and countries which are addressing challenges to coastal ecosystem and livelihood issues.



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MFF is covering, initially, six Tsunami affected countries namely India, Indonesia, Maldives, Seychelles, Sri Lanka and Thailand. Recently it has expanded to include Bangladesh, Cambodia, Myanmar, Pakistan and Viet Nam. India has agreed to participate in the MFF Initiative.

**Mangroves for the Future have two objectives:**

1. The MFF grants facility offers small, medium and large grants to support initiatives that provide practical, hands-on demonstrations of effective coastal management in action.
2. MFF addresses priorities for long-term sustainable coastal ecosystem management which include, among others: climate change adaptation and mitigation, disaster risk reduction, promotion of ecosystem health, development of sustainable livelihoods, and active engagement of the private sector in developing sustainable business practices.

The emphasis is on generating knowledge, empowering local communities and advocating for policy solutions that will support best practice in integrated coastal management. The initiative seeks to effect demonstrable changes and results across four key areas of influence: regional cooperation, national programme support, private sector engagement and community action using a strategy of generating knowledge, empowering institutions and people to use that knowledge and thereby promoting good governance in coastal areas.

Mangroves are the flagship of the initiative, but MFF is inclusive of all types of coastal ecosystem, such as coral reefs, estuaries, lagoons, sandy beaches, seagrasses and wetlands. Each country manages its own MFF programme through a National Coordinating Body which includes representation from government, NGOs and the private sector.

## WETLANDS INTERNATIONAL (WI)

### *About Wetlands International*

Earlier known as the International Wildfowl Inquiry, WI began as part of the British Section of the International Committee of Bird Preservation, with a focus on protecting water birds. In 1954, its name became International Waterfowl & Wetlands Research Bureau (IWRB) and its scope expanded to include the protection of wetland areas. We were based at the Museum of Natural History in London, followed by the Tour du Valat in the Camargue (France) until 1968, and then the Wildfowl Trust in Slimbridge (UK) until 1995. Organisations with similar objectives emerged in Asia and the Americas: the Asian Wetland Bureau (AWB) was initiated as INTERWADER in 1983, and Wetlands for the Americas (WA) formed in 1989. These three organisations started to work closely together in 1991. This working relationship evolved into a single global organization which adopted the name Wetlands International and established its headquarters in the Netherlands in 1996.

With reference to a conservation organization called Wetlands International', which of the following statements is/are correct?

1. It is an intergovernmental organization formed by the countries which are signatories to Ramsar Convention.
2. It works at the field level to develop and mobilize knowledge, and use the practical experience to advocate for better policies.

Select the correct answer using the code given below:

(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2

Solution (b)

### *Objectives*

To sustain and restore wetlands, their resources and biodiversity by

- *Knowledge, Policy and Practice*
- *Empowering local communities*
- *Strategic partnerships*
- *Connecting the local to the global*
- *Working for the long-term*



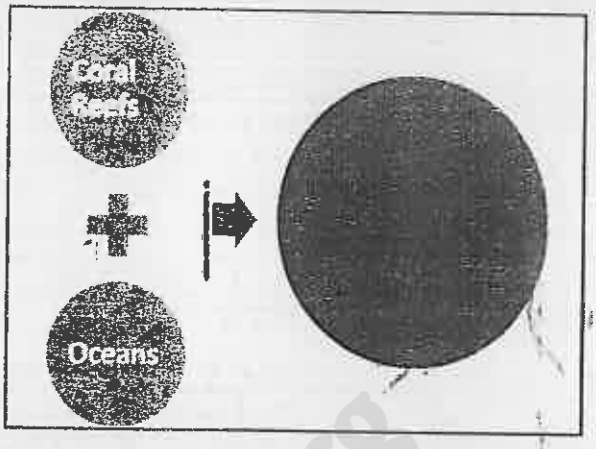
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## MARINE ECOSYSTEMS




They are divided between coral reefs and oceans. Oceans represent the largest and most diverse of the ecosystems. These cover almost 75% of the earth's surface and have enormous impact on planet's climate. Marine ecosystems have salt concentration of approximately 3%. The evaporation of seawater provides most rainfall across the planet. Ocean temperatures affect wind patterns, distribution of energy to land via ocean currents. These supply substantial portion of world's oxygen through photosynthesis by marine algae and photosynthetic bacteria. Marine ecosystems also consume huge amounts of atmospheric carbon dioxide through photosynthesis by marine algae and photosynthetic bacteria. Marine organisms are not distributed evenly throughout the oceans. Variations in characteristics of the marine environment create different habitats and influence what types of organisms will inhabit them. The availability of light, water depth, proximity to land, and topographic complexity all affect marine habitats.

1. The area of inky darkness, which occupies the great bulk of the ocean, is called the **Aphotic zone.**

2. The illuminated region above it is called the Photic zone, within which are distinguished the euphotic and **Disphotic zone.**

3. The **Euphotic zone** is the layer closer to the surface that receives enough light for photosynthesis to occur.

4. Beneath lies the Disphotic zone, which is illuminated but so poorly that rates of respiration exceed those of photosynthesis.

Primary productivity in marine ecosystems is limited by light and nutrients. However, light is the first variable to control primary production in oceans. **Since, solar radiation can only penetrate to a certain depth; more than 50% of solar radiation is absorbed in first meter of water. Even in "clear" water, only 5-10% of radiation** reaches **depth of 20 m.** Since light is primary variable limiting primary production, we would expect production to increase along a gradient from the poles to the equator, but that is not the case and there is no such gradient. There are parts of the ocean in tropics and subtropics that exhibit low primary production. These are due to poor availability of nutrients. Nutrients more than light limit primary productivity in different geographic regions of the ocean.

The light plays a very vital part in the existence of marine ecosystems. The availability of light affects which organisms can inhabit a certain area of a marine ecosystem. The greater the depth of the water, the less light can penetrate until below a certain depth there is no light whatsoever.

The actual depth of these zones depends on local conditions of cloud cover, water turbidity, and ocean surface. In general, the euphotic zone can extend to depths of 80 to 100 metres and the Disphotic zone to depths of 80 to 700 metres. Marine organisms are particularly abundant in the Photic zone, especially the euphotic portion; however, many organisms inhabit the aphotic zone and migrate vertically to the photic zone every night. Other organisms, such as the tripod fish and some species of sea cucumbers and brittle stars, remain in darkness all their lives.

Marine environments can be characterized broadly as

1. Water, or pelagic environment
2. Bottom, or benthic environment.

Within the pelagic environment the waters are divided into the:



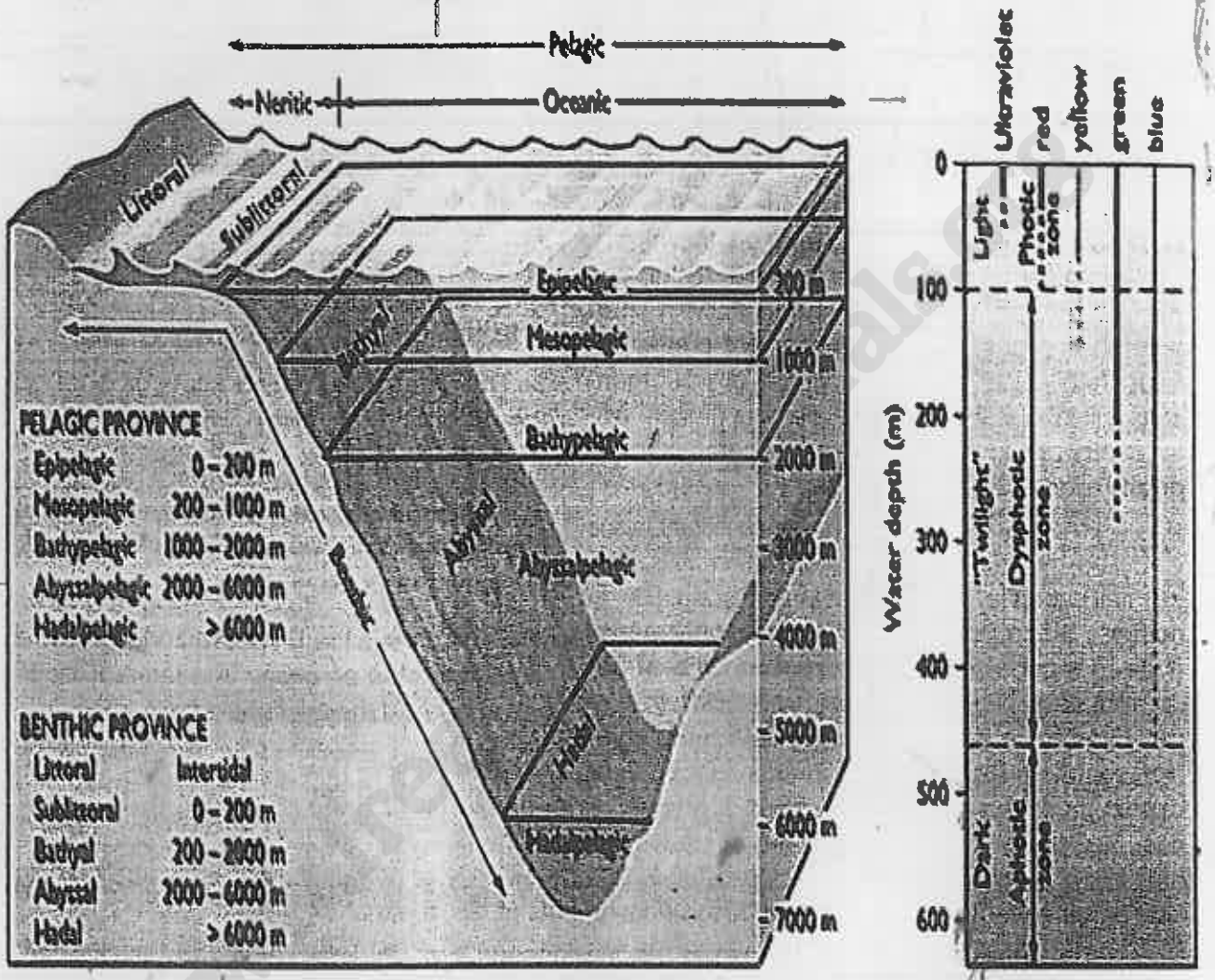
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- Neritic province, which includes the water above the continental shelf.
- Oceanic province, which includes all the open waters beyond the continental shelf.

The high nutrient levels of the neritic province—resulting from dissolved materials in riverine runoff—distinguish this province from the oceanic. The upper portion of both the neritic and oceanic waters—the Epipelagic zone is where photosynthesis occurs; it is roughly equivalent to the photic zone. Below this zone lie the mesopelagic, ranging between 200 and 1,000 metres, the bathype-




(a) BIOZONES (b) LIGHT ZONES

lagic, from 1,000 to 4,000 metres, and the Abyssopelagic, which encompasses the deepest parts of the oceans from 4,000 metres to the recesses of the deep-sea trenches.

The benthic environment also is divided into different zones:

- The Supralittoral is above the high-tide mark and is usually not under water.
- The intertidal or littoral zone ranges from the high-tide mark (the maximum elevation of the tide) to the shallow, offshore waters.
- The Sublittoral is the environment beyond the low-tide mark and is often used to refer to substrata of the continental shelf, which reaches depths of between 150 and 300 metres.

Sediments of the continental shelf that influence marine organisms generally originate from the land, particularly in the form of riverine runoff, and include clay, silt, and sand. Beyond the continental shelf is the Bathyal zone, which occurs at depths of 150 to 4,000 metres and includes the



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descending continental slope and rise. The **Abyssal** (between 4,000 and 6,000 metres) represents a substantial portion of the oceans. The deepest region of the oceans (greater than 6,000 metres) is the **Hadal Zone** of the deep-sea trenches. Sediments of the deep sea primarily originate from a rain of dead marine organisms and their wastes.

**Marine biota**

Marine biota can be classified broadly into those organisms living in either the pelagic environment (plankton and nekton) or the benthic environment (benthos). Some organisms, however, are benthic in one stage of life and pelagic in another. Producers that synthesize organic molecules exist in both environments. Single-celled or multi-celled plankton with photosynthetic pigments are the producers of the photic zone in the pelagic environment. Typical benthic producers are Microalgae (e.g., diatoms), Macroalgae (e.g., the kelp Macrocystispyrifera), or sea grass (e.g., Zostera).

| Plankton | Nekton | Benthos |
|---|---|---|
| These are the numerous, primarily microscopic inhabitants of the pelagic environment. They are critical components of food chains in all marine environments in the article on community ecology) because they provide nutrition for the nekton (e.g., crustaceans, fish, and squid) and benthos (e.g., sea squirts and sponges). They also exert a global effect on the biosphere because the balance of components of the Earth's atmosphere depends to a great extent on the photosynthetic activities of some plankton. The plankton include a wide variety of organisms such as algae, bacteria, protozoans, the larvae of some animals, and crustaceans. Plankton can be broadly divided into Phytoplankton, which are plants or plant like protists (protists are eukaryotic, predominantly single-celled organisms); zooplankton, which are animals or animal-like protists; and microbes such as bacteria. Phytoplanktons carry out photosynthesis and are the producers of the marine community; zooplanktons are the heterotrophic consumers. | Nektons are the active swimmers of the oceans and are often the best-known organisms of marine waters. Nektons are the top predators in most marine food chains of the community ecology. The vast majority of nektons are vertebrates (e.g., fishes, reptiles, and mammals), molluscs, and crustaceans. Nektons are found at all depths and latitudes of marine waters. Whales, penguins, seals, and icefish abound in polar waters. Nektons form the basis of important fisheries around the world. | These organisms are abundant in surface sediments of the continental shelf and in deeper waters, with a great diversity found in or on sediments. In shallow waters, beds of seagrass provide a rich habitat for polychaete worms, crustaceans (e.g., amphipods), and fishes. On the surface of and within intertidal sediments most animal activities are influenced strongly by the state of the tide. On many sediments in the photic zone, however, the only photosynthetic organisms are microscopic benthic diatoms. |

**Organisms of the deep-sea vents**

Deep-sea hydrothermal vents are a non-photosynthetic source of organic carbon available to organisms. A diversity of deep-sea organisms including mussels, large bivalve clams, and vestimentiferan worms are supported by bacteria that oxidize sulphur (sulphide) and derive chemical energy from the reaction. These organisms are referred to as chemoautotrophic, or chemosynthetic, as opposed to photosynthetic, organisms. Many of the species in the vent fauna have developed symbiotic relationships with chemoautotrophic bacteria, and as a consequence the megafauna are principally responsible for the primary production in the vent assemblage.



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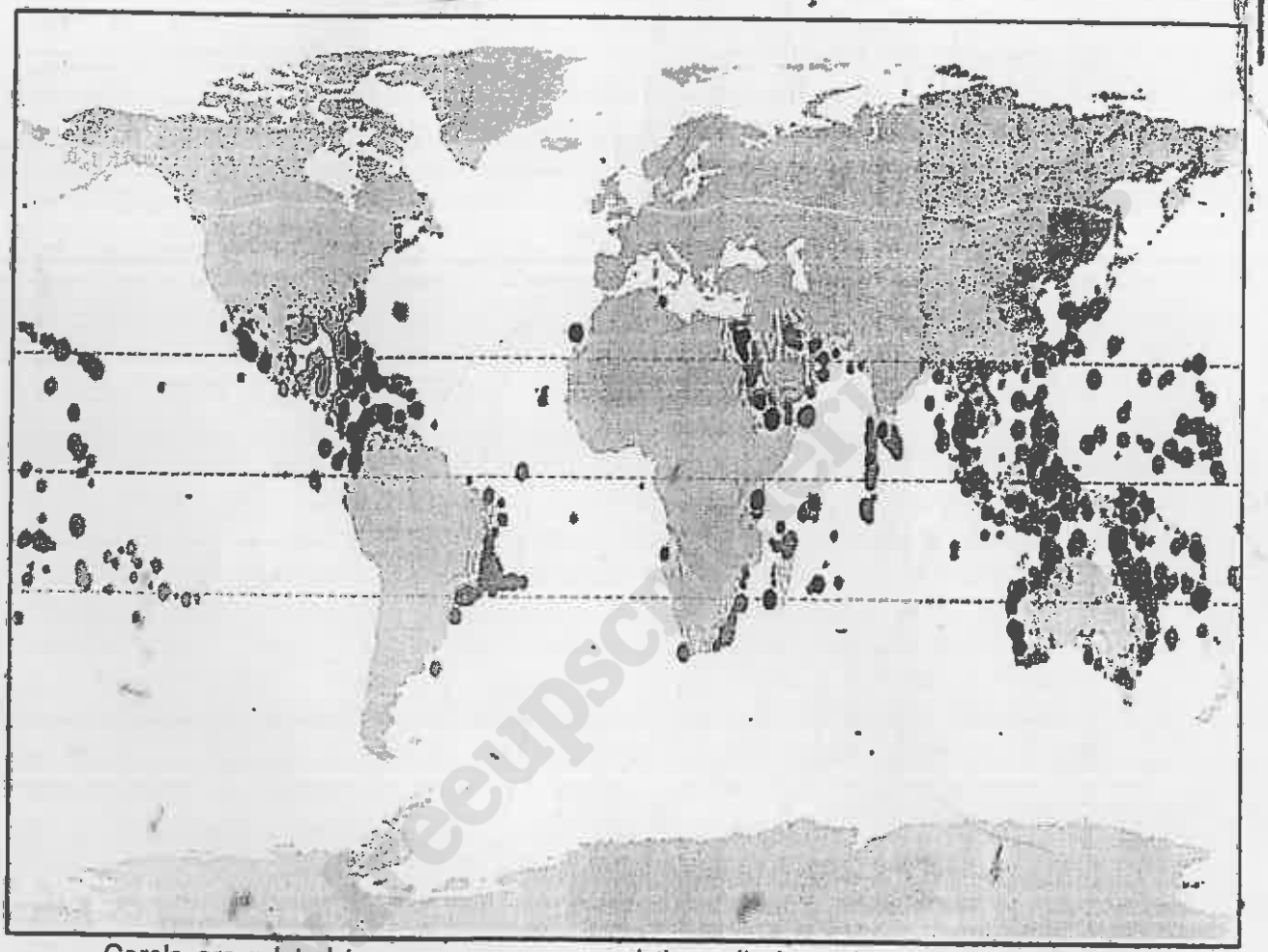
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## CORAL REEFS

Coral reefs are the most diverse of all marine ecosystems. They teem with life, with perhaps one quarter of all ocean species depending on reefs for food and shelter.

Coral Reefs in India are found in - Andaman & Nicobar Islands, Lakshadweep Islands, Gulf of Kutch (Gujarat) and Gulf of Mannar (Tamil Nadu). Most of these are **Fringing Reefs.**



Corals are related to sea anemones, and they all share the same simple structure, the polyp. The polyp is like a tin can open at just one end: the open end has a mouth surrounded by a ring of tentacles. The tentacles have stinging cells, called nematocysts that allow the coral polyp to capture small organisms that swim too close. Inside the body of the polyp are digestive and reproductive tissues. Corals differ from sea anemones in their production of a mineral skeleton. Shallow water corals that live in warm water often have another source of food, the Zooxanthellae. These single-celled algae photosynthesize and pass some of the food they make from the sun's energy to their hosts, and in exchange the coral animal gives nutrients to the algae. It is this relationship (symbiotic relationship) that allows shallow water corals to grow fast enough to build the enormous structures we call reefs. The Zooxanthellae also provide much of the colour that corals have.

Corals themselves are tiny animals which belong to the group Cnidaria. Other Cnidarians include hydras, jellyfish, and sea anemones. Corals are sessile animals, meaning they are not mobile but stay fixed in one place. They feed by reaching out with tentacles to catch prey such as small fish and planktonic animals. Corals live in colonies consisting of many individuals, each of which is called polyp. They secrete a hard calcium carbonate skeleton, which serves as a uniform base or substrate for the colony. The skeleton also provides protection, as the polyps can contract



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into the structure if predators approach. It is these hard skeletal structure that build up coral reefs over time. The calcium carbonate is secreted at the base of the polyps, so the living coral colony occurs at the surface of the skeletal structure, completely covering it. Calcium carbonate is continuously deposited by the living colony, adding to the size of the structure. Growth of these structures varies greatly, depending on the species of coral and environmental conditions-- ranging from 0.3 to 10 cm per year. Different species of coral build structures of various sizes and shapes ("brain corals," "fan corals," etc.), creating amazing diversity and complexity in the coral reef ecosystem. Various coral species tend to be segregated into characteristic zones on a reef, separated out by competition with other species and by environmental conditions.

Because the Zooxanthellae depend on light for photosynthesis, reef building corals are found in shallow, clear water where light can penetrate down to the coral polyps. Reef building coral communities also require tropical or sub-tropical temperatures, and exist globally in a band 30 degrees north to 30 degrees south of the equator. Reefs are generally classified in three types:

1. **Fringing reefs**, the most common type, project seaward directly from the shores of islands or continents.
2. **Barrier reefs** are platforms separated from the adjacent land by a bay or lagoon. The longest barrier reefs occur off the coasts of Australia and Belize.
3. **Atolls** rest on the tops of submerged volcanoes. They are usually circular or oval with a central lagoon. Parts of the atoll may emerge as islands. Over 300 atolls are found in the south Pacific.

Coral reefs provide habitats for a large variety of organisms. These organisms rely on corals as a source of food and shelter. Besides the corals themselves and their symbiotic algae, other creatures that call coral reefs home include various sponges; molluscs such as sea slugs, nudibranchs, oysters, and clams; crustaceans like crabs and shrimp; many kinds of sea worms; echinoderms like star fish and sea urchins; other cnidarians such as jellyfish and sea anemones; various types of fungi; sea turtles; and many species of fish.

**Importance of Coral Reefs:**

- **Protect shorelines** from big waves by absorbing wave energy
- Provide a **safe place for fish to spawn** (release eggs into the water)
- Provide habitats for a large variety of organisms and hence **contain staggering biodiversity**.
- **Provide food** (fish and shellfish) for many people living along coastlines
- Source of **medication**—some **anti-cancer drugs and painkillers** come from reefs help in the carbon cycle.
- Are a good sign of ocean water quality: **healthy reefs means healthy water.**
- Coral reefs are beautiful and intrinsically full of wonder, thereby being an extraordinary **tourism and recreational place.**
- Coral associated bacteria, such as the **photosynthetic cyanobacteria**, are one of the few marine organisms that are **able to fix atmospheric Nitrogen** into more absorptive form.
- Coral reefs play an important role in the **supply of sediments or sands to beaches**
- The skeletal composition of some coral species can provide historical accounts of local and regional environmental conditions.

### Threats to Coral Reefs

The **greatest** threats to reefs are rising water temperatures and ocean acidification linked to rising carbon dioxide levels. High water temperatures cause corals to lose the microscopic algae that produce the food corals need—a condition known as coral bleaching. Severe or prolonged bleaching can kill coral colonies or leave them vulnerable to other threats. Meanwhile, ocean acidifica-



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tion means more acidic seawater, which makes it more difficult for corals to build their calcium carbonate skeletons. And if acidification gets severe enough, it could even break apart the existing skeletons that already provide the structure for reefs.

Unfortunately, warming and more acid seas are not the only threats to coral reefs. Pollution, overfishing, destructive fishing practices using dynamite or cyanide, collecting live corals for the aquarium market and mining coral for building materials are some of the many ways that people damage reefs all around the world every day. Invasive species can also threaten coral reefs. Coral reefs also are affected by leaking fuels, anti-fouling paints and coatings, and other chemicals that enter the water Petroleum spills do not always appear to affect corals directly because the oil usually stays near the surface of the water, and much of it evaporates into the atmosphere within days. However, if an oil spill occurs while corals are spawning, the eggs and sperm can be damaged as they float near the surface before they fertilize and settle. So, in addition to compromising water quality, oil pollution can disrupt the reproductive success of corals, making them vulnerable to other types of disturbances. Even activities that take place far from reefs can have an impact. Runoff from lawns, sewage, cities, and farms feeds algae that can overwhelm reefs. Deforestation hastens soil erosion, which clouds water—smothering corals.

**Clean water:** Corals are sensitive to pollution and sediments. Sediment can create cloudy water and be deposited on corals, blocking out the sun and harming the polyps. Wastewater discharged into the ocean near the reef can contain too many nutrients that cause seaweeds to overgrow the reef.
**Saltwater:** Corals need saltwater to survive and require a certain balance in the ratio of salt to water. This is why corals don't live in areas where rivers drain fresh water into the ocean ("estuaries")

**What Do Coral Reefs Need to Survive?**

- Sunlight: Corals need to grow in shallow water where sunlight can reach them. Corals rarely develop in water deeper than 165 feet (50 meters).
- Clear water: Corals need clear water that lets sunlight through; they don't thrive well when the water is opaque. Sediment and plankton can cloud water, which decreases the amount of sunlight that reaches the Zooxanthellae.
- Warm water temperature: Reef-building corals require warm water conditions to survive. Corals generally live in water temperatures of 20–32° C.

### Coral Bleaching

"Coral bleaching is the loss of endosymbiotic algae from the coral, either through expulsion or loss of algal pigmentation."

"Coral bleaching" occurs when coral polyps lose their symbiotic algae, the zooxanthellae. Without their zooxanthellae, the living tissues are nearly transparent, and you can see right through to the stony skeleton, which is white, hence the name coral bleaching. Many different kinds of stressors can cause coral bleaching – water that is too cold or too hot, too much or too little light, or the dilution of seawater by lots of fresh water can all cause coral bleaching. The biggest cause of bleaching today has been rising temperatures caused by global warming. Temperatures more than a degree C above the normal seasonal maximum can cause bleaching. Bleached corals do not die right away, but if temperatures are very hot or are too warm for a long time, corals either die from starvation or disease.

### Protecting Coral Reefs

Coral reefs are some of the most biologically rich and economically valuable ecosystems on Earth. They provide food, jobs, income, and protection to billions of people worldwide. However, coral reefs and the magnificent creatures that call them home are in danger of disappearing if actions are not taken to protect them. They are threatened by an increasing range of impacts includ-



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ing pollution, invasive species, diseases, bleaching, and global climate change. The rapid decline and loss of these valuable, ancient, and complex ecosystems have significant social, economic, and environmental consequences in the United States and around the world.

There is much that we can do locally to protect coral reefs, by making sure there is a healthy fish community and that the water surrounding the reefs is clean. Well-protected reefs today typically have much healthier coral populations, and are more resilient (better able to recover from natural disasters such as typhoons and hurricanes).Fish play important roles on coral reefs, particularly the fish that eat seaweeds and keep them from smothering corals, which grow more slowly than the seaweeds. Fish also eat the predators of corals, such as crown of thorns starfish. **Marine Protected areas (MPAs)** are an important tool for keeping reefs healthy. Large MPAs protect the Great Barrier Reef, Australia created the largest marine reserve network in the world. Smaller ones, managed by local communities, have been very successful in developing countries.

**International Coral Reef Initiative (ICRI)**

The International Coral Reef Initiative (ICRI) is an informal partnership between Nations and organizations which strives to preserve coral reefs and related ecosystems around the world. The Initiative is an informal group whose decisions are not binding on its members, its actions have been pivotal in continuing to highlight globally the importance of coral reefs and related ecosystems to environmental sustainability, food security and social and cultural wellbeing. The work of ICRI is regularly acknowledged in United Nations documents, highlighting the Initiative's important cooperation, collaboration and advocacy role within the international arena.

ICRI's objectives are to:

1. Encourage the adoption of best practice in sustainable management of coral reefs and associated ecosystems
2. Build capacity
3. Raise awareness at all levels on the plight of coral reefs around the world.

ICRI adopted a 'Call to Action' and a 'Framework for Action' as its foundational documents. Both documents set the four cornerstones of ICRI: Integrated Management; Science; Capacity Building and Review.

Clean water is also important. Erosion on land causes rivers to dump mud on reefs, smothering and killing corals. Seawater with too many nutrients speeds up the growth of seaweeds and increases the food for predators of corals when they are developing as larvae in the plankton. Clean water depends on careful use of the land, avoiding too many fertilizers and erosion caused by deforestation and certain construction practices. In the long run, however, the future of coral reefs will depend on reducing carbon dioxide in the atmosphere, which is increasing rapidly due to burning of fossil fuels. Carbon dioxide is both warming the ocean, resulting in coral bleaching, and changing the chemistry of the ocean, causing ocean acidification. Both making it harder for corals to build their skeletons.

**Conservation and Management of Mangroves and Coral Reefs in India**

- Indian Government seeks to protect, sustain and augment mangroves and coral reef in the country by both regulatory and promotional measures. Under the regulatory measures, the Coastal Regulation Zone (CRZ) Notification (2011) and the Island Protection Zone (IPZ) Notification 2011 regulates the development activities along the Sea coast and tidal influenced water bodies. The mangroves and coral reefs areas are categorized as ecological sensitive areas (CRZ-I) where no new constructions are permitted except projects relating to Department of Atomic Energy; pipelines, conveying systems including transmission lines; installation of weather radar for monitoring of cyclones movement and prediction by Indian Meteorological Department and construction of trans harbour sea link and without affecting the tidal flow of water. To enforce and implement the CRZ and IPZ Notifications, the Ministry of Environment and Forests has constituted the National and State/UT level Coastal Zone Management Authorities



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- Zoological Survey of India has been undertaking studies on the serious threat to coral colonies only of Palk Bay continuously for more than a decade. Study initiated in 2010-11, monitoring assessments for which were carried out in 2013 confirm that there is reduction in the live coral cover and increase in rubbles, macro-algae and calcareous algae which indicate continuing degradation of these reefs.
- The Ministry of Environment & Forests also provides financial assistance to Coastal States/Union Territories, who so request, under its Centrally Sponsored Scheme for conservation and management of mangroves and coral reef. In addition Coral reef is included in **Schedule I** of the Wild Life Protection Act, 1972 which affords it the highest degree of protection. Further Protected Areas, viz.4 National Parks, 96 Sanctuaries and 3 Marine Biosphere Reserve have been created all over the country under the provisions of the Wild Life (Protection) Act, 1972 to conserve marine life including coral reef. The Wildlife Crime Control Bureau has also been set up to strengthen the enforcement of law for control of poaching and illegal trade in wildlife and its products.

| | |
|---|---|
| Category I (CRZ-I) | (i) Areas that are ecologically sensitive and important, such as national parks/marine parks, sanctuaries, reserve forests, wildlife habitats, mangroves, corals/coral reefs, areas close to breeding and spawning grounds of fish and other marine life, areas of outstanding natural beauty/historically/heritage areas, areas rich in genetic diversity, areas likely to be inundated due to rise in sea level consequent upon global warming and such other areas as may be declared by the Central Government or the concerned authorities at the State/Union Territory level from time to time.<br>(ii) Area between Low Tide Line and the high Tide Line. |
| Category-II (CRZ-II) | The areas that have already been developed upto or close to the shoreline. For this purpose, "developed area" is referred to as that area within the municipal limits or in other legally designated urban areas which is already substantially built up and which has been provided with drainage and approach roads and other infrastructural facilities, such as water supply and sewerage mains. |
| Category-III (CRZ-III) | Areas that are relatively undisturbed and those which do not belong to either Category-I or II. These will include coastal zone in the rural areas (developed and undeveloped) and also areas within Municipal limits or in other legally designated urban areas which are not substantially built up. |
| Category-IV (CRZ-IV) | Coastal stretches in the Andaman & Nicobar, Lakshadweep and small islands, except those designated as CRZ-I, CRZ-II or CRZ-III. |

***About CRZ***

CRZ area now includes the water area up to 12 nautical miles in the sea and the entire water area of a tidal water body such as creek, river, estuary, etc. And the notification does not impose any restrictions of fishing activities. CRZ is for:

- Protection of livelihoods of traditional fisher communities
- Preservation of coastal ecology
- Promotion of economic activity that have necessarily to be located in coastal regions.

The CRZ notification 2011 enshrines that concept of a Coastal Zone Management Plan (CZMP). It will be prepared with the fullest involvement and participation of local communities.

***What is the definition of the No development Zone?*** The "no development zone" definition has been changed. It is reduced from 200 metres from the high-tide line to 100 meters only. This has



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been done to meet increased demands of housing of fishing and other traditional coastal communities. Importance of CRZ Notification India has a long coastline of 7516 km, ranging from Gujarat to West Bengal, and two island archipelagos (Andaman Island and Lakshadweep). Our coastal ecosystems provide protection from natural disasters such as floods and tsunamis to the 250 million people who live in our coastal areas. Coastal waters provide a source of primary livelihood to 7 million households. Our marine ecosystems are a treasure trove of biodiversity, which we are only beginning to discover and catalogue. Thus, our coastline is both a precious natural resource and an important economic asset, and we need a robust progressive framework to regulate our coast.

***What is allowed and what is not allowed in Coastal Zones?*** Mining of limestone and other similar minerals is prohibited in Coastal Regulation Zone (CRZ) area. The Coastal Regulation Zone (CRZ) Notification, 1991 and the recently issued CRZ Notification, 2011, prohibits the mining of sand, rocks and other substrata material including limestone except rare minerals like, monazite, rutile etc., and exploitation of oil and natural gas. All activities which are permissible under these Notifications are required to obtain clearance under these Notifications. Mining of the sand, rocks and other substrata material is expected to cause damage to the Coastal environment including the Sea water intrusion.

**Norms for Activities**

***CRZ-I***

No new construction shall be permitted in CRZ-I except (a) Projects relating to Department of Atomic Energy and (b) Pipelines, conveying systems including transmission lines and (c) facilities that are essential for activities permissible under CRZ-I. Between the LTL and the HTL, activities as specified under paragraph 2 (xii) may be permitted. In addition, between LTL and HTL in areas which are not ecologically sensitive and important, the following may be permitted: (a) Exploration and extraction of Oil and Natural Gas, (b) activities as specified under proviso of sub-paragraph (ii) of paragraph 2, and (c) Construction of dispensaries, schools, public rain shelters, community toilets, bridges, roads, jetties, water supply, drainage, sewerage which are required for traditional inhabitants of the Sunderbans Bio-sphere reserve area, West Bengal, on a case to case basis, by the West Bengal State Coastal Zone Management Authority.

***CRZ-II***

Buildings shall be permitted only on the landward side of the existing road (or roads approved in the Coastal Zone Management Plan of the area) or on the landward side of existing authorised structures. Buildings permitted on the landward side of the existing and proposed roads/existing authorised structures shall be subject to the existing local Town and Country Planning Regulations including the existing norms of Floor Space Index/Floor Area Ratio:

i. Provided that no permission for construction of buildings shall be given on landward side of any new roads (except roads approved in the Coastal Zone Management Plan) which are constructed on the seaward side of an existing road.

ii. Reconstruction of the authorised buildings to be permitted subject to the existing FSI/FAR norms and without change in the existing use.

iii. The design and construction of buildings shall be consistent with the surrounding landscape and local architectural style.

***CRZ-III***

i. The area upto 200 metres from the High Tide Line is to be earmarked as: **No Development Zone**. No construction shall be permitted within this zone except for repairs of existing authorised structures not exceeding existing FSI, existing plinth area and existing density, and for permissible activities under the notification including facilities essential for such activities. An au-

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thority designated by the State Government/Union Territory Administration may permit construction of facilities for water supply, drainage and sewerage for requirements of local inhabitants. However, the following uses may be permissible in this zone: agriculture, horticulture, gardens, pastures, parks, play fields, forestry and salt manufacture from sea water.

ii. Development of vacant plots between 200 and 500 metres of High Tide Line in designated areas of CRZ-III with prior approval of Ministry of Environment and Forests (MEF) permitted for construction of hotels/beach resorts for temporary occupation of tourists/visitors subject to the conditions as stipulated in the guidelines at Annexure-II.

iii. Construction/reconstruction of dwelling units between 200 and 500 metres of the High TideLine permitted so long it is within the ambit of traditional rights and customary uses such as existing fishing villages and gaothans. Building permission for such construction/reconstruction will be subject to the conditions that the total number of dwelling units shall not be more than twice the number of existing units; total covered area on all floors shall not exceed 33 percent of the plot size; the overall height of construction shall not exceed 9 metres and construction shall not be more than 2 floors ground floor plus one floor. Construction is allowed for permissible activities under the notification including facilities essential for such activities. An authority designated by State Government/Union Territory Administration may permit construction of public rain shelters, community toilets, water supply, drainage, sewerage, roads and bridges. The said authority may also permit construction of schools and dispensaries, for local inhabitants of the area, for those panchayats the major part of which falls within CRZ if no other area is available for construction of such facilities.

iv. Reconstruction/alterations of an existing authorised building permitted subject to (i) to (iii) above.

***CRZ-IV***

***Andaman & Nicobar Islands:***

i. No new construction of buildings shall be permitted within 200 metres of the HTL;

ii. The buildings between 200 and 500 metres from the High Tide Line shall not have more than 2 floors (ground floor and first floor),the total covered area on all floors shall not be more than 50 per cent of the plot size and the total height of construction shall not exceed 9 metres;

iii. The design and construction of buildings shall be consistent with the surrounding landscape and local architectural style.

iv. (a) Corals from the beaches and coastal waters shall not be used for construction and other purposes. (b) sand may be used from the beaches and coastal waters, only for construction purpose upto the 30th day of September 2002 and thereafter it shall not be used for construction and other purposes.

v. Dredging and underwater blasting in and around coral formations shall not be permitted; and

vi. However, in some of the islands, coastal stretches may also be classified into categories CRZ-I or II or III with the prior approval of Ministry of Environment and Forests and in such designated stretches, the appropriate regulations given for respective Categories shall apply.

***Lakshadweep and small Islands:***

i. For permitting construction of buildings, the distance from the High Tide Line shall be decided depending on the size of the islands. This shall be laid down for each island, in consultation with the experts and with approval of the Ministry of Environment & Forests, keeping in view the land use requirements for specific purposes vis-à-vis local conditions including hydrological aspects erosion and ecological sensitivity;



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ii. The buildings within 500 metres from the HTL shall not have more than 2 floors (ground floor and 1st floor), the total covered area on all floors shall not be more than 50 per cent of the plot size and the total height of construction shall not exceed 9 metres;

iii. The design and construction of buildings shall be consistent with the surrounding landscape and local architectural style;

iv. Corals and sand from the beaches and coastal waters shall not be used for construction and other purposes;

v. Dredging and underwater blasting in and around coral formations shall not be permitted; and

vi. However, in some of the islands, coastal stretches may also be classified into categories CRZ-I or II or III, with the prior approval of Ministry of Environment & Forests and in such designated stretches, the appropriate regulations given for respective Categories shall apply.

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# CHAPTER – 6
# ECOSYSTEM

**Overview**
1. *Definition.*
   1.1 *Structure of an Ecosystem*
2. *Functions of an ecosystem*
3. *Ecological niche and habitat*
4. *Ecological succession*

## 1. WHAT IS AN ECOSYSTEM?

"Ecosystem is a system, or a group of interconnected elements, formed by the interaction of a community of organisms with their environment."

The word Ecosystem was coined by an English ecologist Sir Arthur George Tansley in 1935. 'Eco' in Ecosystem has been derived from Oikos, meaning 'house' or habitation in Greek. Ecosystem is referred to the systems involving the habitation of local flora and fauna. It is a subset of Biosphere, wherein various species, their populations and communities interact with each other along with non-living things like land, sunlight, wind, humidity to name a few, called as abiotic elements, whereas, the living things are called as biotic elements. These biotic and abiotic elements continuously produce and exchange materials. The interaction between them involves input, transfer and storage of energy and nutrients. However, as a result of these complex processes, the components of ecosystem tend to attain a state of equilibrium thereby becoming self-sustaining and controlled by limiting factors. The study of ecosystems mainly consists of the study of certain **processes that link the living, or biotic, components to the non-living, or abiotic, components**. Energy transformations and biogeochemical cycling are the main processes that comprise the field of ecosystem ecology. As we learned earlier, ecology generally is defined as the interactions of organisms with one another and with the environment in which they occur. We can study ecology at the level of the individual, the population, the community, and the ecosystem. Studies of individuals are concerned mostly about physiology, reproduction, development or behaviour, and studies of populations usually focus on the habitat and resource needs of individual species, their group behaviours, population growth, and what limits their abundance or causes extinction. Studies of communities examine how populations of many species interact with one another, such as predators and their prey, or competitors that share common needs or resources. In ecosystem ecology we put all of this together and, insofar as we can, we try to understand how the system operates as a whole. This means that, rather than worrying mainly about particular species, we try to focus on major functional aspects of the system. These functional aspects include such things as the amount of energy that is produced by photosynthesis, how energy or materials flow along the many steps in a food chain, or what controls the rate of decomposition of materials or the rate at which nutrients are recycled in the system.

- Each ecosystem has specific and recognisable landscapes, such as desert, forest, wetlands and so on. The ecosystem has localised favourable conditions that support a community of plants and animals having been evolved out of evolution.
- There are many examples of ecosystems - a pond, a forest, an estuary, grassland.
- The boundaries are not fixed in any objective way, although sometimes they seem obvious, as with the shoreline of a small pond. Usually the boundaries of an ecosystem are chosen for practical reasons having to do with the goals of the particular study.

### 1.1 STRUCTURE OF AN ECOSYSTEM

Components that make up are the structural aspects of an ecosystem and it includes Inorganic aspects like Oxygen, Nitrogen, Water; Organic Compounds like Protein, Carbohydrates, Lipids; Physical factors like temperature, pressure, humidity; Producers; Micro-Consumers and so on.



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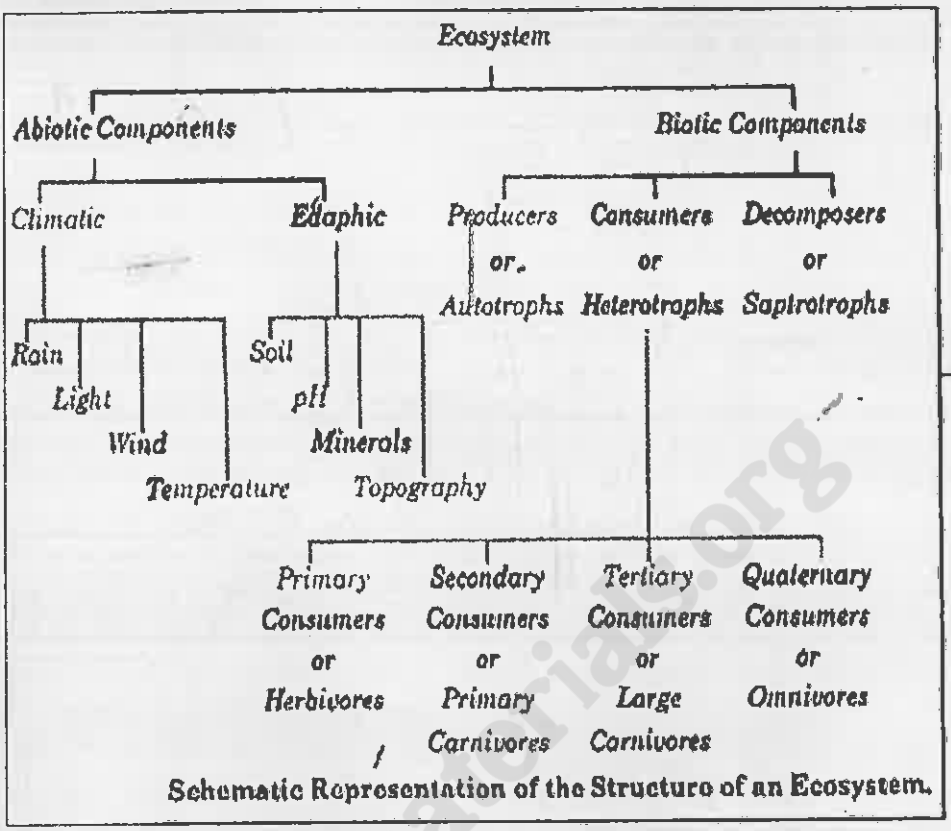
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### Abiotic Components

The way in which plants and animals grow and carry out their different activities is a result of several abiotic factors. These factors are light, temperature, water, atmospheric gases, wind as well as soil (edaphic) and physiographic (nature of land surface) factors.




Schematic Representation of the Structure of an Ecosystem.

### Temperature

The distribution of plants and animals is greatly influenced by extremes in temperature for instance the warm season. The occurrence or non-occurrence of frost is a particularly important determinant of plant distribution since many plants cannot prevent their tissues from freezing or survive the freezing and thawing processes. The following are examples of temperature effects with ecosystems:

- The opening of the flowers of various plants during the day and night is often due to temperature difference between the day and night;
- The seed of some plants (biennials) normally germinate in the spring or summer; this phenomenon is well observed in carrots and is called **vernalisation.**
- Some fruit trees such as the peach require a cold period each year so that it can blossom in the spring;
- Deciduous trees lose their leaves in winter and enter into a state of dormancy, where the buds are covered for protection against the cold;
- The seeds of many plants, e.g. Peach and plum, must be exposed to a cold period before they germinate; this chilling ensures that seeds don't germinate during autumn, but after winter, when the seedlings have better chances to survive;
- In animals, a distinction is made between ectothermic ("cold-blooded" or Poikilothermic) animals and endothermic ("warm-blooded" or Homothermic) animals although the difference is not clear cut;
- In desert conditions are a greater temperature variation between day and night and organisms have distinct periods of activity, for e.g. Many cacti flower at night and are pollinated by nocturnal insects;
- Seasonal changes have also a great influence on animal life in an ecosystem; torpor in winter is common in reptiles and some mammals in South Africa, but a winter sleep occurs in bears of the northern hemisphere; some animals collect fat or other resources during favourable periods (often summer and autumn) and become dormant (this is called Hibernation), there are also



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animals that are dormant during warm and dry conditions and this is known as Aestivation; examples of such animals are snails and the African lung-fish;

- Seasonal movements occur in some animals; this phenomenon is called seasonal migration, examples of such animals are migratory locusts, butterflies and various marine animals like whales, penguins and marine turtles.

**Light**

Light energy (sunlight) is the primary source of energy in nearly all ecosystems. It is the energy that is used by green plants (which contain chlorophyll) during the process of photosynthesis; a process during which plants manufacture organic substances by combining inorganic substances. Visible light is of the greatest importance to plants because it is necessary for photosynthesis. Factors such as quality of light, intensity of light and the length of the light period (day length) play an important part in an ecosystem.

Quality of light (wavelength or colour) - Plants absorb blue and red light during photosynthesis. In terrestrial ecosystems the quality of light does not change much. In aquatic ecosystems, the quality of light can be a limiting factor. Both blue and red light are absorbed and as a result do not penetrate deeply into the water. To compensate for this, some algae have additional pigments which are able to absorb other colours as well.

Light intensity ("strength" of light) - The intensity of the light that reaches the earth varies according to the latitude and season of the year. The southern hemisphere receives less than 12 hours of sunlight during the period between the 21st March and the 23rd of September, but receives more than 12 hours of sunlight during the following six months.

Light requirements of plants differ and as a result distinct layers, or stratification, can be observed in an ecosystem.

- Plants which grow well in bright sunlight are called **Heliophytes.**
- Plants which grow well in shady conditions are known as **Sciophytes.**

***Day length (length of the light period)*** - Certain plants flower only during certain times of the year. One of the reasons for this is that these plants are able to "measure" the length of the night (dark periods). However, it was thought that it is the day length (light periods) to which plants reacted and this phenomenon was termed Photoperiodism. ***Photoperiodism*** can be defined as the relative lengths of daylight and darkness that affect the physiology and behaviour of an organism.

***Short-day Plants*** - These plants flower only if they experience nights which are longer than a certain critical length. The chrysanthemum (Chrysanthemum sp.), the poinsettia (Euphorbia pulcherrima) and the thorn-apple (Datura stramonium) are examples of short day plants.

***Long-day plants*** - These plants flower if they experience nights which are shorter than a certain critical length. Spinach, wheat, barley, clover and radish are examples of long plants.

***Day-neutral plants*** - The flowering of day-neutral plants is not influenced by night length. The tomato (Lycopersicon esculeutum) and the maize plant (Zea mays) are examples of day-neutral plants.

***Phototropism*** - It is the directional growth of plants in response to light where the direction of the stimulus determines the direction of movement; stems demonstrate positive phototropism i.e. they came towards the light when they grow.

***Phototaxis*** – It is the movement of the whole organism in response to a unilateral light source, where the stimulus determines the direction of movement.

***Photokinesis*** – It is the variation in intensity of locomotory activity of animals which is dependent on the intensity of light stimulation, and not the direction, is called photokinesis.

***Photonasty*** - It is the movement of parts of a plant in response to a light source, but the direction of the stimulus does not determine the direction of the movement of the plant.



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**Water**

Habitats of animals and plants vary widely from aquatic environments to the dry deserts. Water is essential for life and all the biotic components of the ecosystem are directly dependent on water for survival.

Land animals are prone to desiccation and these animals show various types of adaptations to this. Some of the adaptations seen in terrestrial animals are:

- Body covering which limits loss of water.
- Some animals have sweat glands which are used as cooling devices.
- The tissues of some animals like camel are tolerant to water loss.
- Some insects are said to absorb water from the water vapour directly from the atmosphere.

*Based upon the water requirements plants are classified as:*

- *Hydrophytes: These are plants which grow in water e.g. water-lilies and rushes.*
- *Mesophytes: These are plants with average water requirements e.g. roses, sweet peas.*
- *Xerophytes: These are plants which grow in dry environments where they often experience a shortage of water e.g. cacti and other succulents.*

**Atmospheric Gases**

Atmospheric gases like oxygen, nitrogen and carbon dioxide are imperative for the survival of flora and fauna of this planet. In addition to keeping the planet warm by greenhouse gas effect, they are vital as seen by following:

- ❖ All organisms require oxygen for respiration.
- ❖ Carbon dioxide is used by green plants to make food by the process of photosynthesis.
- ❖ Nitrogen is necessary for all plants and atmospheric nitrogen is fixed by nitrogen fixing bacteria through the action of lightening.

**Soil (edaphic factors)**

These factors include soil texture, soil air, soil temperature, soil water, soil solution and pH, together with soil organisms and decaying matter.

- ❖ Soil Texture - The size of soil particles varies from microscopic particles called clay to larger particles called sand. Loam soil is a mixture of sand and clay particles. Sandy soils are suitable for growing plants because they are well aerated, excess water drains away quickly, they warm up quickly during the day and is easy to cultivate. Sandy soils is unsuitable because they do not retain much water and soon dry out and contain few soil nutrients required for plant growth. Clay soils are suitable for plant growth because they hold large quantities of water and are rich in mineral nutrients. They are unsuitable in that they are badly aerated, soon becomes water-logged and is difficult to cultivate; it also cold during winter. Loam soils possess desirable properties of both sand and clay - it has a high water retaining capacity, good aeration, and good nutrient content and is easily cultivated.
- ❖ Soil air - Soil air is found in those spaces between the soil particles that are not filled with soil water. The amount of air in a soil depends on how firmly the soil is compacted. In well-aerated soil at least 20% of its volume is made up of air.
- ❖ Soil temperature - Soil temperature is an important ecological factor. It has been found that the temperature of soil below a depth of about 30cm is almost constant during the day but seasonal temperature differences do occur. At low temperature there is little decay by decay-causing micro-organisms.
- ❖ Soil water - Soil water can be classified into three types, namely hygroscopic, capillary and gravitational water. Hygroscopic water occurs as a thin film of water around each soil particle.



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Capillary water is that water held in the small spaces between the soil particles and gravitational water is the water which drains downwards through the soil.

- ❖ Soil solution - Soil solution is the decaying remains of plants and animals, together with animal excretory products and faeces, form humus. This increases the fertility of the soil.
- ❖ PH - Acidity or alkalinity of soil (the pH of the soil) influences the biological activity in soil and the availability of certain minerals. Thus the pH of soil has a greater influence on the growth and development of plants. Some plants e.g. Azaleas, Ericas, ferns and many Protea species grow best in acid soils ( soils with a pH below 7), while Lucerne and many xerophytes grow better in alkaline soils (soils with a pH above 7).

**Topography (Physiographic factors)**
Topography is the landscape shapes which is determined by the aspects of slopes and elevations. Topography gives a variety to the ecosystems. For example, the grassland topography is varied like hills, prairies, cliffs, low lying areas etc., which gives variability to life forms.
The aspect of the direction of the land facing also varies as the land facing towards the south or the sun are hotter and drier than areas in the north, which are away from the sun.
Slope of on areas is also important as water may run downhill and may soak in ground which makes it available for plants. The areas in the southern part with slopes will be much hotter and drier than the northern areas with slopes.

**Climate**

Climate of a region includes the average rainfall, temperature and the patterns of winds that occur. Climate is one of the most important abiotic factors of an ecosystem.

- ≠ Temperature of an area and the precipitation factor determines whether the region is grassland or a forest.
- ≠ The rainfall an area receives influences the productivity of the area and the types of plants.
- ≠ For example: The climate in a grassland ecosystem is dry and hot during the spring and summer and is cool and cold during the winter.
- ≠ Precipitation in winter is snow rather than rainfall. During summers, more water is evaporated from the grasslands making the region deficient of moisture.

Organic – These are compounds made up of Carbon and Hydrogen, such as Proteins, Carbohydrates, Lipids, and Humus Substances etc.
Inorganic - Compounds, such as Carbon, Carbon Dioxide, water, Sulphur, nitrates, phosphates and ions of various metals come under this category.

**Materials**

There ought to be some material present in the ecosystem to contribute wherever necessary.

**Biotic Components**

Biotic means living and biotic factors are the other, living parts of the ecosystem with which an organism must interact. The biotic factors with which an organism interacts depend on whether it is a producer, a consumer, or a decomposer. Their classification can be shown as follows -

**Producers**

Producers are also known as Autotrophs, or self-feeders. Producers manufacture the organic compounds that they use as sources of energy and nutrients. Most producers are green plants or algae that make organic compounds through photosynthesis. This process begins when sunlight is absorbed by chlorophyll and other pigments in the plant. The plants use energy from sunlight to combine carbon dioxide from the atmosphere with water from the soil to make carbohydrates, starches, and cellulose. This process converts the energy of sunlight into energy stored in chemical bonds with oxygen as a by-product. This stored energy is the direct or indirect source of energy for all organisms in the ecosystem.



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A few producers, including specialized bacteria, can extract inorganic compounds from the environment and convert them to organic nutrients in the absence of sunlight. This process is called chemosynthesis. In some places on the floor of the deep ocean where sunlight can never reach, hydrothermal vents pour out boiling hot water suffused with hydrogen sulphide gas. Specialized bacteria use the heat to convert this mixture into the nutrients they need.

**Consumers**

Only producers can make their own food. They also provide food for the consumers and decomposers. The producers are the source of the energy that drives the entire ecosystem. Organisms that get their energy by feeding on other organisms are called Heterotroph. The living components of the ecosystem which depend on producers for their nutrition are called consumers. All the animals and certain plants are included in this category. There are different types of consumers.

Primary consumers - All the herbivorous animals like rodents, cow, el-ephants, deer, goats etc, which directly consume the plants are called pri-mary consumers. Among the aquatic animals, certain kinds of Fish, Crusta-ceans, Molluscs etc. which survive on phytoplankton are also primary con-sumers. Herbivorous animals are key industry animals, because all other animal's life is dependent on these primary consumers.

Secondary consumers - Carnivorous and omnivorous animals belong to this category. These animals predate on herbivorous animals. Omnivorous animals eat herbivorous animals as well as plants. Sparrow, Crow, Fox, Wolves, Cat, Dogs, Snakes etc. belong to this category.

Tertiary consumers - They are strictly carnivorous animals that prey upon carnivores, herbivores, and omnivorous organisms. Lions, Tigers, Vultures etc. are regarded at tertiary consumers.

**Detritus**

Some consumers feed on living plants and animals. Others, called Detrivores, get their energy from dead plant and animal matter, called Detritus. They are also called Saprotrophs. The Detrivores are further divided into detritus feeders and decomposers.

| Detritus feeders | Decomposers |
|---|---|
| Detritus feeders acquire the nutrients they need from partially decomposed organic matter found in shed animal tissues, plant litter, dead bodies of plants and animals, and animal waste products. Some examples of detritus feeders include various species of beetles, various species of ants, earthworms, and termites | These are also called transformers as they transform organic compounds into inorganic or simple compounds. Saprophytic fungi and bacteria belong to this category. They act upon the dead bodies of plants and animals and decompose them to their elemental stage. These in turn can be used by producers for their existence and photosynthetic activity. The decomposers occupy a pivotal place in the ecosystem as they indirectly support the producers. |

**Scavenger**

Scavenging is a feeding behaviour in which an animal feeds on either dead animal or dead plant matter. Scavengers are the animals with scavenging habits. Scavengers' role is vital for the ecosystem as they contribute to the decomposition, while decomposers and detritus feeders are responsible for completing the process. Scavengers do not spend energy to kill their prey, but they sense the smell of food on which they can feed. Vultures, Burying beetle, Raccoons, Jackals, and

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Hyenas are some prime examples for animal scavengers. Termites and earthworms are good examples for plant scavengers.

While the scavengers act on the dead animals and plants, they break them in to small pieces of organic materials. Thus, scavengers start the decomposing process. In addition, big helpers for the decomposition process are the scavengers, while detritus feeders are the small helpers.

**Difference between Decomposer and Detritivores**

Both Detritivores and decomposers aid in decomposition of dead or decaying matter. Decomposition is a chemical reaction where a complex compound is broken down into simpler compounds. Detritivores help in producing essential nutrients. Both decomposers and Detritivores get energy from decaying matter but while Detritivores actually eat organic matter, decomposers secrete enzymes to digest organic matter and then absorb resulting molecules. The word Detritivore actually comes from the word detritus that refers to non-living plant and animal remains, shed parts (skin, antlers) and wastes. Detritivores consume this detritus to derive energy. Decomposers are a special subset of Detritivores that break organic compounds into inorganic form and then absorbing what they need for nutrition.

### Parasites

Plants and animals that infect other living components of the ecosystem and survive on them are regarded as parasites. Various types of fungi, bacteria and a few flowering plants are parasitic. Several protozoans, insects and nematodes are also parasitic.

### Phagotrophs and Osmotrophs

The heterotrophs include all living things that directly ingest food. Such living things

**Biological Rhythms (Biorhythms)**

Regular rhythmic changes occur in the activities of plants and animals. These are caused by factors such as light and heat from the sun, the tides, season and phases of the moon and the rotation of the earth. These regular, rhythmic changes are called biorhythms and they can be divided into:

1) Daily rhythms - The daily rhythm of light and darkness which repeats every 24 hours as a result of the rotation of the earth, has influences on many organisms. Examples:

- Some animals are more active during the day because of the light and temperature example - Springbok, some birds, etc., while others are active during the night example - lions, owls and bats;
- Green plants photosynthesize only in daylight;
- The leaves and flowers of some plants react to light and darkness, example - the drooping of thorn tree leaves as it gets dark and the flowers of vygies which open as the intensity of the light and temperature increases;
- Zooplankton in the sea and lakes show daily rhythmic movements; during day they move vertically deeper into the water, away from the light; during the night they come to the surface where they feed on the drifting phytoplankton.

2) Lunar and Tidal rhythms - The phases of the moon have an influence on the tides in the sea which, in their turn, influence the behaviour of the marine animals which live in the intertidal zone. Examples:

- Many littoral crabs rhythmically change colour from dark at high tide to pale at low tide;
- Intertidal crustaceans and the eel-like grunion have activities which match the activities of the sea. During the spring tides from March to August, these fish swim in pairs (male and female) onto the beaches a couple of days after each high spring tide. While the female lays her eggs, the male curls around her and immediately releases his sperm cells which then fertilize the eggs. The fish then return to the sea on the next wave. Because the eggs are laid while the tides are gradually lessening, the waves will not reach them until the next high spring tide two weeks later. During this time the eggs develop and hatch and the baby fish are then carried back to the sea on the high spring tide.



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3) Seasonal rhythms - The behaviour of plants and animals is usually suited to withstand the seasons. Examples:

- Deciduous trees lose their leaves during winter and become dormant;
- Annual plants form seeds which survive the winter or the dry season and germinates after the first spring rains;
- Certain animals hibernate i.e. their heart beat slowly and respiration decreases so that the winter can passed in a type of unconsciousness, example - bats;
- Adult insects die when the frosts arrive; many spent the winter in the form of eggs and pupae;
- Many animals migrate during the winter to where the weather is warmer example - swallows; various marine mammals also migrate, mainly between feeding and breeding grounds, example - wildebeest migrate in response to seasonal rainfall and food availability.

are called 'Phagotrophs' or consumers. There are some creatures called 'Osmotrophs' which secrete digestive enzymes on their food that helps to break it down to tiny parts which they absorb. The distinction between 'phagotrophs' and 'osmotrophs' is that the former eat their food directly, latter convert their food into simple components (solution) and then absorb.

Humans are one of the few organisms that can control how the other biotic factors affect them. Humans are omnivores, consuming both producers and other consumers. Humans can also adjust the length of the food chain as needed. For example, humans who must deal with shortages of food resources usually alter their eating habits to be closer to the energy source. This is sometimes called eating lower on the food chain. Since approximately 90 percent of the energy available at each level of the food chain is lost to the next higher level, shortening the food chain saves energy and uses food more efficiently.

Humans are also biotic factors in ecosystems. Other organisms are affected by human actions, often in adverse ways. We compete with some organisms for resources, prey on other organisms, and alter the environment of still others.

## 2. FUNCTIONS OF AN ECOSYSTEM

Ecosystems are complex dynamic system. They perform certain functions. These are:-

1. Energy flow through food chain
2. Nutrient cycling (biogeochemical cycles)
3. Ecological succession or ecosystem development
4. Homeostasis (or cybernetic) or feedback control mechanisms

### ENERGY FLOW

Ecosystems maintain themselves by cycling energy and nutrients obtained from external sources. At the first trophic level, primary producers (plants, algae, and some bacteria) use solar energy to produce organic plant material through photosynthesis. Herbivores—animals that feed solely on plants—make up the second trophic level. Predators that eat herbivores comprise the third trophic level; if larger predators are present, they represent still higher trophic levels. Organisms that feed at several trophic levels (for example, hawk that eats snake) are classified at the highest of the trophic levels at which they feed. Decomposers, which include bacteria, fungi, moulds, worms, and insects, break down wastes and dead organisms and return nutrients to the soil. On an average, about 10 percent of net energy production at one trophic level is passed on to the next level.

**How?**

1). Processes that reduce the energy transferred between trophic levels include respiration, growth and reproduction, defecation, and non-predatory death (organisms that die but are not eaten by

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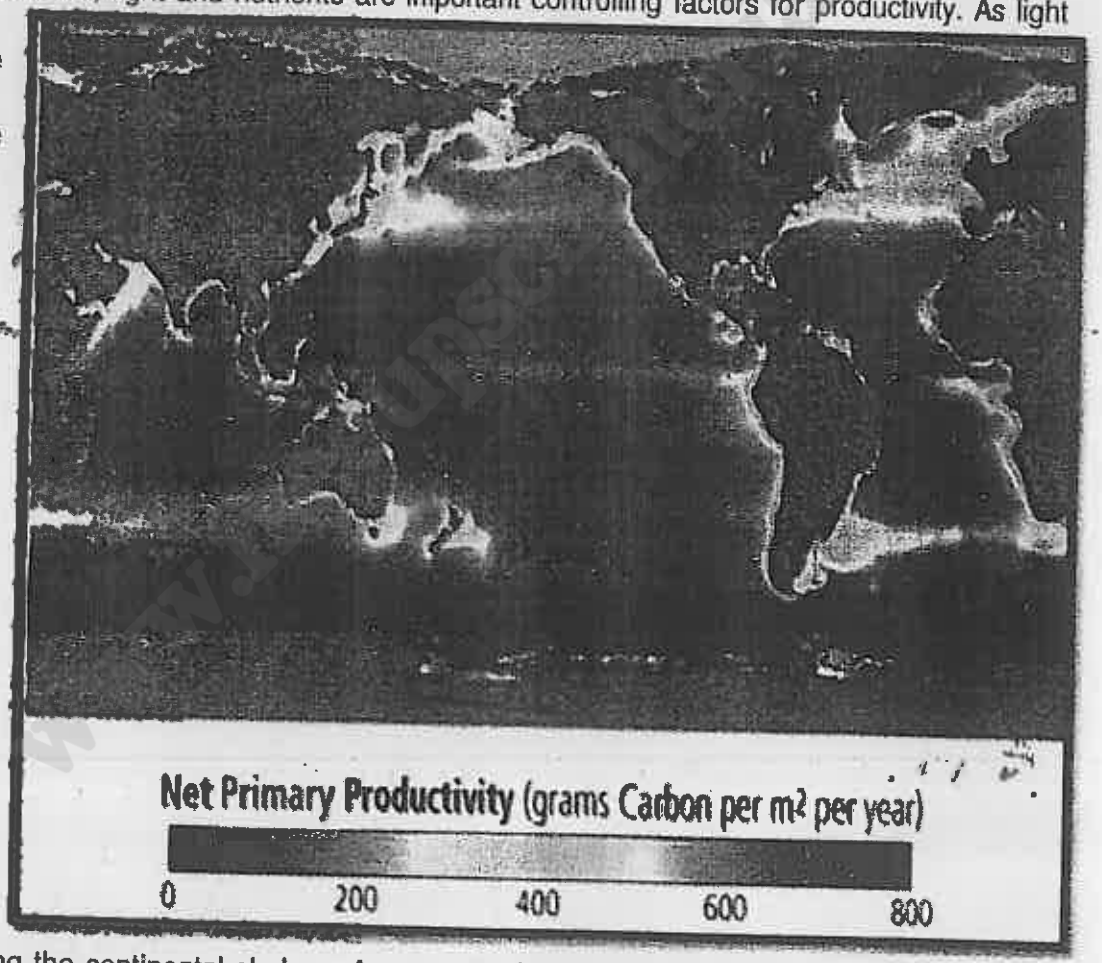


consumers). The nutritional quality of material that is consumed also influences how efficiently energy is transferred, because consumers can convert high-quality food sources into new living tissue more efficiently than low-quality food sources.

2). The low rate of energy transfer between trophic levels makes decomposers generally more important than producers in terms of energy flow. Decomposers process large amounts of organic materials and return nutrients to the ecosystem in inorganic forms, which are then taken up again by primary producers. Energy is not recycled during decomposition, but rather is released, mostly as heat

An ecosystem's Gross Primary Productivity (GPP) is the total amount of organic matter that it produces through photosynthesis. Net Primary Productivity (NPP) describes the amount of energy that remains available for plant growth after subtracting the fraction that plants use for respiration. Productivity in land ecosystems generally rises with temperature up to about 30°C, after which it declines, and is positively correlated with moisture. On land primary productivity thus is highest in warm, wet zones in the tropics where tropical forest biomes are located. In contrast, desert scrub ecosystems have the lowest productivity because their climates are extremely hot and dry.

In the oceans, light and nutrients are important controlling factors for productivity. As light penetrates only into the uppermost level of the oceans, so photosynthesis occurs in surface and near-surface waters. Marine primary productivity is high near coastlines and other areas where upwelling brings nutrients to the surface, , promoting plankton blooms. Runoff from land is also a source of nutrients in estuaries and along the continental shelves. Among aquatic ecosystems, algal beds and coral reefs have the highest net primary production, while the lowest rates occur in the open due to a lack of nutrients in the illuminated surface layers




Growth rates may also be a factor. Phytoplanktons are extremely small but grow very rapidly, so they support large populations of herbivores even though there may be fewer algae than herbivores at any given moment. In contrast, land plants may take years to reach maturity, so an average carbon atom spends a longer residence time at the primary producer level on land than it



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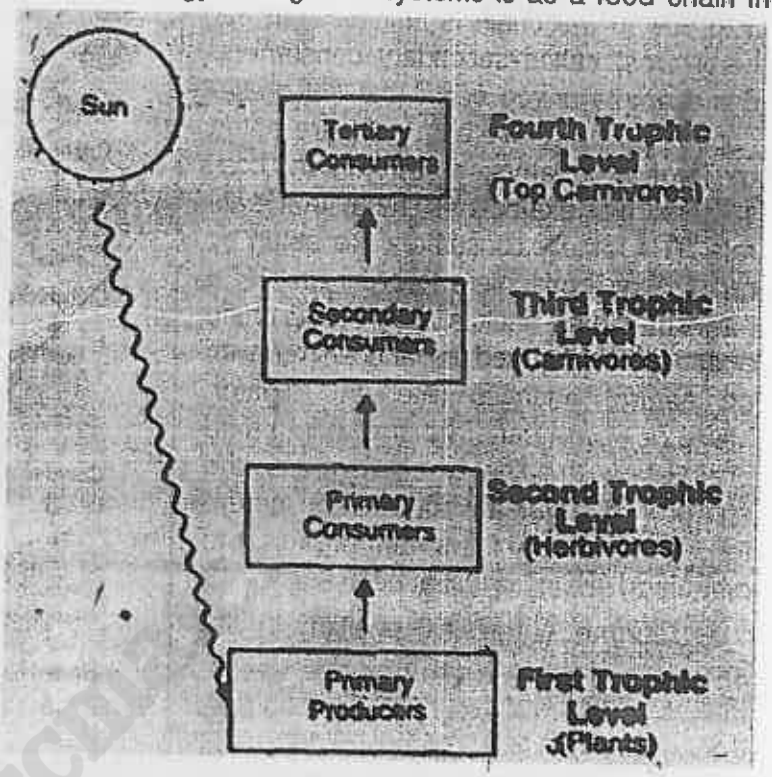
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does in a marine ecosystem. In addition, locomotion costs are generally higher for terrestrial organisms compared to those in aquatic environments.

The simplest way to describe the flux of energy through ecosystems is as a food chain in which energy passes from one trophic level to the next, without factoring in more complex relationships between individual species. Some very simple ecosystems may consist of a food chain with only a few trophic levels




### Trophic Level

Trophic levels are the feeding position in a food chain such as primary producers, herbivore, primary carnivore, etc. Green plants form the first trophic level, the producers. Herbivores form the second trophic level, while carnivores form the third and even the fourth trophic levels. The trophic level interaction involves following three concepts –

1. Food Chain
2. Food Web
3. Ecological Pyramids

**How many trophic levels ca an ecosystem support?**

The answer depends on several factors, including the amount of energy entering the ecosystem, energy loss between trophic levels, and the form, structure, and physiology of organisms at each level. At higher trophic levels, predators generally are physically larger and are able to utilize a fraction of the energy that was produced at the level beneath them, so they have to forage over increasingly large areas to meet their caloric needs.

Because of these energy losses, most terrestrial ecosystems have no more than five trophic levels, and marine ecosystems generally have no more than seven. This difference between terrestrial and marine ecosystems is likely due to differences in the fundamental characteristics of land and marine primary organisms. In marine ecosystems, microscopic phytoplankton carries out most of the photosynthesis that occurs, while plants do most of this work on land. Phytoplankton are small organisms with extremely simple structures, so most of their primar production is consumed and sed for energy by grazing organisms that feed on them. In contrast, a large fraction of the biomass that land plants produce, such as roots, trunks, and branches, cannot be used b herbivores for food, so proportionately less of the energy fixed through primary production travels up the food chain.

### Food chain

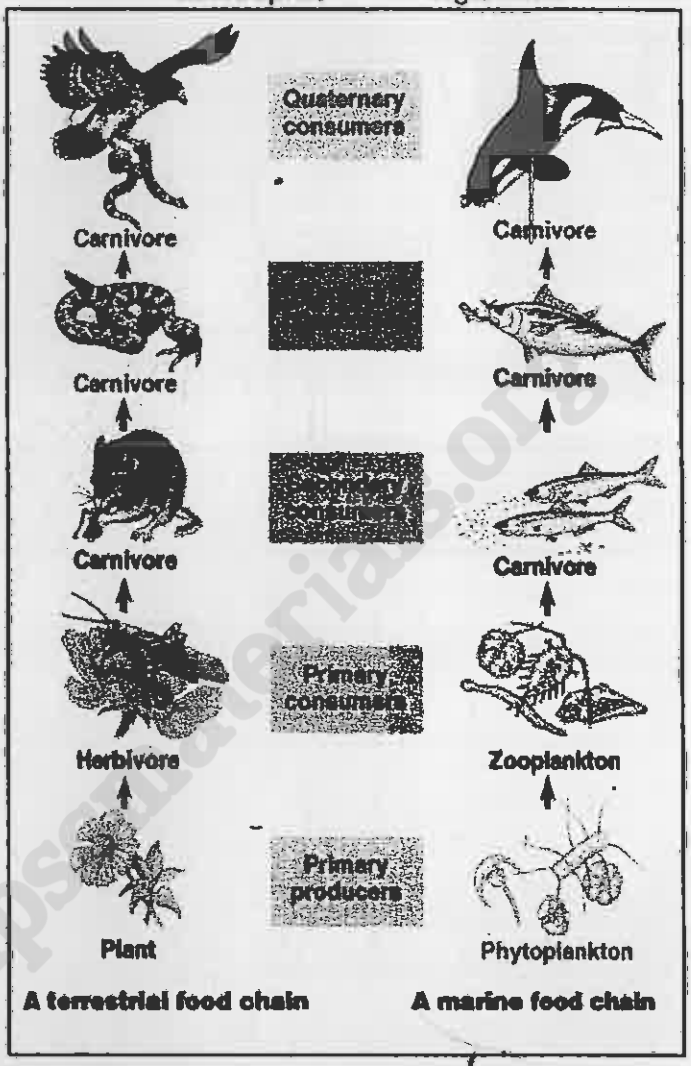
A food chain is the sequence of who eats whom in a biological community (an ecosystem) to obtain nutrition. Alternatively, it is a sequence of organisms that feed on one another. The idea to apply the food chains to ecology and to analyse its consequences was first proposed by Charles Elton. A food chain starts with the primary energy source, usually the sun. The next link in the chain is an organism that makes its own food from the primary energy source. For example photosynthetic plants that make their own food from sunlight by photosynthesis and chemosynthetic bacteria that make their food energy from chemicals in hydrothermal vents. These are called autotrophs or

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primary producers. Next come organisms that eat the autotrophs; these organisms are called herbivores or primary consumers. For example a grasshopper that eats grass. The next link in the chain is animals that eat herbivores, called secondary consumers. For example a frog or rat that eat grasshoppers. In turn, these animals are eaten by larger predators, called tertiary consumers. For example a snake that eats rats. The tertiary consumers are eaten by quaternary consumers. For example a hawk that eats snakes. Each food chain ends with a top predator and animal with no natural enemies (like an alligator, hawk, or polar bear). The arrows in a food chain show the flow of energy, from the sun or hydrothermal vent to a top predator. As the energy flows from organism to organism, energy is lost at each step.




Some organisms' position in the food chain can vary as their diet differs. For example, when a bear eats berries, the bear is functioning as a primary consumer. When a bear eats a plant-eating rodent, the bear is functioning as a secondary consumer. When the bear eats salmon, the bear is functioning as a tertiary consumer (this is because salmon is a secondary consumer, since salmon eat herring that eat zooplankton that eat phytoplankton, that make their own energy from sunlight). Similarly, humans have similar place in Food Chain.

**Difference between Grazing food chain and Detritus food chain**

| Grazing Food Chain | Detritus Food Chain |
|---|---|
| ➢ The Chain begins with green plants (producers) at first trophic level | ➢ The Chain begins with detrivores (decomposers) at first trophic level |
| ➢ Energy comes from the sun | ➢ Energy comes from the remains of dead organic matters |
| ➢ It consists of all macroscopic organisms | ➢ It consists of sub-soil organisms |
| ➢ Food chain is longer in size | ➢ Food chain is smaller in size |
| ➢ Plant> Grass hopper> Rat> Snake> Hawk | ➢ Dead Bodies> Bacteria> Molluscs> Fish |

**Food web**

Trophic levels in an ecosystem are not linear rather they are interconnected and make a food web. All of the interconnected and overlapping food chains in an ecosystem make up a food web. A food web consists of all the food chains in a single ecosystem. Each living thing in an ecosystem is part of multiple food chains. Food web is an important ecological concept. Basically, food web represents feeding relationships within a community. It also implies the transfer of food energy from its source in plants through herbivores to carnivores. Normally, food

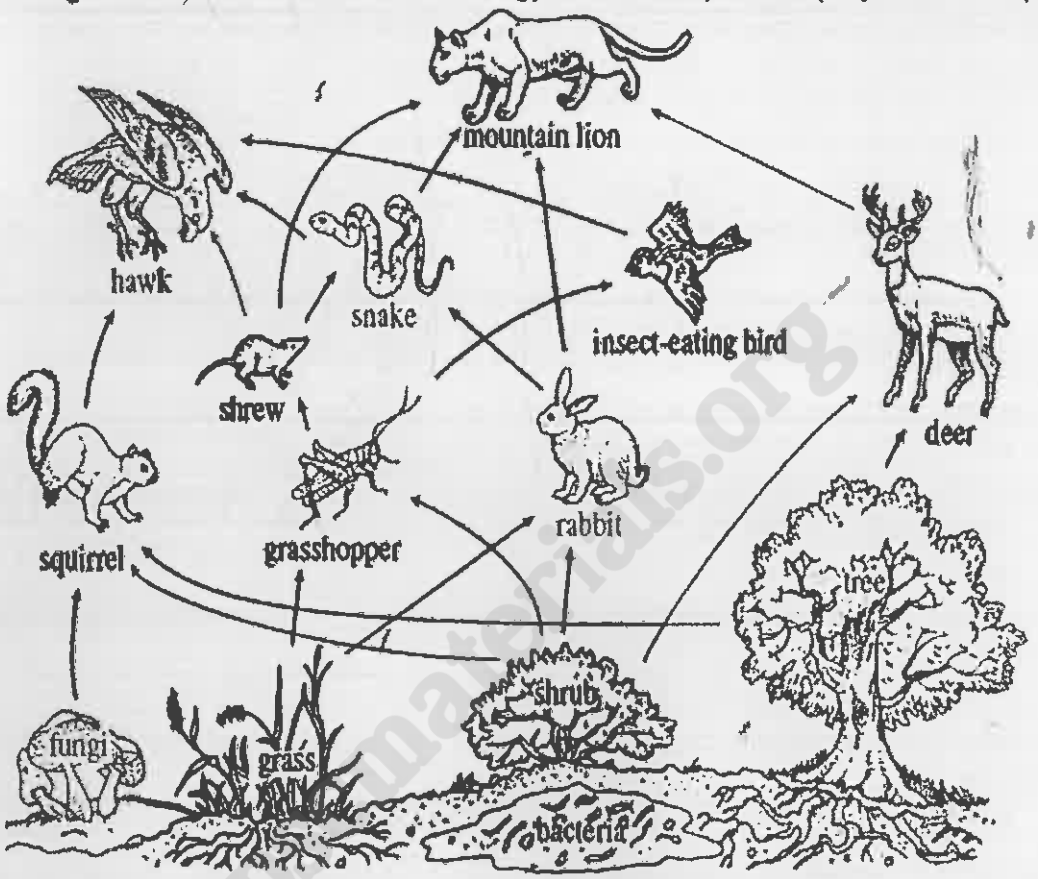
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webs consist of a number of food chains meshed together. Food web offers an important tool for investigating the ecological interactions that define energy flows and predator-prey relationship. Most feed webs are complex and involve many species with both strong and weak interactions among them.




Food web is used to describe direct or indirect species interactions, to study bottom-up or top-down control of community structure and to reveal different patterns of energy transfer in terrestrial and aquatic ecosystems.

## ECOLOGICAL PYRAMIDS

The concept of ecological pyramid was developed by Charles Elton; these pyramids are also known as Eltonian pyramids. Ecological pyramids are diagrams that illustrate how ecologically important factors, such as energy, biomass, and population size, vary between trophic levels in an ecosystem. Traditionally, these diagrams place the primary producers (photosynthetic organisms such as plants) at the bottom and the highest trophic levels at the top of the diagram. The size of the portion of the diagram associated with each trophic level illustrates the amount of energy, biomass, or number of individuals found in each trophic level. The ecological pyramids may be of following three kinds –

- Pyramid of energy, showing the rate of energy flow and/or productivity at successive trophic levels
- Pyramid of numbers, showing the number of individual organisms at each level and
- Pyramid of biomass, showing the total dry weight and other suitable measure of the total amount of living matter

### Pyramid of Energy

The energy pyramid shows how the amount of energy entering each level varies across trophic levels. An energy pyramid's shape shows how the amount of useful energy that enters each level — chemical energy in the form of food — decreases as it is used by the organisms in that level.

Cell respiration "burns" food to release its energy, and in doing so, produces ATP, which carries some of the energy as well as heat, which carries the rest. ATP is then used to fuel count-

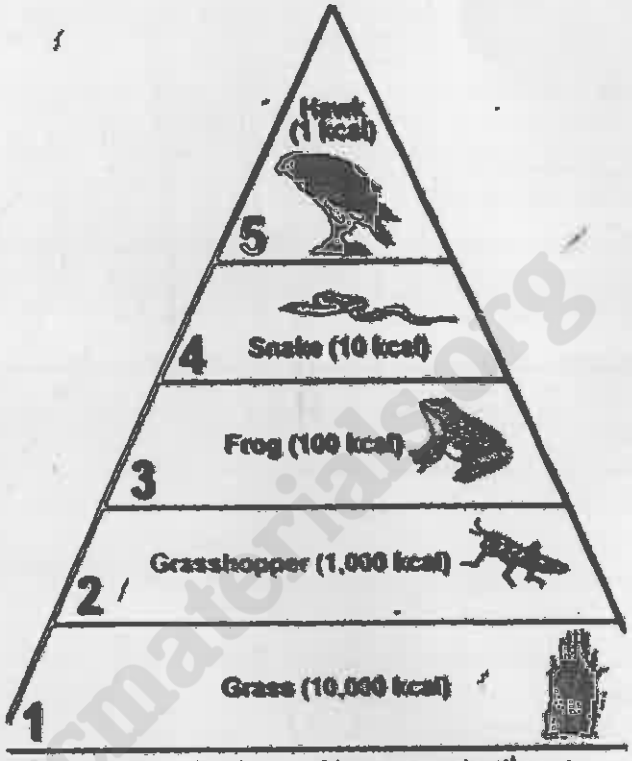
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less life processes. The consequence is that even though a lot of energy may be taken in at any level, the energy that ends up being stored there, which is the food available to the next level is far less. Scientists have calculated that an average of 90% of the energy entering each step of the food chain is "lost" this way (although the total amount in the system remains unchanged).

The consumers at the top of a food pyramid, as a group, thus have much less energy available to support them than those closer to the bottom. That's why their numbers are relatively few in most communities. Eventually, the amount of useful energy left can't support another level. That's why energy flow is depicted in the shape of a pyramid. The energy that enters a community is ultimately lost to the living world as heat. To sum up –

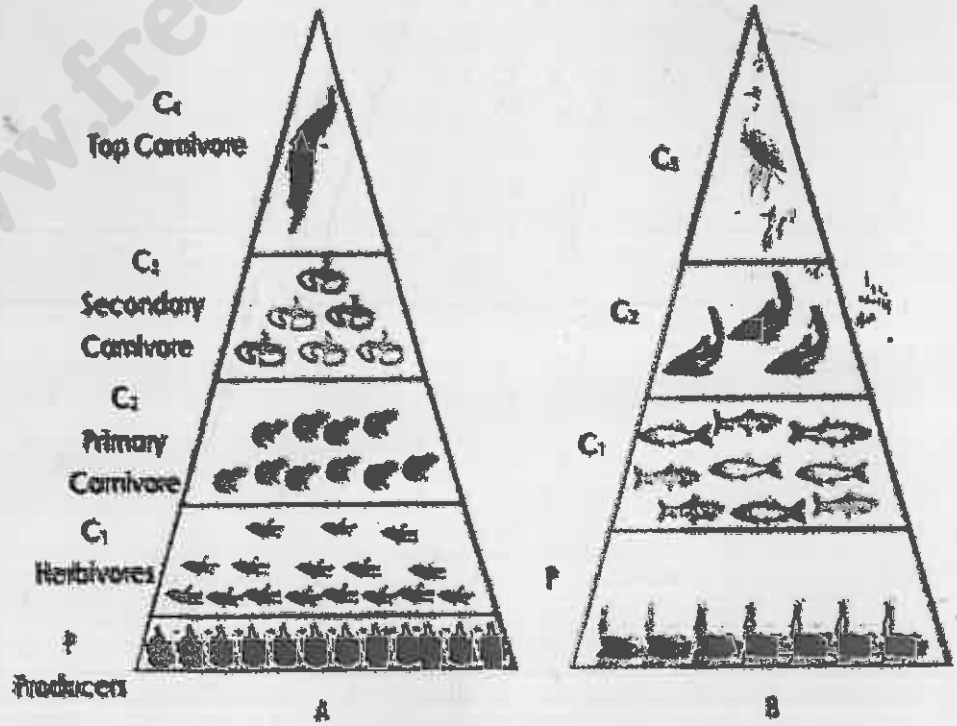



- The energy pyramid always upright and erect.
- It shows the rate of energy flows at different trophic levels.
- It shows that energy is maximum at producer level and minimum at the carnivores' level.
- At every successive trophic level there is a loss of energy in the form of heat, respiration etc.

**Pyramid of Numbers**

Pyramids of numbers show the relationship between producers, herbivores and carnivores at successive trophic levels in terms of their number.

In grassland the producers, which are mainly grasses are always maximum in number. This number then shows a decrease towards apex, as the primary consumers (herbivores) like rabbits, mice etc. are lesser in number than the grasses; the secondary consumers, snakes and lizards are lesser in number than the rabbits and mice. Finally, the top (tertiary) consumer's hawks or other birds are least in number. Thus, the pyramid becomes




Upright Pyramids of Numbers (A) in a Grass Land (B) in a Pond



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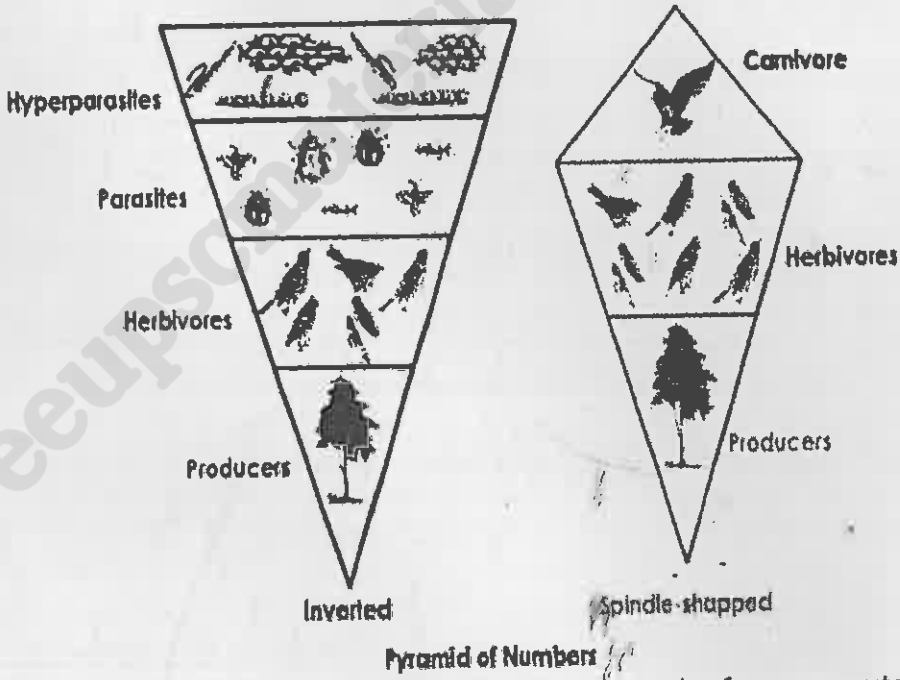


upright.

Similarly, in a pond ecosystem the pyramid is upright. Here the producers which are mainly the Phytoplankton as algae, bacteria etc. are maximum in number. The herbivores, which are smaller fish rotifers etc. are lesser in number than producers and the secondary consumers (carnivores), such as small fish eating each other, water beetles etc. are lesser in number than the herbivores. Finally, the top (tertiary) consumers, the bigger fish are least in number.

In a forest ecosystem, however, the pyramid of numbers is somewhat different in shape. The producers, which are mainly large-sized trees, are lesser in number, and form the base of the pyramid. The herbivores, which are the fruit-eating birds, elephants, deer's etc. are more in number than the producers. Then there is a gradual decrease number of successive carnivores, thus making the pyramid again upright. Hence, in this case, Pyramid of Numbers is partly upright and partly inverted.

However in a parasitic food chain the pyramids are always inverted. This is due to the fact that a single plant may support the growth of many herbivores and each herbivore in turn may provide nutrition to several parasites which support many hyper parasites. Thus, from the producer towards consumers, there is a reverse position, i.e. the number of organisms gradually shows an increase making the pyramid inverted in shape.




Actually the pyramids of numbers do not give a true picture of the food chain as they are not very functional. They do not indicate the relative effects of the 'geometric', 'food-chain' and 'size' factors of the organisms. When plotted the relationships among the number of producers, primary consumers (herbivores), secondary consumers, tertiary consumers and so on in any ecosystem, it forms a pyramidal structure called the pyramid of number. The shape of this pyramid varies from ecosystem to ecosystem.

**Pyramid of Biomass**

The biomass pyramid shows how the biomass of living organisms (total dry weight) varies across trophic levels. This dry weight (biomass) represents the amount of organic matter. They are comparatively more fundamental instead of geometric factor showing the quantitative relationships. The shape of the biomass pyramid in any ecosystem depends on a number of factors. If the amount of biomass in a trophic level depends on the amount of energy entering that trophic level, then, all else being equal, the biomass pyramid should have the same shape as the energy pyramid. However, when biomass of primary producers is rapidly removed by herbivores the biomass of primary consumers (herbivores) in an ecosystem at any time may be greater than the biomass of primary producers (e.g. plants). Thus, the resulting biomass pyramid becomes inverted. The shape of the biomass pyramid is also influenced by the growth form of the dominant plants in the ecosystem. For

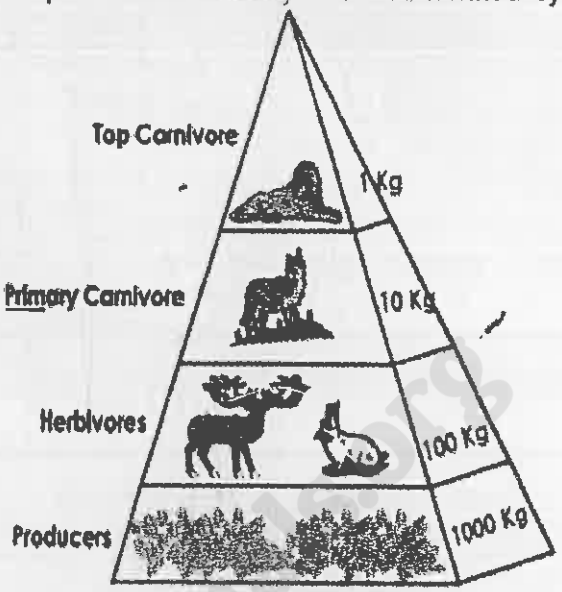


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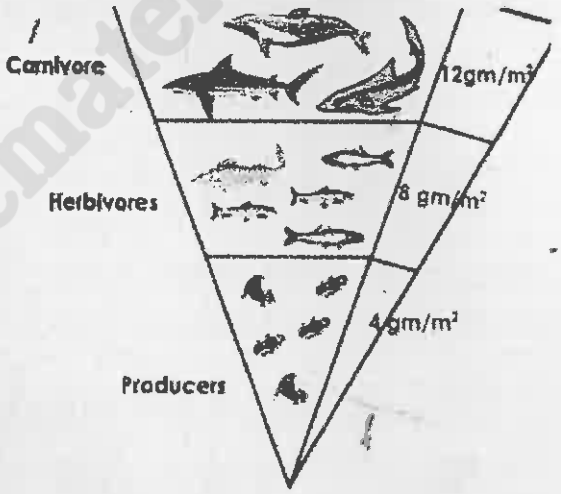
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example, woody plants store biomass that has been accumulated for a number of years so there might be much more biomass in the primary producer trophic level in ecosystems dominated by long-lived woody plants (e.g., forests) than in ecosystems dominated by herbaceous plants (e.g., grasslands). In grassland and forest, there is generally a gradual decrease in biomass of organisms at successive levels from the producers to the top carnivores, making the pyramid upright. However, in a pond as the producers are small organisms, their biomass is least, and this value gradually shows an increase towards the apex of the pyramid, thus making the pyramid inverted in shape.



Upright Pyramid of Biomass in a Forest Ecosystem



Inverted Pyramid of Biomass in a Pond

### The Trophic Transfer of Toxins

Trophic transfer is the major mechanism for contaminant accumulation in organisms higher up in the food web. Toxins ingested by single-celled organisms are subse-quently eaten by larger and larger organisms, compounding the amount of toxin at each level in comparison to the amount of tainted food eaten. This can further be elaborated as follows:

1. Bioaccumulation – Bioaccumulation is the accumulation of contaminants by species in concentrations that are orders of magnitude higher than in the surrounding environment. Alternatively, Bioaccumulation is the gradual build up over time of a chemical in a living organism. This occurs either because the chemical is taken up faster than it can be used, or because the chemical cannot be broken down for use by the organism (that is, the chemical cannot be metabolized). This can occur through a number of different routes, such as breathing, eating (ingesting), drinking (usually water), or through skin contact. Bioaccumulation need not be a concern if the accumulated compound is not harmful. Compounds that are harmful to health, such as Polychlorinated Biphenyl (PCBs), Dioxins, DDT, mercury etc. however, can accumulate in living tissues. For example, Minamata disease is a neurological syndrome caused by severe mercury poisoning on consumption of fishes of water polluted by Mercury.
2. Bioconcentration – Bioconcentration is the direct uptake of a substance by a living organism from the medium (e.g., water) via skin, gills, or lungs and the subsequent concentration of that substance within the organism's tissues to a level that exceeds ambient environmental concentrations. It should be noted here that, Bio-concentration does not include the direct eating of contaminated substances.
3. Biomagnification – Biomagnification refers to the tendency of pollutants to concentrate as they move from one trophic level to the next. Biomagnification is also called Bioamplification. It is increase in concentration of a pollutant from one link in a food chain to another. In order for Biomagnification to occur, the pollutant must be long-lived, mobile, soluble in fats, biologically active. If a pollutant is short-lived, it will be broken down before it can become dangerous. If it is



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not mobile, it will stay in one place and is unlikely to be taken up by organisms. If the pollutant is soluble in water it will be excreted by the organism. Pollutants that dissolve in fats, however, may be retained for a long time. It is traditional to measure the amount of pollutants in fatty tissues of organisms such as fish. In mammals, we often test the milk produced by females, since the milk has a lot of fat in it and because the very young are often more susceptible to damage from toxins (poisons). If a pollutant is not active biologically, it may Biomagnify, but we really don't worry about it much, since it probably won't cause any problems.

## BIOGEOCHEMICAL CYCLES

Biogeochemical cycles are pathways for the transport and transformation of matter within four categorical areas that make up planet Earth (biosphere, hydrosphere, lithosphere, and the atmosphere).Biogeochemical cycles are components of the broader cycle that govern the functioning of planet Earth. The Earth is a system open to electromagnetic radiation from the sun and outer space, but is a virtually closed system with regard to matter. This means that the planet has minimal flux of matter, other than meteorite collisions and minor amounts of intergalactic particle trapping (or loss) by the upper atmosphere. Therefore, matter that Earth contained from the time of its birth is transformed and circulated geographically. This is in line with the law of conservation of matter which states that matter cannot be created nor destroyed but can be transformed including the transformation between matter and energy.

**The importance of biogeochemical cycles**

Biogeochemical cycles enable the transformation of matter from one form to another. For example humans utilize water in liquid form. Through the hydrological cycle, water vapour is condensed to liquid and ice converted to liquid water.

Biogeochemical cycles enable the transfer of molecules from one locality to another.

Biogeochemical cycles facilitate the storage of elements. Elements carried through the biogeochemical cycles are stored in their natural reservoirs, and are released to organisms in small consumable amounts.

Biogeochemical cycles assists in functioning of ecosystems. An ecosystem is a system that properly functions in a state of equilibrium, and whenever any imbalances occur, the ecosystem through the biogeochemical cycles restores to the equilibrium state; this may take a few days or many years.

Biogeochemical cycles link biotic and abiotic elements of an ecosystem by flow on nutrients.

Biogeochemical cycles regulate the flow of substances. Since the biogeochemical cycles pass through different spheres, the flow of elements is regulated because each sphere has a particular medium and the rate at which elements flow is determined by the viscosity and density of the medium.

The transfer of matter involves biological, geological and chemical processes; hence the name biogeochemical cycles derives. Biogeochemical cycles may also be referred to as cycles of nature because they link together all organisms and abiotic features on earth. Matter is continually recycled among living and abiotic elements on earth. Biogeochemical cycles facilitate the transfer of matter from one form to another and from one location to another on planet earth. Additionally, biogeochemical cycles are sometimes called nutrient cycles, because they involve the transfer of compounds that provide nutritional support to living organisms.

Elements transported in the biogeochemical cycles have been categorized as:

1. Micro elements – these are elements required by living organisms in smaller amounts. Examples of such elements include boron used mainly by green plants, copper used by some enzymes and molybdenum used by nitrogen-fixing bacteria.
2. Macro elements – these are elements required by living organisms in larger amounts. Examples of such elements include carbon, hydrogen, oxygen, nitrogen, phosphorous, sulphur.



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**Types of Biogeochemical Cycles**

On the basis of replacement period, they have been classified under two headings –

1. Perfect Nutrient Cycle: A perfect nutrient cycle is one in which the nutrients are replaced as fast as they are used up. Most gaseous cycles are generally considered perfect
2. Imperfect Nutrient Cycle: In this type of Cycle, some nutrients are lost from the cycle into the soil and sediments and become unavailable for immediate cycling i.e., there are more stages in which short-term or long-term stagnation occurs. Sedimentary Cycles are considered Imperfect Nutrient Cycle.

On the basis of pathways or reservoir, Biogeochemical Cycles can be divided into following two categories –

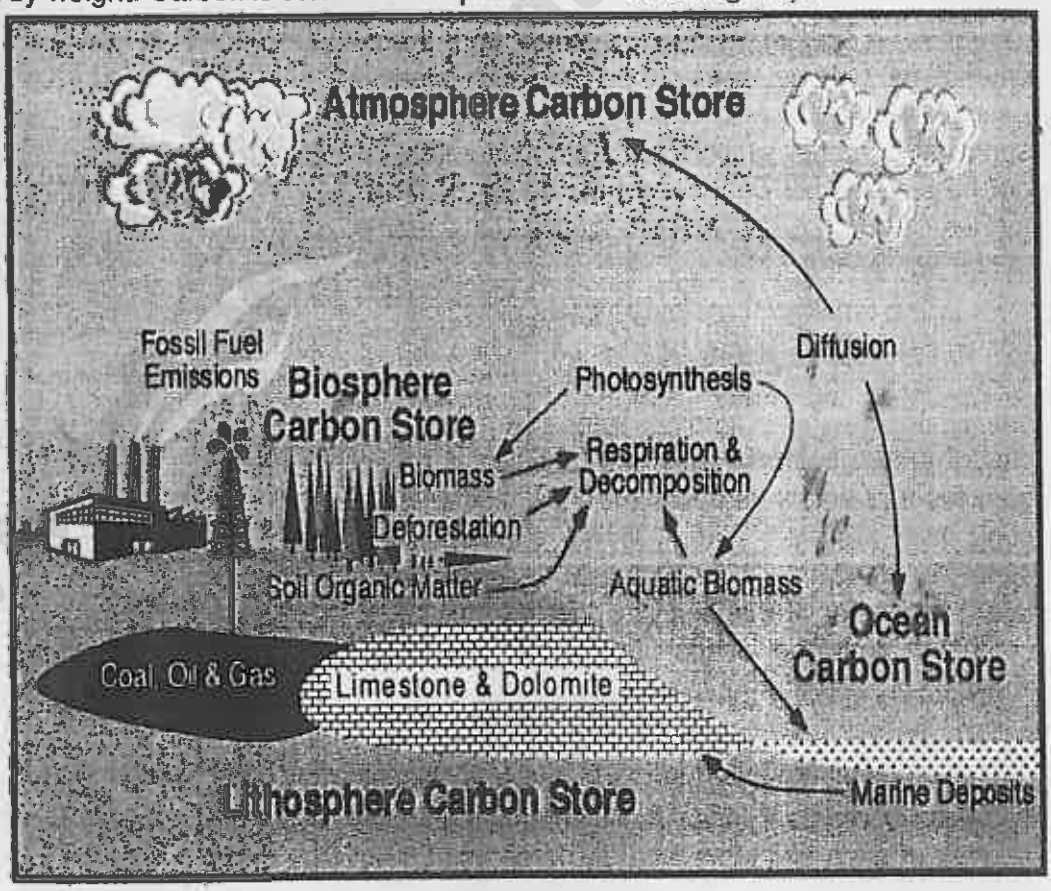
1. Gaseous cycles: These involve the transportation of matter through the atmosphere.
2. Sedimentary cycles: These cycles involve the transportation of matter through the ground to water; that is to say from the lithosphere to the hydrosphere.

**Gaseous Cycles**

**1. Carbon Cycles:**

Carbon is the major chemical constituent of most organic matter, from fossil fuels to the complex molecules (DNA and RNA) that control genetic reproduction in organisms. Yet by weight, carbon is not one of the most abundant elements within the Earth's crust. In fact, the lithosphere is only 0.032% carbon by weight. Carbon is stored on our planet in the following major sinks –

- As organic molecules in living and dead organisms found in the biosphere;
- As the gas carbon dioxide in the atmosphere;
- As organic matter in soils;
- In the lithosphere as fossil fuels and sedimentary rock deposits such as limestone, dolomite and chalk; and
- In the oceans as dissolved atmospheric carbon dioxide and as calcium carbonate shells in marine organisms.




Ecosystems gain most of their carbon dioxide from the atmosphere. A number of autotrophic organisms have specialized mechanisms that allow for absorption of this gas into their cells. With the addition of water and energy from solar radiation, these organisms use photosynthesis to



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chemically convert the carbon dioxide to carbon-based sugar molecules. These molecules can then be chemically modified by these organisms through the metabolic addition of other elements to produce more complex compounds like proteins, cellulose, and amino acids. Some of the organic matter produced in plants is passed down to heterotrophic animals through consumption.

- Carbon is released from ecosystems as carbon dioxide gas by the process of Respiration. Respiration takes place in both plants and animals and involves the breakdown of carbon-based organic molecules into carbon dioxide gas and some other compound by-products. The detritus food chain contains a number of organisms whose primary ecological role is the decomposition of organic matter into its abiotic components. Another portion of the carbon that flows from the atmosphere to the biota becomes part of the detritus food chain. Partially decomposed organic matter becomes part of the soil carbon storage pool. Eventually, the organic material in the soil is decomposed to its constituents, water and carbon dioxide, which return to the atmosphere. Together with respiration, these flows account for most but not all of the carbon removed from the atmosphere by photosynthesis.
- Carbon dioxide enters the waters of the ocean by simple diffusion. Once dissolved in seawater, the carbon dioxide can remain as is or can be converted into carbonate or bicarbonate. When Carbon Dioxide enters the ocean, carbonic acid is formed. Certain forms of sea life biologically fix bicarbonate with calcium to produce calcium carbonate. This substance is used to produce shells and other hard body parts by organisms such as coral, clams, oysters, some protozoa, and some algae. When these organisms die, their shells and body parts sink to the ocean floor where they accumulate as carbonate-rich deposits. After long periods of time, these deposits are physically and chemically altered into sedimentary rocks. Ocean deposits are by far the biggest sink of carbon on the planet.
- Carbon is stored in the lithosphere in both inorganic and organic forms. Inorganic deposits of carbon in the lithosphere include fossil fuels like coal, oil, and natural gas, oil shale, and carbonate-based sedimentary deposits like limestone. Organic forms of carbon in the lithosphere include litter, organic matter, and Humic substances found in soils. Some carbon dioxide is released from the interior of the lithosphere by volcanoes. Carbon dioxide released by volcanoes enters the lower lithosphere when carbon-rich sediments and sedimentary rocks are subducted and partially melted beneath tectonic boundary zones.

**2. Hydrological Cycle (Water Cycle)**

The hydrologic cycle is a conceptual model that describes the storage and movement of water between the biosphere, atmosphere, lithosphere, and the hydrosphere. Water on our planet can be stored in any one of the following major reservoirs: atmosphere, oceans, lakes, rivers, soils, glaciers, snowfields, and groundwater. Water moves from one reservoir to another by way of processes like evaporation, condensation, precipitation, deposition, runoff, infiltration, sublimation, transpiration, melting, and groundwater flow. The oceans supply most of the evaporated water found in the atmosphere. Of this evaporated water, only 91% of it is returned to the ocean basins by way of precipitation. The remaining 9% is transported to areas over landmasses where climatological factors induce the formation of precipitation. The resulting imbalance between rates of evaporation and precipitation over land and ocean is corrected by runoff and groundwater flow to the oceans.

Water is more or less constantly moving and changing from one state to another (solid, liquid, or vapour/gas) while interacting with the physical processes present in the atmosphere, lithosphere, and biosphere. These changes and movements of water are linked together in the hydrologic cycle. Components of the hydrologic cycle include water vapour and clouds in the atmosphere, but also include liquid surface waters (oceans, lakes and streams) on continents as well as groundwater. Other important components of the hydrologic cycle include glacial ice held on conti-



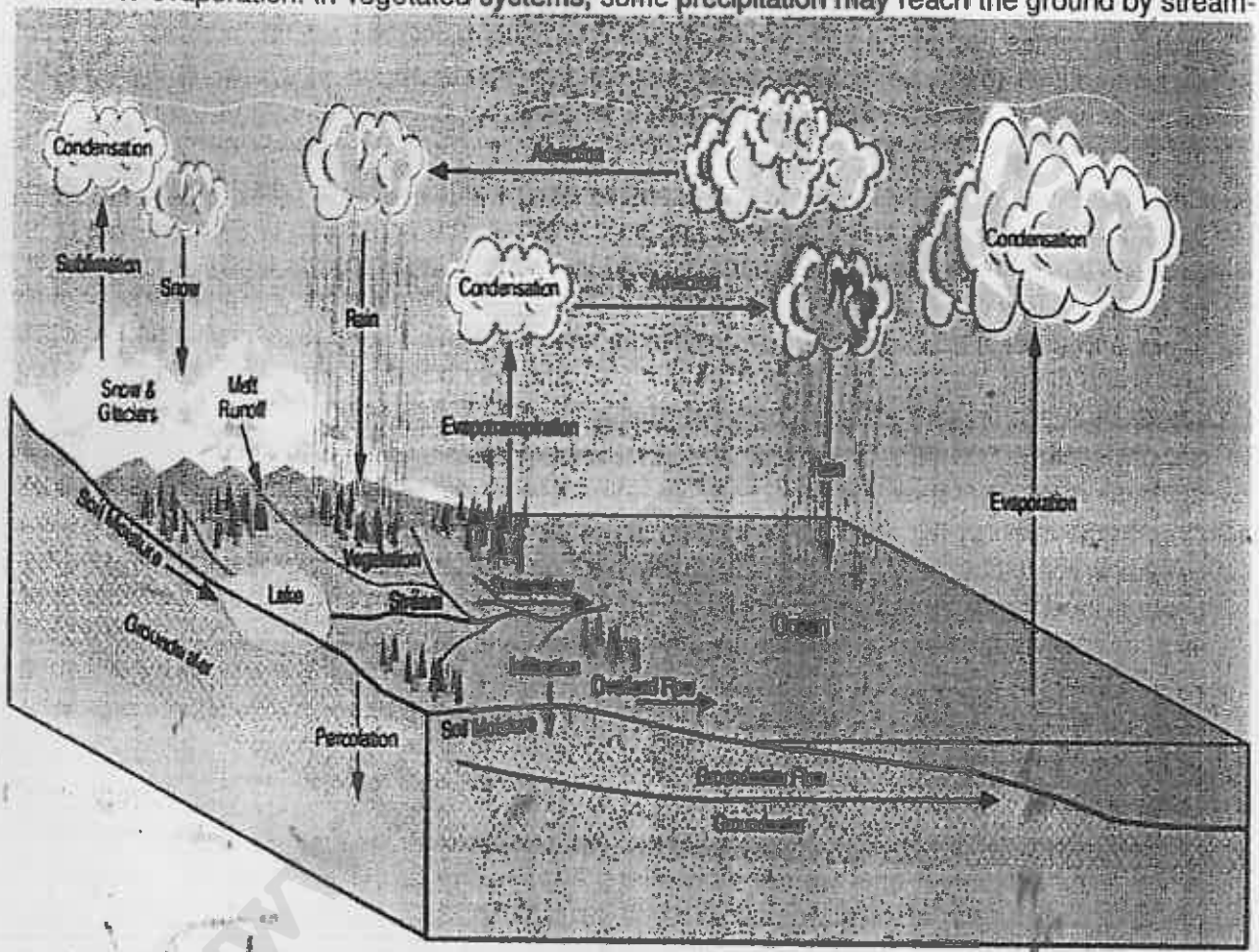
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nents, and water contained in biomass. Plants and animals are about 70% water, by volume. Water evaporates in enormous quantities from the oceans and then falls as precipitation either on land or ocean. That portion which falls on land evaporates, is transpired by plants, runs off, or infiltrates by some measure. Between the various stages of the hydrologic cycle, water moves between temporary storage areas often called reservoirs. These movements are controlled by climatic conditions, which include rain, snow, wind, and other meteorological processes. Eventually, all water ends up back in the ocean.

Various pathways exist in the hydrologic cycle. In non-vegetated systems interception processes usually do not occur, however, within vegetated systems, precipitation can be intercepted and lost to evaporation. In vegetated systems, some precipitation may reach the ground by stream-




flow, but most often reaches the soil by a process called through fall. Precipitation that reaches the soil surface can then infiltrate and recharge soil waters. From there it can percolate through soil to deeper soil layers or groundwater supplies. The rate of evaporation from soils or surface waters (including oceans) can be influenced by several factors including radiation, temperature, relative humidity, and wind. Warmer air can hold more water vapour, thereby generating increased evapo ration rates. Drier air can accept much more water vapour than air that is nearly saturated, and windy conditions generally accelerate evaporation. Transpiration from plants takes place via water loss from the stomata, the gas exchange organs found on the leaves of plants. The

Air can only hold a certain amount of water vapour. The amount depends largely upon temperature; thus, as mentioned, hotter air can hold more water vapour than colder air. When air is saturated with water vapour, the water vapour condenses into droplets of water, forming clouds. When the droplets gain enough mass, they fall to the ground as rain or snow



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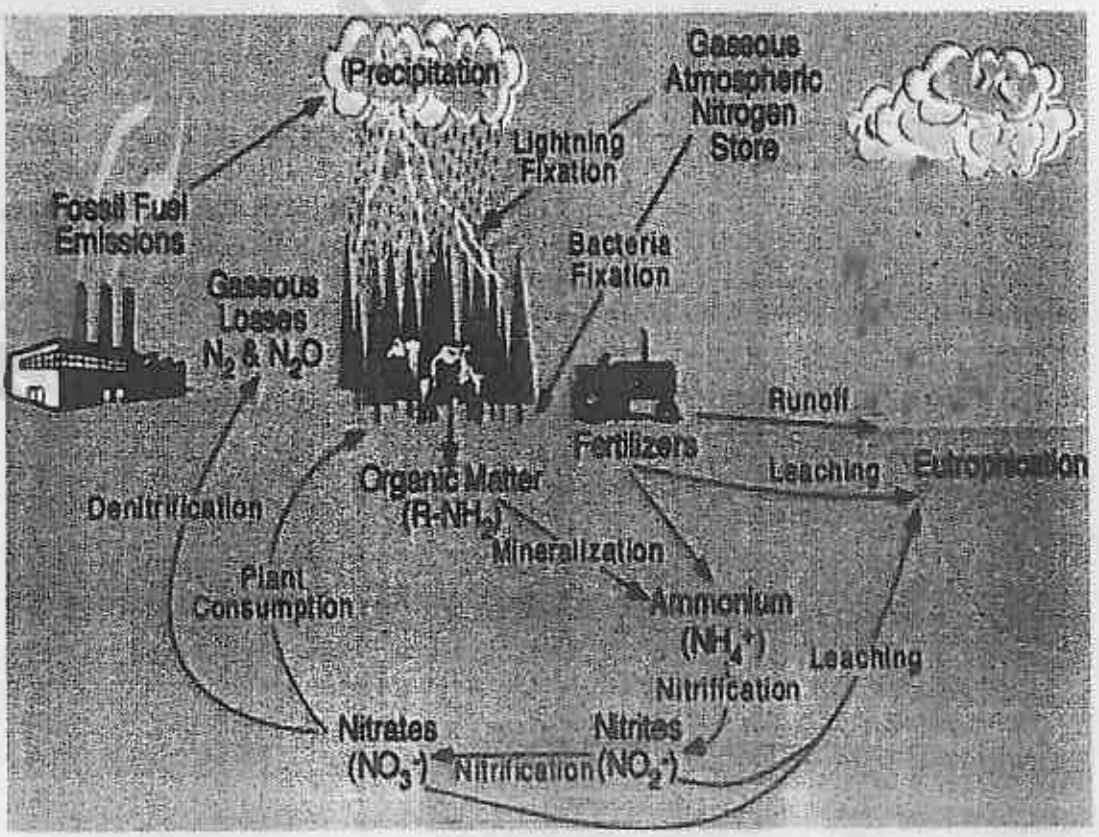


stomata also acts as an important cooling mechanism for plants by means of latent heat absorbed and transferred from the plants through evaporation/transpiration processes. This process is also that which supplies the tensional forces necessary to help draw water into roots from the surrounding soil. Transpiration is often lumped with evaporation and is then called evapotranspiration. With enough energy added, water can be converted directly from a solid (ice) to water vapour. This process is called sublimation. Sublimation is the result of ice going directly from a solid to water vapour without passing through a liquid state.

Water that falls as snow or rain evaporates, sublimates, runs off the ground surface (runoff) or soaks into the ground (infiltration). Whether the water runs off or infiltrates is controlled by a number of mechanisms including precipitation rate, soil water content, slope and vegetation. With increased rates of precipitation, runoff rates tend to increase. In extreme cases, rapid cloudbursts of precipitation can result in flash floods and potential landslides. Prior to rainfall, the relative amount of soil water content can dictate the amount of water that soil can hold before saturation. Generally, more water will infiltrate into dry soil than into a wet soil, and more water will run off steeper slopes than off moderate slopes. The presence of vegetation can counteract this process by holding more water than the hill slopes would by themselves. Hillsides that have undergone timber harvest or have been burned will often suffer severely from mudslides and flooding. Runoff processes within the hydrologic cycle include streamflow and groundwater flow, each of which eventually results in flow to ocean reservoirs. Lakes and streams may occur in low points of the landscape due to streamflow, or where the groundwater table emerges above the surface. Other contributors of the runoff process include melting of glacial ice, and calving of icebergs into the sea. On a global basis, precipitation exceeds evapotranspiration over continents, and evaporation exceeds precipitation over ocean reservoirs, while excess water moves from continents to oceans as runoff. The ratio of precipitation rate to evaporation rate can vary dramatically between regions. For example, in tropical rainforests, precipitation may greatly exceed evapotranspiration.

### 3. Nitrogen Cycle

The nitrogen cycle represents one of the most important nutrient cycles found in ecosystems. Nitrogen is a required nutrient for all living organisms to produce a number of complex organic molecules like amino acids, the building blocks of






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proteins, and nucleic acids, including DNA and RNA. The ultimate store of nitrogen is in the atmosphere, where it exists as nitrogen gas ($N_2$). Other major stores of nitrogen include organic matter in soil and the oceans. Despite its abundance in the atmosphere, nitrogen is often the most limiting nutrient for plant growth. This problem occurs because $N_2$ gas is not biochemically usable by plants. Plants can only take up nitrogen in the form of ammonium ion ($NH_4^+$), nitrate ion ($NO_3^-$), or, less common, as amino acids. Animals receive the nitrogen they need for metabolism, growth, and reproduction by the consumption of living or dead organic matter containing molecules composed partially of nitrogen.

Nitrogen in the form of ammonium can be absorbed onto the surfaces of clay particles in the soil. The ammonium ion has a positive molecular charge and is normally held by negatively charged soil colloids. This process is sometimes called micelle fixation. Ammonium is released from the colloids by way of cation exchange. When released, most of the ammonium is often chemically altered by a specific type of autotrophic into nitrite ($NO_2^-$). Further modification by another type of bacteria converts the nitrite to nitrate ($NO_3$-). Both of these processes involve chemical oxidation and are known collectively as Nitrification. Unlike ammonium, nitrate is negatively charged and therefore does not absorb onto negatively charged clay surface. Consequently, nitrate is very mobile in soil and it is easily by leaching. Some of this leached nitrate flows through the hydrologic system until it reaches the oceans where it can be returned to the atmosphere by denitrification. Denitrification is also common in anaerobic soils and is carried out by heterotrophic bacteria. The process of denitrification involves the metabolic reduction of nitrate ($NO_3^-$) into nitrogen ($N_2$) or nitrous oxide ($N_2O$) gas. Both of these gases then diffuse into the atmosphere, thus removing nitrogen from the soil, accounting for the name, denitrification.

> In most ecosystems, nitrogen is primarily stored in living and dead organic matter. This organic nitrogen is converted into inorganic forms when it re-enters the biogeochemical cycle via decomposition. Decomposers chemically modify the nitrogen found in organic matter to ammonium ion ($NH_4^+$). This process is known as mineralization and it is carried out by a variety of bacteria and fungi.

Almost all of the nitrogen found in any ecosystem **originally comes from the atmosphere.** Significant amounts enter the soil in rainfall or through the effects of lightning. The majority, however, is biochemically fixed in ecosystems by specialized micro-organisms, all of which are bacteria of various types, including a variety of Gram-positive and Gram-negative bacteria, Actinomycetes, and cyanobacteria. Members of the bean family (legumes) and some other kinds of plants form mutualistic symbiotic relationships with certain types of nitrogen-fixing bacteria. In exchange for some nitrogen, the bacteria receive from the plants carbohydrates and special structures (nodules) in the roots where they can exist in a protected environment. Humans now fix approximately as much nitrogen industrially as does natural nitrogen fixation, thus dramatically altering the nitrogen cycle. Some of the major processes involved in this alteration include:

- The application of nitrogen fertilizers to crops has caused increased rates of denitrification and leaching of nitrate into groundwater. The additional nitrogen entering the groundwater system eventually flows into streams, rivers, lakes, and estuaries. In these systems, the added nitrogen can lead to eutrophication and associated hypoxia.
- Increased deposition of nitrogen from atmospheric sources because of fossil fuel combustion and forest burning. Both of these processes release a variety of solid forms of nitrogen through combustion and contribute to acid rain.
- Livestock ranching. Livestock release large amounts of ammonia into the environment from their wastes. This nitrogen enters the soil system and then the hydrologic system through leaching, groundwater flow, and runoff.
- Sewage waste and septic tank leaching.



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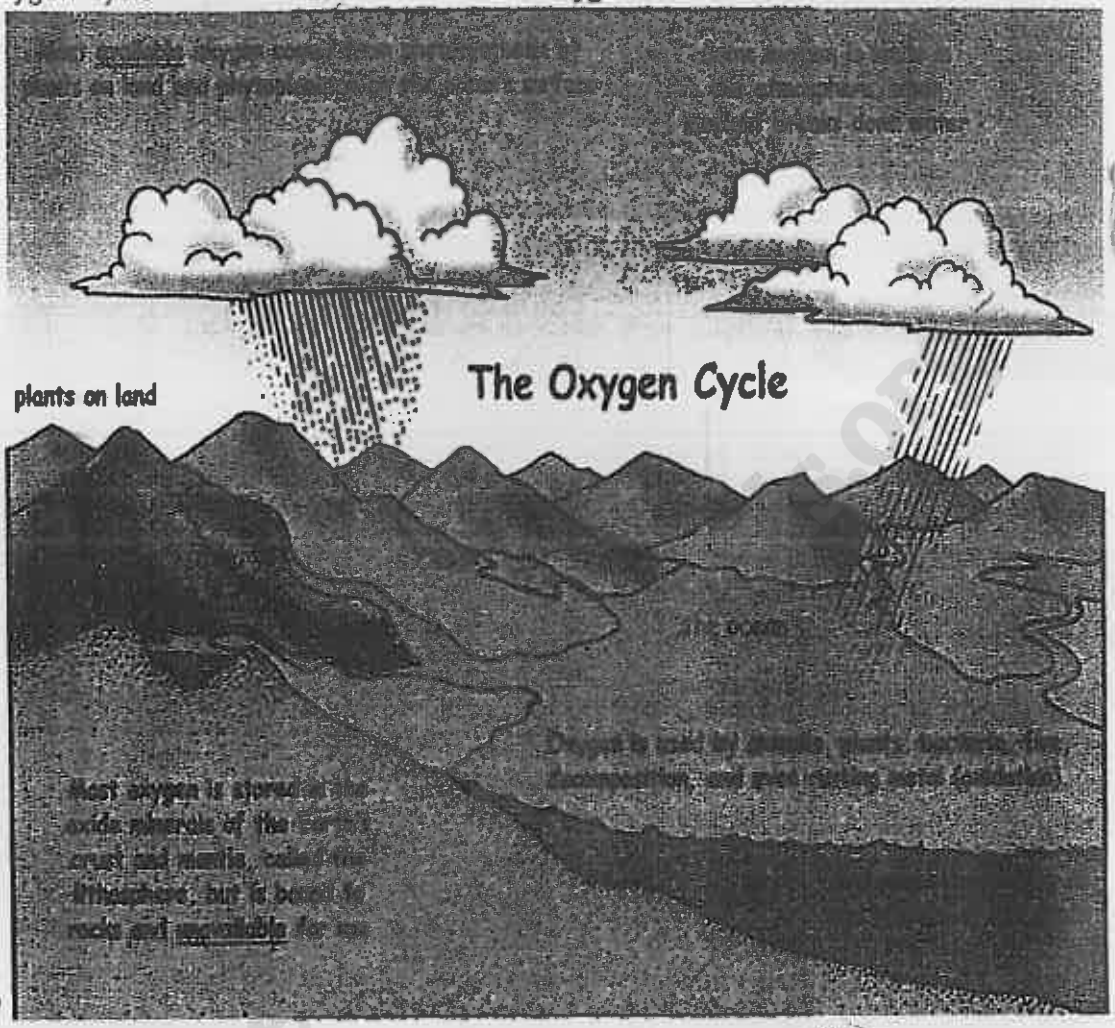
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### 4. Oxygen Cycle

The oxygen cycle describes the movement of oxygen within and between its three main reservoirs: the atmosphere, the biosphere, and the lithosphere. The main driving factor of the oxygen cycle is photosynthesis and because of this, oxygen and carbon cycles are usually linked and the two cycles are collectively called oxygen-carbon cycle.

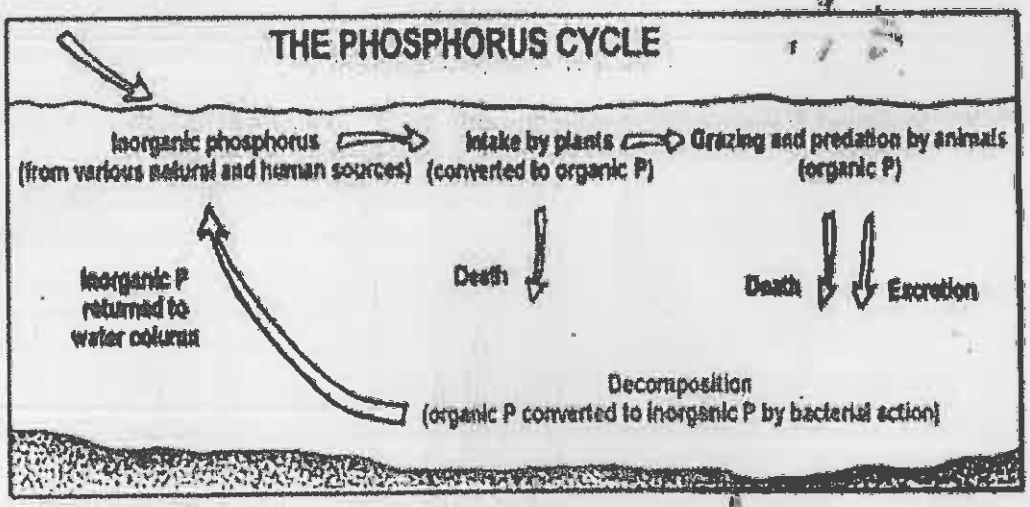



Oxygen, like carbon and hydrogen, is a basic element of life. In addition, in the form of $O_3$, ozone, it provides protection of life by filtering out the sun's UV rays as they enter the stratosphere. In addition to constituting about 20% of the atmosphere, oxygen is ubiquitous. It also occurs in combination as oxides in the Earth's crust and mantle, and as water in the oceans.

### Sedimentary cycles

#### *1. Phosphorous Cycle*

The phosphorus cycle is the biogeochemical cycle which characterizes the transport and chemical transformation of phosphorus through the lithosphere, hydrosphere and biosphere. Unlike






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many other biogeochemical cycles, the atmosphere does not play a significant role in the movement of phosphorus, since phosphorus and phosphorus-based compounds are typically solids at the normal ranges of temperature and pressure found on Earth. Therefore most of the phosphorus remains within rock, sediments, sand, and the ocean floor, with a fraction in living biomass. Phosphorus moves among trophic levels in an ecosystem by plant growth, herbivorous and carnivorous.

Phosphorus in the Earth's crust generally occurs in its maximally oxidized state, such as inorganic phosphate rocks. Phosphates are liberated from rocks in the weathering process of the natural environment. The small phosphorus losses in a terrestrial system caused by leaching through the action of rain are countered by gains from weathering rocks. In soil, phosphate is absorbed on clay surfaces and organic matter particles and becomes incorporated.

Plant species dissolve ionized forms of phosphate and take the mineral into their system. Herbivores obtain phosphorus by consuming plant biomass, and carnivores by consuming herbivores. Herbivores and carnivores excrete phosphorus as a waste product in urine and faeces. Phosphorus is then released back into the soil when plants or animal matter decompose and the cycle repeats. Phosphorus is an essential nutrient for plants and animals in the form of ions, including phosphate and hydrogen phosphate.

Phosphates are effective fertilizers, but they also cause pollution problems in lakes streams. Because phosphorus is often the nutrient in limited supply, even a small increase in availability can cause a significant effect. Over-enrichment of phosphate can lead to algae blooms. This excess of algae causes increased consumption by bacteria, which then leads to even higher bacterial concentrations. In the process the bacteria use up much of the dissolved oxygen in the water during cellular respiration and thereby cause the death of fish due to oxygen deprivation. The primary biological importance of phosphates is as a component of nucleotides, which serve as energy storage within cells (Adenosine triphosphate [ATP]) or, when linked together, form the nucleic acids deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). Phosphorus, primarily in the form of hydroxyapatite is a key structural component of animals. Approximately 80% of the phosphorus in vertebrate animals is in their bones and teeth. This element is also an important constituent of phospholipids, which are in all biological membranes.

### *2. Sulphur Cycle*

Sulphur is an even rarer component of living molecules than is nitrogen. Every protein needs disulphide bridges to make long three-dimensional polypeptide chains whose complex folds allow proteins to be engaged in countless biochemical reactions. Some volcanic eruptions are very large sources of sulphate.

Biogenic sulphur is produced on land by both sulphur-oxidizing and sulphate-reducing bacteria present in water, mud, and hot springs. Emitted gases are dominated by hydrogen sulphide, dimethyl sulphide (DMS), propyl sulphide, and Methyl Mercaptan. DMS is also generated in relatively large amounts by the decomposition of algal methionine in the ocean, and these emissions have been suggested to act as homeostatic controllers of the earth's climate. Higher concentrations of DMS would increase albedo by providing more condensation nuclei for increased cloudiness, the resulting reduced insolation would lower planktonic photosynthesis, and diminished DMS emissions would provide fewer condensation nuclei and let in more solar radiation. Later studies showed that not just the magnitude but also the very direction of this feedback are questionable.

Sulphur dioxide ($SO_2$) emitted from fossil fuel combustion and nonferrous metallurgy is rapidly oxidized to sulphates, whose deposition is the leading source of acid deposition, both in dry and in wet forms. Before their deposition, sulphur compounds remain up to 3 or 4 days in the lowermost



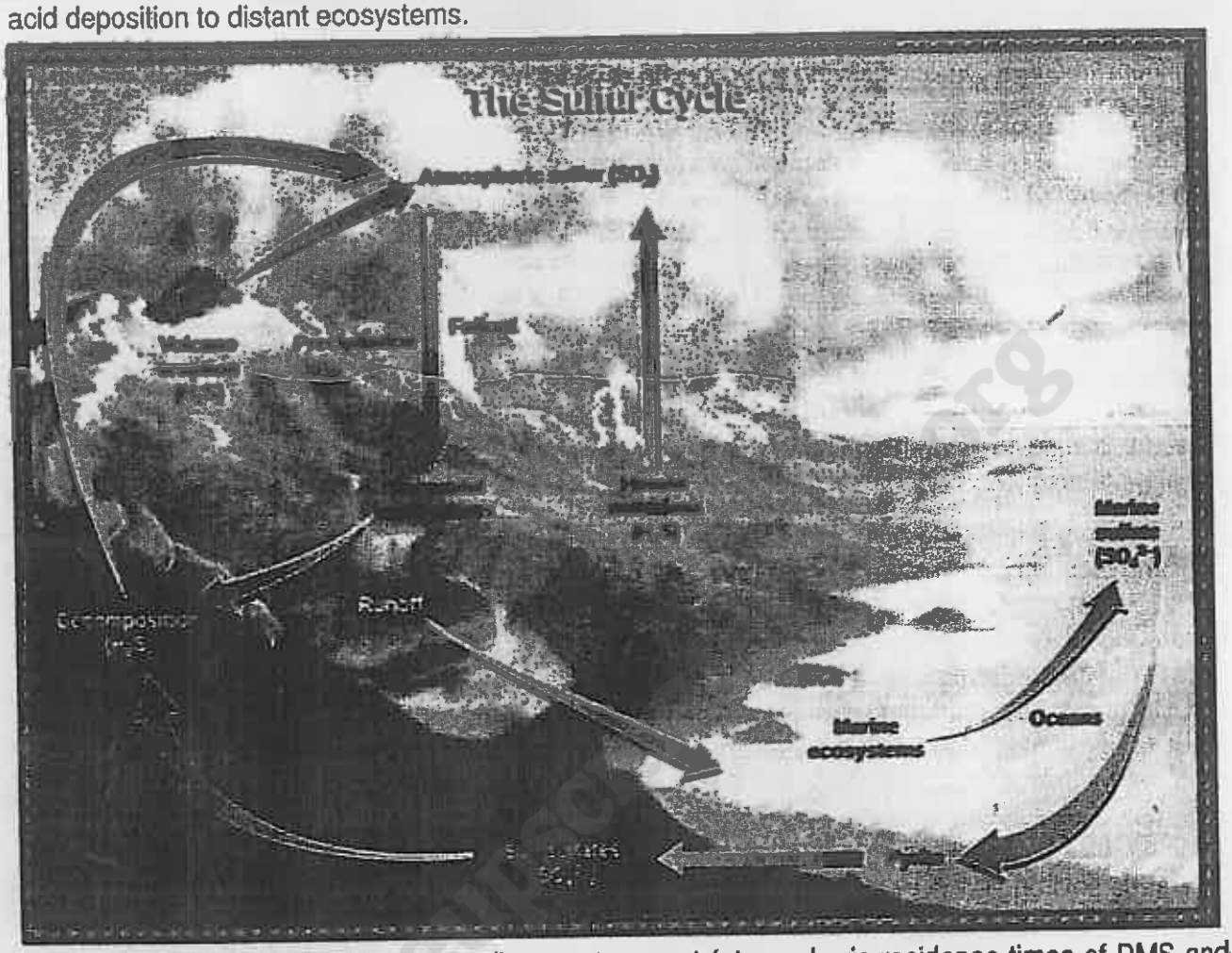
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troposphere, which means that they can travel several hundred to more than 1000 km and bring acid deposition to distant ecosystems.




Because of the limits on long-distance transport (atmospheric residence times of DMS and Hydrogen Sulphide are also short-lived), sulphur does not have a true global cycle as does carbon (via $CO_2$) or nitrogen (via de-nitrification), and the effects of significant acid deposition are limited to large regions or to semi continental areas. Deposited sulphates (and nitrates) have the greatest impact on aquatic ecosystems, especially on lakes with low or no buffering capacity, leading to the decline and then the demise of sensitive fish, amphibians, and invertebrates and eventually to profound changes in a lake's biodiversity. Leaching of alkaline elements and mobilization of toxic aluminium from forest soils is another widespread problem in acidified areas. Airborne sulphates also play a relatively major role in the radiation balance of the earth because they partially counteract the effect of greenhouse gases by cooling the troposphere.

## 3. ECOLOGICAL NICHE AND HABITAT

Every organism has a place to live in nature, a functional role in that place, and a complex set of adaptations for reproducing its kind. On the surface, this observation might seem to be obvious, even trivial. However, in order to understand our biological world—the biosphere, how it operates and ultimately how to protect it—we need to understand at a deep level how organisms interact with each other.

Organisms use their environment, relate to each other, and assemble into communities or ecosystems. The most fundamental and perhaps most difficult of these concepts is that of the ecological niche. A niche refers to the way in which an organism fits into an ecological community or



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ecosystem. Through the process of natural selection, a niche is the evolutionary result of a species' morphological (morphology refers to an organism's physical structure), physiological, and behavioural adaptations to its surroundings. At the same time, habitat is the actual location in the environment where an organism lives and consists of all the physical and biological resources available to a species.

## NICHE

Perhaps the simplest, most general definition of the ecological niche is an organism's "ecological position in the world". Even though this may seem straightforward, determining what constitutes an organism's position in the greater scheme of things is not a trivial pursuit.

An ecological niche is the role and position a species has in its environment - how it meets its needs for food and shelter, how it survives, and how it reproduces. A species' niche includes all of its interactions with the biotic and abiotic factors of its environment. It is advantageous for a species to occupy a unique niche in an ecosystem, because it reduces the amount of competition for resources that species will encounter.

### Individual Ecological Niches

Every living thing on Earth has a role to play in its environment. Many organisms living and working together fulfil their ecological niches. For example, in a forest where there are leaves scattered on the ground and an old rotting log sitting on the forest floor. There can be earthworms just under the soil feeding on decaying organic matter! There could also be centipedes eating small beetles and other organisms as well as a colony of ants that work and feed on dead insects. Even a couple of millipedes strolling around feeding on decaying leaves can also be found. In this small section of the vast forest, all of these organisms are filling an individual ecological niche. To some degree, their niches may overlap, but if looked into all aspects of their lives including where they live, how they survive, and how they reproduce, it may well be observed that they are each truly individual niches. Each ecological niche can be thought of as parts of a puzzle that go together to make the environment successful.

Overlap between the niches of two species (more precisely, overlap between their resource use curves) causes the species to compete if resources are limited. One might expect to see species constantly dying off as a result, but in many cases competing species can coexist without either being eliminated. This happens through niche partitioning (also referred to as resource partitioning), in which two species divide a limiting resource such as light, food supply, or habitat.

Species with narrow niches tend to be specialists, relying on comparatively few food sources. As a result, they are highly sensitive to changes in key environmental conditions, such as water temperature in aquatic ecosystems. For example, pandas, which only eat bamboo, have a highly specialized diet. Many endangered species are threatened because they live or forage in particular habitats that have been lost or converted to other uses. One well-known case, the northern spotted owl lives in cavities of trees in old-growth forests (forests with trees that are more than 200 years old and have not been cut, pruned, or managed), but these forests have been heavily logged, reducing the owl's habitat.

In contrast, species with broad niches are generalists that can adapt to wider ranges of environmental conditions within their own lifetimes (i.e., not through evolution over generations, but rather through changes in their behaviour or physiologic functioning) and survive on diverse types of prey. For example, wolf can kill and eat large, medium, or small prey, from deer to house cats, as well as other foods such as invertebrates and fruit, and can live in a range of habitats, from forests to open landscapes, farmland, and suburban neighbourhoods.



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One of the very important aspects of Niche is the relationship and interaction between organisms themselves. Owing to the innumerable biotic elements' existence in almost every region, biotic interaction is inevitable.




## Biotic Interaction

Biotic interactions are the effects; organisms in a community have on one another. In the natural world no organism exists in absolute isolation, and thus every organism must interact with the environment and other organisms. An organism's interactions with its environment are fundamental to the survival of that organism and the functioning of the ecosystem as a whole.

Biotic interactions can involve individuals of the same species (intraspecific interactions) or individuals of different species (interspecific interactions). These can be further classified by either the mechanism of the interaction or the strength, duration and direction of their effects. Species may interact once in a generation (e.g. pollination) or live completely within another (e.g. endosymbiosis). Effects range from consumption of another individual (predation, herbivory, or cannibalism), to mutual benefit (mutualism). Interactions need not be direct; individuals may affect each other indirectly through intermediaries such as shared resources or common enemies.

The types of Biotic Interaction can be classified further as follows –

### Competition

The competition is defined as the process in which the organism fights for the same resources. It can be intra specific or inter specific. The competition between the organisms of the same species is referred as an intra-specific com-



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petition. This type of competition is very severe as the organism of the same species has same requirement for food, water, shelter and light etc. The completion between the organisms of the different species is refereed as an inter-specific competition. The intra specific competition keeps a close check on the size of population. It decreases the birth and survival rate. The organism in this group has similar characteristics and establishes their own territory. The plants of the same species can grow only when they are shaped properly. The population belongs to the similar trophic level. They compete for the same natural resources. For example, in forests the different types of trees and vegetations compete for water, sunlight and other similar resources. The carnivorous animals compete for the similar prey. The individuals of different species have no such common interest. They prove their superiority and inferiority to survive. If the resources are few the superior individuals outperform the inferior individuals.

**Predation**

The predation is defined as an interaction between the members of different species. In this one member catches the prey and kills them. They are known as predators. The majority of them are animals which are mainly carnivorous. The herbivorous animals can also act as a predator. They remove the plants as well as seeds. There are few plants which also act as predators and are known as insectivorous plants. Their role is interchangeable that means the predators can act preys and vice a versa. For example, frog feeds for snakes and the snakes feed for eagle. The predators have strength, agility, tearing ability to capture and eat the prey. The population of predator is small. The preys are larger in number and cannot be eliminated. The prey has a high reproductive ability. If there are no predators the population of the prey will increase at such a rate that it will cross the carrying capacity of environment. The species go under degeneration. The predator keeps the population under check. The prey maintains its optimum activity as the sick individuals are removed by predators.

**Parasitism**

The parasitism is defined as the process in which two organisms of different species are present and in which one of the organism acts as a parasite and the other organism acts as a host. The food is obtained from the host. The parasite spends a part or their full life in the body of host. There are different types of parasites available on our planet. There are Ecto and Endo parasites. The Ecto parasites occur on the body surface of host and the Endo parasites occur inside the body of host. They can be intracellular or extracellular. They can be tissue parasites, gut parasites and the body fluid parasite. The Ecto parasites suck blood, juice etc. There are also temporary and permanent parasites. The temporary parasites occur in the host for some part of their life. It includes the female mosquitoes and bed bugs. The permanent parasites occur in the host for whole of their life. It includes the Ascaris and Lice. They are also known as the intermittent parasites. There are Holo parasites and hemi parasites in which the Holo parasites depend completely on the host for their requirements. It includes Rafflesia and Cuscuta. The Cuscuta receives the flower inducing hormone from host. It can be a short day plant or long day plant. The host can also be a short day or long day. The hemi parasites do not depend completely on the host for their requirements. They make themselves rest of their food. There are certain parasites which occur in the plant and are known as the Phyto parasites. They can be stem or root parasites. The stem parasites occur in the region of stem of plant. It includes Viscum and aphids. The root parasites occur in the region of root of plant. It includes the Rafflesia and root nematodes. The pathogenic parasites are those which harm the host and include the corny bacterium, mycobacterium, vibrio, rusts and smuts, fungal and the ring worm disease. The non-pathogenic parasites are those which do not harm the host cell. The host cells provide food and nutrition and they are spared. It includes the Entamoeba Coli. There is a hyper parasite which resides on the other parasite. It includes the bacterial virus and the powdery mildew. The parasite infects the host through skin, direct contact with the



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person who is infected; enter the human body through insect bite, cyst or egg swallowing. They can be Ascaris or Tape worm. It also includes the kala azar and Tse Tse fly. There are certain general features of the parasites. They are anaerobic and have resistant eggs which provide the safety. It helps in the safe transfer of off springs. They lose some of their organs and divide at a faster rate. They have adhesive organs.

**Mutualism**

Mutualism is the name given to associations between pairs of species that bring mutual benefit. The individuals in the populations of each mutualist species grow and/or survive and/or reproduce at a higher rate when in the presence of individuals of the other species. This type of interaction is an extremely widespread phenomena. For example, most rooting plants have mutualistic associations with fungal Mycorrhizae. Mycorrhizae increase the capability of plant roots to absorb nutrients like nitrogen and phosphorus. In return, the roots of the host provide support and a constant supply ofcarbohydrates for consumption. Mutualistic interactions between species can be of two types: **symbiotic or non-symbiotic.** In a symbiotic mutualism, individuals interact physically and their relationship is biologically essential for survival. At least one member of the pair cannot live without close contact with the other. For example, the fungal-algal symbiosis that occurs in lichens. More common in nature is the non-symbiotic mutualism. In this interaction, the mutualists live independent lives yet cannot survive without each other. The most obvious example of an interaction of this type is the relationship between flowering plants and their insect pollinators.

**Commensalism**

The commensalism is defined as the process in which two organisms of different species are present and in which one organism is benefitted while the other one acts as a neutral organism. It is neither harmed and nor benefitted. The lions are followed by the jackals and the fox follows the seal to obtain food. There are small plants which grow on the larger plants for only space and are known as epiphytes. They do not depend upon the nutrition. The seeds and fruits of the plants are dispersed by the animals which are present on their fur. The commensal can be harmful or non-harmful. In the human intestine E.Coli is present which acts on the undigested food and also keep an eye on the putrefying bacteria. They also release some vitamins.

**Amensalism**

The amensalism is defined as the process in which two organisms of different species are present and in which one organism do not allow the other organism to survive. This mode of inhibition occurs with the use of Allochemics. For example, the growth of staphylococcus is inhibited by the use of penicillin. There are the smoother crops which are barley, sorghum and sunflower. They do not allow theweed to grow near them. The black nut has roots which form a chemical called the Juglone. The growth of wheat is inhibited by the convolvulus. The Juglone is toxic to apple and tomato. The plant known as Grevillea does not allow its seedlings to grow nearby by secreting an Allo chemical by its roots.

**Neutralism**

Neutralism is the most common type of inter-specific interaction. Neither population directly affects the other. What interactions occur are slight and indirect. The simple presence of the two species should not directly affect the population level of either. An example of neutralism would be the interaction between rainbow trout and dandelions living in a mountain valley.

**Natural Selection in Ecosystems**

As species interact, their relationships with competitors, predators, and prey contribute to natural selection and thus influence their evolution over many generations. These common goals drive natural selection for a wide range of traits and behaviours, some of which are:



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- **Mimicry** – In the ecosystem, organisms have evolved adhering to their survival. They have developed many different characteristics which may be crucial for their survival in the ecosystem. Mimicry is a similar phenomenon assisting one of the nature's enchantment. The mimicry is defined as the process of resemblance of organism to the other organism or with the other object so that they can be concealed or protected as the time demands. Mimic is an organism which exhibits the mimicry. The model is defined as an object which resembles a mimic. In this type the colour, form, pattern and scent of an organism resemble to the other organism or the surrounding objects. It helps the organism to protect it from predator and also help in the easy trapping of prey. It also helps to secure pollination in the orchid. The prey develops a mimicry which is known as the protective mimicry. The predator develops a mimicry which is known as the aggressive mimicry. The protective mimicry is of different types. It can be concealing or warning. In concealing type the organism resembles the surroundings so that they cannot be detected easily. It includes the stick insect, larva of moth and the leaf insect. These different types of organism resemble the twigs and green leaf. In the warning type the organism resembles the poisonous organisms. It includes the palatable butterfly and non-palatable butterfly. The aggressive mimicry is of different types. It can be concealing and alluring. In concealing type the predator resembles the surroundings so that they cannot be detected easily. They hide and strike suddenly. It includes the praying mantis. In alluring type the predator attracts the prey by resembling an object which is liked by the prey. It includes the mouth of African lizard which resembles a flower. The spider also resembles an orchid flower.
- Optimal foraging strategies enable predators to obtain a maximum amount of net energy per unit of time spent foraging. Predators are more likely to survive and reproduce if they restrict their diets to prey that provide the most energy per unit of handling time and focus on areas that are rich with prey or that are close together.
- Avoidance/escape features help prey elude predators. These attributes may be behavioural patterns, such as animal herding or fish schooling to make individual organisms harder to pick out. Markings can confuse and disorient predators: for example, the Automeris moth has false eye spots on its hind wings that misdirect predators.
- Features that increase handling time help to discourage predators. Spines serve this function for many plants and animals, and shells make crustaceans and molluscs harder to eat. Behaviors can also make prey harder to handle: squid and octopus emit clouds of ink that distract and confuse attackers, while hedgehogs and porcupines increase the effectiveness of their protective spines by rolling up in a ball to conceal their vulnerable underbellies.
- Some plants and animals emit noxious chemical substances to make themselves less profitable as prey. These protective substances may be bad-tasting, antimicrobial, or toxic. Many species that use noxious substances as protection have evolved bright coloration that signals their identity to would-be predators—for example, the black and yellow coloration of bees, wasps, and yellow jackets. The substances may be generalist defences that protect against a range of threats, or specialist compounds developed to ward off one major predator. Sometimes specialized predators are able overcome these noxious substances.

| Type of Interaction | Effect of Interaction | Examples |
|---|---|---|
| *Competition* | Both species are harmed (population growth rates are reduced). | Oak trees and maple trees competing for light in a forest, wading birds foraging for food in a marsh |
| *Predation* | One species benefits, one is | Predation: wolf and rabbit |



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| | | |
|---|---|---|
| *Parasitism* | harmed. | Parasitism: flea and wolf |
| *Mutualism* | Both species benefit. Relationship may not be essential for either. | Humans and house pets, insect pollination of flowers |
| *Commensalism* | One species benefits, one is not affected. | Cow's excreta as food and shelter for Dung Beetles |
| *Amensalism* → | One species harms another (typically by releasing a toxic substance), but is not affected itself. | Allelopathy (plants that produce substances harmful to other plants): rye and wheat suppress weeds when used as cover crops, broccoli residue suppresses growth of other vegetables in the same plant family |
| *Neutralism* | No net benefit or harm to either species | Spiders and Cacti in desert |

## 4. ECOLOGICAL SUCCESSION

### *What is an ecological succession?*

"Ecological succession is the gradual process by which ecosystems change and develop over time. Nothing remains the same and habitats are constantly changing. There are two main types of succession, primary and secondary."

"Ecological succession" is the observed process of change in the species structure of an ecological community over time. Within any community some species may become less abundant over some time interval, or they may even vanish from the ecosystem altogether. Similarly, over some time interval, other species within the community may become more abundant, or new species may even invade into the community from adjacent ecosystems. This observed change over time in what is living in a particular ecosystem is "ecological succession".

Ecological succession may also occur when the conditions of an environment suddenly and drastically change. A forest fires, wind storms, and human activities like agriculture all greatly alter the conditions of an environment. These massive forces may also destroy species and thus alter the dynamics of the ecological community triggering a scramble for dominance among the species still present. Succession is one of the major themes of our Nature Trail. It is possible to observe both the on-going process of succession and the consequences of past succession events at almost any point along the trail. The rise and the decline of numerous species within our various communities illustrate both of the types of motive forces of succession: the impact of an established species to change a site's environmental conditions, and the impact of large external forces to suddenly alter the environmental nature of a site. Both of these forces necessarily select for new species to become ascendant and possibly dominant within the ecosystem.

Every species has a set of environmental conditions under which it will grow and reproduce most optimally. In a given ecosystem, and under that ecosystem's set of environmental conditions, those species that can grow the most efficiently and produce the most viable offspring will become the most abundant organisms. As long as the ecosystem's set of environmental conditions remains constant, those species optimally adapted to those conditions will flourish. The "engine" of succession, the cause of ecosystem change, is the impacts of established species have upon their own environments. A consequence of living is the sometimes subtle and sometimes overt alteration of one's own environment. The original environment may have been optimal for the first species of plant or animal, but the newly altered environment is often optimal for some other species of plant



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or animal. Under the changed conditions of the environment, the previously dominant species may fail and another species may become ascendant.

Ecological Succession proceeds through various stages, starting from Pioneer Community to Climax stage. Each such stage is called sere or seral community. A seral community (or sere) is an intermediate stage found in ecological succession in an ecosystem advancing towards its climax community. In many cases more than one seral stage evolves until climax conditions are attained. A prisere is a collection of seres making up the development of an area from non-vegetated surfaces to a climax community. A seral community is the name given to each group of plants within the succession. Depending on the substratum and climate, a seral community can be one of the following:

- Hydrosere - Community in water
- Lithosere - Community on rock
- Psammosere - Community on sand
- Xerosere - Community in dry area
- Halosere - Community in saline body (e.g. a marsh)

**Processes**

The processes of ecological succession are –



1. *Nudation:* It is the development of a bare site uninhabited by any organisms. The process is usually caused by disturbances. These factors can be either topographic (soil erosion, wind action etc.) ;Climatic (hails, storm, glaciations, fire etc.) ;Or biotic (human activities). The area thus formed can sustain only autotrophic organisms which can utilize inorganic substrates. The environmental conditions are set up for the inhabitation of new species. For example, secretion of acidic substances by lichen species helps in breakdown of rocks into soil.
2. *Invasion or migration*: The process of invasion or migration helps the arrival of seeds, spores or other reproductive propagules for establishment of species. Invasive species are non-native organisms which can spread widely in a community. These are usually threatening the normal ecosystem and causative agents for community disturbance. However, in succession process, they help to alter the soil texture and function.
3. *Ecesis:* This is the initial establishment of plant community. This is dependent on the soil structure. The stage is also called as 'colonization'. In this stage, the early colonizing species proliferate abundantly through germination, growth, and reproduction. This is the stage at which the pioneer species survive the dispersal mechanisms. The different pioneer species can have different maturation rates which allow this process to be longer and gradually allowing replacement of some species by others. The process also makes the soil structure suitable for those species whose seeds were present in the existing ecosystem but were unable to germinate for lack of suitable community support.
4. *Aggregation* is the increase in population of the species which has become established in the area. The shrubs replace the small herbs in most successions. This also proves as a source of food for future inhabitants.
5. *Competition*: Once the few initial species have become established the intra as well as inter specific competition among the species starts. This stage is called competition. The competition is usually for resources such as food, water etc. Competition is found in both plants as well as



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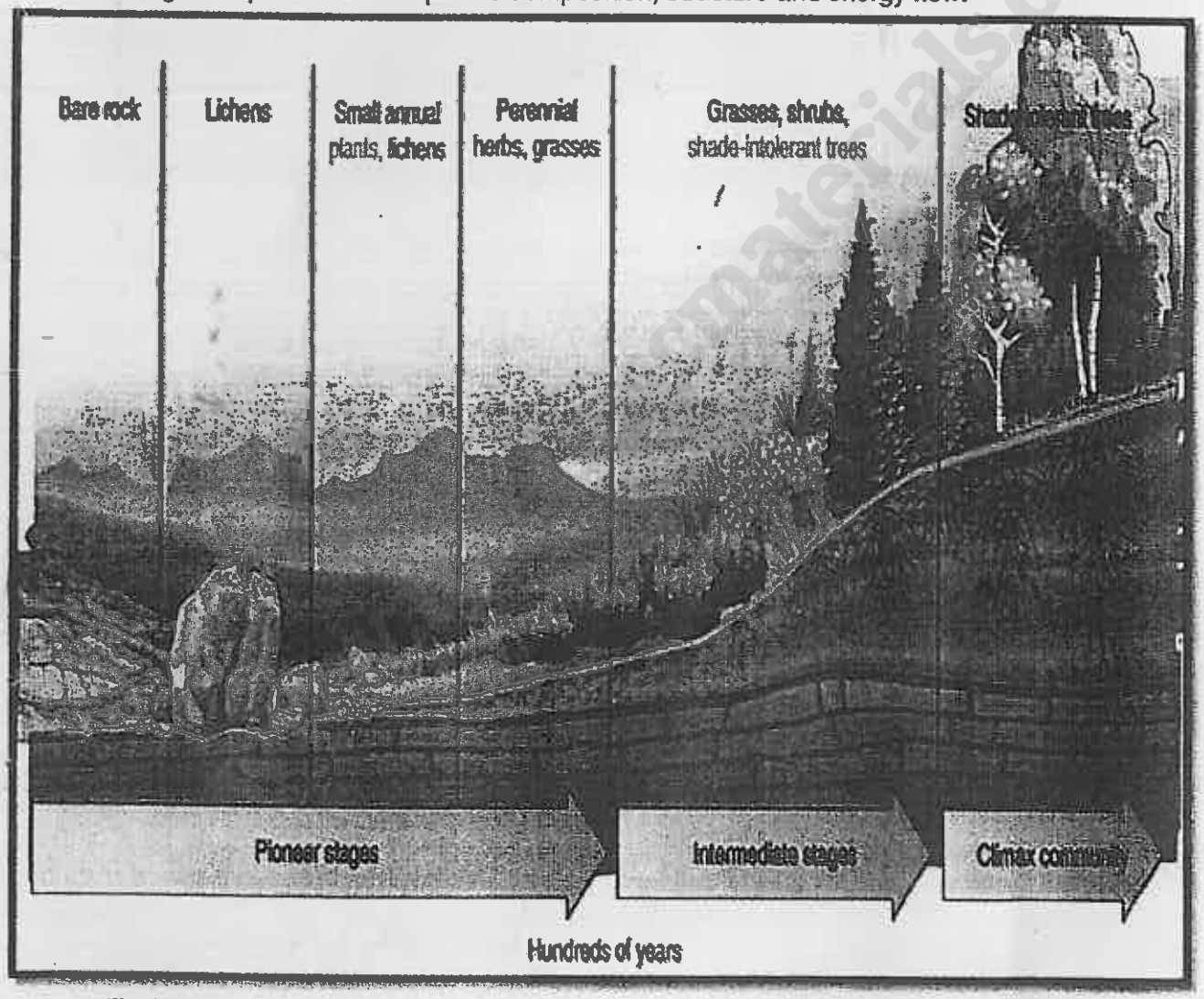
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animal species. The process leads to sharing of resources (resource partitioning) or competitive exclusion.

6. *Reaction:* The environmental conditions get modified by the action of species occupying the habitat. These changes subsequently trigger the displacement and replacement of one species by another. The existing community will be unable to support itself due to the harsh conditions. The major underlying mechanism is autogenic succession in which the plants themselves alter the environmental conditions. Early colonizers usually facilitate the way for establishment of mature species.
7. *Stabilization* is the process by which the climax community gets established. A climax community is mature, self-sustaining, stable and is the final stage of succession. The physical and chemical conditions are altered and stabilized to such levels that it supports the entire community. The climax communities are best adapted to the regions of succession and the community structure is likely to continue until another disturbance steps in. This represents a steady state of ecological equilibrium with specific composition, structure and energy flow.




Ecological succession breaks down into three fundamental phases: **Primary Succession, Secondary Succession** and a **Climax Community** .

**Primary Succession**

Primary succession occurs when organisms colonize an area devoid of life, usually after a catastrophic natural event that leaves the land barren. Often the first organisms to take hold are al-



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gae, fungi and simple plants such as lichens and mosses. Over time a thin layer of soil builds up so that more advanced plants, such as grasses and ferns, can take root. Along with the successful colonization of plants come animals such as insects, birds and small invertebrates. One example of primary succession is the pioneer communities that begin to inhabit a newly created lava bed, where life cannot exist until the rock surface cools to a moderate temperature.

*Pioneer Community –*

It is a group of organisms that invade a new area in the process of Ecological Succession. These organisms are typically plants, animals and fungi. They are the first to move into a new habitat and often make the habitat more hospitable for future inhabitants. A variety of processes lead to the formation of new habitats on Earth. Some examples of these processes include wildfires and volcanic eruptions. Most newly formed habitats are not immediately able to host a large variety of organisms. There is often a lack of nutrients to support a variety of life, among other limiting factors. The process of a habitat slowly gaining more complex organisms over time is known as biological succession. The first organisms involved in the succession are the pioneer communities.

The Pioneers through their death and decay leave patches of organic matter in which small animals can live. The organic matter produced by these pioneer species produce organic acids during decomposition that dissolve and etch the substratum releasing nutrients to the substratum. Organic debris accumulates in pockets and crevices, providing soil in which seeds can become lodged and grow. As the community of organisms continues to develop, it becomes more diverse and competition increases, but at the same time new niche opportunities develops. The pioneer species disappear as the habitat conditions change and invasion of new species progresses, leading to the replacement of the preceding community.

**Secondary Succession**

Most ecological change occurs as secondary succession. In fact, most biological communities are in a continual state of secondary succession. This term describes the process in which an established community is replaced by a different set of plants and animals. Secondary succession is gradual, always moving toward the climax community. It occurs when an area that has previously had an ecological community is so disturbed or changed that the original community was destroyed and a new community moves in. This is more common than primary succession, and is often the result of natural disasters such as fires, floods, and winds, as well as human interference such as logging and clear-cutting. It starts from previously built-up substrata with already exists living matter. This type of succession starts in a given area where the conditions of life favourable because of the fact that the area was occupied earlier by well-developed community e.g., succession in an abandoned crop field. Such successions are comparatively more rapid

***Some other types of Ecological Succession are as follows:***

**Autotrophic Succession:** It is characterised by early and continued dominance of autotrophic organisms like green plants. It begins in a predominantly inorganic environment and the energy flow is maintained indefinitely.

**Allogenic Succession:** In some cases, however, the replacement of the existing community is caused largely by any another external condition and not by the existing organisms. Such a course is referred to as allogenic succession.

**Autogenic Succession:** After the succession has begun, in most of the cases, it is the community itself, which, as a result of its reactions with the environment, modifies its own environment and thus causing its own replacement by new communities.

**Micro Succession:** This involves the succession of microorganisms. It begins in a predominantly organic environment and there is a progressive decline in the energy content. The succession of protozoa in the hay infusion is called micro-succession.



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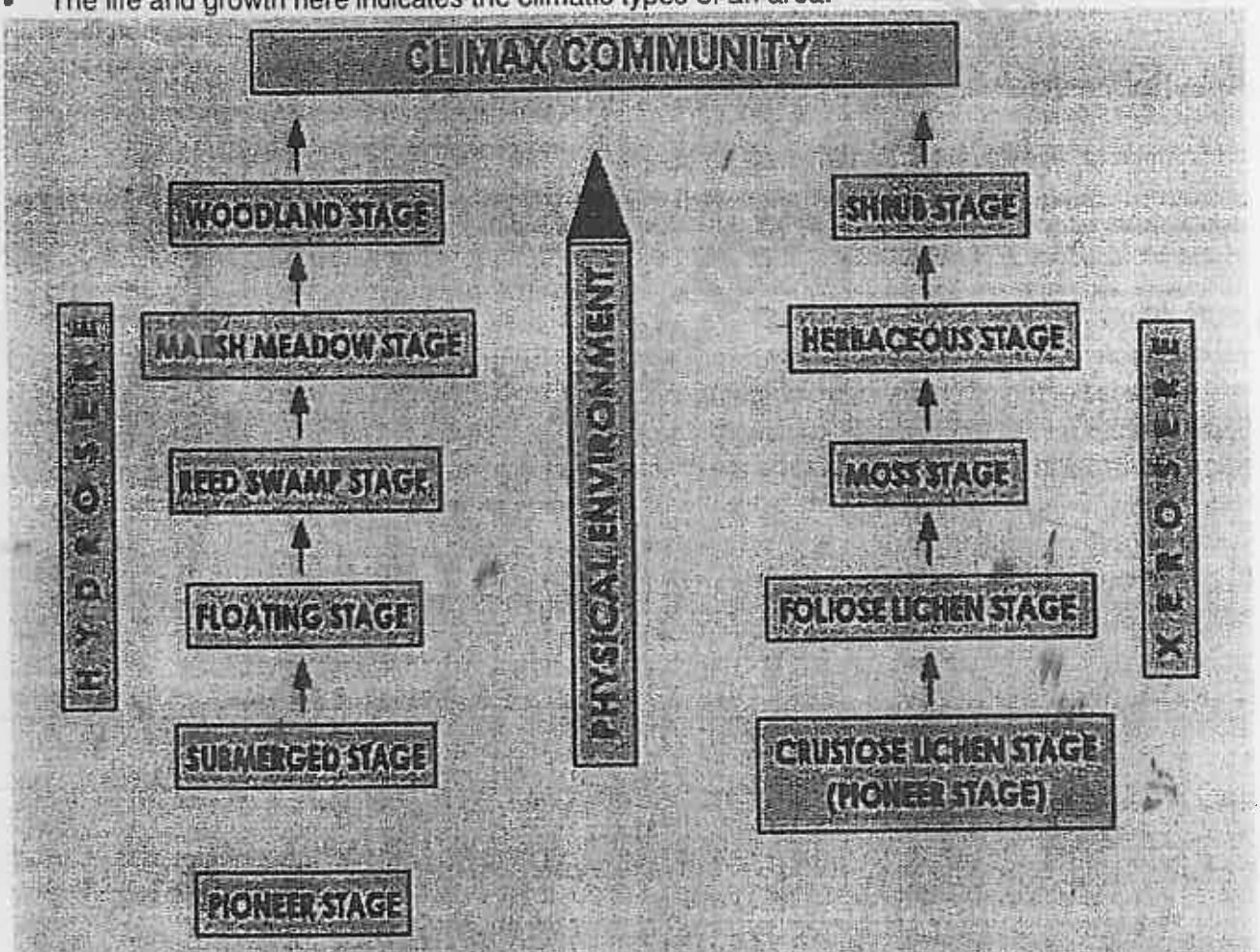
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**Climax** Community

The culminating stage in the succession is the establishment of a stable community in the area, and this is known as the climax community. Thus, the final stage of ecological succession is the formation of the climax community. Climax communities are relatively stable and can vary widely in a given region. Some of the features or the characteristics of the climax community are:

- The vegetation of this region is tolerant to the environmental conditions.
- The species diversity is large and the food chains of these species are complex and with spatial structure.
- It is a balanced ecosystem.
- There is also equilibrium between the nutrients taken in from the soil and the return of the nutrients to the soil by litter fall.
- The individual organisms in the climax ecosystem are replaced by other organisms of the same kind. Thus maintaining species equilibrium.
- The life and growth here indicates the climatic types of an area.




A diagrammatic respresentation of the developmental stages of plant succession during hydrosere and xerosere(lithosere) leading to the formation of mesophytic climax forest community



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# CHAPTER – 7
# ENVIRONMENTAL POLLUTION

## 1. WHAT IS POLLUTION?

Pollution is defined as Presence of matter (gas, liquid, solid) or energy (heat, noise, radiation) whose nature, location, or quantity directly or indirectly alters characteristics or processes of any part of the environment, and causes (or has the potential to cause) damage to the condition, health, safety, or welfare of animals, humans, plants, or property. The agents which cause environmental pollution are called pollutants. Pollutants may be defined as a physical, chemical or biological substance unintentionally released into the environment which is directly or indirectly harmful to humans and other living organisms.

Overview

1. Definition
   1.1. Classification of Pollutants
   1.2. Types of Pollution
2. Air Pollution
   2.1 Smog
   2.2 Indoor Air pollution
3. Water Pollution
4. Noise Pollution
5. Soil Pollution
6. Radiation Pollution
7. Plastic Pollution

### 1.1. CLASSIFICATION OF POLLUTANTS

| Existence in nature | Form they persist in | Their degradability | Their origin |
|---|---|---|---|
| 1. Quantitative Pollutants- The substances which are already present in the environment, but are termed as pollutants when their concentration (quantity) increases in the environment. For example $CO_2$ is present in the environment in greater quantity than normal and is hence termed as a quantitative pollutant.<br>2. Qualitative pollutant- The substances which are not normally present in the environment and are added by human beings and are pollutants by nature. E.g. Insecticides, pesticides | 1. Primary Pollutants- The substances which are directly emitted from the source and remain in that form are termed as primary pollutants. For example smoke, fumes, ash, dust, nitric oxide and sulphur dioxide<br>2. Secondary pollutants- The substances which are formed by chemical reaction between the primary pollutants and constituents of the environment (i.e. those which are already present in the environment). For example smog, ozone, sulphur trioxide, nitrogen dioxide. | 1. Biodegradable pollutants - Such pollutants are quickly degraded by microbes (bacteria and fungi) in nature. For example sewage, kitchen waste etc.<br>2. Slowly-degradable pollutants - These pollutants remain in the environment for many years in an unchanged condition and take decades or longer to degrade. For example DDT (pesticides) and most plastics.3. Non-biodegradable pollutants -Such pollutants are not degraded by microbes in the nature and they keep on accumulating. Sometimes they may get biologically accumulated (magnified) as they pass through food chains. Examples of such pollutants are: DDT, mercury, lead, arsenic, some pesticides, radioactive substances, glass, plastic, aluminium pieces, etc. | 1. Natural<br>2. Anthropogenic |

## 1.2 TYPES OF POLLUTION

Different **Types** of pollution are categorized based on the part of the environment which they affect or result which the particular pollution causes. Each of these types has its own distinctive



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causes and consequences. Categorized study of pollution helps to understand the basics in more detail and produce protocols for the specific types. Accordingly, the main types of pollution are:

- *Air Pollution (Smog and Indoor Air pollution)*
- *Water Pollution*
- *Noise Pollution*
- *Soil Pollution*
- *Radiation Pollution*
- *Plastic Pollution*

## 2. AIR POLLUTION

Air pollution may be defined as the presence of any solid, liquid or gaseous substance including noise and radioactive radiation in the atmosphere in such concentration that may be directly and indirectly injurious to humans or other living organisms, plants, property or interferes with the normal environmental processes. Air pollutants are of two types:

1. Particulate matter, and
2. Gaseous pollutants

**Particulate Matter (PM) –**

**What are particulates?**

These are small pieces of solid material dispersed into the atmosphere. **Examples** smoke particles from fires, bits of asbestos, dust particles and ash from industries)

The effects of particulates range from soot to the carcinogenic effects of asbestos, dust particles and ash from industrial plants that are dispersed into the atmosphere. Repeated exposure to particulates can cause them to accumulate in the lungs and interfere with the ability of lungs to exchange gases. Their size ranges from 0.001 to 500 μm in diameter. Particles less than 10μm ($PM_{10}$) float and move freely with the air current. Particles which are more than 10μm in diameter settle down. Particles less than 0.02 μm ($PM_{2.5}$) form persistent aerosols.

**Fly Ash**

Fly ash is a by-product from burning pulverized coal in electric power generating plants. During combustion, mineral impurities in the coal (clay, feldspar, quartz, and shale) fuse in suspension and float out of the combustion chamber with the exhaust gases. As the fused material rises, it cools and solidifies into spherical glassy particles called fly ash. Fly ash is collected from the exhaust gases by electrostatic precipitators or bag filters. Fly Ash particles are oxide rich and consist of silica, alumina, oxides of iron, calcium and magnesium and toxic heavy metals like lead, arsenic, cobalt and copper. Fly ash is a type of particulate matter and therefore is a contributor to pollution in following ways:

- Groundwater contamination
- As SPM in lower atmosphere
- Respiratory problems
- Reducing efficiency of plants and trees by accumulating over their leaves
- Even their exposures are perceived to be a health hazard

Fly ash is used by industries and households in contemporary times as

- prime material in blocks, paving or bricks
- it provides an excellent prime material to be used in blended cement, mosaic tiles, and hollow blocks among others
- it has also been used recently for embankment and mine fills.
- it can be used for reclaiming the wastelands

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**Lead and other metals particles**

Tetraethyl lead (TEL) is used as an anti-knock agent in petrol for smooth and easy running of vehicles. The lead particles coming out from the exhaust pipes of vehicles are mixed with air. If inhaled it produces injurious effects on kidney and liver and interferes with development of red blood cells. It can also cause nervous system damage and digestive problems and, in some cases, cause cancer. Lead mixed with water and food can create cumulative poisoning. It has long term effects on children as it lowers intelligence.

Oxides of Iron, aluminium, manganese, magnesium, zinc and other metals have adverse effect due to deposition of dust on plants during mining operations and metallurgical processes. They create physiological, biochemical and developmental disorders in plants and also contribute towards reproductive failure in plants.

**Gaseous Pollutants**

These are type of pollutants which gets mixed with air and alters the constituents of the air. Power plants, industries, different types of vehicles – both private and commercial use petrol, diesel as fuel and release gaseous pollutants such as carbon dioxide, oxides of nitrogen and sulphur dioxide along with particulate matter in the form of smoke. All of these have harmful effects on plants and humans. Other examples of gaseous pollutants include Ozone, Ammonia, Carbon Monoxide etc.

***Major Gaseous Air Pollutants***

**Carbon Monoxide (CO):**

- Carbon monoxide (CO) is a colourless, odourless gas emitted from incomplete combustion of carbon based fuels including petrol, diesel and wood. In urban areas, the majority of CO emissions to ambient air come from mobile sources. CO is also produced from the combustion of natural and synthetic products such as cigarettes.
- CO can cause harmful health effects by reducing oxygen delivery to the body's organs (like the heart and brain) and tissues. At extremely high levels, CO can cause death.
- Exposure to CO can reduce the oxygen-carrying capacity of the blood. People with several types of heart disease already have a reduced capacity for pumping oxygenated blood to the heart, which can cause them to experience myocardial ischemia (reduced oxygen to the heart), often accompanied by chest pain (angina), when exercising or under increased stress. For these people, short-term CO exposure further affects their body's already compromised ability to respond to the increased oxygen demands of exercise or exertion. It can slow our reflexes and make us confused and sleepy.

**Carbon Dioxide ($CO_2$):**

Carbon dioxide is the most prominent gas emitted due to the burning of fossil fuels. It is the major Green House Gases contributing to the global warming.

**Sulphur Dioxide ($SO_2$):**

Sulphur dioxide ($SO_2$) is one of a group of highly reactive gasses known as "oxides of sulphur." The largest sources of $SO_2$ emissions are from fossil fuel combustion at power plants (73%) and other industrial facilities (20%). Smaller sources of $SO_2$ emissions include industrial processes such as extracting metal from ore, and the burning of high sulphur containing fuels by locomotives, large ships, and non-road equipment. $SO_2$ is linked with a number of adverse effects on the respiratory system.

Short-term exposures to $SO_2$, ranging from 5 minutes to 24 hours, with an array of adverse respiratory effects including bronchoconstriction and increased asthma symptoms. These effects

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are particularly important for asthmatics at elevated ventilation rates (e.g., while exercising or playing.) Emissions that lead to high concentrations of $SO_2$ generally also lead to the formation of other oxides of Sulphur (SOx). Control measures that reduce $SO_2$ can generally be expected to reduce people's exposures to all gaseous SOx. This may have the important co-benefit of reducing the formation of fine sulphate particles, which pose significant public health threats. SOx can react with other compounds in the atmosphere to form small particles. These particles penetrate deeply into sensitive parts of the lungs and can cause or worsen respiratory disease, such as emphysema and bronchitis, and can aggravate existing heart disease, leading to increased hospital admissions and premature death.

**Nitrous Oxide ($NO_2$):**

- Nitrogen dioxide is a nasty-smelling gas. Some nitrogen dioxide is formed naturally in the atmosphere by lightning and some is produced by plants, soil and water. However, only about 1% of the total amount of nitrogen dioxide found in our cities' air is formed this way.
- Nitrogen dioxide is an important air pollutant because it contributes to the formation of photochemical smog, which can have significant impacts on human health. The major source of nitrogen dioxide is the burning of fossil fuels: coal, oil and gas. Most of the nitrogen dioxide in cities comes from motor vehicle exhaust (about 80%). Other sources of nitrogen dioxide are petrol and metal refining, electricity generation from coal-fired power stations, other manufacturing industries and food processing.
- The main effect of breathing in raised levels of nitrogen dioxide is the increased likelihood of respiratory problems. Nitrogen dioxide inflames the lining of the lungs, and it can reduce immunity to lung infections. This can cause problems such as wheezing, coughing, colds, flu and bronchitis. Increased levels of nitrogen dioxide can have significant impacts on people with asthma because it can cause more frequent and more intense attacks. Children with asthma and older people with heart disease are most at risk.

**Ozone ($O_3$):**

- Ozone ($O_3$) is a gas that can form and react under the action of light and that is present in two layers of the atmosphere. High up in the atmosphere, ozone forms a layer that shields the Earth from ultraviolet rays. However, at ground level, ozone is considered a major air pollutant. Ground-level ozone or "bad" ozone" is formed from other pollutants and can react with other substances, in both cases under the action of light. Ground level Ozone is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC from paints, solvents, printing inks, petroleum products, vehicles etc.) in the presence of sunlight. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapours, and chemical solvents are some of the major sources of NOx and VOC.
- Ozone in the air we breathe can harm our health—typically on hot, sunny days when ozone can reach unhealthy levels. Even relatively low levels of ozone can cause health effects. Children, people with lung disease, older adults, and people who are active outdoors, including outdoor workers, may be particularly sensitive to ozone. Breathing ozone can trigger a variety of health problems including chest pain, coughing, throat irritation, and congestion. It can worsen bronchitis, emphysema, and asthma. Ground level ozone also can reduce lung function and inflame the linings of the lungs. Repeated exposure may permanently scar lung tissue.

**Hydrocarbons:**

Hydrocarbons are a group of compounds consisting of carbon and Hydrogen atoms. They either evaporate from fuel supplies or are remnants of fuel that did not burn completely. Hydrocar-



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bons are washed out of the air when it rains and run into surface water. They cause [illegible] on the surface and do not as such cause a serious issue until they react to [illegible].

**Ammonia ($NH_3$):**

Ammonia is a nitrogen-containing compound with the chemical formula $NH_3$, and it is emitted almost exclusively by agricultural sources, including livestock production and nitrogen fertilizer use. Much atmospheric ammonia is re-deposited from the air to nearby land and water, a process called nitrogen deposition. Ammonia binds with other pollutants and changes from a gas to a solid particle form.

Atmospheric ammonia is increasingly being recognized as a pollutant of key environmental concern. Ammonia contributes to several environmental problems, including direct toxic effects on vegetation, atmospheric nitrogen deposition, leading to the eutrophication and acidification of sensitive ecosystem, and to the formation of secondary particulate matter in the atmosphere, with effects on human health, atmospheric visibility and global radiative balance.

| Harmful effects of photo chemical smog |
|---|
| • Photochemical smog is capable of inflicting irreversible damage on the lungs and heart. |
| • It causes painful irritation of the respiratory system, reduced lung function and difficulty breathing; this is more evident while exercising or working outdoors. |
| • High levels of smog also trigger asthma attacks because the smog causes increased sensitivity to allergens, which are triggers for asthma. |
| • Photochemical smog has devastating effects on the environment |
| • Ground-level ozone also can interfere with the growth and productivity of trees |
| • The effects of smog on animals are also similar to its effect on humans; it decreases lung capacity and lung elasticity |
| • Heavy smog results in the reduction of natural vitamin D production, leading to a rise in the cases of rickets |

**Chlorofluorocarbons (CFC)**

These are gases that are released mainly from air-conditioning systems and refrigeration. When released into the air, CFCs rise to the stratosphere, where they come in contact with few other gases, which lead to a reduction of the ozone layer that protects the earth from the harmful UV rays of the sun. Of late, some of their alternatives have turned out to be Green House Gases.

**Effects of Air Pollution can be summarised in the following ways:**

**1. Health Effect**

| Name of Pollutant | Sources | Health Effects |
|---|---|---|
| Sulphur Oxides | fossil fuel combustion | Irritation of eyes, nose, throat; damage to lungs Acute and chronic asthma, bronchitis and emphysema |
| Nitrogen Oxides | fossil fuel combustion | incidence of respiratory illness, Chronic obstructive pulmonary diseases, Emphysema Infant and cardiovascular death |
| Ozone | VOCs, Automobile emissions | Burning nose and watering eyes. Coughing, wheezing and throat irritation. Susceptibility to respiratory infections, Aggravation of asthma and Cancer |
| Carbon Monoxide | Incomplete combustion of fossil fuels | Toxicity of the central nervous system and heart, Headaches, dizziness, consciousness, loss of muscular coordination and [illegible] |

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| | | |
|---|---|---|
| | | the baby of a pregnant woman |
| Carbon Dioxide | fossil fuel combustion | Impairs reflexes, judgement and vision, severe headaches and heart strain |
| Ammonia | Livestock farming, animal waste and fertilizer application | Nose & throat irritation and burns, Pulmonary edema, Chronic lung disease, Lung fibrosis, dermatitis, Cataracts and glaucoma |
| Volatile organic compounds (propane, benzene, ethanol, methanol, ether, carbon tetrachloride and vinyl chloride) | petrol and resins | Tiredness, vertigo, drowsiness, dizziness, nausea, confusion, unconsciousness, Anaemia, Bone marrow damage, Liver damage, Cancer; specifically leukaemia, Abnormal changes in foetus development, birth defects and Cardiovascular diseases |
| Photochemical Smog | Industries and vehicular pollution | Respiratory problems and intense irritation to eyes |
| Dust particles | Combustion of fossil fuels, Construction | Stuffy noses, sinusitis, sore throats, wet cough, dry cough, head colds, burning eyes, wheezing, lung disease, chest pain, Aggravated asthma and Chronic bronchitis |
| Smoke | Cigarettes, combustion of fossil fuels and wood | Chronic bronchitis, Asthma, lung cancer and irritation of eyes, nose and throat |
| Mercury | Industries – | Nervous disorders, insomnia, memory loss, excitability, irritation, tremor and Minamata disease |
| Lead | Leaded petrol emissions | Damage to brain and central nervous system, kidneys and brains, impaired intelligence and interference with development of RBCs |
| Cadmium | Industries | Affects the heart |
| Silica Dust | Silicon quarrying | Silicosis affects the lungs |
| Cotton Dust | Cotton textile factories | Byssinosis involves destruction of lung tissues, chronic cough, bronchitis and emphysema |
| Asbestos Dust | Asbestos mining, asbestos sheet manufacturing | Asbestosis, which involves severe respiratory problems and may lead to cancer |
| Radioactive pollutants | Cosmic rays, x-rays, beta rays, radon and radium | Destroy living tissues and blood cells, affect cell membrane and cell enzyme functions, leukaemia, and permanent genetic changes |
| Coal dust and particles | Coal Mines | Black lung cancer, pulmonary fibrosis which lead to respiratory failure |

| 2. Effects on Animals | 3. Effects on vegetation | 4. Economic Losses |
|---|---|---|
| 1. Acid rain caused due to oxides of Sulphur and Nitrogen affects freshwater animal life | 1. Physical injury to leaves is the immediate effect of air pollution on plants Ozone produces a speckle of brown spots, which appear on the flat | 1. Direct medical losses |

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| | | |
|---|---|---|
| | areas of leaf between the veins; Nitrogen dioxide produces irregular brown or white collapsed lesions on inter-costal tissue and near the leaf edge; Ammonia: unnatural green appearance with tissue drying out. | |
| 2. Affect animals through plants on which they feed. | 2. Cell metabolism disruption. | 2. Lost income from being absent from work |
| 3. Excessive ultraviolet radiation coming from the sun through the ozone layer in the upper atmosphere which is eroded by some air pollutants, may cause skin cancer in wildlife | 3. Leaf injury and loss. | 3. Decreased productivity |
| 4. Many higher order animals (especially those closely related to humans, ex. mountain gorillas) experience air pollution effects similar to those experienced by humans. | 4. Reduced growth and reproduction. | 4. Travel time losses due to reduced visibility |
| | 5. Increase in susceptibility of plants to attacks by insect herbivores. | 5. Losses from repair of damage to buildings |
| | 6. Particulate matters often affect plants and trees via blocking of leaf stomata through which plants undertake the gas exchange necessary for photosynthesis and respiration. | 6. Increased costs of cleaning |
| | 7 .Leaf necrosis and chlorosis, bark peeling | 7. Losses due to damage to crops & plants |

## 2.1 PHOTOCHEMICAL SMOG

≠ Photochemical smog is a mixture of pollutants that are formed when nitrogen oxides and volatile organic compounds (VOCs) react to sunlight, creating a brown haze above cities. It tends to occur more often in summer, because that is when we have the most sunlight. The two major primary pollutants, nitrogen oxides and VOCs, combine to change in sunlight in a series of chemical reactions, explained below, to create what are known as secondary pollutants. The secondary pollutant that causes the most concern is the ozone that forms at ground level. While ozone is produced naturally in the upper atmosphere, it is a dangerous substance when found at ground level. Many other hazardous substances are also formed, such as Peroxyacetyl nitrate (PAN).

≠ The significance of the presence of the VOCs in these last two reactions is paramount. Ozone is normally consumed by nitric oxide, as in reaction 3. However, when VOCs are present, nitric oxide and nitrogen dioxide are consumed as in reactions 4 and 5, allowing the build-up of ground



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| | | |
|---|---|---|
| | | the baby of a pregnant woman |
| Carbon Dioxide | fossil fuel combustion | Impairs reflexes, judgement and vision, severe headaches and heart strain |
| Ammonia | Livestock farming, animal waste and fertilizer application | Nose & throat irritation and burns, Pulmonary edema, Chronic lung disease, Lung fibrosis, dermatitis, Cataracts and glaucoma |
| Volatile organic compounds (propane, benzene, ethanol, methanol, ether, carbon tetrachloride and vinyl chloride) | petrol and resins | Tiredness, vertigo, drowsiness, dizziness, nausea, confusion, unconsciousness, Anaemia, Bone marrow damage, Liver damage, Cancer; specifically leukaemia, Abnormal changes in foetus development, birth defects and Cardiovascular diseases |
| Photochemical Smog | Industries and vehicular pollution | Respiratory problems and intense irritation to eyes |
| Dust particles | Combustion of fossil fuels, Construction | Stuffy noses, sinusitis, sore throats, wet cough, dry cough, head colds, burning eyes, wheezing, lung disease, chest pain, Aggravated asthma and Chronic bronchitis |
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level ozone. Such ground level Ozone, PAN and fine particulates are termed as Photochemical Smog.

**Formation of Photochemical Smog**

1. Nitrogen dioxide ($NO_2$) can be broken down by sunlight to form nitric oxide (NO) and an oxygen radical (O): $NO_2$ + Sunlight → NO + O
2. Oxygen radicals can then react with atmospheric oxygen ($O_2$) to form ozone ($O_3$): $O + O_2 \rightarrow O_3$
3. Ozone is consumed by nitric oxide to produce nitrogen dioxide and oxygen: $O_3 + NO \rightarrow NO_2 + O_2$
4. Harmful products, such as PAN, are produced by reactions of nitrogen dioxide with various hydrocarbons (R), which are compounds made from carbon, hydrogen and other substances: $NO_2$ + R → Products such as Peroxyacetyl nitrate (PAN)
5. The main source of these hydrocarbons is the VOCs. Similarly, oxygenated organic and inorganic compounds (ROx) react with nitric oxide to produce more nitrogen oxides: NO + $RO_x$ → $NO_2$ + Other Products

## 2.2 INDOOR AIR POLLUTION

It refers to the physical, chemical, and biological characteristics of air in the indoor environment within a home, building, or an institution or commercial facility.

| **Indoor air pollution in the rural areas and the urban areas.** | |
|---|---|
| In the developing countries, people continue to rely on traditional fuels such as firewood, charcoal, and cow-dung for cooking and heating. Concentrations of indoor pollutants in households that burn traditional fuels are alarming. Burning such fuels produces large amount of smoke and other air pollutants in the confined space of the home, resulting in high exposure. Women and children are the groups most vulnerable as they spend more time indoors and are exposed to the smoke. Although many hundreds of separate chemical agents have been identified in the smoke from biofuels, the four most serious pollutants are particulates, carbon monoxide, polycyclic organic matter, and formaldehyde. | In Developed areas, exposure to indoor air pollution has increased due to a variety of reasons, including the construction of more tightly sealed buildings, reduced ventilation, the use of synthetic materials for building and furnishing and the use of chemical products, pesticides, and household care products. Indoor air pollution can begin within the building or be drawn in from outdoors. Other than nitrogen dioxide, carbon monoxide, and lead, there are a number of other pollutants that affect the air quality in an enclosed space |

1. Indoor air pollution is a concern in the developed countries, where energy efficiency improvements sometimes make houses relatively airtight, reducing ventilation and raising pollutant levels.
2. Indoor air problems can be subtle and do not always produce easily recognized impacts on health.

The major pollutants contributing to Indoor Air Pollution include:

- Pesticides
- Tobacco smoke – It generates a wide range of harmful chemicals and is known to cause cancer. It is well known that passive smoking causes a wide range of problems to the passive smoker (the person who is in the same room with a smoker and is not himself/herself a smoker)



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ranging from burning eyes, nose, and throat irritation to cancer, bronchitis, severe asthma, and a decrease in lung function.

- Volatile organic compounds – They originate mainly from solvents and chemicals. The main indoor sources are perfumes, hair sprays, furniture polish, glues, air fresheners, moth repellents, wood preservatives, and many other products used in the house. The main health effect is the irritation of the eye, nose and throat. In more severe cases there may be headaches, nausea and loss of coordination. In the long term, some of the pollutants are suspected to damage to the liver and other parts of the body.
- Formaldehyde – It is a gas that comes mainly from carpets, particle boards, and insulation foam. It causes irritation to the eyes and nose and may cause allergies in some people.
- Biological pollutants – These include pollen from plants, mite, hair from pets, fungi, parasites, and some bacteria. Most of them are allergens and can cause asthma, hay fever, and other allergic diseases.
- Asbestos – It is mainly a concern because it is suspected to cause cancer.
- Radon – It is a gas that is emitted naturally by the soil. Due to modern houses having poor ventilation, it is confined inside the house causing harm to the dwellers.
- Styrene – It is a colourless, flammable liquid, which has a sweet odour and is highly volatile. Styrene is widely used to make plastics and rubber, which are used to manufacture a variety of products, such as insulation, pipes, automobile parts, printing cartridges, food containers, and carpet backing. Styrene is carcinogenic and can even cause lung tumours

**Control Measures for Air Pollution**

Air pollution can be controlled by preventive measure, effluent control and regulations. Some of these have been discussed as follows:

**Source Correction Methods :**

Industries make a major contribution towards causing air pollution. Formation of pollutants can be prevented and their emission can be minimised at the source itself. By carefully investigating the early stages of design and development in industrial processes e.g., those methods which have minimum air pollution potential can be selected to accomplish air-pollution control at source itself. Examples of Source Correction Methods are:

1. Substitution of raw materials: If the use of a particular raw material results in air pollution, then it should be substituted by another purer grade raw material which reduces the formation of pollutants. Thus,
   (a) Low sulphur fuel which has less pollution potential can be used as an alternative to high Sulphur fuels, and,
   (b) Comparatively more refined liquid petroleum gas (LPG) or liquefied natural gas (LNG) can be used instead of traditional high contaminant fuels such as coal.
2. Process Modification: The existing process may be changed by using modified techniques to control emission at source. For example,
   (a) If coal is washed before pulverization, then fly-ash emissions are considerably reduced.
   (b) If air intake of boiler furnace is adjusted, then excess Fly-ash emissions at power plants can be reduced.
3. Modification of existing equipment: Air pollution can be considerably minimised by making suitable modifications in the existing equipment:

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(a) For example, smoke, carbon-monoxide and fumes can be reduced if open hearth furnaces are replaced with controlled basic oxygen furnaces or electric furnaces.

(b) In petroleum refineries, loss of hydrocarbon vapours from storage tanks due to evaporation, temperature changes or displacement during filling etc. can be reduced by designing the storage tanks with floating roof covers.

(c) Pressurising the storage tanks in the above case can also give similar results.

4. Maintenance of equipment: An appreciable amount of pollution is caused due to poor maintenance of the equipment which includes the leakage around ducts, pipes, valves and pumps etc. Emission of pollutants due to negligence can be minimised by a routine check-ups of the seals and gaskets.

**Pollution Control Equipment**: Sometimes pollution control at source is not possible by preventing the emission of pollutants. Then it becomes necessary to install pollution control equipment to remove the gaseous pollutants from the main gas stream. The pollutants are present in high concentration at the source and as their distance from the source increases they become diluted by diffusing with environmental air. Pollution control equipment's are generally classified into two types:

(a) Control devices for particulate contaminants.

(b) Control devices for gaseous contaminants.

**Diffusion of Pollutants in Air**: Dilution of the contaminants in the atmosphere is another approach to the control of air pollution. If the pollution source releases only a small quantity of the contaminants then pollution is not noticeable as these pollutants easily diffuse into the atmosphere but if the quantity of air contaminants is beyond the limited capacity of the environment to absorb the contaminants then pollution is caused. However, dilution of the contaminants in the atmosphere can be accomplished through the use of tall stacks which penetrate the upper atmospheric layers and disperse the contaminants so that the ground level pollution is greatly reduced.

**Vegetation**: Plants contribute towards controlling air-pollution by utilizing carbon dioxide and releasing oxygen in the process of photosynthesis. This purifies the air (removal of gaseous pollutant—$CO_2$) for the respiration of men and animals. Gaseous pollutants like carbon monoxide are fixed by some plants, namely, Coleus Blumeri, Ficus variegata and Phascolus Vulgaris. Species of Pinus, Quercus, Pyrus, Juniperus and Vitis depollute the air by metabolising nitrogen oxides. Plenty of trees should be planted especially around those areas which are declared as high-risk areas of pollution.

**Zoning**: This method of controlling air pollution can be adopted at the planning stages of the city. Zoning advocates setting aside of separate areas for industries so that they are far removed from the residential areas. The heavy industries should not be located too close to each other. New industries, as far as possible, should be established away from larger cities (this will also keep a check on increasing concentration of urban population in a few larger cities only) and the locational decisions of large industries should be guided by regional planning. The industrial estate of Bangalore is divided into three zones namely light, medium and large industries. In Bangalore and Delhi very large industries are not permitted.

**Policy Measure**

***Air (Prevention and Control of Pollution) Act 1981***

The Government of India enacted the Air (Prevention and Control of Pollution) Act 1981 to arrest the deterioration in the air quality. The act prescribes various functions for the Central Pollution Control Board (CPCB) at the apex level and State Pollution Control Boards at the state level. The main functions of the Central Pollution Control Board are as follows:



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1. To advise the Central Government on any matter concerning the improvement of the quality of the air and the prevention, control and abatement of air pollution.
2. To plan and cause to be executed a nation-wide programme for the prevention, control and abatement of air pollution.
3. To provide technical assistance and guidance to the State Pollution Control Board.
4. To carry out and sponsor investigations and research related to prevention, control and abatement of air pollution.
5. To collect, compile and publish technical and statistical data related to air pollution; and
6. To lay down and annul standards for the quality of air. Central Pollution Control Board

The **Policy Statement for Abatement of Pollution**, adopted in 1992 lays emphasis on pollution prevention in place of the conventional end-of-the-pipe treatment also identified the adoption of best available and practicable technologies as the key element for pollution prevention. The whole issue of pollution prevention and control is dealt with by a combination of command and control methods as well as voluntary regulations, fiscal measures, promotion of awareness etc. Programmes of the Ministry related to prevention and control of pollution are:

1. Environmental Statement (as part of Environmental Audit)
2. Environmental Statistics and Mapping
3. Development and Promotion of Cleaner Technologies
4. Adoption of Cleaner Technologies in Small Scale Industries
5. Waste Minimizing
6. Programme for improvement of Quality of Automotive Fuels (Motor Gasoline and Diesel) for reducing Vehicular Pollution
7. Mission on Control of Vehicular Pollution from On-Road Vehicles
8. Noise Pollution
9. Environmental Epidemiological Studies
10. Development of Standards

**Central Pollution Control Board** (CPCB) of India is a statutory organization under the Ministry of Environment and Forests (MoEF). It was established in 1974 under Water (Prevention and Control of Pollution) Act, 1974. CPCB is also entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981. It serves as a field formation and also provides technical services to the Ministry of Environment and Forests of the provisions of the Environment (Protection) Act, 1986. It Co-ordinate the activities of the State Boards by providing technical assistance and guidance and resolve disputes among them. It is an apex organization in country in the field of pollution control, as technical wing of MoEF.

**National Air Quality Monitoring Programme (NAMP)**

Central Pollution Control Board is executing a nation-wide programme of ambient air quality monitoring known as National Air Quality Monitoring Programme (NAMP). The objectives of the N.A.M.P. are

1. To determine status and trends of ambient air quality;
2. To ascertain whether the prescribed ambient air quality standards are violated,
3. To Identify Non-attainment Cities
4. To obtain the knowledge and understanding necessary for developing preventive and corrective meas-

Under N.A.M.P., four air pollutants viz. Sulphur Dioxide ($SO_2$), Oxides of Nitrogen as $NO_2$ and Suspended Particulate Matter (SPM) and Respirable Suspended Particulate Matter (RSPM/PM 10), have been identified for regular monitoring at all the locations. The monitoring of meteorological parameters such as wind speed and direction, relative humidity and temperature was also integrated with the



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ures;

5. To understand the natural cleansing process undergoing in the environment through pollution dilution, dispersion, wind based movement, dry deposition, precipitation and chemical transformation of pollutants generated.

**National Air Quality Index (AQI)**

***What's AQI?***

"Air quality index (AQI) is a number used to communicate to the public how polluted the air currently is or how polluted it is forecast to become".

If the AQI increases, an increasingly large percentage of the population is likely to experience increasingly severe adverse health effects. **Launched under Swachh Bharat Abhiyan, It is outlined as 'One Number- One Colour-One Description' for the common man to judge the air quality within his vicinity.** While the earlier measuring index was limited to three indicators, the current measurement index had been made quite comprehensive by the addition of five additional parameters to consider eight parameters.

There are six AQI categories, namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe. The proposed AQI will consider eight pollutants ($PM_{10}$, $PM_{2.5}$, $NO_2$, $SO_2$, CO, $O_3$, $NH_3$, and Pb) for which short-term (**up to 24-hourly averaging period**) National Ambient Air Quality Standards are prescribed. Associated likely health impacts for different AQI categories and pollutants have been also been suggested, with primary inputs from the medical expert members of the group. The AQI values and corresponding ambient concentrations (health breakpoints) as well as associated likely health impacts for the identified eight pollutants are in the picture. Some notable features of AQI –

- One Number- One Colour-One Description, easy to understand
- Coverage of entire India after five years
- No monitoring of Benzene
- No separate indexes for each area

**AQI Category, Pollutants and Health Breakpoints**

| AQI (Category) (Range) | $PM_{10}$ 24-hr | $PM_{2.5}$ 24-hr | $NO_2$ 24-hr | $O_3$ 8-hr | CO 8-hr (mg/m$^3$) | $SO_2$ 24-hr | $NH_3$ 24-hr | Pb 24-hr | Associated Health Impacts |
|---|---|---|---|---|---|---|---|---|---|
| Good | 0-50 | 0-30 | 0-40 | 0-50 | 0-1.0 | 0-40 | 0-200 | 0-0.5 | Minimal Impact |
| Satisfactory | | | | | | | | | |
| Moderately polluted | 101-250 | 61-90 | 81-180 | 101-168 | 2.1-10 | 81-380 | 401-800 | 1.1-2.0 | May cause breathing discomfort to people with lung disease such as asthma, and discomfort to people with heart disease, children and older adults. |
| Poor | 251- | 91- | 181- | 169- | 10- | 381- | 801- | 2.1- | May cause breathing |



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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 350 | 120 | 280 | 208 | 17 | 800 | 1200 | 3.0 | discomfort to people on prolonged exposure, and discomfort to people with heart disease. |

**System of Air Quality Forecasting and Research (SAFAR)**

It is a computerized system jointly developed by Indian institute of Tropical Meteorology (IITM), Pune (under Ministry of Earth Science) and India Meteorological Department (IMD). It can forecast quality of air **24-72 hours in advance**. It provides data on Air Quality Index – health advisory UV Index – skin advisory and Dynamic city pollution maps.

## 3. WATER POLLUTION

***What is Water pollution?***

Water pollution is the contamination of natural water bodies by chemical, physical, radioactive or pathogenic microbial substances so that it becomes unfit for use. Water gets polluted in surface water, ground water as well as in open oceans and seas.

Water pollutants are classified as following:

- **Chemical water pollutants** – These are generally atoms or molecules, which have been discharged into natural water bodies, usually by activities of humans. Common examples of such chemical water pollutants are mercury emanating from mining activity, certain nitrogen compounds used in agriculture, chlorinated organic molecules arising from sewage or water treatment plants or various acids which are the externalities of various manufacturing activities.
- **Physical water pollutants** – These are either much larger particles or physical factors such as temperature change, both of which while not typically toxic, cause a variety of harmful effects. The most obvious of physical pollutants are (a) Excessive sediment load, mostly arising from over-intense land use practices and (b) Rubbish discarded from human manufacturing activity (e.g. plastic bags, bottles). While these materials are not so harmful to human health as chemicals or pathogens, they comprise the majority of visual impact of water pollution.
- **Radioactive substances** – These are really merely a special sub-class of chemical pollutants, and by mass represent the smallest of the contributors to water pollution; however, their potential for harm allows recognition as a separate class. In fact, most discharge of radioactiv-



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≠ Urban land use: In our urban areas rainfall run-off as stormwater is one of the major nonpoint sources of pollution impacting the water quality of our waterways and bays. Stormwater from street surfaces is often contaminated with car oil, dust and the faeces of animals and soil and sediment run-off from construction sites and in industrial areas often contains more toxicants and chemicals. In some outer-urban and urban fringe areas, a reticulated sewerage system is not available so sewage is discharged to onsite wastewater systems and septic tanks. Seepage and surface run-off of septic tank effluents may also be forms of non-point source pollution of streams in these areas.

≠ Agriculture land use: In farming areas non-point sources of pollution include pesticides, fertilisers, animal manure and soil washed into streams in rainfall run-off. Where stock are given access to stream banks they may foul the water and accelerate erosion. Fertilisers contain major plant nutrients such as nitrogen, phosphorous and potassium. These may leach into water bodies. Pesticides, insecticides and fungicides contain wide range of chemicals such as Chlorinated Hydrocarbons, Organophosphates, Metallic Salts, Carbonates, Thiocarbonates etc. which can prove detrimental for the existence of ecosystem.

≠ Forestry land use: Forestry operations may contribute to non-point source pollution of streams by increasing soil erosion and sediment run-off.

≠ Thermal Pollution: Power plants-thermal and nuclear, chemical and other industries use lot of water (about 30 % of all abstracted water) for cooling purposes and the used hot water is discharged into rivers, streams or oceans. The waste heat from the boilers and heating processes increases the temperature of the cooling water. Discharge of hot water may increase the temperature of the receiving water by 10 to 15 °C above the ambient water temperature. This is thermal pollution. Increase in water temperature decreases dissolved oxygen in water which adversely affects aquatic life. Unlike terrestrial ecosystems, the temperature of water bod-

**Indicators of water pollution**

**Dissolved Oxygen (DO)**

DO test measures the concentration of oxygen dissolved in a water or wastewater sample. It refers to the level of free, non-compound oxygen present in water or other liquids. It is an important parameter in assessing water quality because of its influence on the organisms living within a body of water. Water having DO content below 8.0 mg/L is considered to be contaminated. Eutrophication decreases DO.

**Biological Oxygen Demand (BOD)**

Biochemical oxygen demand is a measure of the quantity of oxygen used by microorganisms (e.g., aerobic bacteria) in the oxidation of organic matter. BOD is the traditional, most widely used test to establish concentration of organic matter in wastewater samples. The higher value of BOD indicates low DO content of water. BOD is limited to bio-degradable materials only.

**Chemical Oxygen Demand (COD)**

It is the measure of oxygen equivalent of the requirement of oxidation of total organic matter (i.e. biodegradable and non-biodegradable) present in water. COD is the most popular alternative test to BOD for establishing the concentration of organic matter in wastewater samples. COD can test wastewater that is too toxic for the BOD test.

**Total Oxygen Demand (TOD)**

According to its name, this parameter defines the total oxygen demand of the water sample. It is based on the same principle as the COD. This analytical technique was developed to be equivalent to COD testing, in that oxygen uptake was measured as a result of combustion or other oxidation techniques.

**Total Organic Carbon (TOC)**

Total Organic Carbon is a term used to describe the measurement of organic (carbon based) contaminants in a water system. Organic contamination can come from a variety of sources, since "organics" are compounds such as sugar, sucrose, alcohol, petroleum, PVC cement, plastic based derivatives, etc.



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ity is not from the negligible escape from nuclear power plants, but rather arises from agricultural practices such as tobacco farming, where radioactive contamination of phosphate fertilizer is a common method of introduction of radioactive materials into the environment.

- **Pathogens** – Common pathogenic microbes introduced into natural water bodies are pathogens from untreated sewage or surface runoff from intensive livestock grazing. One of the most common disease agents is Giardia Lamblia, a parasitic protozoan common in faecal material of many fauna including humans; this microbe is particularly insidious, due to its resistance to conventional sewage treatment. This and other protozoans and bacteria are important causes of illness and mortality in developing countries where population density, water scarcity and inadequate sewage treatment combine to occasion widespread parasitic and bacterial disease.

**Pollution Sources –**

Pollutants enter the water environment from two main types of sources:

1. Point Sources – A point source is a single, identifiable source of pollution, such as a pipe or a drain. Here pollutant travels directly from source to water. These are easy to regulate and control. Industrial wastes are commonly discharged to rivers and the sea in this way.
2. Non-Point Sources: Non-point sources of pollution are often termed 'diffuse' pollution and refer to those inputs and impacts which occur over a wide area and are not easily attributed to a single source. They vary spatially and temporally and are difficult to regulate. They are often associated with particular land uses, as opposed to individual point source discharges.

From plastic bags to pesticides - most of the waste we produce on land eventually reaches the oceans, either through deliberate dumping or from run-off through drains and rivers. This includes:

- ≠ Oil –Oil spills cause huge damage to the marine environment. It is one of the most dangerous of all water pollutants. Oil Spills from tankers at sea or leaks from underground storage tanks on land are very difficult to control as oil tends to spread very fast, affecting a large area in a very short time. Oil spills at sea decrease the oxygen level in the water and cause harm to the organisms. Oil spills are also a source of air and groundwater pollution
- ≠ Fertilizers – Fertilizer runoff from farms and lawns is a huge problem for coastal areas. The extra nutrients cause eutrophication - flourishing of algal blooms that deplete the water's dissolved oxygen and suffocate other marine life .
- ≠ Seas of garbage – Solid garbage also makes its way to the ocean. Plastic bags, balloons, glass bottles, shoes, and packaging material – if not disposed of correctly, almost everything we throw away can reach the sea. Plastic garbage, which decomposes very slowly, is often mistaken for food by marine animals. High concentrations of plastic material, particularly plastic bags, have been found blocking the breathing passages and stomachs of many marine species, including whales, dolphins, seals, puffins, and turtles. Plastic six-pack rings for drink bottles can also choke marine animals. This garbage can also come back to shore, where it pollutes beaches and other coastal habitats.
- ≠ Sewage Disposal – In many parts of the world, sewage flows untreated, or under-treated, into the ocean. For example, 80% of urban sewage discharged into the Mediterranean Sea is untreated. This sewage can also lead to eutrophication. In addition, it can cause human disease and lead to beach closures.



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ies remains steady and does not change very much. Accordingly, aquatic organisms are adapted to a uniform steady temperature of environment and any fluctuation in water temperature severely affects aquatic plants and animals. Hence discharge of hot water from power plants adversely affects aquatic organisms. Aquatic plants and animals in the warm tropical water live dangerously close to their upper limit of temperature, particularly during the warm summer months. It requires only a slight deviation from this limit to cause a thermal stress to these organisms.

- Groundwater Pollution: Lot of people around the world depend on ground water for drinking, domestic, industrial and agricultural uses. Generally groundwater is a clean source of water. However, human activities such as improper sewage disposal, dumping of farm yard manures and agricultural chemicals, industrial effluents are causing pollution of ground water.
- Marine Pollution: Marine pollution occurs when harmful, or potentially harmful, effects result from the entry into the ocean of chemicals, particles, industrial, agricultural and residential waste, noise, or the spread of invasive organisms.

**Effects of Water Pollution**

The effects of water pollution have a strong impact on the delicate balance in the natural ecosystem. This will ultimately impact the humans and other living organisms. The effects of water pollution are different and depend on the chemicals dumped in that particular location. The effects of water pollution could be classified into:

| 1. On Ecosystem | 2. On Animal Health | 3. On Human Health |
|---|---|---|
| a. Ecosystems can be severely affected or damaged by water pollution.<br>b. Contamination of groundwater from pesticides causes damage to the reproductive system in the wildlife ecosystem.<br>c. When sewage water, agricultural run-off that contain organic materials are discharged into fresh water, causes increase in the growth of algae in turn causing oxygen depletion.<br>d. Low levels of oxygen in rivers and lakes due to water pollution are a major cause for extinction of indigenous organisms.<br>e. Destruction in ecosystem is caused due to the rise in temperature in water like the coral reefs are affected by the bleaching effect due to | a. Water pollution kills life that depends on these water bodies.<br>b. Fishes and the aquatic organisms are poisoned due to industrial chemicals and agricultural pesticides.<br>c. Human litter let into water system gets the aquatic animals caught and can get killed due to suffocation.<br>d. Oil spills in water causes animals to die as they ingest it or come across it. Oil cannot be dissolved in water so it causes suf- | a. Humans are affected by water pollution. Diseases like hepatitis are caused by eating seafood that is poisoned or contaminated.<br>b. In developing nations, there are frequent outbreaks of cholera and diseases due to poor drinking water quality from contaminated waters.<br>c. Swimming and drinking in contaminated water can causes skin diseases and also can lead to cancer, reproductive problems, typhoid, fever and stomach ailments in humans.<br>d. Heavy metals poisoning due to consumption of contaminated fish. For example: Mercury poisoning interferes with the nervous system development in foetuses and young children.<br>e. Polluted drinking water can cause cholera or typhoid infections and also diarrhoea.<br>f. Highly polluted water can harm |



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warmer temperatures.

f. Water pollution may also cause flooding due to accumulation of solid waste and soil erosion in streams and rivers.

g. Ground water and surface water are contaminated with heavy metals, persistent organic pollutants and nutrients.

h. Water pollution kills life that inhabits the water-based ecosystem, disrupting the natural food chain.

i. Due to water pollution other than inorganic nutrient input and inflow of waste water; organic wastes and plant nutrients like nitrates and phosphates are decomposed. This promotes algal bloom especially blue-green algae. These algae grow fast consuming all the dissolved oxygen, killing the water animals. This is known as eutrophication.

j. The non-biodegradable pesticides and chemicals cause mass destruction of aquatic life.

k. Steep increase in the BOD (Biological Oxygen Demand) levels of water.

l. Imbalance in host-parasite relations in the ecosystem, changing the food webs and food chain.

m. Affects microbial population.

n. Deposition of hazardous chemicals in soil leads to soil infertility

focation in fish and birds.

e. Oil-contaminated water causes water birds to die from exposure to cold water and air due to feather damage.

f. Animals that eat dead fish from contaminated streams are affected.

g. Fish, birds, dolphins and many other animals are killed by pollutants in their habitat.

h. Reproduction rate in reduced in aquatic organisms.

i. Incidences of diseases increase.

j. Bio-accumulative and non-biodegradable pesticides are accumulated in animal bodies.

k. Bio-magnification of hazards chemicals like organochlorine pesticides like DDT, BHC, Endrin.

internal organs like heart and kidneys.

g. Pesticide contamination of ground water can cause endocrine and reproductive problems to animals and humans.

h. Sewage contamination carries harmful pathogens and causes disease outbreak.

i. Synthetic organics cause serious damage to human health.

j. Chemicals like fluoride, arsenic, lead, chlorine and petrochemicals in water can causes adverse effect on human health.

k. Water borne diseases like hepatitis, cholera, dysentery and typhoid are common and affect large populations in the tropical regions.

l. Pesticides like organophosphates and carbonates affect and damage the nervous system and are carcinogenic.

m. Lead accumulation in the body can affect the central nervous system, putting children and pregnant women at high risk.

n. Excess of fluorides causes yellowing of teeth and damage to spinal cord and other crippling diseases.

o. Nitrate contamination can prove fatal for infants as it can restrict the oxygen to the reach the brain causing the 'blue-baby' syndrome. It can also cause digestive tract cancers and eutrophication in water bodies.

p. Arsenic poisoning cause serious liver and nervous system damage, vascular disease and skin cancer.

q. Minamata disease due to intake of Mercury, Blue Baby Syndrome (Methaemo-globinemia) due to excess nitrate and Fluorosis due to excess fluoride in drinking water are some very infamous diseases



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| | | |
|---|---|---|
| | | associated with water pollution. |

Control measures of water pollution

Following are the control measures of water pollution :

1. Stabilisation of ecosystem: It involves following practices:
   a) Reduction of waste at source
   b) Harvesting and removal of biomass
   c) Trapping of the nutrients.
   d) Fish management.
2. Using water hyacinth to remove water pollutants: Water hyacinth is extremely efficient in absorbing and concentrating dissolved nutrients from water in which it lives.
3. Using chemical methods: Several chemical methods have been devised for the treatment of industrial effluents before discharging them in water bodies, like
   a) Ion Exchange: It is a reversible reaction where in an iron from solution is exchanged for a similar Charged ion attached to an immobile solid particle which is either naturally occurring inorganic Zeolite or synthetically produced organic resins.
   b) Reverse Osmosis: It involves the purification of water with the semi permeable membrane. When used as pre-treatment steps for deionization systems, reverse osmosis will remove feed water bacteria, organics and silica and reduce the dissolved salt content by greater than 95% only.
   c) Precipitation: This process transform dissolved contaminants into an insoluble solid, facilitating the contaminant's subsequent removal from the liquid phase by sedimentation or filtration.
   d) Coagulation: Chemical coagulation enhances the removal of colloidal particles by destabilising and chemically precipitating them and accumulating the precipitated material into larger floe particles which can either removed by gravity setting or filtration.
4. Cooling methods: For preventing thermal pollution such methods are used like cooling waste water effluent, evaporation tower, cooling ponds, dry cooling towers, wet cooling towers etc.
5. Recycling, Renovation, Recharge and Reuse (4R concept) of waste water: The waste water consisting of domestic sewage industrial effluents, thermal and radioactive pollutants receive some sort of treatment before mixing into water bodies. Urban sewage and sludge etc may be recycled and reused to generate cheaper fuel, gas and electricity.
6. Oil spills in water can be cleaned with the help of Bregoli – a by-product of paper industry resembling saw dust, oil zapper, microorganisms.

## 4. NOISE POLLUTION

### *What is Noise Pollution?*

Noise Pollution may be defined as a form and level of environmental sound that is generally considered likely to annoy, distract or even harm other people. Noise pollution is undesired sound that is disruptive or dangerous and can cause harm to life, nature, and property. It is often said that noise differs from other forms of pollution in that, unlike atmospheric pollutants for example, once abated; noise leaves no residual accumulation in the environment or the human body. Noise does leave behind its effects, however, and these can deteriorate after continued exposure to harmful sounds. Noise level is measured in terms of decibels (dB). W.H.O. (World Health Organization) has

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prescribed optimum noise level as 45 dB by day and 35 dB by night. Anything above **80 dB** is hazardous.

**Sources of Noise Pollution –**

- Industrialization: Most of the industries use big machines which are capable of producing large amount of noise.
- Poor Urban Planning: Congested houses, large families sharing small space, fight over parking, frequent fights over basic amenities leads to noise pollution which may disrupt the environment of society.
- Social Events: Noise is at its peak in most of the social events. Whether it is marriage, parties, pub, disc or place of worship, people normally flout rules set by the local administration and create nuisance in the area.
- Transportation: Large number of vehicles on roads, aeroplanes flying over houses, underground trains produce heavy noise and people get it difficult to get accustomed to that
- Construction Activities: Under construction activities like mining, construction of bridges, dams, buildings, stations, roads, flyovers take place in almost every part of the world.
- Household Chores: We people are surrounded by gadgets and use them extensively in our daily life. Gadgets like TV, mobile, mixer grinder, pressure cooker, vacuum cleaners, washing machine and dryer, cooler, air conditioners are minor contributors to the amount of noise that is produced but it affects the quality of life of your neighbourhood in a bad way.

**Sources of some noises and their intensity**

| Source | Intensity | Source | Intensity |
|---|---|---|---|
| Quiet Conversation | 20-30 dB | Radio Music | 50-60 dB |
| Loud Conversation | 60 dB | Traffic Noise | 60-90 dB |
| Lawn Mower | 60-80 dB | Heavy Truck | 90-100 dB |
| Aircraft Noise | 90-120 dB | Space Vehicle Launch | 140-179 dB |
| Beat Music | 120 dB | Jet Engine | 140 dB |
| Motor Cycle | 105 dB | | |

**Effects of Noise Pollution –**

- Hearing Problems: Constant exposure to loud levels of noise can easily result in the damage of our eardrums and loss of hearing. It also reduces our sensitivity to sounds that our ears pick up unconsciously to regulate our body's rhythm.
- Health Issues: Excessive noise pollution in working areas such as offices, construction sites, bars and even in our homes can influence psychological health. Studies show that the occurrence of aggressive behaviour, disturbance of sleep, constant stress, fatigue and hypertension can be linked to excessive noise levels. These in turn can cause more severe and chronic health issues later in life.
- Sleeping Disorders: Loud noise can certainly hamper your sleeping pattern and may lead to irritation and uncomfortable situations. Without a good night sleep, it may lead to problems related to fatigue and your performance may go down in office as well as at home. It is therefore recommended to take a sound sleep to give your body proper rest.
- Cardiovascular Issues: Blood pressure levels, cardio-vascular disease and stress related heart problems are on the rise. Studies suggest that high intensity noise causes high blood pressure and increases heart beat rate as it disrupts the normal blood flow. Bringing them to a manageable level depends on our understanding noise pollution and how we tackle it.

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- Trouble Communicating: High decibel noise can put trouble and may not allow two people to communicate freely. Constant sharp noise can give severe headache and disturb emotional balance.
- Effect on Wildlife: Wildlife faces far more problems than humans because noise pollution since they are more dependent on sound. Animals develop a better sense of hearing than us since their survival depends on it. The ill effects of excessive noise begin at home. Pets react more aggressively in households where there is constant noise.

**Real Time Ambient Noise Monitoring Network**

In pursuance to National Environmental Policy, ambient noise inclusion as an environmental quality parameter and its monitoring in specified urban areas is regularly needed. Central Pollution Control Board (CPCB) established the National Ambient Noise Monitoring Network (NANMN) covering 35 locations in seven metro cities like Delhi, Lucknow, Hyderabad, Kolkata, Mumbai, Chennai and Bangalore spread over seven States including Delhi, Uttar Pradesh, Andhra Pradesh, West Bengal, Maharashtra, Tamil nadu and Karnataka.

For the first time General Packet Radio Service modem is used in NANMN, for data communication from un-manned field noise monitoring stations to central receiving station. Therefore, every second, data shall be monitored and stored in the central receiving station at Delhi. The data thus generated will be available on the website of CPCB as real time data and the implementing authorities will utilize this data for identification of the source to be controlled for policy implementation. Adequate Noise data, thus generated, will be used for effective management plan to mitigate and control ambient noise levels. The main objective is to monitor noise for compliance with the norms so as to avoid adverse health impact .

**Prevention and control of noise pollution**

1. Road traffic noise can be reduced by better designing and proper maintenance of vehicles.
2. Noise abatement measures include creating noise mounds, noise attenuation walls and well maintained roads and smooth surfacing of roads.
3. Retrofitting of locomotives, continuously welded rail track, use of electric locomotives or deployment of quieter rolling stock will reduce noises emanating from trains.
4. Air traffic noise can be reduced by appropriate insulation and introduction of noise regulations for take-off and landing of aircrafts at the airport.
5. Industrial noises can be reduced by sound proofing equipment like generators and areas producing lot of noise.
6. Power tools, very loud music and land movers, public functions using loudspeakers, etc should not be permitted at night. Use of horns, alarms, refrigeration units, etc. is to be restricted. Use of fire crackers which are noisy and cause air pollution should be restricted.
7. A green belt of trees is an efficient noise absorber.

## 5. SOIL POLLUTION

***What is soil pollution?***

Addition of substances which adversely affect the quality of soil or its fertility is known as soil pollution. In a general sense, soil pollution definition is the presence of toxic chemicals (pollutants or contaminants) in soil in high enough concentrations to be of risk to human health and/or ecosystem.

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**Causes of Soil Pollution**

- Farming: Chemical utilization has gone up tremendously since technology provided us with modern pesticides and fertilizers. They are full of chemicals that are not produced in nature and cannot be broken down by it. As a result, they seep into the ground after they mix with water and slowly reduce the fertility of the soil. Other chemicals damage the composition of the soil and make it easier to erode by water and air. Plants absorb many of these pesticides and when they decompose, they cause soil pollution since they become a part of the land.
- Mining and quarrying: Mining waste is generally left on site in the form of spoil heaps. These spoil heaps may contain a wide variety of toxic, or poisonous substances which then leach into the soil due to rainfall, or are blown around by wind. This can have a great impact on the regeneration of vegetation on the site.
- Disposal of household waste: As a nation we produce vast quantities of household waste every year, much of which could and should be recycled or allowed to degrade naturally. Much of our waste is either incinerated - with potential problems of air pollution - or buried in landfill sites, where leaching of waste builds up problems for the future.
- Factory waste: Heavy industry often produces quantities of unwanted chemicals, which, if allowed to come in contact with the soil, can cause extensive pollution. If cleaning agents such as detergents are released irresponsibly, they can cause pollution both to the soil and again to the water supplies. Underground storage tanks can be a major source of pollution if they should leak.
- Road traffic: Vehicles are a major cause of pollution to the soil close to roads, especially where vehicles are running on the old leaded petrol.
- Accidental Oil Spills: Oil leaks can happen during

**Control measures of Soil Pollution**

# CONTROL of soil erosion – Soil erosion can be controlled by a variety of forestry and farm practices. Ex: Planting trees on barren slopes, Contour cultivation and strip cropping may be practiced instead of shifting cultivation; Terracing and building diversion channels may be undertaken. Reducing deforestation and substituting chemical manures by animal wastes also helps arrest soil erosion in the long term.

# Proper dumping of unwanted materials – Excess wastes by man and animals pose a disposal problem. Open dumping is the most commonly practiced technique. Nowadays, controlled tipping is followed for solid waste disposal. The surface so obtained is used for housing or sports field.

# Production of natural fertilizers – Bio-pesticides should be used in place of toxic chemical pesticides. Organic fertilizers should be used in place of synthesized chemical fertilizers. Ex: Organic wastes in animal dung may be used to prepare compost manure instead of throwing them wastefully and polluting the soil.

# Proper hygienic condition – People should be trained regarding sanitary habits. Ex: Lavatories should be equipped with quick and effective disposal methods.

# Public awareness – Informal and formal public awareness programs should be imparted to educate people on health hazards by environmental education. Ex: Mass media, Educational institutions and voluntary agencies can achieve this.

# Recycling and Reuse of wastes: To minimize soil pollution, the wastes such as paper, plastics, metals, glasses, organics, petroleum products and industrial effluents etc should be recycled and reused. Ex: Industrial wastes should be properly treated at source. Integrated waste treatment methods should be adopted.

# Ban on Toxic chemicals: Ban should be imposed on chemicals and pesticides like DDT, BHC, etc which are fatal to plants and animals. Nuclear explosions and improper disposal of radioactive wastes should be banned.

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storage and transport of chemicals. This can be seen at most of the fuel stations. The chemicals present in the fuel deteriorates the quality of soil and make them unsuitable for cultivation. These chemicals can enter into the groundwater through soil and make the water undrinkable.

- Acid Rain: Acid rain is caused when pollutants present in the air mixes up with the rain and fall back on the ground. The polluted water could dissolve away some of the important nutrients found in soil and change the structure of the soil.
- Radioactive wastes: Radioactive elements from mining and nuclear power plants, find their way into water and then into the soil.

**Effects of Soil pollution**

1. On Human Health
   - Soil pollution has major consequences on human health. Consumption of crops and plants grown on polluted soil cause health hazards. This could explain small and terminal illness.
   - Long term exposure to polluted soil affects the genetic make-up of the body and may congenital illnesses and chronic health diseases.
   - Chronic exposure to heavy metals, petroleum, solvents and agricultural chemicals can be carcinogenic.
   - Exposure to benzene for a long term is associated with higher incidence of leukemia. Mercury causes higher incidences of kidney damage. Cyclodienes are linked to liver toxicity.
   - Organophosphates can lead to chain of responses leading to neuromuscular blockage.
   - Chlorinated solvents induce damages to liver, kidney, depression of the central nervous system.
2. On Plant Growth
   - The balance of ecological system is affected due to contamination of the soil.
   - Plants are mostly unable to adapt to the change in the chemistry of the soil in short time period.
   - The microorganisms found in the soil decline and create additional problems of soil erosion.
   - Fertility of the soil decreases due to soil pollution, making it unsuitable for agriculture and local vegetation to survive.
   - Soil pollution is hazardous to health.
   - Polluted lands cannot support most forms of life.
3. On Soil Fertility
   - The chemicals present in the soil due to pollution are toxic and can decrease the fertility of the soil, thereby decreasing the soil yield.
   - Agriculture on contaminated soil produces fruits and vegetable that lack quality nutrients.
   - Consumption of these may be poisonous and cause serious health problems to people consuming them.
4. On Soil Structure
   - Soil pollution can lead to death of many soil organisms like the earthworms which can lead to alteration in the soil structure.
   - This can force other predators to move to other places in search of food.

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## 6. RADIATION POLLUTION

### *What is Radiation Pollution?*

| There are three types of radiation particles |
|---|
| Alpha particles (α) - It can be blocked by a piece of paper and human skin. |
| Beta particles (β) – It can penetrate through skin, while can be blocked by some pieces of glass and metal. |
| Gamma rays (□) – It can penetrate easily to human skin and damage cells on its way through, reaching far, and can only be blocked by a very thick, strong, massive piece of concrete. |

The radioactive pollution is defined as the physical pollution of air, water and the others by radioactive materials. The ability of certain materials to emit the proton, gamma rays and electrons by their nuclei is known as the radioactivity. The protons are known as the alpha particle and the electrons are also known as the beta particle. Those materials are known as the radioactive elements. The environmental radiations can be from different sources and can be natural or manmade. Radiation is the process by which radiant energy is transferred from one place to another in the form of electro-magnetic waves. The various types of radiation differ from one another by their frequency or wavelength. Higher the frequency or lower the wave-length of a radiation, higher will be its energy. Again, higher the energy of the radiation, it will cause higher damage to the living organisms.

| Types of Radiation | |
|---|---|
| **Non-Ionising Radiations** | **Ionising Radiations** |
| a) These are the radiations which induce the ionisation of atoms and molecules. These affect only those components which absorb them and have low penetrability.<br>b) They include short-wave radiations such as ultraviolet rays, which forms a part of solar radiation<br>c) They damage eyes which may be caused by reflections from coastal sand, snow directly looking towards sun during eclipse.<br>d) They injure the cells of skin and blood capillaries producing blisters and reddening called sunburns | a) These have high penetration power and cause breakage of macro molecules.<br>b) They include X-rays, cosmic rays and atomic radiations<br>c) The molecular damage may produce short range (burns, impaired metabolism, dead tissues and death of the organisms) or long range effects (mutations, increased incidence of tumours and cancer, shortening of life-span and development changes). |

| Sources of Radiation Pollution | |
|---|---|
| **Natural Sources** | **Man-made Sources** |
| 1. Radioactive Minerals: The minerals containing Uranium- 235 (U235), Uranium-238 (U238), Thorium-232 (Th232), Plutonium- 239 (Pu239) etc. are capable of emitting energetic radiations causing pollution. | 1. Nuclear Power Plants: Nuclear power plants emit radiation to a very smaller extent except accidental leaks (Chernobyl accident of undivided USSR, Fukuschima Accident). |
| 2. Cosmic Rays: The cosmic rays containing highly energetic particles reach the surface of the earth causing pollution. The intensity of cosmic rays depends on latitudes and altitude of the place. The intensity is maximum at the poles and minimum at the equator. | 2. Radio-active Wastes: The nuclear power plants produce a lot of nuclear radio-active wastes. The disposal of these wastes has become a global problem. Some countries producing large quantity of nuclear wastes dump them in ocean near other countries. |
| 3. Radio nuclides: The unstable radio-nuclides in | 3. Nuclear Explosion: During nuclear explosion, |

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| | |
|---|---|
| the atmosphere can be splitted up into smaller parts emitting energetic radiation. The smaller radio-nuclides enter into the body of organism along with air during respiration | a large number of radio-nuclides are generated in the atmosphere. The radio nuclides settle down with rain contaminating the soil and water bodies. Finally, these enter into food chain causing serious problem to the living organisms. |
| | 4. Radio-isotopes: Radio-isotopes are also prepared artificially either by nuclear fusion or by nuclear fission. If these radio-isotopes are not properly handled, these emit radiations causing pollution. |
| | 5. Television Set: Television sets produce radiations which can also cause cancer. |

**Effect of Radiation Pollution:**

1. On the Environment

≠ When soil is contaminated by radioactive substances, the harmful substances are transferred into the plants growing on it. It leads to genetic mutation and affects the plant's normal functioning. Some plants may die after such exposure, while others may develop weak seeds. Eating any part of the contaminated plant, primarily fruits, poses serious health risks. Since plants are the base of all food chains, their contamination can lead to radioactive deposition all along the food web. Similarly, when radioactive waste is washed up in a water source, it can affect the entire aquatic food web.

≠ Both terrestrial and aquatic radioactive contamination can culminate in human consumption. Since humans are apex predators, the accumulation of radioactive materials on the last rung of the food chain would be maximum.

2. On Human Beings

≠ The impact of radioactive pollution on human beings can vary from mild to fatal; the magnitude of the adverse effects largely depends on the level and duration of exposure to radioactivity. Low levels of localized exposure may only have a superficial effect and cause mild skin irritation. Effects of long, but low-intensity exposures include nausea, vomiting, diarrhea, loss of hair, bruises due to subcutaneous bleeding etc.

≠ Long-term exposure or exposure to high amounts of radiation can have far more serious health effects. Radioactive rays can cause irreparable damage to DNA molecules, and can lead to a life-threatening condition. Prolonged exposure leads to a large number of molecules in the body being ionized into free radicals. Free radicals promote the growth of cancerous cells, i.e. tumours, in the body. People with heavy radiation exposure are at a very high risk for cancers.

≠ The rapidly growing/dividing cells, like those of the skin, bone marrow, intestines, and gonads are more sensitive towards radioactive emissions. On the other hand, cells that do not undergo rapid cell division, such as bone cells and nervous cells, aren't damaged so easily. Skin cancer, lung cancer and thyroid cancer are some of the common types of cancers caused by radiation.

≠ The effects of genetic mutation are passed on to the future generations as well. In other words, if the parents are exposed to nuclear radiation, their child could have severe congenital birth defects, both physical and mental. This is tragically illustrated in the case of Hiroshima and Nagasaki, where the after effects of nuclear radiation were carried on for generations, and thousands of children were born with physical abnormalities and mental retardation. The radiation also brought about a spike in cancer; the region still (after more than 65 years) has a much higher rate of cancer and congenital abnormalities than the rest of Japan.

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## 7. PLASTIC POLLUTION

***What is plastic pollution?***

Plastic Pollution is the introduction of plastic products into the environment which then upset the existing ecosystems in different ways.

**Common Causes of Plastic Pollution**

1. Plastic bags from shopping
2. Plastic Toys
3. Pet Bottles
4. Failure to recycle
5. Using Plastic Disposables
6. Plastic Fishing Nets
7. Poor Disposal of Plastic Waste

**Effects of Plastic Pollution**

1. Affects Human life and Health
2. Degrades Quality of Land and Affects Agriculture
3. Poses Threat To Animal Health
4. Disrupts Marine life
5. Air Pollution
6. Blocks The Drainage System
7. Loss of Tourism

**What is plastic?**

A MATERIAL that is made from plastic can easily be shaped or deformed. Plastics are synthetic materials that are made from synthetic resins or organic polymers. Examples of these polymers include nylon, PVC, and polyethylene. Plastics are categorized into two groups, those that go through a chemical change process in their constituents when subjected to heat (thermosetting polymers) and those that do not (thermoplastics). Examples of thermoplastics include polypropylene and polyethylene.

**Preventive and Control Measures**

Our actions introduce plastics into the ecosystem and cause pollution. That means that we can also be proactive and enforce preventive and control measures so that we do not have to deal with the bad effects. Here are some of the preventive and control measures that can help reduce this menace:

# Alternatives to Plastics
# Reusable Water
# Waste
# Recycling
# Government Policies

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# CHAPTER – 8
# ENVIRONMENTAL IMPACT ASSESSMENT

***What's EIA?***

Project proponent has to prepare an EIA report with the help of an environment consultant to:

- Study the predictable environmental consequences and the best combination of economic and environmental costs and benefits of the proposed project.
- Mitigation of harmful impacts and maximizes the beneficial effects.

On the basis of such report, the EIA may be either comprehensive EIA or Rapid EIA.

≠ ***Comprehensive EIA.*** If the EIA report has to incorporate the data of all four seasons of a year

≠ ***Rapid EIA.*** If the EIA report has only one season data.

The EIA process finds its origin from United States where due to huge public pressure; the government enacted National Environmental Policy Act (NEPA) in 1970s. The role of EIA process was formally recognized at the Earth Summit in Rio Conference in 1992 in which the Rio declaration stated that EIA shall be taken as national instrument for proposed projects which might adversely impact the environment.

The EIA notification classifies all kinds of developmental projects into various schedules. The project investor has to identify to which schedule his proposed project belongs to. **All projects and activities are broadly categorized into two categories - Category A and Category B, based on the spatial extent of potential impacts and potential impacts on human health and natural and manmade resources.**

| CATEGORY 'A' | CATEGORY 'B' |
|---|---|
| • *'All projects or activities included as Category 'A' in the Schedule, including expansion and modernization of existing projects or activities and change in product mix, shall require prior environmental clearance from the Central Government in the Ministry of Environment and Forests on the recommendations of an* ***Expert Appraisal Committee (EAC)*** *to be constituted by the Central Government for the purposes of this notification.* | • *All projects or activities included as Category 'B' in the Schedule, including expansion and modernization of existing projects or change in product mix, but excluding those which fulfill the General Conditions (GC) stipulated in the Schedule, will require prior environmental clearance from the State/Union territory Environment Impact Assessment Authority (SEIAA). The SEIAA shall base its decision on the recommendations of a State or Union territory level Expert Appraisal Committee (SEAC) as to be constituted for in this notification. In the absence of a duly constituted SEIAA or SEAC, a Category 'B' project shall be treated as a Category 'A' project.* |

**EIA is conducted by:**

1. The project proponent or
2. Independent agencies (in India) like NEERI, NCAER, TERI, WAPCOS, Ernst & Young etc.

**Purpose of EIA:**

- To systematically examine both beneficial and adverse consequences of the proposal.

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- To ensure that those consequences are taken into account during project design.
- To identify possible environmental effects of the proposal and means to mitigate them.
- To predict whether there will be significant adverse effects even after the mitigation.
- To lessen conflicts by promoting community participation and informing decision makers

**PROCEEDURE**

| Screening | Identification | Evaluation | Mitigation | Documentation | Review of EIA |
|---|---|---|---|---|---|
| First stage of EIA, which determines whether the proposed project requires an EIA and if it does, then the level of assessment required. | This stage identifies the key issues and impacts that should be further investigated. This stage also defines the boundary and time limit of the study. | This stage of EIA identifies and predicts the likely environmental and social impact of the proposed project and evaluates the significance. | This step in EIA recommends the actions to reduce and avoid the potential adverse environmental consequences of development activities. | This stage presents the result of EIA in a form of a report to the decision-making body and other interested parties. | It examines the adequacy and effectiveness of the EIA report and provides the information necessary for decision-making. |

| | |
|---|---|
| **Decision-Making and Post Monitoring** | 1.It decides whether the project is rejected, approved or needs further change.<br>2. This stage comes into play once the project is commissioned. It checks to ensure that the impacts of the project do not exceed the legal standards and implementation of the mitigation measures are in the manner as described in the EIA report. |

**Issues:**

The related issues can be classified in two categories:

**Report Issues**

1. Ambiguous definitions – In the EIA notification 2006, there is a lack of clarity in overall conductance of the Screening process. As it is discretion of the State Level committee to decide which projects are B1 and which are B2, many a times the bias of respective State Governments come into play. The Scoping process faces same types of issues because of lack of clarity in guidelines.
2. Misleading EIA reports – sometimes the EIA reports lack the expected degrees of honesty, owing to bias, corruption, exaggeration and wrong claims. Due to poor knowledge of the project area the agencies lift paragraphs and sentences from other sources, thus presenting contradictory, inconsistent and outdated information. Moreover there is no process for punishing the agencies tabling such dishonest EIA reports.
3. Incomplete and Arbitrary EIA reports – Agencies or project proponents also prepare incomplete EIA reports, which include incomplete surveys, arbitrary demarcation of EIA study area

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and unsubstantiated statements. Sometimes the impact with respect to flash floods, landslides, peak precipitation etc. round the year is grossly ignored in reports.

4. Underqualified EIA professionals – This happens mostly when the proponents themselves conduct the EIA. They intentionally hire local and incompetent professionals to save cost over the whole process or some other vested reasons. These poor professionals prepare a poor quality of EIA reports.

**Public Hearing Issues**

1. Awareness – There is a gross lack of awareness among the local people, about the process of EIA, its significance for them, role of various players and their own rights and responsibilities. Moreover there is a communication gap between authorities and local people because the notice for Public hearing is issued in local newspapers only and no separate notices are sent to individual concerned panchayats. Most of the times local people are unaware of the Public hearing meetings.
2. Language – Most of the time EIA reports are not available in local languages, thus local people are unable to decipher the reports, and are misled by the proponents. This can be interpreted as a clear violation of the right to information on their part. The irony is local people are totally unaware of such implications.
3. Unaware public officials – The concerned officials for example those in Public Hearing committee are ignorant of their roles and responsibilities. Sometimes they don't even get a copy of EIA report and it is passed without their consent, owing to gross corruption of the system.
4. Overindulgence of Public hearing consultants – In the public hearing meeting, the consultants should not be allowed to have a dominant say, except responding to the issues of the people. On the contrary, they get involved in public hearings beyond requirements and thus mislead the local people.
5. Piling-up of issues – The issues raised by people in public hearings remains unanswered and they do not know what happens to the issues, nor do they know if the issues raised are reflected in public hearing reports that is presented to Ministry of Environment and forests.

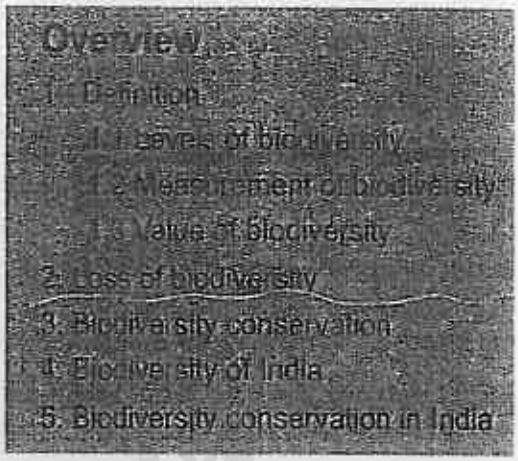
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# CHAPTER – 9
# BIODIVERSITY

## 1. DEFINITION




"Biodiversity is defined as the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."

The biodiversity we see today is the fruit of billions of years of evolution, shaped by natural processes and, increasingly, by the influence of humans. It forms the web of life of which we are an integral part and upon which we so fully depend. This diversity is often understood in terms of the wide variety of plants, animals and microorganisms.

Biodiversity describes how much variety an ecosystem has, in terms of resources and species; and also genetically within species. A more diverse ecosystem will have more resources to help it recover from famine, drought, disease or even the extinction of a species. There are several levels of biodiversity, each indicating how diverse the genes, species and resources are in a region.

### 1.1 LEVELS OF BIODIVERSITY

**a) Species Diversity**

Species diversity refers to the variety of species within a region. Every ecosystem contains a unique collection of species, all interacting with each other. Some ecosystems may have many more species than another. In some ecosystems, one species has grown so large that it dominates the natural community. When comparing the biodiversity of ecosystems, an ecosystem that has a large number of species, but no species greatly outnumbering the rest, would be considered to have the most species diversity. A large number of species can help an ecosystem recover from ecological threats, even if some species go extinct. There are approximately 1.8 million different species classified on Earth. Of all the species identified, nearly 1 million are insects! New species are being discovered each year. Scientists estimate that there may be between 5 to 30 million species that actually live on Earth. Each year, approximately 13,000 more species are added to this growing list of known species.

Determining which community has greater species diversity is easy when either species richness or evenness is held constant while the other parameter varies, but often communities will vary in both richness and evenness. Scientists have developed a variety of mathematical equations (or indices) that incorporate both species richness and evenness into a single measure of species diversity (e.g., the Shannon-Wiener Index and Simpson's Index). Different diversity indices assign different weightings to species richness and evenness, so the so most useful index to choose depends on the circumstances.

**b) Genetic Diversity**

Genetic diversity refers to the diversity (or genetic variability) within species. Each individual species possesses genes which are the source of its own unique features: In human beings, for example, the huge variety of people's faces reflects each person's genetic individuality. The term genetic diversity also covers distinct populations of a single species, such as the thousands of breeds

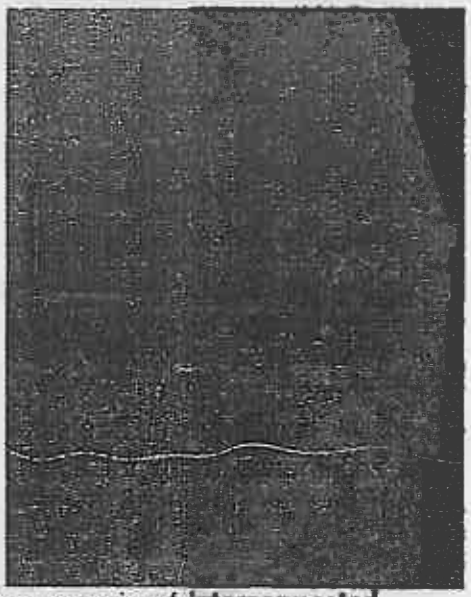
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of different dogs or the numerous varieties of roses. The diversity in wild species forms the 'Gene Pool' from which present flora and fauna have been developed over thousands of years.



Genetic diversity describes how closely related the members of one species are in a given ecosystem. In simple terms, if all members have many similar genes, the species has low genetic diversity. Because of their small populations, endangered species may have low genetic diversity due to inbreeding. This can pose a threat to a population if it leads to inheritance of undesirable traits or makes the species more susceptible to disease. Having high genetic diversity helps species adapt to changing environments.

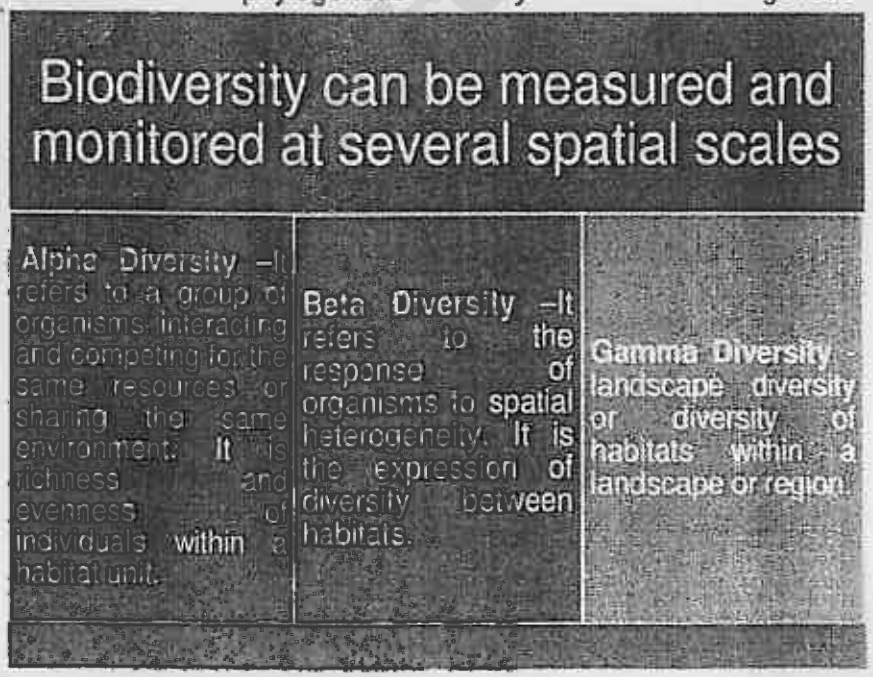
**c) Ecosystem Diversity**

Ecosystem diversity refers to the variety of ecosystems in a given place. Within any broader landscape there is a mosaic of **interconnected** ecosystems. It may be of habitat or community diversity. A region may have several ecosystems, or it may have one. Wide expanses of oceans or deserts would be examples of regions with low ecological diversity. A mountain area that has lakes, forests and grasslands would have higher biodiversity, in this sense. A region with several ecosystems may be able to provide more resources to help native species survive, especially when one ecosystem is threatened by drought or disease.

## 1.2 MEASUREMENT OF BIODIVERSITY

Species diversity can be measured in terms of:

- Species richness – refers to the number of various species in a defined area.
- Species abundance – refers to the relative numbers among species. For example, the number of species of plants, animals and microorganisms may be more in an area than that recorded in another area.
- Taxonomic or phylogenetic diversity – refers to the genetic relationships between different groups of species.




Biodiversity is a measure that combines richness and evenness across species. It is often measured because high biodiversity is perceived a synonymous with ecosystem health. In general diverse communities are believed to have increased stability, increased productivity, and resistance to invasion and other disturbances.

## 1.3 VALUE OF BIODIVERSITY

Biodiversity is the combination of life forms and their interactions with each other and with the rest of the environment that has made Earth a

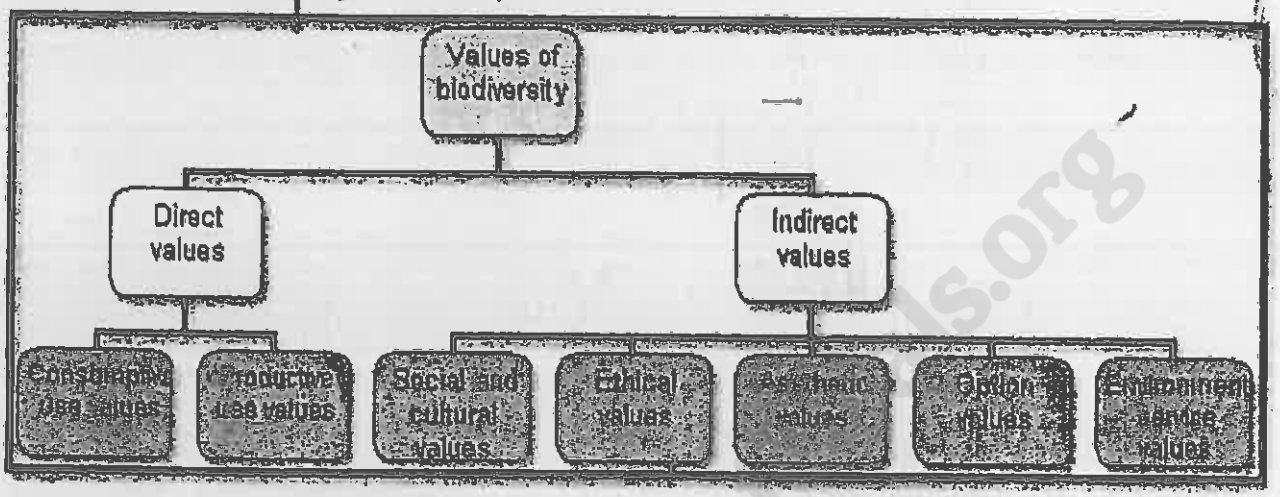
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uniquely habitable place for humans. Biodiversity provides a large number of goods and services that sustain our live-protecting biodiversity is in our self-interest. Biological resources are the pillars upon which we build civilizations. Nature's products support such diverse industries as agriculture, cosmetics, pharmaceuticals, pulp and paper, horticulture, construction and waste treatment. The loss of biodiversity threatens our food supplies, opportunities for recreation and tourism, and sources of wood, medicines and energy. It also interferes with essential ecological functions.

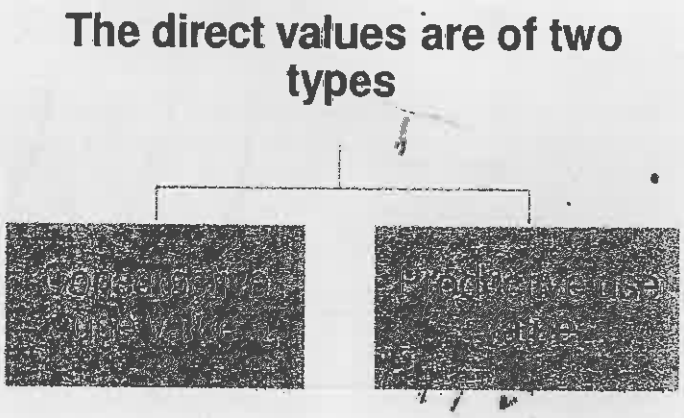
**The value of biodiversity can be depicted as follows:**




### Direct values

The direct value include food resources like grains, vegetables, fruits which are obtained from plant resources and meat, fish, egg, milk and milk products from animal resources. These also include other values like medicine, fuel, timber, fibre, wool, wax, resin, rubber, silk and decorative items.

**Consumptive use value:** These are the direct use values where the biodiversity products can be harvested and consumed directly. Example: Food, fuel and drugs. These goods are consumed locally and do no figure in national and international market.




(a) Food:

- Plants: The most fundamental value of biological resources particularly plants is providing food. Basically three crops i.e. wheat, maize and rice constitute more than two third of the food requirement all over the world.
- Fish: Through the development of aquaculture, techniques, fish and fish products have become the largest source of protein in the world.

(b) Fuel: Since ages forests have provided wood which is used as a fuel. Moreover fossil fuels like coal, petroleum, natural gas are also product of biodiversity which are directly consumed by humans.

(c) Drugs and medicines: The traditional medical practice like Ayurveda utilizes plants or their extracts directly. In allopathy, the pharmaceutical industry is much more dependent on natural products. Many drugs are derived from plants like



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- Quinine: The famous anti malaria drug is obtained from cinchona tree.
- Penicillin: A famous antibiotic is derived from Pencillium, a fungus.
- Tetracycline: It is obtained from bacterium.
- Recently Vinblastine and Vincristine, two anti-cancer drugs have been obtained from Catharanthus plant which has anti-cancer alkaloids.

These are the direct use values where the product is commercially sold in national and international market. Many industries are dependent upon these values. Example- Textile, leather, silk, paper and pulp industry etc. Although there is an international ban on trade of products from endangered species like tusks of elephants, wool from sheep, fur of many animals etc. These are traded in market and fetch a booming business.

**Indirect values**

Biodiversity provides indirect benefits to human beings supporting the existence of biological life and other benefits which are difficult to quantify. These include social and cultural values, ethical values, aesthetic values, and ecosystem services.

**Social and cultural value:** Many plants and animals are considered holy and sacred in India and are worshipped like Tulsi, Peepal, cow, snake etc. In Indian society great cultural value is given to forest and as such tiger, peacock and lotus are named as the national animal, bird and flower respectively.

**Ethical:** These values are related to conservation of biodiversity where ethical issue of 'all life forms must be preserved' is laid down. There is an existence value which is attached to each species because biodiversity is valuable for the survival of human race. Moreover all species have a moral right to exist independent of our need for them.

| Ecosystem Services |
|---|
| The production of oxygen by land based plants and marine algae. |
| The maintenance of fresh water quality by vegetation slowing run off, trapping sediment and removing nutrients and by soil organisms breaking down pollutants. |
| The production and maintenance of fertile soil as a result of many interacting processes; |
| The provision of foods such as fish, pastures for cattle and sheep, timber, fire wood and harvested wildlife such as kangaroos and native cut flowers. |
| The provision of native species and genes used in industry research and development, for instance, in traditional breeding and biotechnology applications in agriculture, forestry, horticulture, aquaculture, pharmacy, chemicals production and bioremediation . |
| Pollination of agricultural crops, forest trees and native flowering plants by native insects, birds and other creatures. |
| Pest control in agricultural land by beneficial native predators. |
| Flood mitigation by vegetation slowing run off and trapping sediment. |
| Breakdown of pollutants by micro-organisms in soil and aquatic ecosystems and sequestration of heavy metals in marine and fresh water sediments. |
| Greenhouse gas reduction by, for instance, sequestering atmospheric carbon in wood and marine calcium carbonate deposits. |
| Maintenance of habitats for native plants and animals. |
| Maintenance of habitats that are attractive to humans for recreation, tourism and cultural activities and that has spiritual importance. |



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**Aesthetic value:** There is a great aesthetic value which is attached to biodiversity. Natural landscapes at undisturbed places are a delight to watch and also provide opportunities for recreational activities like bird watching, photography etc. It promotes eco-tourism which further generates revenue by designing of zoological, botanical gardens, national parks, wild life conservation etc.

## 2. LOSS OF BIODIVERSITY

Loss of species, ecosystems, genes and extinction of flora and fauna is termed as loss of biodiversity. The loss of biodiversity often reduces the productivity of ecosystems, thereby shrinking nature's basket of goods and services, from which we constantly draw. It destabilizes ecosystems, and weakens their ability to deal with natural disasters such as floods, droughts, and hurricanes, and with human-caused stresses, such as pollution and climate change. The reduction in biodiversity also hurts us in other ways. Our cultural identity is deeply rooted in our biological environment. Plants and animals are symbols of our world, preserved in flags, sculptures, and other images that define us and our societies. We draw inspiration just from looking at nature's beauty and power. While loss of species has always occurred as a natural phenomenon, the pace of extinction has accelerated dramatically as a result of human activity. Ecosystems are being fragmented or eliminated, and innumerable species are in decline or already extinct.

**Causes** – The main cause of the loss of biodiversity can be attributed to the influence of human beings on the world's ecosystem; In fact human beings have deeply altered the environment, and have modified the territory, exploiting the species directly. The threats to biodiversity can be summarized in the following main points:

- *Habitat loss* – The habitat loss has been through changes of land use in particular the conversion of natural ecosystems to cropland, continues to be the biggest direct cause of biodiversity loss. Already, more than half of the Earth's 14 terrestrial biomes have had between 20% and 50% of their total area converted to cropland.
- *Over-exploitation* – Unsustainable use of ecosystems and over-exploitation of biodiversity continue to be major threats. Many species are used by humans to fulfil basic needs. Many species are in a state of decline because they are being used at unsustainable levels or are being harvested in such a way that threatens the ecosystems on which they depend. These declines are widespread.
- *Climate change* – Climate change is projected to become a progressively more significant threat to biodiversity in the coming decades. Already, changes to the timing of flowering and migration patterns as well as to the distribution of species have been observed worldwide. In Europe, over the last forty years, the beginning of the growing season has advanced by 10 days on average. These types of changes can alter food chains and create mismatches within ecosystems where different species have evolved synchronized inter-dependence, for example between nesting and food availability.
- *Introduction of alien species* – Plants, animals and micro-organisms transported deliberately or accidentally to an area outside their natural geographical ranges can cause great damage to native species by competing with them for food, eating them, spreading diseases, causing genetic changes through inter-breeding with native species or populations, and disrupting various aspects of the food web and the physical environment.
- *Environmental Pollution* – The accumulation of pollution such as phosphorus and nitrogen, largely from excess fertilizers running off farmland, and from sewage and other effluents, causes the build-up of algae able to benefit from the added nutrients. The algae themselves can be toxic and therefore create a health hazard, but the greatest damage to biodiversity is caused



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when they decompose and use up large quantities of oxygen in the water, creating "dead zones" where other forms of life cannot survive. The continuing release pollutants from urban and agricultural sources combined with projected growth in coastal development and agricultural intensification may lead to a multiplication of the number of dead zones in the coming decades, unless substantial changes in policy are implemented.

### Keystone Species

A keystone species is a species that plays a critical role in maintaining the structure of an ecological community and whose impact on the community is greater than would be expected based on its relative abundance or total biomass. A keystone species is a plant or animal that plays a unique and crucial role in the way an ecosystem functions. Without keystone species, the ecosystem would be dramatically different or cease to exist altogether. All species in an ecosystem, or habitat, rely on each other. The contributions of a keystone species are large compared to the species' prevalence in the habitat. A small number of keystone species can have a huge impact on the environment. A keystone species is often, but not always, a predator. A few predators can control the distribution and population of large numbers of prey species. Beavers, Wolves, Mountain Lions, Red mangrove etc. are some of the examples of keystone species.

**A keystone species' disappearance would start a domino effect. Other species in the habitat would also disappear and become extinct**. The keystone species' disappearance could affect other species that rely on it for survival. For example, the population of deer or rabbits would explode without the presence of a predator. The ecosystem cannot support an unlimited number of animals, and the deer soon compete with each other for food and water resources. Their population usually declines without a predator such as a mountain lion. Without the keystone species, new plants or animals could also come into the habitat and push out the native species.

In addition to keystone species, there are other categories of species that are crucial to their ecosystems' survival, such as:

### Foundation Species

Foundation species play a major role in creating or maintaining a habitat that supports other species. Corals are one example of a foundation species in many islands in the South Pacific Ocean. Corals produce the reef structures on which countless other organisms, including human beings, live.

### Umbrella Species

An umbrella species is a large animal or other organism on which many other species depend. Umbrella species are very similar to keystone species, but umbrella species are usually migratory and need a large habitat. Protection of umbrella species is thought to automatically protect a host of other species. Tigers are an example of an umbrella species. Efforts to save wild tigers in forests in Rajasthan also accomplish the goal of saving other species there, such as leopards, boars, hares, antelopes, and monkeys.

### Indicator Species

An indicator species is a plant or animal that is very sensitive to environmental changes in its ecosystem. This means it is affected almost immediately by damage to the ecosystem and can give early warning that a habitat is suffering. Damage from external influences such as water pollution, air pollution, or climate change first appears in indicator species.

## CLASSIFICATION OF ANIMALS AND PLANTS

### Faunal Diversity

There are billions of different kinds of living things (or organisms) on earth. To help study them, biologists have devised ways of naming and classifying them according to their similarities

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and differences. The system most scientists use puts each living thing into seven groups (or taxons), organized from most general to most specific. Therefore, each species belongs to a genus, each genus belongs to a family, each family belongs to an order, etc.

From largest to smallest, these groups are:

- Kingdom – It is the highest primary division in which all objects are placed. All animals are part of the Animal Kingdom.
- Phylum – Each kingdom is divided into smaller units called phyla. Example, chordates are a phylum with members possessing the nerve cord.
- Class – The chordates are further divided into classes such as Mammalia, Birds, Reptilia, and Amphibians. Members of each class have a characteristic that they share with the members of the same class but are not found in members of other classes.
- Order – Order is further classification of Class.
- Family – Orders are further divided into families. Families contain more than one genus.
- Genus – Families are sub-divided into genera. Animals that share the same genus are very similar and probably evolved from the same common ancestor.
- Species – Species is the most fundamental and contains single type of animal.

Example - The lion belongs to the following groups:

- Kingdom Animalia (includes all animals)
- Phylum Chordata (includes all vertebrate animals, as well as some other more primitive ones)
- Class Mammalia (includes all mammals)
- Order Carnivora (includes carnivorous mammals, from bears to raccoons to harbor seals)
- Family Felidae (includes all cats)
- Genus Panthera (includes the great roaring cats: lions, tigers, jaguars, and leopards)
- Species leo (lions!)

Animals are classified into two principal groups, invertebrates (with-out backbone) and vertebrates (with backbone). Backbone is the observable feature which defines whether the animal is vertebrate or invertebrate.

**Invertebrates**

Invertebrates are the animals that do not have a backbone or the vertebral column. Invertebrates are the most abundant organisms on earth. They occupy almost all habitats; they can be found crawling, flying, swimming or floating. These animals do not have internal skeleton made of bone. They play a vital role in the earth's ecosystem.

**Characteristics of Invertebrates –**

- The main characteristic that separates invertebrates from other organisms is the absence of the spinal column and backbone.
- They are multi-cellular organisms, they completely lack cell walls.
- They are devoid of hard bony endoskeleton.
- Due to the lack of complex skeletal systems, some invertebrates tend to be slow and small in nature.
- Due to the lack of the backbone and complex nervous system the invertebrates cannot occupy multiple environments, though they are found in the harshest of the environments.
- Invertebrates live all over the world in various habitats.

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- Body is divided into three parts - head, thorax and the abdomen.
- They do not have lungs for respiration.
- Respiration is through skin.
- Some invertebrate groups possess a hard, chitinous exoskeleton.
- Most of them have tissues that are specific organization of cells.
- Most of them reproduce sexually by the fusion of the male and female gametes.
- Few invertebrates like the sponges are sedentary, but most of the organisms are motile.
- Most invertebrates are organized with symmetric body organization.
- They cannot make their own food, are heterotrophs.

**Vertebrates**

Vertebrates are the animals that have a backbone or the vertebral column. They are not the most numerous group of animals; they are the most advanced group of animals. The characteristics that make vertebrates special are the presence of the spinal cords, vertebrae and notochords.

Characteristics of Vertebrates –

- Vertebrates have a well-developed brain.
- Brain is set inside a bony box, known as cranium.
- Notochord is present in all chordates during sometime of development; it is formed on the dorsal side of the primitive gut in the early embryo stage.
- Most vertebrates possess guts with a non-terminal anus.
- The mouth cavity and the oesophagus are connected by the pharyngeal gill slits to a muscular tube pharynx, which opens to the exterior.
- They possess a dorsal hollow nerve tube at some stage of their life.
- Possess a dorsal cartilaginous nerve rod known as the notochord.
- At some stage of their life possess gill slits in the pharyngeal region.
- Have partially open circulatory system.
- Possess two pairs of appendages.
- The endoskeleton is made of cartilage or bone.
- The first vertebrates were jawless fishes with single caudal fin.
- The advancement of vertebrates with a hinged jaw which opened new food options and jawed fishes became the dominant creatures in the sea.
- All vertebrates have a heart and closed circulatory system.
- Reproduction is normally sexual.
- Feed on variety of organic materials.
- Unisexual animals have one pair of gonads.

| Invertebrates Classification | |
|---|---|
| A. Sponges (Poriferans) | B. Cnidarians |
| • They belong to Phylum Porifera and mostly called sponges. | • They are aquatic animals having marine habitat. |
| • They mostly live in salty sea water fixed to some object. | • Body is tube-like with one opening called mouth. |

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- Their body is covered with pores through which food enters.
- One large pore is present at top of the body. Example - Sycon, Spongilla.

- Mouth is surrounded by tentacles used for capturing prey.
- They have radially symmetrical body. Example-Hydra, Jellyfish.

**C.** Platyhelminthes (Flatworms)

- They can be found in marine/fresh water.
- They have flat, ribbon like body.
- Body is bilaterally symmetrical
- Body is having a single opening.
- Most of them are parasites.

Example-Tapeworms, Liverfluke.

**D.** Nemathelminthes (Roundworms)

- Found in fresh/marine water or on land.
- They have thread like ,rounded body
- They have un-segmented body.
- Body have two openings mouth and anus.
- Body is bilaterally symmetrical.
- Most of them are parasites and reproduce sexually by laying eggs. Example-Pinworm, Ascaris.

**E.** Annelids (Segmented worms)

- Found in marine and fresh water.
- They have segmented bilaterally symmetrical body.
- They have a body cavity.
- They have special organs of excretion called Nephridia
- Example-Earthworm, Leech.

**G.** Molluscs (soft bodied shelled animals)

- Animals have soft un-segmented body with an external hard shell.
- Example-Squid, snail, octopus.

**H.** Echinoderms (Spiny-skinned animals)

- They are marine animals having spines all over the body.
- Body is radially Symmetrical
- Body has two openings mouth and anus.
- They have tube like feet having suckers
- Example-Starfish, Sea urchins.

**F.** Arthropods (Animals with jointed legs)

- They have segmented bilaterally symmetrical body
- Body is divided into three regions- Head, Thorax and Abdomen.
- Body has tough outer covering called exoskeleton
- They have jointed appendages.

Further classified into four subgroups

- **Arachnids**
  - ≠ Head and thorax fused.
  - ≠ Have four pair of legs.
  - ≠ Wings are absent.
  - ≠ Example -Scorpion, Spider
- **Crustaceans**
  - ≠ Head and thorax fused
  - ≠ Appendages present on all segments
  - ≠ Have variable number of jointed legs.
  - ≠ Example -Shrimps, Lobster.
- **Myriapods**
  - ≠ Body divided into many segments.
  - ≠ Some have two pair of legs per segment (millipede) while some have one pair of legs per segment(Centipede)
  - ≠ Example -Millipedes and centipedes
- **Insects**
  - ≠ Body is divided into head thorax and abdomen.

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| | |
|---|---|
| | ≠ Most insects have three pair of legs, two pair of wings.<br>≠ Some insects are wingless.<br>≠ Example-Ants, honeybee. |
| **Vertebrates Classification** | |
| **A. Pisces (fishes)**<br>• They are cold-blooded animals.<br>• They have streamlined body.<br>• They have gills for respiration and fins for locomotion.<br>• Body is often covered with scales which provide protection to the body.<br>• Example -Seahorse, Shark. | **B. Amphibia (frogs and salamanders)**<br>• They are cold-blooded animals.<br>• They can live both on land and in water.<br>• They breathe through both lungs and moist skin.<br>• They reproduce only in water<br>• Example-Toad, Frog, Salamander. |
| **C. Reptilia (lizards and Snakes)**<br>• They are cold -blooded animals.<br>• They live on land.<br>• They breathe with help of lungs.<br>• They have dry and scaly skin.<br>• They lay eggs with leathery shells.<br>• Example- Tortoise, Snake, Crocodile. | **D. Aves (Birds)**<br>• They are warm blooded animals.<br>• Their body is covered with feathers.<br>• Their forelimbs are modified into wings.<br>• They breathe through lungs.<br>• Their bones have large air cavities.<br>• They lay eggs with hard shells. Example-Parrot, Crow |
| **E. Mammals (Animals with mammary glands)**<br>• They are warm blooded animals.<br>• They give birth to babies.<br>• They have mammary glands to produce milk.<br>• They breathe through lungs.<br>• Example-man, mouse | |

## Floral Diversity

There are different types of plant species, which are found on planet earth. They are sorted and classified into a separate kingdom known as Kingdom plantae. This classification is based on their similarities and differences. The Kingdom plantae is also called as kingdom Metaphyta. The Kingdom plantae includes all types of eukaryotic, multi-cellular, photosynthetic plants found in this biosphere. Most of the organism in this kingdom is autotrophs, which synthesis their own food with the help of solar energy. There are very few species, which are both autotrophs and heterotrophs. The history of life on earth and the success of many organisms literally depend on the success of plants. Kingdom Plantae Characteristics –

- Most of the plants are eukaryotic and chlorophyll containing organisms.
- Cell walls of plant cells are comprised of cellulose.

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- They have an ability to grow by cell division.
- In life cycle of plant cells, the interchanges occur from the embryos and are supported by other tissues and self-produce.
- Plants have both organs and organ systems.
- They obtain their energy from sun through photosynthesis.
- Plants reproduce both by sexual and asexual.

Plants have been divided into five types, based on following parameters
≠ The presence of vascular tissue.
≠ The absence of vascular tissue.
≠ The presence of seeds.
≠ The absence of seeds.

- Plants develop a self defence mechanism to protect them from being destroyed by animals, fungi and other plants.
- Organisms within Kingdom Plantae are multi-cellular, eukaryotic and autotrophic.
- They lack motility.

**Kingdom Plantae Classification**

Vascular tissue and the seeds are mainly considered as they play a vital role. Vascular tissue helps in transporting substances (water, minerals and sugars) throughout the plant. Seeds are structures, which contains an embryo that helps in storing food.

1. Algae –
- Algae are chlorophyll-bearing, simple, thalloid, autotrophic and largely aquatic (both fresh water and marine) organisms.
- They occur in a variety of other habitats: moist stones, soils and wood. Some of them also occur in association with fungi (lichen) and animals (e.g., on sloth bear).
- The algae reproduce by vegetative, asexual and sexual methods.
- At least a half of the total carbon dioxide fixation on earth is carried out by algae through photosynthesis. Being photosynthetic they increase the level of dissolved oxygen in their immediate environment.

2. Bryophytes –
- They are non-vascular land plants, which do not contain any conducting tissues and are often referred to as bryophytes.
- These plants are small, grow close to the ground and include mosses and liverworts.
- They are very small in structure and are considered as important members of our ecosystem.
- The reproduction process is carried in their spores. They are non-flowering plant and are found mainly growing on the ground, on other plants and on rocks.
- They play a vital role in preventing soil erosion.
- Examples - Mosses, Liverworts and Hornworts.

3. Pteridophytes –
- They are seedless vascular plants, which contain vascular tissues but do not produce seeds.
- They are involved in transportation of fluids.
- The reproduction process is carried by spores.
- Examples - horsetails, ferns and club mosses.

4. Gymnosperms –
- Gymnosperms are non-flowering plants with undeveloped seeds, which are present in an enclosed structure.
- Monocot begins with a single seed-leaf. The main veins of their leaves are usually parallel and unbranched.

5. Angiosperms –
- Angiosperms are flowering plants, which develops the seeds within a protective structure.
- The reproduction process is carried by Angiosperm.
- They develop their seeds within an ovary, which itself is embedded in a flower. After the stage of fertilization, the flower falls and the ovary bulges to become a fruit.
- Angiosperms in the class Dicotyledoneae grows into two seed-leaves (cotyledons).
- An angiosperms leaf consists of a single, branched, main vein, which originates from the base of the leaf blade. In few plats, it may also

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| | |
|---|---|
| • Monocot plays an important role in providing us with our primary sources of nutrition, which includes grains, fruits, etc. Examples - palms, carpet lawns, etc. | consist of four or more main veins diverging from the same base.<br>Examples - trees, shrubs, vines and flowers. |

## The extinction of Species

We're currently experiencing the worst spate of species die-offs since the loss of the dinosaurs 65 million years ago. Although extinction is a natural phenomenon, humans have catalysed it, to intensify the process. Unlike past mass extinctions, caused by events like asteroid strikes, volcanic eruptions, and natural climate shifts, the current crisis is almost entirely caused by us — humans. In fact, 99 percent of currently threatened species are at risk from human activities, primarily those driving habitat loss, introduction of exotic species, and global warming. Because the rate of change in our biosphere is increasing, and because every species' extinction potentially leads to the extinction of others bound to that species in a complex ecological web, numbers of extinctions are likely to snowball in the coming decades as ecosystems unravel. Nobody really knows how many species are in danger of becoming extinct. The IUCN has assessed roughly 3 percent of described species and identified 16,928 species worldwide as being threatened with extinction, or roughly 38 percent of those assessed.

Species diversity ensures ecosystem resilience, giving ecological communities the scope they need to withstand stress. Thus while conservationists often justifiably focus their efforts on species-rich ecosystems like rainforests and coral reefs — which have a lot to lose — a comprehensive strategy for saving biodiversity must also include habitat types with fewer species, like grasslands, tundra, and polar seas — for which any loss could be irreversibly devastating. And while much concern over extinction focuses on globally lost species, most of biodiversity's benefits take place at a local level, and conserving local populations is the only way to ensure genetic diversity critical for a species' long-term survival.

### Amphibians

No group of animals has a higher rate of endangerment than amphibians. Frogs, toads, and salamanders are disappearing because of habitat loss, water and air pollution, climate change, ultraviolet light exposure, introduced exotic species, and disease. Because of their sensitivity to environmental changes, vanishing amphibians should be viewed as the canary in the global coal mine, signalling subtle yet radical ecosystem changes that could ultimately claim many other species, including humans.

### Birds

Birds occur in nearly every habitat on the planet and are often the most visible and familiar wildlife to people across the globe. As such, they provide an important bellwether for tracking changes to the biosphere. Declining bird populations across most to all habitats confirm that profound changes are occurring on our planet in response to human activities. Habitat loss and degradation have caused most of the bird declines, but the impacts of invasive species and capture by collectors play a big role, too.

### Fish

Increasing demand for water, the damming of rivers throughout the world, the dumping and accumulation of various pollutants, and invasive species make aquatic ecosystems some of the most threatened on the planet; thus, it's not surprising that there are many fish species that are endangered in both freshwater and marine habitats.

### Invertebrates

Invertebrates, from butterflies to molluscs to earthworms to corals, are vastly div... Freshwater invertebrates are severely threatened by water pollution, groundwater withdrawal ...

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water projects, while a large number of invertebrates of notable scientific significance have become either endangered or extinct due to deforestation, especially because of the rapid destruction of tropical rainforests. In the ocean, reef-building corals are declining at an alarming rate.

**Mammals**

Perhaps one of the most striking elements of the present extinction crisis is the fact that the majority of our closest relatives — the primates — are severely endangered. About 90 percent of primates — the group that contains monkeys, lemurs, lorids, galagos, tarsiers, and apes (as well as humans) — live in tropical forests, which are fast disappearing. Several species of whales, dolphins, and porpoises — are among those mammals slipping most quickly toward extinction.

**Reptiles**

Human activities fragment continental habitats, creating "virtual islands" are the prominent reasons for their extinction, as they isolate species from one another, preventing

**Bird's Migration**

The reasons for bird's migration are complex and not fully understood. But a simple explanation is food and a safe place to breed. Birds which breed in the summer in the extreme north such as the Arctic benefit from an abundance of food as plants and insect life flourish in the long daylight hours; and because few large permanent predators can survive the harsh winter.

Migration is affected not only by food supply, but also by wind and oceans currents. These make some routes and locations easier to reach. While many birds migrate from northern breeding areas in the summer, to southern wintering grounds (mainly because there is more land near the northern pole than the southern), there are many other migration patterns. Some birds breed in the far south of South America, Australasia and Africa, and migrate to northern wintering grounds. Some birds migrate horizontally, to enjoy the milder coastal climates in winter. Other birds migrate in terms of altitude; moving higher up a mountain in summer, and wintering on the lowlands.

Birds exploit the winds to their favour so they can go the distance by burning minimal fuel. They may shift altitude to find the best wind "conveyor belt". Winds at high altitude may blow in the opposite direction from wind on the ground, and usually are blowing strongly. Larger birds rely on thermals (hot air) rising from the ground in the mornings to gain altitude by simply soaring. These birds usually migrate during the day. They may also follow strong updrafts along ridges.

Studies suggest birds orientate themselves to the compass points using the position of the sun during the day, and the stars at night. They can also sense magnetic north. In addition they use other clues such as visual layout of the land, smell (of the sea) and sound. The most amazing aspect of bird migration is that the location, route and perhaps even the techniques are hard-wired into their brains. Many migrating birds abandon their young as soon as they fledge, and a short time later, the young make the migration on their own. Sadly, in addition to surviving storms and bad weather, exhaustion and other natural obstacles, migrating birds are increasingly face human threats. Habitat destruction that affects staging posts handicap their ability to re-fuel. These include draining wetlands, cutting down forests. Pollution of the sea, water and air also affects them. Migrating birds are also distracted and killed by lit-up skyscrapers, lighthouses and other unnatural man-made formations that mislead them. Sadly, many migrating birds are also hunted, for food, and for sport or superstitious reasons.

**Migratory Birds Coming to India**

In Winter Season: Siberian Cranes, Greater Flamingo, Ruff, Black winged Stilt, Common Teal, Common Greenshank, Northern Pintail, Yellow Wagtail, White Wagtail, Northern Shoveler, Rosy Pelican, Gadwall, Wood Sandpiper, Spotted Sandpiper, Eurasian Wigeon, Black tailed Godwit, Spotted Redshank, Starling, Bluethroat, Long billed Pipit

In Summer Season: Asian Koel, Black crowned Night Heron, Eurasian Golden Oriole, Comb Duck, Blue-cheeked Bee Eater, Blue-tailed Bee-Eater, Cuckoos

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interbreeding and hindering populations' health. The main threats to reptiles are habitat destruction and the invasion of non-native species, which prey on reptiles and compete with them for habitat and food.

**Plants**

Unlike animals, plants can't readily move as their habitat is destroyed, making them particularly vulnerable to extinction. Indeed, one study found that habitat destruction leads to an "extinction debt," whereby plants that appear dominant will disappear over time because they aren't able to disperse to new habitat patches. Global warming is likely to substantially exacerbate this problem. Already, scientists say, warming temperatures are causing quick and dramatic changes in the range and distribution of plants around the world. With plants making up the backbone of ecosystems and the base of the food chain, that's very bad news for all species, which depend on plants for food, shelter, and survival.

## 3. BIODIVERSITY CONSERVATION

Conservation is the protection, preservation, management, or restoration of wildlife and natural resources such as forests and water. Through the conservation of biodiversity the survival of many species and habitats which are threatened due to human activities can be ensured. Conserving biodiversity means ensuring that natural landscapes, with their array of ecosystems, are maintained, and that species, populations, genes, and the complex interactions between them, persist into the future. Conservation can broadly be divided into two types:

**1. IN-SITU CONSERVATION** – The process of protecting an endangered plant or animal species in its natural habitat is commonly known as in situ conservation. Alternatively, it is Conserving the areas where populations of species exist naturally is an underlying condition for the conservation of biodiversity. That's why protected areas form a central element of any national strategy to conserve biodiversity. It involves the creation of protected areas such as national parks, Biosphere Reserves, Wildlife Sanctuaries, Reserved Forests, Nature Reserves, wetlands protection zones etc. The principal aims of in situ conservation include:

- The creation of protected areas
- The promotion of sustainable management of the territory
- The protection and restoration of degraded areas
- The development of strategies for the conservation of marine environments
- The integration of conservation and biodiversity into agricultural, marine, wildlife and urban development policy
- The creation of natural corridors linking areas of biological interest to prevent further habitat fragmentation
- The introduction of legislation
- Information, education and raised awareness
- Vocational reconversion (e.g. Poachers become wardens)
- The involvement of neighbouring communities
- The employment of local resources (especially human)
- The development of alternative and sustainable economic mechanisms

**2. EX-SITU CONSERVATION** – Ex situ conservation is the re-location of endangered or rare species from their natural habitat to protected areas equipped for their protection and preservation. It is an essential alternative strategy when in situ conservation is inadequate. This involves conservation

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of genetic resources, as well as wild and cultivated or species, and draws on a diverse body of techniques and facilities. Some of these include:

- Gene banks, e.g. seed banks, sperm and ova banks, field banks;
- In vitro plant tissue and microbial culture collections;
- Captive breeding of animals and artificial propagation of plants, with possible reintroduction into the wild; and
- Collecting living organisms for zoos, aquaria, and botanic gardens for research and public awareness.

There have been numerous efforts at the global level to conserve the fascinating and unique biodiversity of the blue planet. Some of these have been discussed here under following headings:

**Convention on Biological Diversity (CBD)**

The Convention on Biological Diversity (CBD) is a multilateral treaty to conserve and promote the biodiversity of the world. CBD provides a global legal framework for action on biodiversity. It brings together the Parties in the Conference of the Parties (COP) which is the Convention's governing body that meets every two years, or as needed, to review progress in the implementation of the Convention, to adopt programmes of work, to achieve its objectives, and provide policy guidance .CBD entered into force on 29 December 1993. It has 3 main objectives:

1. The conservation of biological diversity
2. The sustainable use of the components of biological diversity
3. The fair and equitable sharing of the benefits arising out of the utilization of genetic resources

2010 was the International Year of Biodiversity. On 22 December 2010, the UN declared the period from 2011 to 2020 as the UN Decade on Biodiversity.

**CARTAGENA PROTOCOL**

The Cartagena Protocol on Biosafety to the Convention on Biological Diversity is an international treaty governing the movements of living modified organisms (LMOs) resulting from modern biotechnology from one country to another. It was adopted on 29 January 2000 as a supplementary agreement to the Convention on Biological Diversity and entered into force on 11 September 2003.

The Protocol seeks to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology. It establishes an advance informed agreement (AIA) procedure for ensuring that countries are provided with the information necessary to make informed decisions before agreeing to the import of such organisms into their territory. The Protocol contains reference to a precautionary approach and reaffirms the precaution language in Principle 15 of the Rio Declaration on Environment and Development. The Protocol also establishes a Biosafety Clearing-House to facilitate the exchange of information on living modified organisms and to assist countries in the implementation of the Protocol.

**NAGOYA PROTOCOL**

Nagoya Protocol on Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity is an international agreement which aims at sharing the benefits arising from the utilization of genetic resources in a fair and equitable way, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding, thereby contributing to the conservation of biological diversity and the sustainable use of its components. It was adopted by the Conference of the Parties to the Convention on Biological Diversity at its tenth meeting on

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October 2010 in Nagoya, Japan. The Nagoya Protocol entered into force on 12 October 2014, 90 days after the date of deposit of the fiftieth instrument of ratification.

The fair and equitable sharing of the benefits arising out of the utilization of genetic resources is one of the three objectives of the Convention on Biological Diversity.

**Aichi Biodiversity targets**

The Aichi Biodiversity Targets are a set of 20, time-bound, measureable targets agreed by the Parties to the Convention on Biological Diversity in Nagoya, Japan, in October 2010, that are now being translated into revised national strategies and action plans by the 193 Parties to the Convention. Achievement of the targets will contribute to reducing, and eventually halting, the loss of biodiversity at a global level by the middle of the twenty-first century.

**These 20 targets have been classified under following five Strategic Goals:**

A) Strategic Goal A: Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society

1) Make people are aware of the values of biodiversity
2) Integrating biodiversity values into national and local development and poverty reduction strategies
3) Elimination of harmful subsidies
4) Implementing plans for sustainable production and consumption

B) Strategic Goal B: Reduce the direct pressures on biodiversity and promote sustainable use

5) Halting loss of all natural habitats, including forests
6) Sustainable harvest of all fish and invertebrate stocks and aquatic plants
7) Sustainable management of agriculture, aquaculture and forestry ensuring conservation of biodiversity.
8) Reducing Pollution
9) Identification and prioritization of invasive alien species and pathways
10) Minimise the choral reflow destruction, ocean acidification

C) Strategic Goal C: To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity

11) Conserving terrestrial and inland water, coastal – marine areas
12) Prevention of extinction of known threatened species
13) Maintaining genetic diversity of agro-plants, domesticate animals and minimizing genetic erosion

D) Strategic Goal D: Enhance the benefits to all from biodiversity and ecosystem services

14) Restoration of ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being
15) Enhancement of ecosystem resilience and the contribution of biodiversity to carbon stocks, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems.
16) Operationalise the Nagoya protocol on genetic resources, via national legislations

E) Strategic Goal E: Enhance implementation through participatory planning, knowledge management and capacity building

17) Implementing an effective, participatory and updated national biodiversity strategy and action plan

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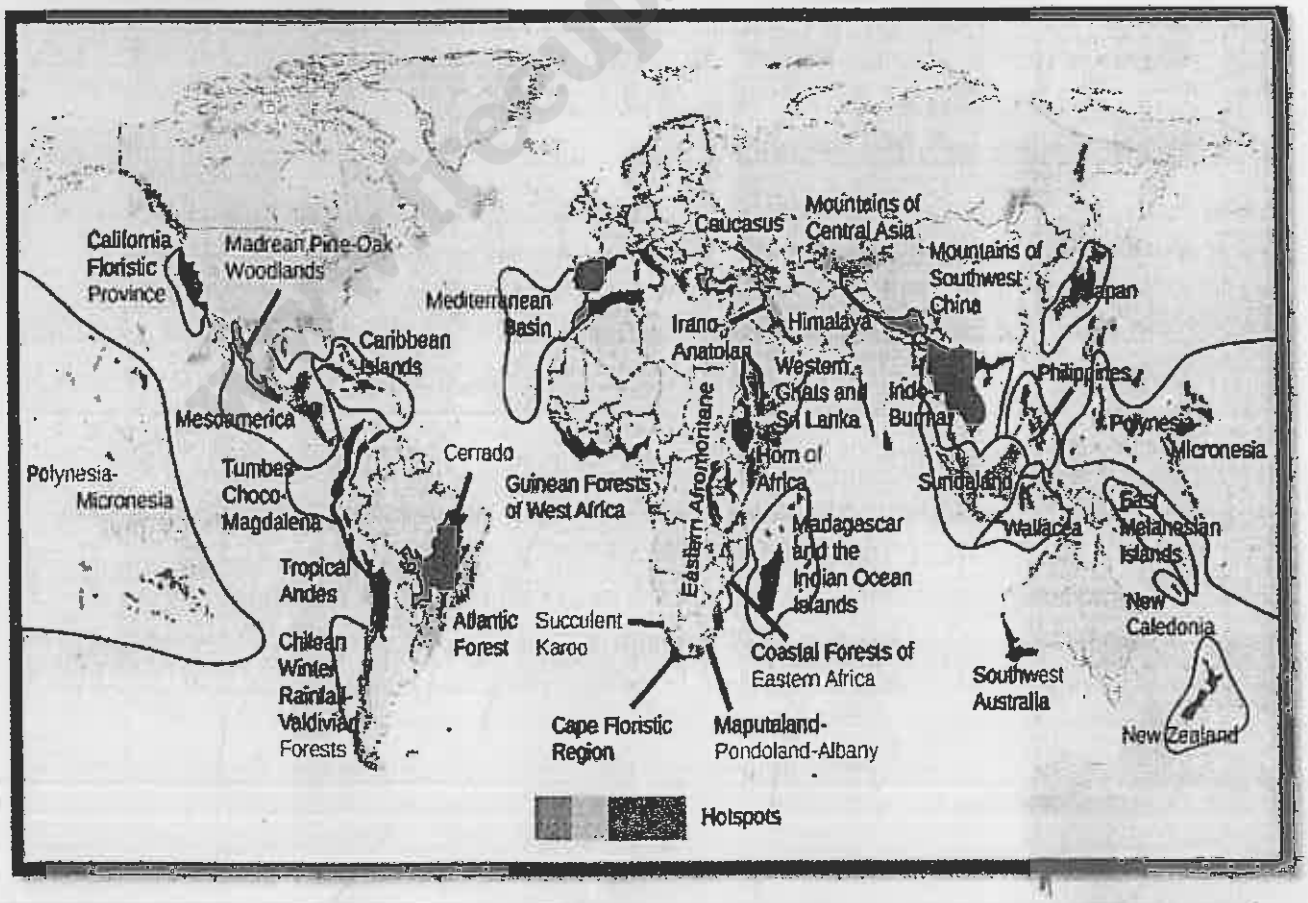
18) Integrating the traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources
19) Scientific and technological knowledge sharing application
20) mobilization of financial resources

## BIODIVERSITY HOT-SPOTS

Biodiversity hotspots are areas that support natural ecosystems that are largely intact and where native species and communities associated with these ecosystems are well represented. They are also areas with a high diversity of locally endemic species, which are species that are not found or are rarely found outside the hotspot. The concept of Hot-Spot was given by Norman **Myers** through the two articles he published in The Environmentalist (1988 & 1990). The current, planned or potential management activities in hotspots place the natural values at risk, and it is likely this risk will increase in the future in the absence of active conservation management. Because the natural values of hotspots are largely intact, undertaking action now to maintain these values has the potential to provide value-for-money in contributing to our efforts in biodiversity conservation. **Mega-diverse** Countries.

To qualify as a hotspot, a region must meet two strict criteria:
1. It must contain at least 1,500 species of vascular plants (> 0.5 percent of the world's total) as endemics.
2. It has to have lost at least 70 percent of its original habitat.

The concept of mega-diversity is based on the total number of species in a country and the degree of endemism at the species level and at higher taxonomic levels. The World Conservation Monitoring Centre recognised 17 mega-diverse countries in July 2000 including Australia, Brazil, China, Colombia, Democratic Republic of the Congo (DRC) (formerly Zaire), Ecuador, India, Indonesia, Madagascar, Malaysia, Mexico, Papua New Guinea, Peru, the Philippines, South Africa, the




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United States of America (USA) and Venezuela. Together, these 17 countries harbour more than 70% of the earth's species. There are 34 Biodiversity Hot-Spots in the world currently.

**Some interesting hotspot facts:**

- **34 biodiversity hotspots have been identified.**
- **They once covered 15.7 percent of the Earth's land surface.**
- **86 % of the hotspots' habitat has already been destroyed.**
- **The intact remnants of the hotspots now cover only 2.3 % of the Earth's land surface.**
- **They contain 150,000 plant species as endemics, 50 % of the world's total.**
- **Terrestrial vertebrates endemic to the hotspots: 11,980, representing 42 percent of all terrestrial vertebrate species.**
- **Reptiles and amphibians, are more prone to hotspot endemism than are the more wide-ranging mammals and birds, but the overall similarity between taxonomic groups is remarkable.**
- **Overall, 22,022 terrestrial vertebrate species call the hotpots home, 77 percent of the world's total.**

## BIOSPHERE RESERVES

Biosphere reserves are areas comprising terrestrial, marine and coastal ecosystems. Each reserve promotes solutions reconciling the conservation of biodiversity with its sustainable use. Biosphere reserves are 'Science for Sustainability support sites' – special places for testing interdisciplinary approaches to understanding and managing changes and interactions between social and ecological systems, including conflict prevention and management of biodiversity. Hence, Biosphere Reserves have three functions:

1. The conservation of ecosystems and genetic variation;
2. The promotion of sustainable economic and human development, and
3. They serve as examples of education and training on local, regional, national and international issues of sustainable development.

Biosphere reserves are nominated by national governments and remain under the sovereign jurisdiction of the states where they are located. Their status is internationally recognized. There are 631 biosphere reserves in 119 countries, including 14 trans-boundary sites.

Biosphere reserves have three interrelated zones that aim to fulfil three complementary and mutually reinforcing functions:

- The core area(s) comprises a strictly protected ecosystem that contributes to the conservation of landscapes, ecosystems, species and genetic variation.
- The buffer zone surrounds or adjoins the core areas, and is used for activities compatible with sound ecological practices that can reinforce scientific research, monitoring, training and education.
- The transition area is the part of the reserve where the greatest activity is allowed, fostering economic and human development that is socio-culturally and ecologically sustainable.

### World Heritage Site

A UNESCO World Heritage Site is a place (such as a forest, mountain, lake, island, desert, monument, building, complex, or city) that is listed by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as of special cultural or physical significance. The list is main-



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tained by the international World Heritage Programme administered by the UNESCO World Heritage Committee. Conservation of Biodiversity is done in the World Natural Heritage Site, which are selected based on following criteria:

- The site contains superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance;
- Place is an outstanding example representing major stages of Earth's history, including the record of life, significant ongoing geological processes in the development of landforms, or significant geomorphic or physiographic features;
- It is an outstanding example representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems, and communities of plants and animals;
- The site 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.

**UNESCO's Natural World Heritage Sites of India**

1. Kaziranga National Park
2. Manas Wildlife Sanctuary
3. Great Himalayan National Park
4. Nanda Devi and Valley of Flowers National Park
5. Sunderbans National Park
6. Western Ghats
7. Keoladeo National Park

**The Ramsar Conventions on Wetlands**

It is an international convention for the conservation and sustainable utilization of wetlands. The Convention's mission is "the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world". The Convention uses a broad definition of wetlands. It includes all lakes and rivers, underground aquifers, swamps and marshes, wet grasslands, peatlands, oases, estuaries, deltas and tidal flats, mangroves and other coastal areas, coral reefs, and all human-made sites such as fish ponds, rice paddies, reservoirs and salt pans.

| **Under the "three pillars" of the Convention, the Contracting Parties commit to** |
|---|
| Work towards the wise use of all their wetlands; |
| Designate suitable wetlands for the list of Wetlands of International Importance (the "Ramsar List") and ensure their effective management; |
| Cooperate internationally on trans-boundary wetlands, shared wetland systems and shared species. |

**THE MONTREUX RECORD**

The Montreux Record is a register of wetland sites on the List of Wetlands of International Importance where changes in ecological character have occurred, are occurring, or are likely to occur as a result of technological developments, pollution or other human interference. It is maintained as part of the Ramsar List. At present, 59 Ramsar sites are present in the Montreux. Keoladeo National Park, Rajasthan and Loktak Lake, Manipur in India are in Montreux record.

**Ramsar's International Organization Partners (IOPs) –**

The Ramsar Convention works especially closely with some global non-governmental organizations (NGOs) which have been associated with the treaty since its beginnings. They have been given the formal status of International Organization Partners (IOPs) of the Convention. The five IOPs are:

1. BirdLife International (formerly ICBP) – BirdLife International is the world's largest nature conservation Partnership. The BirdLife Partnership strives to conserve birds, their habitats and global biodiversity, working with people towards sustainability in the use of natural resources.

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2. IUCN (The International Union for the Conservation of Nature)
3. IWMI (The International Water Management Institute) - It is a non-profit, scientific research organization focusing on the sustainable use of water and land resources in developing countries. IWMI's Mission is to provide evidence-based solutions to sustainably manage water and land resources for food security, people's livelihoods and the environment.
4. Wetlands International (formerly IWRB, the Asian Wetlands Bureau, and Wetlands for the Americas) - Wetlands International is dedicated to maintaining and restoring wetlands, for their environmental values as well as for the services they provide to people.
5. WWF (World Wide Fund for Nature) International – It is an international NGO working on issues regarding the conservation, research and restoration of the environment.

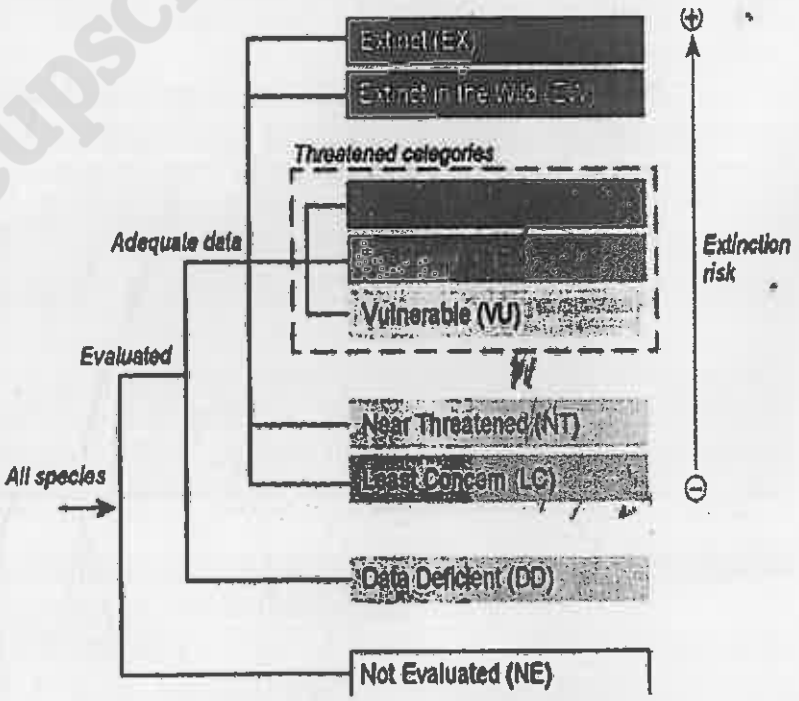
**IUCN (International Union for Conservation of Nature)**

IUCN, International Union for Conservation of Nature, helps the world find pragmatic solutions to our most pressing environment and development challenges. IUCN's work focuses on valuing and conserving nature, ensuring effective and equitable governance of its use, and deploying nature-based solutions to global challenges in climate, food and development. IUCN supports scientific research, manages field projects all over the world, and brings governments, NGOs, the UN and companies together to develop policy, laws and best practice.

**IUCN Red List**

The IUCN Red List is the world's most comprehensive information source on the global conservation status of wild species and their links to livelihoods. Far more than a list of species and their status, it is a powerful tool to inform and catalyse action for biodiversity conservation, critical to protecting the natural resources we need to survive.

All the species have been categorised into nine categories in IUCN Red List, which are described as follows:




1. Extinct (EX), a designation applied to species in which the last individual has died or where systematic and time-appropriate surveys have been unable to log even a single individual
2. Extinct in the Wild (EW), a category containing those species whose members survive only in captivity or as artificially supported populations far outside their historical geographic range
3. Critically Endangered (CR), a category containing those species that possess an extremely high risk of extinction as a result of rapid population declines of 80 to more than 90 percent over the previous 10 years (or three generations), a current population size of fewer than 50 individuals, or other factors
4. Endangered (EN), a designation applied to species that possess a very high risk of extinction as a result of rapid population declines of 50 to more than 70 percent over the previous 10 years (or three generations), a current population size of fewer than 250 individuals, or other factors

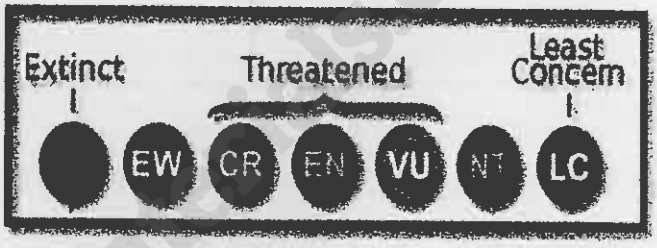


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5. Vulnerable (VU), a category containing those species that possess a very high risk of extinction as a result of rapid population declines of 30 to more than 50 percent over the previous 10 years (or three generations), a current population size of fewer than 1,000 individuals, or other factors
6. Near Threatened (NT), a designation applied to species that are close to becoming threatened or may meet the criteria for threatened status in the near future
7. Least Concern (LC), a category containing species that are pervasive and abundant after careful assessment
8. Data Deficient (DD), a condition applied to species in which the amount of available data related to its risk of extinction is lacking in some way. Consequently, a complete assessment cannot be performed. Thus, unlike the other categories in this list, this category does not describe the conservation status of a species.
9. Not Evaluated (NE), a category used to include any of the nearly 1.6 million species described by science but not yet assessed by the IUCN




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

CITES is an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Because the trade in wild animals and plants crosses borders between countries, the effort to regulate it requires international cooperation to safeguard certain species from over-exploitation. CITES was conceived in the spirit of such cooperation. Today, it accords varying degrees of protection to more than 35,000 species of animals and plants, whether they are traded as live specimens, fur coats or dried herbs. CITES works by subjecting international trade in specimens of selected species to certain controls. All import, export, re-exports and introduction from the sea of species covered by the Convention has to be authorized through a licensing system. Each Party to the Convention must designate one or more Management Authorities in charge of administering that licensing system and one or more Scientific Authorities to advise them on the effects of trade on the status of the species.

**CMS (Convention on the Conservation of Migratory Species of Wild Animals)**

As an environmental treaty under the aegis of the United Nations Environment Programme, CMS provides a global platform for the conservation and sustainable use of migratory animals and their habitats. CMS brings together the States through which migratory animals pass, the Range States, and lays the legal foundation for internationally coordinated conservation measures throughout a migratory range. As the only global convention specializing in the conservation of migratory species, their habitats and migration routes, CMS complements and co-operates with a number of other international organizations, NGOs and partners in the media as well as in the corporate sector. Migratory species threatened with extinction are listed on Appendix I of the Convention. CMS Parties strive towards strictly protecting these animals, conserving or restoring the places where they live, mitigating obstacles to migration and controlling other factors that might endanger them. Besides establishing obligations for each State joining the Convention, CMS promotes concerted action among the Range States of many of these species. Migratory species that need or would significantly benefit from international co-operation are listed in Appendix II of the Convention. For this reason, the Convention encourages the Range States to conclude global or regional agreements.

In this respect, CMS acts as a framework Convention. The agreements may range from legally binding treaties (called Agreements) to less formal instruments, such as Memoranda of Un-

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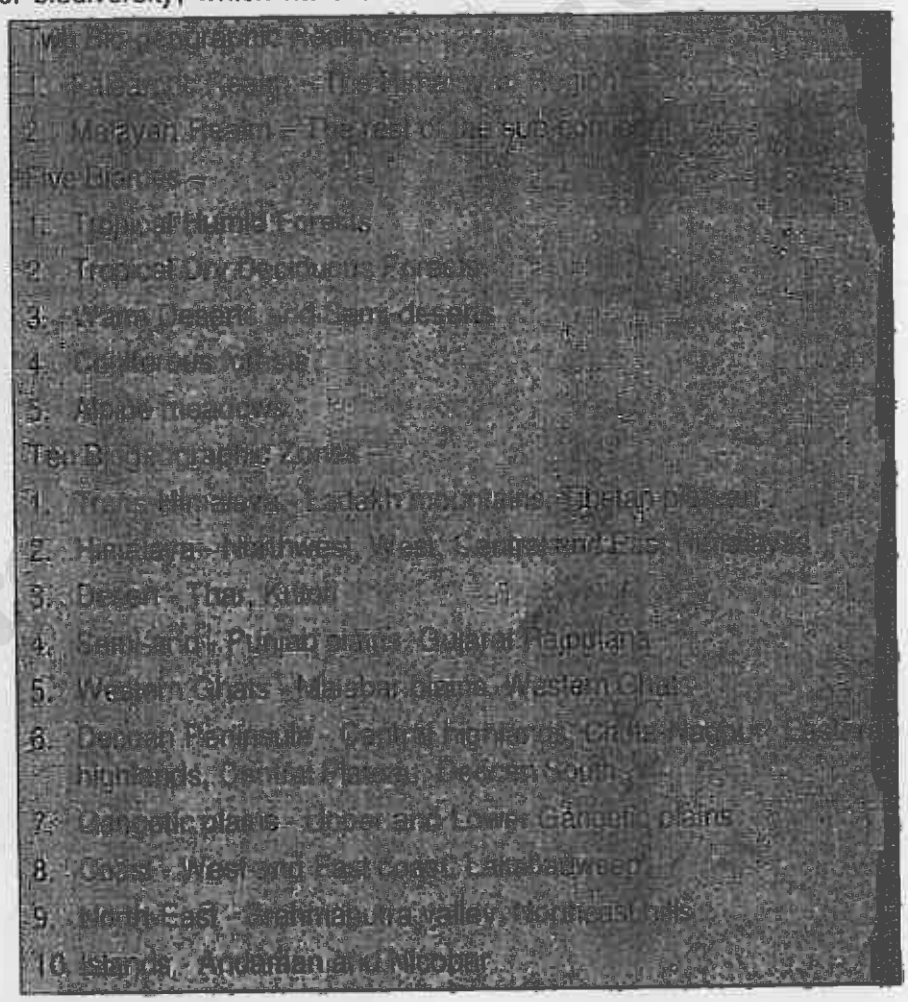
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derstanding, and can be adapted to the requirements of particular regions. The development of models tailored according to the conservation needs throughout the migratory range is a unique capacity to CMS.

## 4. BIODIVERSITY OF INDIA

India is one of the 17 mega-diverse countries with 2.4% of the land area, accounting for 7-8% of the species of the world, including about 91,000 species of animals and 45,500 species of plants that have been documented in its ten bio-geographic regions. Of these 12.6% of mammals, 4.5% of birds, 45.8% of reptiles, 55.8% of amphibians and 33% of Indian plants are endemic, being found nowhere else in the world. India also has three of 34 global biodiversity hotspots, 7 Natural World Heritage Sites, 9 Biosphere reserves in UNESCO Man and Biosphere Programme list and 26 Ramsar Wetland Sites; which are unique, biologically rich areas but facing severe conservation threats. The varied Edaphic, Topographic and Climatic Conditions have resulted in a wide range of ecosystems and habitats such as forests, grasslands, wetlands, coastal and marine ecosystems, and deserts in India with greater biodiversity, which have been classified as below under various sub headings:



### WILDLIFE OF INDIA

**Endemic Species –**

≠ Primates unique to India include the Lion-tailed Macaque, the Southern Plains Gray Langur, the Nilgiri Langur, the Bonnet Macaque and the Arunachal Macaque. Other endemic mammals include the Nilgiri Marten, the Brown Palm Civet, the Malabar Civet, the Indian Giant Squirrel, the Namdapha Flying Squirrel, and the Long-tailed Climbing Mouse. Also sometimes considered full species are the Khur, the Kashmir Deer, the Sangai, the Upland Barasingha, and the Deccan Chinkara. Representing endemic genera are the Nilgiri Tahr, the Pygmy Hog, the Madras Tree Shrew, Salim Ali's Fruit Bat, the Elvira Rat), and the Malabar Spiny Dormouse.

≠ Birds found only in India include the Himalayan Quail, the Nicobar Scrubfowl, the Gray Junglefowl, the Forest Owlet, the Andaman Serpent Eagle, the Narcondam Hornbill, the Malabar Parakeet, the Nilgiri Woodpigeon, Jerdon's Courser, the Crimson-backed Sunbird, the Black-and-orange Flycatcher, the Nilgiri Laughing thrush, the Green Avadavat, and the Bugun Liocichla

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≠ Reptile genera restricted to India include the Cochin Forest Cane Turtle, the Bay Island Forest Lizard, the Chilka Spotted Skink, Ristella, Sepsophis, the narrow-headed snakes Xylophis , and three shieldtail snakes:Teretrurus , Melanophidium and Plectrurus. Other endemic reptiles include the Andaman Day Gecko, the Indian Golden Gecko the Southern Flying Lizard, Whitaker's Boa, the Andaman Cobra, Bibron's Coral Snake, and the Nicobar Pitviper.

≠ India has four endemic amphibian families: the Purple Frog Nasikabatrachidae, the dancing

≠ Frogs Micrixalide, the Kerala Indian Frog Ranixalide, and caecilians of the genus Chikila Chikilidae. Other endemic amphibian genera include the toads Ghatophryne and Xanthophryne, frogs Nyctibatrachus, Melanobatrachus, Ghatixalus,

≠ Bedddomixalus and Mercurana inervarya, and the caecilians Geogeneophis, Uraeotyphlus, and Indotyphlus. Other endemic amphibians include the Malabar Flying Frog, the Malabar Tree Toad, the Resplendent Bush Frog, and Philautus chlorosomma.

≠ Among numerous endemic freshwater fish genera are Mesonoemacheilus, Horaglanis, Osteochilichthys, Rohtee, Hypselobarbus, and Betadevario. The Kryptoglanidae is a recently recognized endemic catfish family and Horabagrus is also sometimes considered to comprise an endemic family, the Horabagridae. Other endemic freshwater fish include the Denison Barb, the Canara Pearlspot, the Malabar Pufferfish, the Zebra Loach, and the Brown Spike-tailed Paradise Fish. Endemic marine fish include the Jester Goby, a wrasse Xyrichtys cyanifrons, and a filefish Lalmohania velutina

≠ Invertebrate families known solely from India include an amphipod crustacean Kotumsaridae, a land snail Staffordiidae, a beetle Podabrocephalidae, and grasshoppers Mastacideidae. Endemic butterflies include the Malabar Rose, the Palni Fritillary, the Malabar Tree Nymph, the Nilgiri Tiger, and the Southern Birdwing. Other endemic arthropods include the Syrandiri Clubtail Davidioides martini, a stag beetle Odontolabis burmeisteri , a longhorned beetle Acanthophorus serraticornis , the Jumping Ant , an ant-mimicking planthopper Formiscurra indicus , and the Wonderful Parachute Spider. Endemic molluscs include Cyclophorus altivagus, Indrella ampulla, Pseudomulleria dalyi, and Cremnochonchus syhadrensis.

Among some 7000 endemic vascular plants are such orchids as Paphiopedilum druryi, Schoenorchis manipurensis, Phalaenopsis speciosa, and the genus Smithsonia. Endemic genera include an aroidAnaphyllum, a palm Bentinckia Agasthiyamalaia, Blepharistemma, Cynarospermum, Erinocarpus, Adenon, Lamprachaenium, Meteoromyrtus Haplanthodes, Moullava , Otonephelium, Jerdonia, and Pinda. Other endemic plants include the Neelakurinji, the Forest Spider Lily, the Siroi Lily, a banana Musa velutina,Geranium clarkei , the Surangi, Impatiens tomentosa,Rhododendron macabeanum, and the Khasi Pitcher Plant.

**Critically Endangered Animal Species of India**

Critically endangered is the highest risk category assigned by the IUCN (International Union for Conservation of Nature) Red List to wild species. There are five quantitative criteria to determine whether a taxon is threatened. A taxon is critically endangered when the best available evidence indicates that it meets any of the following criteria:

I. Populations have declined or will decrease, by greater than 80% over the last 10 years or three generations.

II. Have a restricted geographical range.

III. Small population size of less than 250 individuals and continuing decline at 25% in 3 years or one generation.

IV. Very small or restricted population of fewer than 50 mature individuals.

V. High probability of extinction in the wild.



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## BIRDS

1. The Jerdon's Courser (Rhinoptilus bitorquatus) – It is a nocturnal bird found only in the northern part of the state of Andhra Pradesh in peninsular India.
2. The Forest Owlet (Heteroglaux blewitti) – It is found in the dry deciduous forest of South Madhya Pradesh, in north-west Maharashtra and north-central Maharashtra.
3. The White-bellied Heron (Ardea insignis) – It is an extremely rare bird found in five or six sites in Assam and Arunachal Pradesh, one or two sites in Bhutan, and a few in Myanmar.
4. Vultures – Out of nine species of vultures, the population of three species- White-backed Vulture (Gyps bengalensis), Slender-billed Vulture (Gyps tenuirostris) and Long-billed Vulture (Gyps indicus) has declined by 99%. The Red- headed Vulture (Sarcogyps calvus) has also suffered a rapid decline in the recent past. Vultures keep the environment clean, by scavenging on animal carcasses. The decline in vulture populations has associated disease risks, including increased risk of spread of rabies and anthrax, besides adversely impacting the observance of last rites by the Parsis in the Towers of Silence.
5. The Bengal Florican (Houbaropsis bengalensis) –It is a rare bustard species that is very well known for its mating dance. It is native to only 3 countries in the world - Cambodia, India and Nepal. In India, it occurs in 3 states, namely Uttar Pradesh, Assam and Arunachal Pradesh.
6. The Himalayan Quail (Ophrysia superciliosa) – It is found in western Himalayas
7. The beautiful Pink- headed Duck (Rhodonessa caryophyllacea) – Its males have a deep pink head and neck from which the bird derives its name. Its maximum records are from north-east India.
8. The Sociable Lapwing (Vanellus gregarious) – It is a winter migrant to India. It is found in Kazakhstan, Russia, Kyrgyzstan, Tajikistan, Uzbekistan, Turkmenistan, Afghanistan, Armenia, Georgia, Azerbaijan, Iran, Iraq, Saudi Arabia, Syria, Turkey, Egypt, India, Pakistan and Oman. In India, distribution is restricted to the north and north-west of the country.
9. The Spoon Billed Sandpiper (Eurynorhynchus pygmeus) – It requires highly specialized breeding habitat, a constraint that has always kept its population scarce. India is home to some of the last existing wintering grounds of this species. It has been recorded in West Bengal, Orissa, Kerala and Tamil Nadu.
10. The Siberian Crane (Grus leucogeranus) – It is a large, strikingly majestic migratory bird that breeds and winters in wetlands. They are known to winter at Keoladeo National Park, Rajasthan.

## MAMMALS

1. The Pygmy Hog (Porcula salvania) – It is the world's smallest wild pig, with adults weighing only 8 kg. This species constructs a nest throughout the year. It is one of the most useful indicators of the management status of grassland habitats. Formerly, the species was more widely distributed along the southern Himalayan foothills but now is restricted to only a single remnant population in Manas Wildlife Sanctuary and its buffer reserves.
2. Andaman White-toothed Shrew (Crocidura andamanensis), Jenkin's Andaman Spiny Shrew (Crocidura jenkinsi) and The Nicobar White-tailed Shrew (Crocidura nicobarica) – These are endemic to India. They are usually active by twilight or in the night and have specialized habitat requirements. The Andaman White-toothed Shrew is found on Mount Harriet in the South Andaman Islands. The Jenkin's Andaman Spiny Shrew is found on Wright Myo and Mount Harriet in the South Andaman Islands. The Nicobar White-tailed Shrew (Crocidura nicobarica) is found in the southern tip of Greater Nicobar Island and is also recorded in the

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area extending from the Campbell Bay National Park to the Galathea River in the Andaman and Nicobar Islands.

3. Kondana Rat (Millardia kondana) – It is a nocturnal burrowing rodent that is found only in India. It is Known only from the small Sinhagarh Plateau (about one km²), near Pune in Maharashtra.
4. The Large Rock Rat or Elvira Rat (Cremnomys elvira) –It is a medium sized, nocturnal and burrowing rodent that is endemic to India. It is known only from Eastern Ghats of Tamil Nadu.
5. The Namdapha Flying Squirrel (Biswamoyopterus biswasi) – It is a unique (the only one in its genus) flying squirrel, that is restricted to a single valley in the Namdapha Tiger Reserve in Arunachal Pradesh.
6. The Malabar Civet (Viverra civettina) –It is considered to be one of the world's rarest mammals. It is endemic to India and was first reported from Travancore, Kerala. It is nocturnal in nature and found exclusively in the Western Ghats.
7. The Sumatran Rhinoceros (Dicerorhinus sumatrensis) –It is the smallest and most endangered of the five rhinoceros species. It is now thought to be regionally extinct in India, though it once occurred in the foothills of the Himalayas and north-east India.
8. The Javan Rhinoceros (Rhinoceros sondaicus) – It is also believed to be extinct in India and only a small number survive in Java and Vietnam.

**REPTILES**

1. The Gharial (Gavialis gangeticus) –It is the most uniquely evolved crocodilian in the world, a specialized, river-dwelling, fish-eater. Only viable population is found in the National Chambal Sanctuary, spread across three states of Uttar Pradesh, Rajasthan and Madhya Pradesh in India. Small non-breeding populations exist in Son, Gandak, Hoogly and Ghagra rivers. It is now extinct in Myanmar, Pakistan, Bhutan and Bangladesh.
2. The Hawksbill Turtle (Eretmochelys imbricata) – It is a heavily exploited species. The species is migratory in nature and nesting occurs in about 70 countries across the world. In India they are found in the Andaman and Nicobar Islands, the coast of Tamil Nadu and Orissa.
3. The Leatherback Turtle (Dermochelys coriacea) – It is the largest of the living sea turtles, weighing as much as 900 kg.It is found in tropical and temperate waters of the Atlantic, Pacific, and Indian Oceans.
4. Four-toed River Terrapin or River Terrapin (Batagur baska) – It is found in Bangladesh, Cambodia, India, Indonesia and Malaysia.
5. Red-crowned Roofed Turtle or the Bengal Roof Turtle (Batagur kachuga) – It is mainly restricted to the Ganga basin. Males have a bright red coloration during the breeding season.
6. Sispara day gecko (Cnemaspis sisparensis) – It is a large gecko which dwells usually in forests; it is largely insectivorous and is active by night. It is endemic to Western Ghats, and found in Sispara, Nilgiris, Kavalai near Cochin.

**AMPHIBIANS**

1. The Anamalai Flying Frog (Rhacophorus pseudomalabaricus) – It is confined to rainforests of south-western Ghats. It is found in Andiparai Shola, Pudothottam and the Anamalai Hills of Tamil Nada and Kerala.
2. The Gundia Indian Frog (Indirana gundia) – It is known only to exist in Gundia, Kempholey in the Western Ghats ~~region~~ of Karnataka, South India .

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3. The Kerala Indian Frog (Indirana phrynoderma) – It is found in Anamalai Hills of Kerala and Tamil Nadu in the Western Ghats of South India.
4. The Charles Darwin's Frog (Ingerana charlesdarwini) – This species is currently restricted to its type locality of Mount Harriet in South Andaman Island and Saddle Peak in the North Andaman Island, India.
5. The Kottigehar Bubble-nest Frog (Micrixalus kottigeharensis) – It is only known to occur in Kottigehar, Kadur in the Western Ghats of Karnataka state.
6. The Amboli Bush Frog (Pseudophilautus amboli) – This species has been recorded from its type locality of Amboli forest, Sawantwadi district; and Amba, Kolhapur district of Maharashtra; Londa, Belgaum district, Jog Falls-Mavingundi, Shimoga district, Castle Rock, Uttara Kannada district, Kudremukh Malleshwaram, Chikamangalur district of Karnataka.
7. The Chalazodes Bubble-Nest Frog (Raorchestes chalazodes) – All recorded specimens have been from the Western Ghats, India
8. The Small Bush Frog (Raorchestes chotta) – It is the smallest bush frog found in India with a snout to vent length of 1.7 cm only. It is known only to occur in Ponmudi in Thiruvananthapuram district of Kerala, south India.
9. The Green-eyed Bush Frog (Raorchestes chlorosomma) – It is known only to occur in the type locality of Munnar, Idukki district, Kerala in the Western Ghats of South India.
10. The Griet Bush Frog (Raorchestes griet) – It is a small frog of snout to vent length ranging from 2-2.2 cm only. It is found in Munnar, Devikulam and Vagaman in Idukki district of Kerala; and Anamalai Hills and Valparai in Coimbatore district of Tamil Nadu.
11. The Kaikatt's Bush Frog (Raorchestes kaikatti) – It is known only to occur in the type locality Kaikatti-Nelliyampathi in Palakkad district of Kerala, south India. It is believed to be endemic to the Nelliyampathi Hills.
12. The Mark's Bush Frog (Raorchestes marki) – It is currently known to occur only in Kaikatti-Nelliyampathi in Palakkad district, Kerala, India.
13. The Munnar Bush Frog (Raorchestes munnarensis) –It is currently known only to occur in two locations, Devikulam and Munnar, Idukki district, Kerala, south India.
14. The Large Ponmudi Bush Frog (Raorchestes ponmudi) – It is found in Ponmudi and Agasthyamala Hills, Thiruvananthapuram district, Gavi, Pathanamthitta district, Vagaman, Idukki district, Wayanad Plateau, Kalpetta, Mananthavady and Sultan's Battery, Wayanad district of Kerala; Anamalai Hills and Valparai, Coimbatore district, Tamil Nadu.
15. The Resplendent Shrub Frog (Raorchestesresplendens) – It is currently known to occur in Anamudi Summit, Eravikulam National park in the Idukki district, Kerala.
16. The Sacred Grove Bush frog (Raorchestes sanctisilvaticus) – It is known only to occur in Kapildhara Falls, Amarkantak, Jabalpur District, Madhya Pradesh.
17. The Sushil's Bush Frog (Raorchestes sushili) – It is known only to occur in Valparai and its vicinity, Coimbatore district, Tamil Nadu.
18. The Shillong Bubble-nest Frog (Raorchestes shillongensis) – It is currently known to occur in the type locality of Malki Forest, Shillong, Meghalaya and in Mizoram.
19. The Tiger toad (Xanthophryne tigerinus) – It is found only in Amboli, Sindhudurg district, Maharashtra.

**FISH**

1. The Pondicherry Shark (Carcharhinus hemiodon) – It is a marine fish that occurs or occurred inshore on continental and insular shelves. This is a very rare and little-known spe-



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cies. It is found in Indian Ocean - from Gulf of Oman to Pakistan, India and possibly Sri Lanka. It is scattered localities spanning India to New Guinea. It has also been recorded at the mouth of the Hooghly River.

2. The Ganges Shark (Glyphis gangeticus) – It is a uniquely adapted fish-eating shark that occurs in the turbid waters of the Ganga river and the Bay of Bengal. The small eyes suggest that it is adapted to living in turbid water, while the slender teeth of the species suggest that it is primarily a fish-eater. It occurs in India and possibly in Pakistan. The Ganga river system and Hooghly river mouth are its known habitats.
3. The Knife-tooth Sawfish (Anoxypristis cuspidata) – It has a long narrow snout with blade-like teeth and a shark-like body. It spends most of its time near the bottom of the sea. It is widespread in western part of the Indo-Pacific region, including Red Sea.
4. Large-tooth Sawfish (Pristis microdon) – It is distributed in western part of the Indo-Pacific (East Africa to New Guinea, Philippines and Vietnam to Australia). In India, it is known to enter the Mahanadi River, up to 64 km inland, and also is very common in the estuaries of the Ganga and Brahmaputra.
5. Long-comb Sawfish or Narrow-snout Sawfish (Pristis zijsron) – It grows up to 4.3m in length and is heavily exploited by humans. This species was reported as frequently found in shallow water. It is distributed Indo-Pacific region including Australia, Cambodia, China, India, Indonesia and Malaysia.

## SPIDERS

1. The Rameshwaram Ornamental or Rameshwaram Parachute Spider (Poecilotheria hanumavilasumica) It can give a nasty bite which usually is not fatal. The species is semi-social, which means they live partly in groups. It is endemic to India and spreads along the coastal savannah, tropical lowland rain forests and montane forests up to an altitude of 2000 m above mean sea level.
2. The Gooty Tarantula, Metallic Tarantula or Peacock Tarantula (Poecilotheria metallica) It is steel blue in colour with patches of intense orange-yellow, black and white. It is endemic to India.

## CORALS

Fire corals (Millepora boschmai): These are more closely related to jellyfish than corals. On contact, one usually feels a burning sensation similar to a sting from a jellyfish. They are distributed in Indonesia, Gulf of Chiriquí, Panama Pacific Province. They have become possibly extinct from Australia, India, Indonesia, Malaysia, Panama, Singapore and Thailand.

## Rare and Endangered plants of India

1. Polygala irregularis, Gujarat (rare) - commonly known as Milkwort is an annual or perennial herb. The plants are destroyed due to human habitation and land for agriculture.
2. Lotus corniculatus, Gujarat (rare) - This plant belongs to pea family. They are also called as bird's foot refers to the appearance of the seed pods on their stalk.
3. Amentotaxus assamica, Arunachal Pradesh (threatened) - otherwise called Assam catkin yew. They are shrubs or small trees found in moist deciduous forest of Assam. They are found in three regions of Arunachal Pradesh that is in Turoo hills, Delei Valley, and in Dafla hills.
4. Psilotum nudum, Karnataka(rare) – It is known as Moa, skeleton, forkfern, whiskfern, and is a rootless, leafless, forming low growing clump.



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5. Diospyros celibica, Karnataka (threatened) Ebony tree -It is a flowering tree and considered highly by woodworkers as they are widely used for making high quality furniture conditions. But in the past two centuries it has become a very scarce and hardly found in India.
6. Actinodaphne lawsonii, Kerala (threatened) - it belongs to lauraceae family. It is endemic and it is threatened by habitat loss.
7. Acacia planifrons, Tamilnadu (rare) (umbrella thorn) - they grow as a shrub or a short tree.In tamil they are called kudai vel,the tree is used as a fuel and fodder for sheep and goats. When the tree is fully grown it appears as a spreaded umbrella.
8. Abutilon indicum, Tamilnadu (rare) - commonly known as Indian mallow is a small shrub in Malvaceae family. It is used as medicinal plant and they occur in number of tropical and subtropical zones.
9. Chlorophytum tuberosum, Tamilnadu - It is an endangered plant also called musli. It is a flowering plant native to Africa and India.
10. Chlorophytum malabaricum, Tamilnadu (threatened) – It is known as malabar lily found in Western Ghats. It is small herbs with stem closely attached with leaves. Flowers are star shaped and highly fragrant. They are found in Western Ghats of India.
11. Nymphaea tetragona, Jammu and Kashmir (endangered and threatened) - It is a pygmy water lily is the tropical representative of diminutive water lilies. The original distribution was confined to Jammu Kashmir and Megalaya.
12. Belosynapsis vivipara, Madhyapradesh (rare and endangered) - Commonly called Spider wort they are distributed in India,South Asia,to New Guinea.
13. Colchicum luteum, Himachal Pradesh (rare and threatened) - This herb is generally found at the height of 2000 to 9000 feet.
14. Pterospermum reticulatum, Kerala,Tamilnadu (rare,threatened) - They are trees can grow up to 20m tall, commonly known as Malayuram, Malavuram.

**Medicinal Plants of India**

| Common Name / Maturity Period | Botanical Name or Family | Parts Used | Medicinal Use |
|---|---|---|---|
| Amla (T), After 4th year | Emblica officinalis Fam : Euphorbiaceae | Fruit | Vitamin - C, Cough, Diabetes, cold, Laxative, hyper acidity. |
| Ashok (T), 10 years onward | Saraca Asoca Fam : Caesalpinanceae | Bark Flower | Menstrual Pain, uterine, disorder, Diabetes |
| Aswagandha (H), 1 year | Withania Somnifera Fam: Solanaccae | Root, Leafs | Restorative Tonic, stress, nerves disorder, aphrodia |
| Bael / Bilva (T), After 4-5 year | Aegle marmelous Fam: Rutaccae | Fruit, Bark | Diarrhoea, Dysentery, Constipation. |
| Bhumi Amla (H), With in 1 year | Phyllanthous amarus Fam : Euphorbiaccae | Whole Plant | Anaemic, jaundice, Dropsy |
| Brahmi (H) , 1 year | Bacopa,Monnieri Fam: Scrophulariaccae | Whole plant | Nervous, Memory enhancer, mental disorder. |
| Chiraita (H), | Swertia Chiraita | Whole | Skin Disease, Burning sensa- |



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| | | | |
|---|---|---|---|
| with in 1 year | Fam : Gentianaccac | Plant | tion, fever. |
| Gudmar / madhunasini (V), After 4 year | Gymnema Sylvestre<br>Fam: Asclepiadaccac | Leaves | Diabetes, hydrocil, Asthma. |
| Guggul (T), After 8 years | Commiphora Wightii<br>Fam: Burseraccac | Gum rasine | Rheumatoid arthritis, paralysis, laxative. |
| Guluchi / Giloe (C), With in 1 year | Tinospora Cordifolia<br>Fam:Menispermaceae | Stem | Gout, Pile, general debility, fever, Jaundice. |
| Calihari / panchangulia Glori Lily , 5 years | Gloriosa superba<br>Fam: Liliaccac | Seed, tuber | Skin Disease, Labour pain, Abortion, General debility. |
| Kalmegh/ Bhui neem (H) , With in 1 year | Andrographis Paniculata<br>Fam : scanthaccac | Whole Plant | Fever, weakness, release of gas. |
| Long peeper / Pippali (C) , After 2-3 years | Peeper longum<br>Fam : Piperaccac | Fruit, Root | Appetizer, enlarged spleen Bronchitis, Cold, antidote. |
| Makoi (H)Kakamachi, With in 1 year | Solanum nigrum<br>Fam: Solanaccac | Fruit/whole plant | Dropsy, General debility, Diuretic, anti dysenteric. |
| Pashan Bheda / Pathar Chur (H), 1 year | Coleus barbatus<br>Fam : Lamiaccac | Root | Kidney stone, Calculus |
| Sandal Wood (T), 30 years onward | Santalum Album<br>Fam: Santalinaccac | Heart wood , oil | Skin disorder, Burning, sensation, Jaundice, Cough. |
| Sarpa Gandha (H), After 2 year | Ranwolfia Serpentina<br>Fam: Apocynaccac | Root | Hyper tension, insomnia. |
| Satavari (C), After 2-3 year | Asparagus Racemosus<br>Fam: Liliaceae | Tuber, root | Enhance lactation, general weakness, fatigue, cough. |
| Senna (S), With in 1 year | Casia augustifolia<br>Fam: Liliaceae | Dry Tubers | Rheumatism, general debility, tonic, aphrodisiac. |
| Tulsi (perennial) , Each 3 months | Ocimum sanclum<br>Fam: Lamiaceae | Leaves/ Seed | Cough, Cold, bronchitis, expectorant |
| Vai Vidanka (C), 2nd year onward | Embelia Ribes<br>Fam: Myrsinaccac | Root, Fruit, Leaves | Skin disease, Snake Bite, Helminthiasis. |
| Pippermint (H) Perennial | Mentha pipertia<br>Fam: Lamiaceae | Leaves, Flower, Oil | Digestive, Pain killer |
| Henna/Mehdi (S) , 1/25 years | Lawsennia iermis<br>Fam: Lytharaceae | Leaf, Flower, Seed | Burning, Steam, Anti Inflammatory. |
| Ghritkumari(H) , 2nd-5th years | Aloe Vera<br>Fam: Liliaceae | Leaves | Laxative, Wound healing, Skin burns & care, Ulcer. |
| Sada Bahar (H) Periwinkle/Nyantara | Vincea rosea/ catharanthusRoseus<br>Fam : Apocyanace | Whole Plant | Leukaemia, Hypotensive, Antispasmodic , Antidote |



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| | | | |
|---|---|---|---|
| Vringraj (H) | Eclipta alba<br>Fam: Compositae | Seed/whole | Anti-inflammatory, Digestive, hairtonic. |
| Swet chitrak Perennial (H) | Plumbago Zeylanica<br>Fam: Plumbaginaceae | Root, Rootbar | Appetiser, Antibacterial, Anti-cancer. |
| Rakta Chitrak (H) | Plumbago Indica<br>Fam : Plumbaginaceae | Root, Rootbar | Dyspepsia, colic, inflammation, cough. |
| Kochila (T), 15 years | Strychinos nuxvomica<br>Fam: Loganiaceae | Seed | Nervous, Paralysis, healing wound. |
| Harida (T) | Terminalia Chebula<br>Fam: Combretaceae | Seed | Trifala, wound ulcer, leprosy, inflammation, Cough. |
| Bahada (T) | TerminaliaBellerica<br>Fam:Comretaceae | Seed, Bark | Cough, Insomnia, Dropsy, Vomiting, Ulcer, Trifala. |
| Gokhur (H) Crawling Puncture Vine, 1 year | Tribulus Terrestris<br>Fam: Lygophyllaceae | Whole Plant | Sweet cooling, Aphrodisiac, appetizer, Digestive, Urinary. |
| Neem (T) | Azardirchata – indica<br>Fam : Mahaceae | Rhizome | Sedative, analgesic, epilepsy, hypertensive |
| Anantamool/sariva (S) Indian Sarap sarilla | Hemibi smus Indicus<br>Fam: Asclepiadaceae | Root/ Leaf | Appetiser, Carminative, aphrodisiac, Astringent. |
| Bach (H) Sweet Flag, 1 year | Acorus Calamus<br>Fam : araceae | Rhizome | Sedative, analgesic, epilepsy, hypertensive |
| Vasa (S) | Adhatoda vesica<br>Fam : Sacanthaceae | Whole Plant | Antispasmodic, respiratory, Stimulant. |
| Nageswar, (T) Nag Champa | Mesua Ferrea<br>Fam : Guttiferae | Bark, Leaf, Flower | Asthma, Skin, Burning, Vomiting, Dysentery, Piles. |
| Benachar (S) Khus/khus | Vetiveria Ziziinoides<br>Fam : Toaceae / Graminae | Root | Hyperdipsia, Burning, ulcer, Skin, Vomiting. |
| Mandukparni (H) Indian pennywort | Centella asiatica<br>Fam : Umdelliferae | Whole plant | Anti-inflammatory, Jaundice, Diuretic, Diarrhoea. |
| Kaincha/Creeper Baidanka | Mucuna Truriens<br>Fam : Fabaceae | Root, Hair, Seed, Leaf | Nervous, Disorder, Constipation, Nephropathy, Strangury, Dropsy. |
| Dalchini Perenial (S) | Cinnamomum Zeylanicum<br>Fam : Lauraceae | Bark, Oil | Bronchitis, Asthma, Cardiac, Disorder, Fever. |
| Kurai (S) | Holorheena antidysentrica<br>Fam:Apocyaceaceae | Bark, Seed | Scabies, Antipyretic, Amoebic dysentery. |
| Kantakari / Akranti Perennial (H) | Solanum Xanthocarpum<br>Fam : Solanaceae | Whole Plant, Fruit, Seed | Diuretic, Anti-inflammatory, Appetiser, Stomach |

Where, Fam - Family, T - Tree, H - Herb, C - Climber, S- shrub



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## 5. BIODIVERSITY CONSERVATION IN INDIA

India, one of the 17 mega-diverse nations, is one of the richest nations in terms of biological diversity. India owes this to its position in the tropical and subtropical latitudes. India has a great diversity of natural ecosystems ranging from the cold and high Himalayan regions to the sea coasts; from the wet north-eastern green forests to the dry north-western arid deserts; with different types of forests, wetlands, islands and the oceans. India consists of fertile river plains and high plateaus and several major rivers, including the Ganges, Brahmaputra and Indus. The diverse physical features and climatic situations have formed ecological habitats like forests, grasslands, wetlands, coastal and marine ecosystems and desert ecosystems, which harbour and sustain immense biodiversity.

Biodiversity is not only essential for maintaining the ecological functions but also provides the base for the livelihoods, cultures and economies of several hundred millions of people, including farmers, fisher folk, forest dwellers and artisans. The rapid erosion of biodiversity in the last few decades has impacted on the health of the land, water bodies and people. Hence, it has become imperative to conserve and protect our rich biodiversity. There have been numerable of strategies, which have been adapted for the conservation of Biodiversity in India.

**Protected Area Network in India:**

A National Board for Wildlife (NBWL), chaired by the Prime Minister of India provides for policy framework for wildlife conservation in the country. The National Wildlife Action Plan (2002-2016) was adopted in 2002, emphasizing the people's participation and their support for wildlife conservation. India's conservation planning is based on the philosophy of identifying and protecting representative wild habitats across all the ecosystems. The Indian Constitution entails the subject of forests and wildlife in the Concurrent list. The Federal Ministry acts as a guiding torch dealing with the policies and planning on wildlife conservation, while the provincial Forest Departments are vested with the responsibility of implementation of national policies and plans.

| | No. | Total Area (km²) | % Coverage of Country |
|---|---|---|---|
| National Parks (NPs) | 103 | 40500.13 | 1.23 |
| Wildlife Sanctuaries (WLSs) | 537 | 118006.89 | 3.59 |
| Conservation Reserves (CRs) | 67 | 4949.38 | 0.97 |
| Community Reserves | 26 | 46.93 | 0.001 |
| Protected Areas (PAs) | 733 | 160901.77 | |

**National parks**

This is an area having adequate ecological, faunal, floral, geomorphological, natural or zoological significance. The National Park is declared for the purpose of protecting, propagating or developing wildlife or its environment. National Parks are considered as IUCN category II protected areas.

The difference between a Sanctuary and a National Park mainly lies in the vesting of rights of people living inside. Unlike a Sanctuary, where certain rights can be allowed, in a National Park no rights are allowed. No grazing of any livestock shall also be permitted inside a National Park while in a Sanctuary; the Chief Wildlife Warden may regulate, control or prohibit it. In addition, while any removal or exploitation of wildlife or forest produce from a Sanctuary requires the recommendation of the State Board for Wildlife, removal etc., from a National Park requires recommendation of the National Board for Wildlife (However, as per orders of the Supreme Court, such removal or exploitation from a Sanctuary also requires recommendation of the Standing Committee of National Board for Wildlife).



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State-wise break up of National Parks

| | | | |
|---|---|---|---|
| **Andaman & Nicobar Islands** | | | |
| 1 | Campbell Bay NP | 1992 | 426.23 |
| 2 | Galathea Bay NP | 1992 | 110.00 |
| 3 | Mahatama Gandhi Marine (Wandoor) NP | 1983 | 281.50 |
| 4 | Middle Button Island NP | 1987 | 0.44 |
| 5 | Mount Harriett NP | 1987 | 46.62 |
| 6 | North Button Island NP | 1987 | 0.44 |
| 7 | Rani Jhansi Marine NP | 1996 | 256.14 |
| 8 | Saddle Peak NP | 1987 | 32.54 |
| 9 | South Button Island NP | 1987 | 0.03 |
| **Andhra Pradesh** | | | |
| 1 | Papikonda NP | 2008 | 1012.86 |
| 2 | Rajiv Gandhi (Rameswaram) NP | 2005 | 2.40 |
| 3 | Sri Venkateswara NP | 1989 | 353.62 |
| **Arunachal Pradesh** | | | |
| 1 | Mouling NP | 1986 | 483.00 |
| 2 | Namdapha NP | 1983 | 1807.82 |
| **Assam** | | | |
| 1 | Dibru-Saikhowa NP | 1999 | 340.00 |
| 2 | Kaziranga NP | 1974 | 858.98 |
| 3 | Manas NP | 1990 | 500.00 |
| 4 | Nameri NP | 1998 | 200.00 |
| 5 | Rajiv Gandhi Orang NP | 1999 | 78.81 |
| **Bihar** | | | |
| 1 | Valmiki NP | 1989 | 335.65 |
| **Chhattisgarh** | | | |
| 1 | Guru Ghasidas (Sanjay) NP | 1981 | 1440.71 |
| 2 | Indravati (Kutru) NP | 1982 | 1258.37 |
| 3 | Kanger Valley NP | 1982 | 200.00 |
| **Goa** | | | |
| 1 | Mollem NP | 1992 | 107.00 |
| **Gujarat** | | | |
| 1 | Vansda NP | 1979 | 23.99 |
| 2 | Blackbuck (Velavadar) NP | 1976 | 34.53 |

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| | | | |
|---|---|---|---|
| 3 | Gir NP | 1975 | 258.71 |
| 4 | Marine (Gulf of Kachchh) NP | 1982 | 162.89 |
| | **Haryana** | | |
| 1 | Kalesar NP | 2003 | 46.82 |
| 2 | Sultanpur NP | 1989 | 1.43 |
| | **Himachal Pradesh** | | |
| 1 | Great Himalayan NP | 1984 | 754.40 |
| 2 | Inderkilla NP | 2010 | 104.00 |
| 3 | Khirganga NP | 2010 | 710.00 |
| 4 | Pin Valley NP | 1987 | 675.00 |
| 5 | Simbalbara NP | 2010 | 27.88 |
| | **Jammu & Kashmir** | | |
| 1 | City Forest (Salim Ali) NP | 1992 | 9.00 |
| 2 | Dachigam NP | 1981 | 141.00 |
| 3 | Hemis NP | 1981 | 3350.00 |
| 4 | Kishtwar NP | 1981 | 425.00 |
| | **Jharkhand** | | |
| 1 | Betla NP | 1986 | 226.33 |
| | **Karnataka** | | |
| 1 | Anshi NP | 1987 | 417.34 |
| 2 | Bandipur NP | 1974 | 874.20 |
| 3 | Bannerghatta NP | 1974 | 260.51 |
| 4 | Kudremukh NP | 1987 | 600.32 |
| 5 | Nagarahole (Rajiv Gandhi) NP | 1988 | 643.39 |
| | **Kerala** | | |
| 1 | Anamudi Shola NP | 2003 | 7.50 |
| 2 | Eravikulam NP | 1978 | 97.00 |
| 3 | Mathikettan Shola NP | 2003 | 12.82 |
| 4 | Pambadum Shola NP | 2003 | 1.32 |
| 5 | Periyar NP | 1982 | 350.00 |
| 6 | Silent Valley NP | 1984 | 89.52 |
| | **Madhya Pradesh** | | |
| 1 | Bandhavgarh NP | 1968 | 448.85 |
| 2 | Fossil NP | 1983 | 0.27 |
| 6 | Indira Priyadarshini Pench NP | 1975 | 292.85 |
| 3 | Kanha NP | 1955 | 940.00 |
| 4 | Madhav NP | 1959 | 375.22 |

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| | | | |
|---|---|---|---|
| 5 | Panna NP | 1981 | 542.67 |
| 7 | Sanjay NP | 1981 | 466.88 |
| 8 | Satpura NP | 1981 | 585.17 |
| 9 | Van Vihar NP | 1979 | 4.45 |
| | **Maharashtra** | | |
| 1 | Chandoli NP | 2004 | 317.67 |
| 2 | Gugamal NP | 1975 | 361.28 |
| 3 | Nawegaon NP | 1975 | 133.88 |
| 4 | Pench (Jawaharlal Nehru) NP | 1975 | 257.26 |
| 5 | Sanjay Gandhi (Borivilli) NP | 1983 | 86.96 |
| 6 | Tadoba NP | 1955 | 116.55 |
| | **Manipur** | | |
| 1 | Keibul-Lamjao NP | 1977 | 40.00 |
| | **Meghalaya** | | |
| 1 | Balphakram NP | 1985 | 220.00 |
| 2 | Nokrek Ridge NP | 1986 | 47.48 |
| | **Mizoram** | | |
| 1 | Murlen NP | 1991 | 100.00 |
| 2 | Phawngpui Blue Mountain NP | 1992 | 50.00 |
| | **Nagaland** | | |
| 1 | Intanki NP | 1993 | 202.02 |
| | **Odisha** | | |
| 1 | Bhitarkanika NP | 1988 | 145.00 |
| 2 | Simlipal NP | 1980 | 845.70 |
| | **Rajasthan** | | |
| 1 | Mukundra Hills NP | 2006 | 200.54 |
| 2 | Desert NP | 1992 | 3162.00 |
| 3 | Keoladeo Ghana NP | 1981 | 28.73 |
| 4 | Ranthambhore NP | 1980 | 282.00 |
| 5 | Sariska NP | 1992 | 273.80 |
| | **Sikkim** | | |
| 1 | Khangchendzonga NP | 1977 | 1784.00 |
| | **Tamil Nadu** | | |
| 1 | Guindy NP | 1976 | 2.82 |
| 2 | Gulf of Mannar Marine NP | 1980 | 6.23 |
| 3 | Indira Gandhi (Annamalai) NP | 1989 | 117.10 |
| 4 | Mudumalai NP | 1990 | 103.23 |

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| | | | |
|---|---|---|---|
| 5 | Mukurthi NP | 1990 | 78.46 |
| | **Telangana** | | |
| 1 | Kasu Brahmananda Reddy NP | 1994 | 1.43 |
| 2 | Mahaveer Harina Vanasthali NP | 1994 | 14.59 |
| 3 | Mrugavani NP | 1994 | 3.60 |
| | **Tripura** | | |
| 1 | Clouded Leopard NP | 2007 | 5.08 |
| 2 | Bison (Rajbari) NP | 2007 | 31.93 |
| | **Uttar Pradesh** | | |
| 1 | Dudhwa NP | 1977 | 490.00 |
| | **Uttarakhand** | | |
| 1 | Corbett NP | 1936 | 520.82 |
| 2 | Gangotri NP | 1989 | 2390.02 |
| 3 | Govind NP | 1990 | 472.08 |
| 4 | Nanda Devi NP | 1982 | 624.60 |
| 5 | Rajaji NP | 1983 | 820.00 |
| 6 | Valley of Flowers NP | 1982 | 87.50 |
| | | | |
| | **West Bengal** | | |
| 1 | Buxa NP | 1992 | 117.10 |
| 2 | Gorumara NP | 1992 | 79.45 |
| 3 | Jaldapara NP | 2014 | 216.51 |
| 4 | Neora Valley NP | 1986 | 159.89 |
| 5 | Singalila NP | 1986 | 78.60 |
| 6 | Sunderban NP | 1984 | 1330.10 |

**Wild life Sanctuaries –**

Sanctuary is an area which is of adequate ecological, faunal, floral, geomorphological, natural or zoological significance. The Sanctuary is declared for the purpose of protecting, propagating or developing wildlife or its environment. Certain rights of people living inside the Sanctuary could be permitted. Further, during the settlement of claims, before finally notifying the Sanctuary, the Collector may, in consultation with the Chief Wildlife Warden, allow the continuation of any right of any person in or over any land within the limits of the Sanctuary.

**Conservation Reserves –**

These can be declared by the State Governments in any area owned by the Government, particularly the areas adjacent to National Parks and Sanctuaries and those areas which link one Protected Area with another. Such declaration should be made after having consultations with the local communities. Conservation Reserves are declared for the purpose of protecting landscapes, seascapes, flora and fauna and their habitat. The rights of people living inside a Conservation Reserve are not affected.



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Community Reserves –

| State | S. No. | Name | Year of Estd. |
|---|---|---|---|
| Punjab | 1. | Keshopur Chhamb | 2007 |
| | 2. | Lalwan | 2007 |
| Kerala | 3. | Kadalundi | 2007 |
| Karnataka | 4. | Kokkare Bellur | 2007 |
| Meghalaya | 5. | Ka Khloo Thangbru Umsymphu | 2014 |
| | 6. | Ka Khloo Pohblai Mooshutia | 2014 |
| | 7. | Ka Khloo Langdoh Kur Pyrtuh | 2014 |
| | 8. | Nongsangu | 2014 |
| | 9. | Raid Nongbri | 2014 |
| | 10. | Lum Jusong | 2014 |
| | 11. | Jirang | 2014 |
| | 12. | Raid Nonglyngdoh/ Pdah Kyndeng | 2014 |
| | 13. | Phudja-ud | 2014 |
| | 14. | Lawbah | 2014 |
| | 15. | Ryngibah | 2014 |
| | 16. | Mongalgre | 2014 |
| | 17. | Dangkipara | 2014 |
| | 18. | Aruakgre | 2014 |
| | 19. | Resu Haluapra | 2014 |
| | 20. | Kitmadamgre | 2014 |
| | 21. | Kpoh Eijah | 2014 |
| | 22. | Miewsyiar | 2014 |
| | 23. | Umsum Pitcher Plant | 2014 |
| | 24. | Lumkohkriah | 2014 |
| | 25. | Ryngud | 2014 |
| | 26. | Thangkharang | 2014 |
| | | **Total Area (sq km)** | **46.93** |

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These can be declared by the State Government in any private or community land, not comprised within a National Park, Sanctuary or a Conservation Reserve, where an individual or a community has volunteered to conserve wildlife and its habitat. Community Reserves are declared for the purpose of protecting fauna, flora and traditional or cultural conservation values and practices. As in the case of a Conservation Reserve, the rights of people living inside a Community Reserve are not affected.

### Coastal Protected Areas

India's coastline, which runs for 7,500 kms, is inhabited by approximately 25% of our population. Almost all of these individuals live within 50 kms of the shoreline. This includes 10 million fisherfolk who depend directly on the sea for their livelihood. Keeping in view the importance of the coastal environment and the need to protect the coastal ecosystems from the pressures of developmental activities, the Ministry had issued the Coastal Regulation Zone (CRZ) Notification, 1991

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under the Environment (Protection) Act, 1986. These acts have been amended many times and the frequent changes to the 1991 Notification have been consolidated in the 2011 Notification. It classifies the coastal stretch of the country into CRZ-I (ecologically sensitive areas), CRZ-II (built up municipal areas), CRZ-III (rural areas) and CRZ-IV (Islands of Lakshadweep and Andaman & Nicobar).

The main objectives of the Coastal Regulation Zone Notification, 2011 are:

- To ensure livelihood security to the fishing communities and other local communities living in the coastal areas;
- To conserve and protect coastal stretches and;
- To promote development in a sustainable manner based on scientific principles, taking into account the dangers of natural hazards in the coastal areas and sea level rise due to global warming.

**Marine Protected Areas**

It is necessary to monitor marine areas to assess impact of conservation measures, status of habitats within the protected areas, impact of development on the quality and quantity of the resources, etc. There are a total of 128 marine Protected Areas in India. Out of these, there are four Marine National Parks, sixty-seven Marine Sanctuaries, National Parks and Wild Life Sanctuaries, three Marine Biosphere Reserves, three Ramsar Coastal Wetlands, one Tiger Reserve (Sunderbans), one National Mangrove Genetic Resource Centre and Gene Centre and the Coral Reefs of Lakshadweep (seventeen), thirty two Mangrove Notifies Forests. Examples of Marine Protected Areas include - Gulf of Kachchh Marine National Park (MNP), Jamnagar, Gujarat; Gulf of Kachchh Marine Sanctuary (MS), Jamnagar, Gujarat; Malvan Marine Sanctuary, Sindhudurg, Maharashtra; Gulf of Mannar MNP, Biosphere Reserve (BR), Tamil Nadu; Bhitarkanika National Park (NP), Cuttack, Orissa; Sunderbans NP-Tiger Reserve; North Andaman and North Nicobar.

**Sacred Groves**

India has a long tradition of prudent use and wise conservation of all resources that are useful to people. Forests have been the lifelines for forest-dwelling communities since ancient times. One method for conservation of this green resource was the creation of sacred groves, usually dedicated to a local deity. A traditional

| Examples of sacred groves – |
|---|
| Shipin, about 12 km from Shimla, is believed to be the biggest deodar grove in this district and is home to trees that are hundreds of years old. |
| Sacred groves in the hills of Garhwal and Kumaon are mentioned in old Hindu scriptures like the Puranas. The largest known sacred grove is in Hariyali, near Ganchar in Chamoli District. Others include Askot, Binsar, and Gananath. In all these areas, fairs are held regularly and rituals performed. |
| Some of the richest groves in the country are found in the Khasi Hills of Meghalaya, where almost every village is said to have had a grove, known locally as the lawkyntangs. The largest of them are in Mawphlang and Mausmai. |
| In Jharkhand sacred groves, known as sarnas, are found mainly in the Chotanagpur region. These areas are not very large and consist of 2 to 20 trees. They are usually full of creepers, shrubs, and grasses. |
| The sacred groves of Rajasthan are the oraans of Jaisalmer, Jodhpur, and Bikaner, the kenkris of Ajmer, the vanis of Mewar, and the shamlat dehs of Alwar. The oraans cover the largest area, though their species diversity differs from area to area. |
| Maharashtra has about 250 sacred groves, known as deorais or devrais, in the districts of Pune, Ratnagiri, Raigad, and Kolhapur. These areas are full of a large variety of rare species with great biodiversity. |
| Kerala has about 240 sacred groves, known as kavus, where more than 3000 rare species of plants are found. The largest grove, spread over more than 20 hectares, is in Ernakulam District. |

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means of biodiversity conservation, these groves can be considered the ancient equivalent of natural sanctuaries where all forms of living creatures are given protection by a deity. No one is permitted to cut any tree or plant, kill animals and birds, or harm any form of life in this area. Ancient Indian texts have many references to sacred groves, for example, Kalidaasa's Vikramorvawsiyam.

Today, there are only about 1000 square kilometres of undisturbed sacred groves, scattered in patches all over the country. Only the groves in the remote and inaccessible areas remain untouched. While religious taboo protected the groves near towns earlier, today they are protected with the means of barbed wire fencing or hedges. The decline of sacred groves can be attributed to the change in social values and religious beliefs as a result of modernization and urbanization. The expansion of the market economy, which places heavy demand on resources such as timber, is another major cause. For most villagers, economics is easier to understand than ecology.

Sacred groves vary in size from a few trees to dense forests covering vast tracts of land. These groves are important today as they are banks of genetic and plant diversity that have to be preserved and sustained. These areas often contain species that have disappeared from the regions outside the grove. The extant groves are proof that the forests exist not only because there are regulations but also because there are traditions.

**Biosphere Reserves in India**

Biosphere Reserves (BRs) are representative parts of natural and cultural landscapes extending over large area of terrestrial or coastal/marine ecosystems or a combination thereof and representative examples of bio-geographic zones/provinces.

BR scheme is different from other conservation related schemes. It has the focus on the welfare of local inhabitants through provision of supplementary and alternate livelihood support to the people in the buffer and transition zones in order to reduce biotic pressure on biodiversity of the natural reserves of core zone.

Criteria for designation of BR

- A site that must contain an effectively protected and minimally disturbed core area of value of nature conservation.
- The core area should be typical of a bio-geographical unit and large enough to sustain viable populations representing all trophic levels in the ecosystem.
- The management authority to ensure the involvement/cooperation of local communities to bring variety of knowledge and experiences to link biodiversity conservation and socio-economic development while managing and containing the conflicts.
- Areas potential for preservation of traditional tribal or rural modes of living for harmonious use of environment.

**Structure and functions of BR:**

Biosphere reserves are demarcated into following 3 inter-related zones:

1. **Core Zone –**

   Core zone must contain suitable habitat for numerous plant and animal species, including higher order predators and may contain centres of endemism. Core areas often conserve the wild relatives of economic species and also represent important genetic reservoirs having exceptional scientific interest. A core zone being National Park or Sanctuary/protected/regulated mostly under the Wildlife (Protection) Act, 1972. Whilst realizing that perturbation is an ingredient of ecosystem functioning, the core zone is to be kept free from human pressures external to the system.

2. **Buffer Zone –**

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The buffer zone adjoins or surrounds core zone, uses and activities are managed in this area in the ways that help in protection of core zone in its natural condition. These uses and activities include restoration, demonstration sites for enhancing value addition to the resources, limited recreation, tourism, fishing, grazing, etc; which are permitted to reduce its effect on core zone. Research and educational activities are to be encouraged. Human activities, if natural within BR, are likely to continue if these do not adversely affect the ecological diversity.

**3. Transition Zone –**

The transition area is the outermost part of a biosphere reserve. This is usually not delimited one and is a zone of cooperation where conservation knowledge and management skills are applied and uses are managed in harmony with the purpose of the biosphere reserve. This includes settlements, crop lands, managed forests and area for intensive recreation and other economic uses characteristics of the region.

Tripartite functions of BR (Conservation, Development and logistic support)

- To conserve the diversity and integrity of plants and animals within natural ecosystems
- To safeguard genetic diversity of species on which their continuing evolution depends
- To ensure sustainable use of natural resources through most appropriate technology for improvement of economic well-being of the local people
- To provide areas for multi-faceted research and monitoring
- To provide facilities for education and training

| S. No. | Name | Date of Notification | Area (in $km^2$) | Location (State) |
|---|---|---|---|---|
| 1 | Nilgiri | 01.09.1986 | 5520 (Core 1240 & Buffer 4280) | Part of Wayanad, Nagarhole, Bandipur and Madumalai, Nilambur, Silent Valley and Siruvani hills (Tamil Nadu, Kerala and Karnataka). |
| 2 | Nanda Devi | 18.01.1988 | 5860.69 (Core 712.12, Buffer 5,148.570) & T. 546.34) | Part of Chamoli, Pithoragarh, and Bageshwar districts (Uttarakhand). |
| 3 | Nokrek | 01.09.1988 | 820 (Core 47.48 & Buffer 227.92, Transition Zone 544.60) | Part of Garo hills (Meghalaya). |
| 4 | Great Nicobar | 06.01.1989 | 885 (Core 705 & Buffer 180) | Southern most islands of Andaman And Nicobar (A&N Islands). |
| 5 | Gulf of Mannar | 18.02.1989 | 10,500 km2 Total Gulf area (area of Islands 5.55 km2) | Indian part of Gulf of Mannar between India and Sri Lanka (Tamil Nadu). |
| 6 | Manas | 14.03.1989 | 2837 (Core 391 & | Part of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamprup and Darang |

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| | | | | |
|---|---|---|---|---|
| | | | Buffer 2,446) | districts (Assam) |
| 7 | Sunderbans | 29.03.1989 | 9630 (Core 1700 & Buffer 7900) | Part of delta of Ganges and Brahamaputra river system (West Bengal). |
| 8 | Simlipal | 21.06.1994 | 4374 (Core 845, Buffer 2129 & Transition 1400 | Part of Mayurbhanj district (Orissa). |
| 9 | Dibru-Saikhowa | 28.07.1997 | 765 (Core 340 & Buffer 425) | Part of Dibrugarh and Tinsukia Districts (Assam) |
| 10 | Dehang-Dibang | 02.09.1998 | 5111.50 (Core 4094.80 &Buffer 1016.70) | Part of Siang and Dibang Valley in Arunachal Pradesh. |
| 11 | Pachmarhi | 03.03.1999 | 4926 | Parts of Betul, Hoshangabad and Chindwara districts of Madhya Pradesh. |
| 12 | Khangchendzonga | 07.02.2000 | 2619.92 (Core 1819.34 & Buffer 835.92) | Parts of Khangchendzonga hills and Sikkim. |
| 13 | Agasthyamalai | 12.11.2001 | 1828 | Neyyar, Peppara and Shendurney Wildlife Sanctuaries and their adjoining areas in Kerala. |
| 14 | Achanakamar - Amarkantak | 30.3.2005 | 3835.51 (Core 551.55 & Buffer 3283.86) | Covers parts of Anupur and Dindori districts of M.P. and parts of Bilaspur districts of Chhattishgarh State. |
| 15 | Kachchh | 29.01.2008 | 12,454 km2 | Part of Kachchh, Rajkot, Surendra Nagar and Patan Civil Districts of Gujarat State |
| 16 | Cold Desert | 28.08.2009 | 7770 | Pin Valley National Park and surroundings; Chandratal and Sarchu&Kibber Wildlife Sancturary in Himachal Pradesh |
| 17 | Seshachalam Hills | 20.09.2010 | 4755.997 | Seshachalam Hill Ranges covering parts of Chittoor and Kadapa districts of Andhra Pradesh |
| 18 | Panna | 25.08.2011 | 2998.98 | Part of Panna and Chhattarpur districts in Madhya Pradesh |

**RAMSAR WETLANDS SITES**

| Sl. No. | Name of Site | State Location | Date of Declaration | Area *(in sq.km.)* |
|---|---|---|---|---|
| 1 | Asthamudi Wetland | Kerala | 19.8.2002 | 1860 |

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| | | | | |
|---|---|---|---|---|
| 2 | Bhitarkanika Mangroves | Orissa | 19.8.2002 | 525 |
| 3 | Bhoj Wetlands | Madhya Pradesh | 19.8.2002 | 31 |
| 4 | Chandertal Wetland | Himachal Pradesh | 8.11.2005 | 38.56 |
| 5 | Chilka Lake | Orissa | 1.10.1981 | 1140 |
| 6 | Deepor Beel | Assam | 19.8.2002 | 4.14 |
| 7 | East Calcutta Wetlands | West Bengal | 19.8.2002 | 378 |
| 8 | Harike Lake | Punjab | 23.3.1990 | 86 |
| 9 | Hokera Wetland | Jammu and Kashmir | 8.11.2005 | 13.75 |
| 10 | Kanjli Lake | Punjab | 22.1.2002 | 14.84 |
| 11 | Keoladeo Ghana NP | Rajasthan | 1.10.1981 | 28.73 |
| 12 | Kolleru Lake | Andhra Pradesh | 19.8.2002 | 673 |
| 13 | Loktak Lake | Manipur | 23.3.1990 | 945 |
| 14 | Nalsarovar Bird Sanctuary | Gujarat | 24/09/12 | 120 |
| 15 | Point Calimere | Tamil Nadu | 19.8.2002 | 17.26 |
| 16 | Pong Dam Lake | Himachal Pradesh | 19.8.2002 | 307.29 |
| 17 | Renuka Wetland | Himachal Pradesh | 8.11.2005 | Not Available |
| 18 | Ropar Lake | Punjab | 22.1.2002 | 41.36 |
| 19 | Rudrasagar Lake | Tripura | 8.11.2005 | 2.40 |
| 20 | Sambhar Lake | Rajasthan | 23.3.1990 | 736 |
| 21 | Sasthamkotta Lake | Kerala | 19.8.2002 | 11.3 |
| 22 | Surinsar-Mansar Lakes | Jammu and Kashmir | 8.11.2005 | 3.50 |
| 23 | Tsomoriri Lake | Jammu and Kashmir | 19.8.2002 | 120 |
| 24 | Vembanad Kol Wetland | Kerala | 19.8.2002 | 4583 |
| 25 | Upper Ganga River (Brijghat to Narora Stretch) | Uttar Pradesh | 8.11.2005 | 265.90 |
| 26 | Wular Lake | Jammu & Kashmir | 23.3.1990 | 173 |
| | | **Total Area (sq. km.)** | | **12119.03** |

## Biodiversity Hot-Spots in India

There are three Biodiversity Hot-Spots in India, which have been discussed as follows –

### 1. Western Ghats

The Western Ghats region, which is spread into 6 states of India, shows biogeographical affinities to the Malayan region. Their proximity to the ocean and through orographic effect, they receive high rainfall. These regions have moist deciduous forest and rain forest. The region shows high species diversity as well as high levels of endemism. Nearly 77% of the amphibians and 62% of the reptile species found here are found nowhere else.

There are over 6000 vascular plants belonging to over 2500 genera in this hotspot, of which over 3000 are endemic. Much of the world's spices such as black pepper and cardamom have their origins in the Western Ghats. The highest concentration of species in the Western Ghats is believed to be the Agasthyamalai Hills in the extreme south. The region also harbours over 450 bird species,

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about 140 mammalian species, 260 reptiles and 175 amphibians. Over 60% of the reptiles and amphibians are completely endemic to the hotspot. Remarkable as this diversity is, it is severely threatened today. The vegetation in this hotspot originally extended over 190,000 square kms. Today, it has been reduced to just 43,000 sq. km.

**2. The Eastern Himalayas**

The Eastern Himalayas is the region encompassing Bhutan, north-eastern India, and southern, central, and eastern Nepal. The region is geologically young and shows high altitudinal variation. Together, the Himalayan mountain system is the world's highest, and home to the world's highest peaks, which include Mount Everest and K2. Some of the world's major river systems arise in the Himalayas and their combined drainage basin is home to some 3 billion people (almost half of Earth's population) in 18 countries.

The Eastern Himalayan hotspot has nearly 163 globally threatened species including the One-horned Rhinoceros (Rhinoceros Unicornis), the Wild Asian Water buffalo (Bubalusbubalis (Arnee)) and in all 45 mammals, 50 birds, 17 reptiles, 12 amphibians, 3 invertebrate and 36 plant species. The Relict Dragonfly (Epiophlebialaidlawi) is an endangered species found here with the only other species in the genus being found in Japan. The region is also home to the Himalayan Newt (Tylototritonverrucosus), the only salamander species found within Indian limits. There are an estimated 10,000 species of plants in the Himalayas, of which one-third are endemic and found nowhere else in the world. Five families - Tetracentraceae, Hamamelidaceae, Circaesteraceae, Butomaceae and Stachyuraceae - are completely endemic to this region. Many plant species are found even in the highest reaches of the Himalayan Mountains. For example, a plant species Ermaniahimalayensis was found at an altitude of 6300 metres in north-western Himalayas. A few threatened endemic bird species such as the Himalayan Quail, Cheer pheasant, Western tragopan are found here, along with some of Asia's largest and most endangered birds such as the Himalayan vulture and White-bellied heron.

The Himalayas are home to over 300 species of mammals, a dozen of which are endemic. Mammals like the Golden langur, The Himalayan Tahr, the pygmy hog, Langurs, Asiatic wild dogs, sloth bears, Gaurs, Muntjac, Sambar, Snow leopard, Black bear, Blue sheep, Takin, the Gangetic dolphin, wild water buffalo, swamp deer call the Himalayan ranged their home. The only endemic genus in the hotspot is the Namadapha flying squirrel which is critically endangered and is described only from a single specimen from Namdapha National Park.

**3. Indo-Burma**

The Indo-Burma region is spread out from Eastern Bangladesh to Malaysia and includes North-Eastern India south of Brahmaputra River, Myanmar, the southern part of China's Yunnan province, Lao People's Democratic Republic, Cambodia, Vietnam and Thailand. The Indo-Burma region is spread over 2 million sq. km of tropical Asia. Since this hotspot is spread over such a large area and across several major landforms, there is a wide diversity of climate and habitat patterns in this region.

Much of this region is still a wilderness, but has been deteriorating rapidly in the past few decades. In recent times, six species of large mammals have been discovered here: Large-antlered muntjac, Annamitemuntjac, Grey-shanked douc, Annamite striped rabbit, Leaf deer, and the Saola. This region is home to several primate species such as monkeys, langurs and gibbons with populations numbering only in the hundreds. Many of the species, especially some freshwater turtle species, are endemic. Almost 1,300 bird species exist in this region including the threatened white-eared night-heron, the grey-crowned crocias, and the orange-necked partridge. It is estimated that there are about 13,500 plant species in this hotspot, with over half of them endemic. Ginger, for example, is native to this region.

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## LEGISLATIVE EFFORTS

Formal policies and programmes for conservation and sustainable utilisation of biodiversity resources date back to several decades. The concept of environmental protection is enshrined in the Indian constitution in articles 48a and 51a (g). Major central acts relevant to biodiversity include:

**1. Wildlife (Protection) Act, 1972 (Management of National Parks and Wildlife Sanctuaries, protection to Scheduled Species, Community and Conservation Reserves)**

The Wildlife (Protection) Act of 1972 provides the basic framework to ensure the protection and management of wildlife. The Act was amended subsequently in 1982, 1986, 1991 and 1993 to accommodate provision for its effective implementation. The Wildlife Protection Act, 1972 which we read today is a product of process which started long ago in 1887 for the protection of a few wild birds and after addition of wild animals in 1912 and specified plants in 1991 it covered almost all the wildlife resources which need protection and management. An expert committee, constituted by the Indian Board of Wildlife considers amendments to the Act, as and when necessary. With the amendment of the Act in 1991, powers of the State Governments have been withdrawn almost totally. Now the State Governments are not empowered to declare any wild animal a vermin. Further by addition of provision, immunization of livestock within a radius of 5 km from a National Park or sanctuary has been made compulsory. Broadly speaking the amendment provides the follows:

- Greater powers to enforcement authority.
- Greater say to individuals or NGOs in matter concerning wildlife protection. The Central Government Officers as well as individuals now can file complaints in the court for offences.
- NGOs like WWF-India and Traffic-India will make available technical and legal guidance when needed.
- More impact on wildlife trade.
- Setting up of a Central Zoo Authority.
- Greater protection to wildlife through prohibiting hunting of wild animals other than vermin.
- Provision to prohibit collection and exploitation of wild plants which are threatened with extinction.
- Provision to extract and deal in snake venom for producing lifesaving drugs.
- Provision to ban trade in Africa ivory.
- Enhanced punishments for isolations.
- Payment of rewards to persons helping in apprehension of offenders.

**National Board for Wild Life**

It is a "Statutory Organization" constituted under the Wildlife Protection Act, 1972. Theoretically, the board is "advisory" in nature and advises the Central Government on framing policies and measures for conservation of wildlife in the country. However, it is a very important body because it serves as apex body to review all wildlife-related matters and approve projects in and around national parks and sanctuaries. Primary function of the Board is to promote the conservation and development of wildlife and forests. It has power to review all wildlife-related matters and approve projects in and around national parks and sanctuaries. No alternation of boundaries in national parks and wildlife sanctuaries can be done without approval of the NBWL. NBWL's standing committee is entrusted with responsibility of giving green clearances to projects that pass through protected areas like tiger reserves, wildlife sanctuaries and also those falling within 10-kilometre distance of the wildlife sanctuary or national parks. The previous committee's term ended on September 6 2013. But for nearly 10 months it was not reconstituted and was reconstituted only in July 2014 by Modi government. However, the new government in July 2014 had constituted NBWL and nominated

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only one NGO -- Gujarat Ecological Education and Research Foundation (which is said to be under Gujarat government's control hence not an NGO) -- and two experts – Professor Raman Sukumar and Dr HS Singh -- against the required number of five NGOs and ten eminent conservationists, ecologists and environmentalists. The government also appointed only five states against the requirement of one representative each from 10 states and union territories. Following that, the new standing committee of NBWL in its very first meeting on August 12-13 cleared more than 130 projects worth several thousands of crores which were pending for months. This created lots of ruckus and furore, which ultimately led the Supreme Court to remark that prima facie they found that the environment ministry had violated the law while constituting the board and had issued a notice to the central government to explain the stand. While SC had refused to stay the decisions taken by NBWL's standing committee it ensured that they would not come into effect till next hearing in the apex court. Following the order the government reconstituted NBWL giving full representation from civil society -- five NGO's and ten eminent conservationists, ecologists and environmentalists -- as required by law in September 2014. However, since then the board has cleared several infrastructure projects compromising with wild lives of the country haphazardly. The high incidence of wildlife clearances by the board also follows the Environment ministry's move to limit the extent of eco-sensitive zones of protected habitats like Okhla Bird Sanctuary in Uttar Pradesh to 100 metres, Dadra and Nagar Haveli Sanctuary by 100 metres, and the Kaimur Wildlife Sanctuary in Bihar.

**Central Zoo Authority –**

In India, functioning of zoos is regulated by an autonomous statutory body called Central Zoo Authority which has been constituted under the Wild Life (Protection) Act. The main objective of the authority is to complement the national effort in conservation of wild life. Standards and norms for housing, upkeep, health care and overall management of animals in zoos has been laid down under the Recognition of Zoo Rules, 1992. Every zoo in the country is required to obtain recognition from the Authority for its operation. The Authority's role is more of a facilitator than a regulator. It, therefore, provides technical and financial assistance to such zoos which have the potential to attain the desired standard in animal management. Apart from the primary function of grant of recognition and release of financial assistance, the Central Zoo Authority also regulates the exchange of animals of endangered category Listed under Schedule-I and II of the Wildlife Protection Act) among zoos. Exchange of animals between Indian and foreign zoos is also approved by the Authority before the requisite clearances under EXIM Policy and the CITES permits are issued by the competent authority.

**2. Environment Protection Act, 1986 (Restoration of degraded lands, management of watersheds, Wetland management, and identification of Ecologically Sensitive Areas).**

The Act has given powers to the Central Government to take measures to protect and improve environment while the state government coordinates the actions. The most important functions of Central Govt. under this Act

Under the Environmental (Protection) Rules 1986 the State Pollution Boards have to follow the guidelines provided under Schedule VI, some of which are as follows:

- They have to advise the Industries for treating the waste water and gases with the best available technology to achieve the prescribed standards.
- The industries have to be encouraged for recycling and reusing the wastes.
- They have to encourage the industries for recovery of biogas, energy and reusable materials.
- While permitting the discharge of effluents and emissions into the environment, the State Boards have to take into account the assimilative capacity of the water body.
- The Central and State Boards have to emphasize on the implementation of clean technologies by the industries in order to increase fuel efficiency and reduce the generation of environmental pollutants.

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include setting up of:

- The standards of quality of air, water or soil for various areas and purpose.
- The maximum permissible limits of concentration of various environmental pollutants (including noise) for different areas.
- The procedures and safeguards for the handling of hazardous substances in different areas.
- The prohibition and restriction on the location of industries and to carry on process and operations in different areas.
- The procedures and safeguards for the prevention of accidents which may cause environmental pollution and provide remedial measures for such accidents.
- The power of entry and inspection, power to take sample etc. under the act lies with the Central Government or any officer empowered by it.

Under the Environment (Protection) Rules, 1986 the Central Government also made Hazardous Wastes (Management and handling) Rules 1989. Under these rules it is the responsibilities of the occupier that such wastes are properly handled and disposed off without any adverse effects. There are 18 Hazardous Waste categories recognized under this rule and there are guidelines for their proper handling, storage, treatment, transport and disposal which should be strictly followed by the owner. The Environment (Protection) Act, 1986 has also made provision for environmental Audit as a means of checking whether or not a company is complying with the environmental laws and regulations.

**National Biodiversity Authority**

The National Biodiversity Authority (NBA) was established in 2003 to implement India's Biological Diversity Act (2002). The NBA is Autonomous body and that performs facilitative, regulatory and advisory function for Government of India on issue of Conservation, sustainable use of biological resource and fair equitable sharing of benefits of use.

**3. The Biological Diversity Act 2002**

The Act covers conservation, use of biological resources and associated knowledge occurring in India for commercial or research purposes or for the purposes of bio-survey and bio-utilisation. It provides a framework for access to biological resources and sharing the benefits arising out of such access and use. The Act also includes in its ambit the transfer of research results and application for intellectual property rights (IPRs) relating to Indian biological resources.

The Act covers foreigners, non-resident Indians, body corporate, association or organization that is either not incorporated in India or incorporated in India with non-Indian participation in its share capital or management. These individuals or entities require the approval of the National Biodiversity Authority when they use biological resources and associated knowledge occurring in India for commercial or research purposes or for the purposes of bio-survey or bio-utilisation.

**4. The Scheduled tribes and Other Traditional Forest Dwellers Act, also referred as Forest Rights Act (FRA), 2006**

The Act seeks to recognize 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. The Act was notified for operation with effect from 31.12.2007. As per the provisions of the Act and the Rules framed thereunder, the onus of implementation of the Act lies at the level of the State/UT Governments. The Act seeks to recognize and vest certain forest rights in the forest dwelling Scheduled Tribes and other traditional forest dwellers. The Act basically does two things:

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- Grants legal recognition to the rights of traditional forest dwelling communities, partially correcting the injustice caused by the forest laws.
- Makes a beginning towards giving communities and the public a voice in forest and wildlife conservation.

**5. National Green Tribunal (NGT)**

The National Green Tribunal has been established on 18.10.2010 under the National Green Tribunal Act 2010 for effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other natural resources including enforcement of any legal right relating to environment and giving relief and compensation for damages to persons and property and for matters connected therewith or incidental thereto. It is a specialized body equipped with the necessary expertise to handle environmental disputes involving multi-disciplinary issues. The Tribunal shall not be bound by the procedure laid down under the Code of Civil Procedure, 1908, but shall be guided by principles of natural justice.

The Tribunal's dedicated jurisdiction in environmental matters shall provide speedy environmental justice and help reduce the burden of litigation in the higher courts. The Tribunal is mandated to make and endeavour for disposal of applications or appeals finally within 6 months of filing of the same. Initially, the NGT is proposed to be set up at five places of sittings and will follow circuit procedure for making itself more accessible. New Delhi is the Principal Place of Sitting of the Tribunal and Bhopal, Pune, Kolkata and Chennai shall be the other four place of sitting of the Tribunal.

**Other Conservation Efforts**

**National Tiger Conservation Authority (NTCA)**

The National Tiger Conservation Authority is a statutory body under the Ministry of Environment, Forests and Climate Change constituted under enabling provisions of the Wildlife (Protection) Act, 1972, as amended in 2006, for strengthening tiger conservation, as per powers and functions assigned to it under the said Act. The National Tiger Conservation Authority has been fulfilling its mandate within the ambit of the Wildlife (Protection) Act, 1972 for strengthening tiger conservation in the country by retaining an oversight through advisories/normative guidelines, based on appraisal of tiger status, on-going conservation initiatives and recommendations of specially constituted Committees.

Objectives –

- Providing statutory authority to Project Tiger so that compliance of its directives becomes legal.
- Fostering accountability of Center-State in management of Tiger Reserves, by providing a basis for MoU with States within our federal structure.
- Providing for an oversight by Parliament.
- Addressing livelihood interests of local people in areas surrounding Tiger Reserves.

**International Cooperation**

- India has a Memorandum of Understanding with Nepal on controlling trans-boundary illegal trade in wildlife and conservation, apart from a protocol on tiger conservation with China.
- The process is on for bilateral protocol with Bangladesh, Bhutan & Myanmar.
- A Global Tiger Forum of Tiger Range Countries has been created for addressing international issues related to tiger conservation.

**PROJECT TIGER**

The Government of India has taken a pioneering initiative for conserving its national animal, the tiger, by launching the 'Project Tiger' in 1973. From 9 tiger reserves since its formative years, the Project Tiger coverage has increased to 47 at present, spread out in 18 of our tiger range

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states. This amounts to around 2.08% of the geographical area of our country. The tiger reserves are constituted on a core/buffer strategy. The core areas have the legal status of a national park or a sanctuary, whereas the buffer or peripheral areas are a mix of forest and non-forest land, managed as a multiple use area. The Project Tiger aims to foster an exclusive tiger agenda in the core areas of tiger reserves, with an inclusive people oriented agenda in the buffer.

'Project Tiger' is a Centrally Sponsored Scheme of the Environment, Forests and Climate Change, providing funding support to tiger range States, for in-situ conservation of tigers in designated tiger reserves, and has put the endangered tiger on an assured path of recovery by saving it from extinction, as revealed by the recent findings of the All India tiger estimation using the refined methodology.

**Tiger Reserves in India –**

| Sl. No. | Name of Tiger Reserve | State |
|---|---|---|
| 1 | Nagarjunsagar Srisailam (part)* | Andhra Pradesh |
| 2 | Namdapha | Arunachal Pradesh |
| 3 | Kamlang Tiger Reserve | Arunachal Pradesh |
| 4 | Pakke | Arunachal Pradesh |
| 5 | Manas | Assam |
| 6 | Nameri | Assam |
| 7 | Orang Tiger Reserve | Assam |
| 8 | Kaziranga | Assam |
| 9 | Valmiki | Bihar |
| 10 | Udanti-Sitanadi | Chattisgarh |
| 11 | Achanakmar | Chattisgarh |
| 12 | Indravati | Chhattisgarh |
| 13 | Palamau | Jharkhand |
| 14 | Bandipur | Karnataka |
| 15 | Bhadra | Karnataka |
| 16 | Dandeli-Anshi | Karnataka |
| 17 | Nagarahole | Karnataka |
| 18 | Biligiri Ranganatha Temple | Karnataka |
| 19 | Periyar | Kerala |
| 20 | Parambikulam | Kerala |
| 21 | Kanha | Madhya Pradesh |
| 22 | Pench | Madhya Pradesh |
| 23 | Bandhavgarh | Madhya Pradesh |
| 24 | Panna | Madhya Pradesh |
| 25 | Satpura | Madhya Pradesh |
| 26 | Sanjay-Dubri | Madhya Pradesh |
| 27 | Melghat | Maharashtra |



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| | | |
|---|---|---|
| 28 | Tadoba-Andhari | Maharashtra |
| 29 | Pench | Maharashtra |
| 30 | Sahyadri | Maharashtra |
| 31 | Nawegaon-Nagzira | Maharashtra |
| 32 | Bor | Maharashtra |
| 33 | Dampa | Mizoram |
| 34 | Similipal | Odisha |
| 35 | Satkosia | Odisha |
| 36 | Ranthambore | Rajasthan |
| 37 | Sariska | Rajasthan |
| 38 | Mukandra Hills | Rajasthan |
| 39 | Kalakad-Mundanthurai | Tamil Nadu |
| 40 | Anamalai | Tamil Nadu |
| 41 | Mudumalai | Tamil Nadu |
| 42 | Sathyamangalam | Tamil Nadu |
| 43 | Kawal | Telangana |
| 44 | Amrabad | Telangana |
| 45 | Dudhwa | Uttar Pradesh |
| 46 | Pilibhit | Uttar Pradesh |
| 47 | Amangarh (buffer of Corbett TR) | Uttar Pradesh |
| | Corbett | Uttarakhand |
| 48 | Rajaji TR | Uttarakhand |
| 49 | Sunderbans | West Bengal |
| 50 | Buxa | West Bengal |

## PROJECT ELEPHANT

Habitat fragmentation is one of the major threats to India's wildlife. Large, migratory mammals like Asian elephants, with vast resource requirements, are among the worst affected. Many of the elephant habitats are isolated and are further threatened by fragmentation due to developmental activities. Several of these habitats are crucially connected by corridors, which too are steadily being erased by human invasion. Interference in their natural migratory paths has resulted in increased human-elephant conflict and also insidiously in the genetic isolation of Asian elephants in India. One of the main needs for the long-term survival of Asian elephants is connectivity in their habitats, allowing not only sufficient foraging grounds but uninterrupted gene flow to prevent inbreeding. The establishment of corridors and improvement in habitat quality of existing ones to consolidate elephant habitats has emerged as one of the most critically effective methods of maintaining this connectivity. An elephant corridor is roughly defined as a stretch of forested (or otherwise) land that connects larger habitats (with elephant populations) and forms a conduit for animal movement between habitats. This movement helps enhance species survival and birth rate.

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Project Elephant (PE), a centrally sponsored scheme, was launched in February 1992 to provide financial and technical support to major elephant bearing States in the country for protection of elephants, their habitats and corridors. It also seeks to address the issues of human-elephant conflict and welfare of domesticated elephants. The Project is being implemented in 13 States / UTs , viz. Andhra Pradesh , Arunachal Pradesh , Assam , Jharkhand , Karnataka , Kerala , Meghalaya , Nagaland , Orissa , Tamil Nadu , Uttaranchal , Uttar Pradesh and West Bengal. Its main objectives are:

- To protect elephants, their habitat & corridors
- To address issues of man-animal conflict
- Welfare of captive elephants

Main activities under the Project Elephant are as follows:

- Ecological restoration of existing natural habitats and migratory routes of elephants;
- Development of scientific and planned management for conservation of elephant habitats and viable population of Wild Asiatic elephants in India;
- Promotion of measures for mitigation of man elephant conflict in crucial habitats and moderating pressures of human and domestic stock activities in crucial elephant habitats;
- Strengthening of measures for protection of Wild elephants form poachers and unnatural causes of death;
- Research on Elephant management related issues;
- Public education and awareness programmes;
- Eco-development
- Veterinary care
- Elephant Rehabilitation/Rescue Centres

## VULTURE CONSERVATION

Populations of three of India's most common griffon vultures have declined by more than ninety per cent during the last decade. The most significant cause has been the drug, Diclofenac, given to cows by farmers. When vultures fed on drug-contaminated cow carcasses left out, they suffered rapid kidney failure and death. Two of the three affected species, the Oriental white-backed and the long-billed vulture, once regarded as very common in India, are now listed as critically endangered by the IUCN. The third affected species, the slender-billed vulture, has historically been uncommon, but now is regarded as extremely rare. The ecological, social and cultural significance of vultures in India may be summed up as: scavenging on animal carcasses of animals and thereby helping keep the environment clean; and the disposal of dead bodies as per the religious practices of the Parsi community. Hence, it has been imperative to work towards the conservation of Vultures in India.

**Vulture Restaurant** In order to provide the vultures a meal that is free from chemicals, 4 locations in India have been chosen for vulture restaurants - one in the state of Maharashtra and 3 in Punjab. At these places Diclofenac-free meat is being provided to the vultures. Wildlife officers buy carcasses of dead buffaloes, cow and bulls from villagers every day and place them on bricked platforms with boundary walls that serve as the vulture restaurants. The forest officers test for the safety of the carcasses before they are fed to the vultures. These locations have been chosen to not only be a good feeding ground but provide vultures place to nest and breed. It has also been taken into consideration that there is ample

### SAVE (Saving Asia's Vultures from Extinction)

It's a consortium of like-minded, regional and international organisations, created to oversee and coordinate conservation, campaigning and fundraising activities to help the plight of south Asia's vultures. SAVE's mission statement is to: "Respond to the vulture crisis in Asia by striving to halt vulture population declines and working to minimise their negative impacts on ecological and human health"

### Vulture Safe Zone (VSZ) –

Vulture Safe Zones (VSZs) involves ensuring that there is absolutely no Diclofenac in a 30,000 sq. km area (or 100 km radius), especially in the food supply of the vultures such as the cattle carcasses that they feed on. This conservation effort first focuses on

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removing all available stocks of veterinary Diclofenac from the areas surrounding the breeding colony (up to a distance of >50 km) and replacing this with the vulture safe drug Meloxicam. The diclofenac/ meloxicam swapping work is followed up with an extensive education and awareness programme on the value of vultures for the local community in regards their ability to clean up carcasses and therefore help reduce the risk of disease and increasing numbers of feral dogs. The final element of the programme is to attract vultures in to and to retain vultures within the safe area through the provision of regular and safe food supply in the form of a "Jatayu Restaurant" (Vulture Restaurant). The three VSZ in pipeline are North India (Comprising Uttar Pradesh and Uttaranchal; Corbett to Katriya Ghat, a Tarai belt), North East India (Between Dibrugarh, Assam to North Lakhimpur, Arunachal Pradesh) and Central India (comprising Chhattisgarh and Madhya Pradesh).

## RHINOCEROS CONSERVATION IN INDIA

The Indian Rhinoceros (Rhinoceros unicornis) is also called Great One-horned Rhinoceros. It belongs to the Rhinocerotidae family. Listed as a vulnerable species, this large mammal is primarily found in parts of north-eastern India and in protected areas in the Terai of Nepal. These Rhinoceros once ranged throughout the entire stretch of the Indo-Gangetic Plain but excessive hunting reduced their distribution drastically. Today, about 3,400 Rhinos live in the wild, of which 2,400+ are found in Assam alone. A small population is also present in the Dudhwa National Park in Uttar Pradesh.

Threats –

- The Indian rhino is being poached for its horn, which some cultures in East Asia believe has healing and potency powers. It is therefore is used for traditional Chinese medicine and other oriental medicines.
- Habitat Loss
- Floods in Kaziranga National Park and in the vicinity.

The Kaziranga National Park (having the highest number of rhinos) and Manas National Park, Pobitora reserve forest (having the highest Indian rhino density in the world) are most important rhino habitats. Orang National Park and Laokhowa reserve forest in Assam have very small populations. These national parks and habitats of Rhinos have proved to be life saver of Indian Rhinos, failing which the Indian Rhinoceros would have been extinct by now.

### The Indian Rhino Vision 2020

The WWF recently launched the Indian Rhino Vision 2020 (IRV 2020). The programme aims to:

1. Increase the total rhino population in Assam to about 3000 by the year 2020.
2. Ensure that these rhinos are distributed over at least seven protected areas to provide long-term viability of the species. This will be achieved by trans locating the rhinos from two-source populations (Kaziranga and Pobitara) into 3 or 4 target Protected Areas (Manas, Laokhowa, Burachapori, Kochpora, Dibrusaikhowa and possibly, Orang).

## CROCODILES CONSERVATION IN INDIA

The crocodiles are large aquatic tetrapod reptiles. They live throughout the tropics in Africa, Asia, the Americas and Australia. They are cold-blooded creatures. The crocodiles occur mostly in freshwater habitats such as rivers, lakes, wetlands and sometimes in brackish water. They feed mostly on vertebrates – fish, reptiles, and mammals. In India, crocodiles are both revered and loathed as some consider them religious and others consider them a menace. India does not have alligators, instead we have three species of crocodiles and one of which is unique to Indian subcontinent is the gharial (Gavialisgangeticus). The adult male has a bump at the end of the snout resembling an earthen pitcher or ghara, hence the name gharial. Gharials are endemic to the Indian sub-continent. The other two are the mugger or marsh crocodiles and the salt water or estuarine crocodiles. Gharial is listed as 'Critically Endangered' in the IUCN Red List of Endangered Species

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**Conservation efforts –**

In 1970, it was estimated that a mere 100 gharials survived in the wild. Getting alarmed, the Government of India subsequently accorded the highest level of protection to Gharial by bringing it under Schedule I of the Wild Life Protection Act, 1972.By the time crocodile hunting was banned in India in 1972, Gharials were on the verge of extinction. In 1976, Project Crocodile was initiated with support from the United Nations Development Programme and Food and Agriculture Organization. The project included an intensive captive rearing and breeding programme intended to restock depleted Gharial habitats. By the time the primary project ended in 1982, more than 1,000 gharials had been raised and released into sanctuaries, increasing the total population. But in recent years, human-crocodile conflict has once again drastically affected the population of crocodiles in the country.

**Threats**

- Habitat alteration and destruction: A combination of land-use changes and exploitation such as sand-mining, riverside agriculture, livestock grazing, and hydrological modifications such as building of dams for water diversion.
- Prey depletion: Over harvesting of fish stocks. Construction of dams and barrages obstructing dispersal and migration of fish.
- Direct mortality: Drowning of Gharial in fishing nets, its nest destruction and local egg collection.
- Pollution and siltation: Pollution and siltation of rivers damage fish stocks, and are also believed to be the direct cause of the catastrophic dieoff of 2007-2008 in the Chambal.
- Hunting: In the past, Gharial was hunted for skin, trophies and use in indigenous medicine.

## GANGES RIVER DOLPHIN CONSERVATION

The Ganges River dolphin is endemic to the Indian sub-continent and has a fairly extensive distribution range. It is found in the Ganges-Brahmaputra-Meghna and Karnaphuli-Sangu river systems of India and Bangladesh, while a few individuals may survive in the Karnali, and the SaptaKosi Rivers in Nepal. Due to a continued decline in its population, the IUCN changed its status from 'Vulnerable' to 'Endangered' in 1996. Ganges River Dolphin was declared as National Aquatic animal of India and is a part of our national heritage.

| Threats | Importance of the species |
|---|---|
| • The deliberate killing of Ganges River dolphins for oil and meat still occurs.<br>• The construction of more than 50 dams and barrages within the Ganges River dolphin's historic range has drastically altered its habitat and fragmented the meta-population .<br>• Construction of embankments as flood control measures in eastern Uttar Pradesh, Bihar and West Bengal has disrupted the connections between the river and its flood plains and wetlands.<br>• Embankments interrupt access to the spawning habitat for flood plain dependent fish and eliminate eddy-counter currents where the Ganges River dolphins spend much of their time.<br>• Dredging and the removal of stones, sand, and woody debris also compromise the ecological integrity of the riverine environment, especially in small tributaries..<br>• Increasing pollution in the river may adversely affect dolphin health and their bioaccumulation may have serious consequences. | • The Ganges dolphin is an indicator species for the river ecosystem and is at the apex of the food chain.<br>• It is an excellent indicator of riverine ecosystem health.<br>• It is an endemic and rare aquatic mammal found only in the Indian subcontinent and is part of our natural aquatic heritage.<br>• As a signatory to numerous international conventions, India must fulfill its treaty obligations to aid in the conservation of this species. |

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**Conservation Efforts –**

This species has been included in Schedule I of the Indian Wildlife (Protection) Act 1972, in Appendix I of the Convention on International Trade in Endangered Species (CITES), in Appendix II of the Convention on Migratory Species (CMS) and categorised as Endangered on the International Union for the Conservation of Nature's (IUCN) Red List.

**Vikramshila Gangetic Dolphin Sanctuary –**

The Vikramshila Gangetic Dolphin Sanctuary (VGDS) stretches for about 50 km of the Ganga between Sultanganj and Kahalgaon in Bihar, and is the only protected area designated for Ganges River dolphin. Activities harmful to dolphins, such as oil fishing, and use of fishing nets dangerous to the dolphins, were found to be conducted within the VGDS. In the absence of vigorous education, monitoring and enforcement, dolphins are at risk in VGDS.

Aaranyak, a registered conservation NGO working in North East India since 1989, has initiated a project entitled "Conservation of Gangetic dolphin in Brahmaputra river system, India" in collaboration with Dibrugarh University (Assam). The project aims to evaluate the conservation status of the Ganges River dolphin throughout the entire Brahmaputra river system by carrying out research into the species' population status, distribution, habitat preferences and threats.

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# CHAPTER – 10
# CLIMATE CHANGE

Overview
1. Climate Change
2. Institutions in Climate Change
3. Containing Climate Change
4. India and Climate Change

## 1. WHAT IS CLIMATE CHANGE?

Climate change is a change in the usual weather found in a place. This could be a change in how much rain a place usually gets in a year. Or it could be a change in a place's usual temperature for a month or season.

### Why the urgency?

After fighting for years against denialism, scientists have been successful making countries fight Climate change. We need to act urgently if we are to avoid potentially huge cost to the economy and society worldwide caused by "irreversible build-up of greenhouse gases (GHGs), and warming of globe" because of our inaction. If we act now, we have 10 to 15 years' "breathing space" during which action is possible, and that too at a relatively modest cost. But every year of delay reduces this breathing space, while requiring ever more stringent measures to make a difference and will lead to opening of other fronts such as:

| Signs of climate change | Effects of climate change on mankind and surroundings |
|---|---|
| • Higher Temperatures.<br>• Changing Rain and Snow Patterns.<br>• Less Snowpack.<br>• Melting Glaciers.<br>• More Droughts.<br>• Shrinking Sea Ice.<br>• Thawing Permafrost.<br>• Wilder Weather. | • Agriculture<br>• Coastal Areas<br>• Energy<br>• Forests<br>• Plants, Animals, and Ecosystems<br>• Recreation<br>• Water Supplies |

- Population displacement
- Diseases and consequent Health expenditure
- Pollution of water bodies and Water scarcity
- Increase vulnerability of security bases and troops(e.g. Marine and high altitude regions installations, As an example avalanches that take away the precious lives of soldiers guarding Siachen)
- Surge in cost of living
- Inequality

### Perspective

- Climate is the average pattern of weather over the long term. The earth's climate has warmed and cooled for millions of years, since long before we appeared on the scene. There is no doubt that the climate is growing warmer currently; indications of that change are all around us. Though climate change isn't new, the study of how human activity affects the earth's climate is. Climate change is a long-term change in the statistical distribution of weather patterns over periods of time that range from decades to millions of years. It may be a change in the average weather conditions or a change in the distribution of weather events with respect to an average, for example, greater or fewer extreme weather events. Climate change may be limited to a specific region, or may occur across the whole Earth.



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- However, Climate Change, today, pertain to the change in the climate because of human induced factors that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.
- Earth's average temperature has risen by 1°C over the past century, and is projected to rise another 2°C over the next hundred years. Small changes in the average temperature of the planet can translate to large and potentially dangerous shifts in climate and weather.
- The evidence is clear. Rising global temperatures have been accompanied by changes in weather and climate. Many places have seen changes in rainfall, resulting in more floods, droughts, or intense rain, as well as more frequent and severe heat waves. The planet's oceans and glaciers have also experienced some big changes - oceans are warming and becoming more acidic, ice caps are melting, and sea levels are rising. As these and other changes become more pronounced in the coming decades, they will likely present challenges to our society and our environment.
- More than 100 years ago, people around the world started burning large amounts of coal, oil, and natural gas to power their homes, factories, and vehicles. Today, most of the world relies on these fossil fuels for their energy needs. Burning fossil fuels releases carbon dioxide, a heat-trapping gas, into the atmosphere, thereby incrementing the average temperature of the earth, called Global Warming, which is the main reason why the climate is changing.
- Both natural and human factors change Earth's climate. Before humans, changes in climate resulted entirely from natural causes such as changes in Earth's orbit, changes in solar activity, or volcanic eruptions. Since the Industrial Era began, humans have had an increasing effect on climate, particularly by adding billions of tons of heat-trapping greenhouse gases to the atmosphere. Most of the observed warming since the mid-20th century is due to human-caused greenhouse gas emissions.

**Global Warming**

Global Warming is an average increase in the temperature of the atmosphere near the earth's surface and in the Troposphere, which can contribute to changes in global climate patterns. Global Warming can almost be considered as Climate change and can occur from a variety of causes, both natural and human induced. Scientists have determined that Global Warming has mainly been contributed by a number of human activities which add excessive amounts of greenhouse gases to the atmosphere.

**The Signs of Global Warming**

The Earth's climate is getting warmer, and the signs are everywhere. Rain patterns are changing, sea level is rising, and snow and ice are melting sooner in the spring. As global temperatures continue to rise, we'll see more changes in our climate and our environment. These changes will affect people, animals, and ecosystems in many ways. Less rain can mean less water for some places, while too much rain can cause terrible flooding.

More hot days can dry up crops and make people and animals sick. In some places, people will struggle to cope with a changing environment. In other places, people may be able to successfully prepare for these changes.

- Higher Temperatures
- Changing Rain and Snow Patterns
- More Droughts
- Warmer Oceans
- Rising Sea Level
- Wilder Weather
- Increased Ocean Acidity

- Shrinking Sea Ice
- Melting Glaciers
- Less Snowpack
- Thawing Permafrost
- Species Extinction
- Coral Bleaching
- Spread of Tropical diseases
- Enhanced extremities in the weather events.



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The negative impacts of global climate change will be less severe overall if people reduce the amount of greenhouse gases we're putting into the atmosphere and worse if we continue producing these gases at current or faster rates. Some of the signs of Climate Changes have been summarised as follows:

**Effects of Global Warming on People and the Environment**

Global climate change will affect people and the environment in many ways. Some of these impacts, like stronger hurricanes and severe heat waves, could be life threatening. Others, like spreading weeds, will be less serious. And some effects, like longer growing seasons for crops, might even be good! However, as the Earth keeps getting warmer, the negative effects are expected to outweigh the positive ones. The more we learn about how climate change will affect people and the environment, the more we can see why people need to take action to reduce the greenhouse gas emissions that are causing climate change. We can also take steps to prepare for the changes we know are coming. The effects of Climate Change are seen through following domain:

1. **Agriculture** – The crops that we grow for food need specific conditions to thrive, including the right temperature and enough water. A changing climate could have both positive and negative effects on crops. For example, the high latitude parts of the earth have generally cool temperatures, so warmer weather could help certain crops grow. In lower latitudes where temperatures are already hot, even more heat could hurt crop growth. Climate change could make it too hot to grow certain crops, and droughts caused by climate change could reduce the amount of water available for irrigation. Climate change is also likely to cause stronger storms and more floods, which can damage crops. Higher temperatures and changing rainfall patterns could help some kinds of weeds and pests to spread to new areas.
2. Water **Supplies** – Climate change is affecting where, when, and how much water is available for people to use. Many parts of the world already have very little water, and climate change could make this problem worse. Rising temperatures, changing precipitation patterns, and increasing droughts will affect the amount of water in lakes, rivers, and streams, as well as the amount of water that seeps into the ground to replenish ground water.
3. Energy – Global climate change will affect how much energy we need and when we need it. As temperatures rise, more people will need to keep cool by using air conditioning, which uses a lot of electricity. However, some people might need less energy to heat buildings in the winter because it may not get as cold as it used to be. Climate change could also make it harder to produce certain types of electricity, such as hydropower.
4. **Health** – Heat waves, severe storms, air pollution, and diseases linked to climate already threaten people's health in many areas of the world. Global climate change will increase these threats. Some people will be particularly at risk, especially those who are poor, very young or elderly, or disabled, or those who live in coastal areas or big cities. Heat waves are uncomfortable for everyone, but for infants and young children, the elderly, and people who are already sick, they can be especially dangerous. Extreme heat can cause illnesses such as heat cramps, heat stroke, and even death. On the flip side, as the world gets warmer, the number of illnesses and deaths related to extreme cold (like hypothermia and frostbite) may decrease.
5. **Plants, Animals and Ecosystems** – Most plants and animals live in areas with very specific climate conditions, such as temperature and rainfall patterns, that enable them to thrive. Any change in the climate of an area can affect the plants and animals living there, as well as the makeup of the entire ecosystem. Some species are already responding to a warmer climate by moving to cooler locations. Climate change also alters the life cycles of plants and animals. For example, as temperatures get warmer, many plants are starting to grow and bloom earlier in the spring and survive longer into the fall. Some animals are waking from hibernation sooner or mi-



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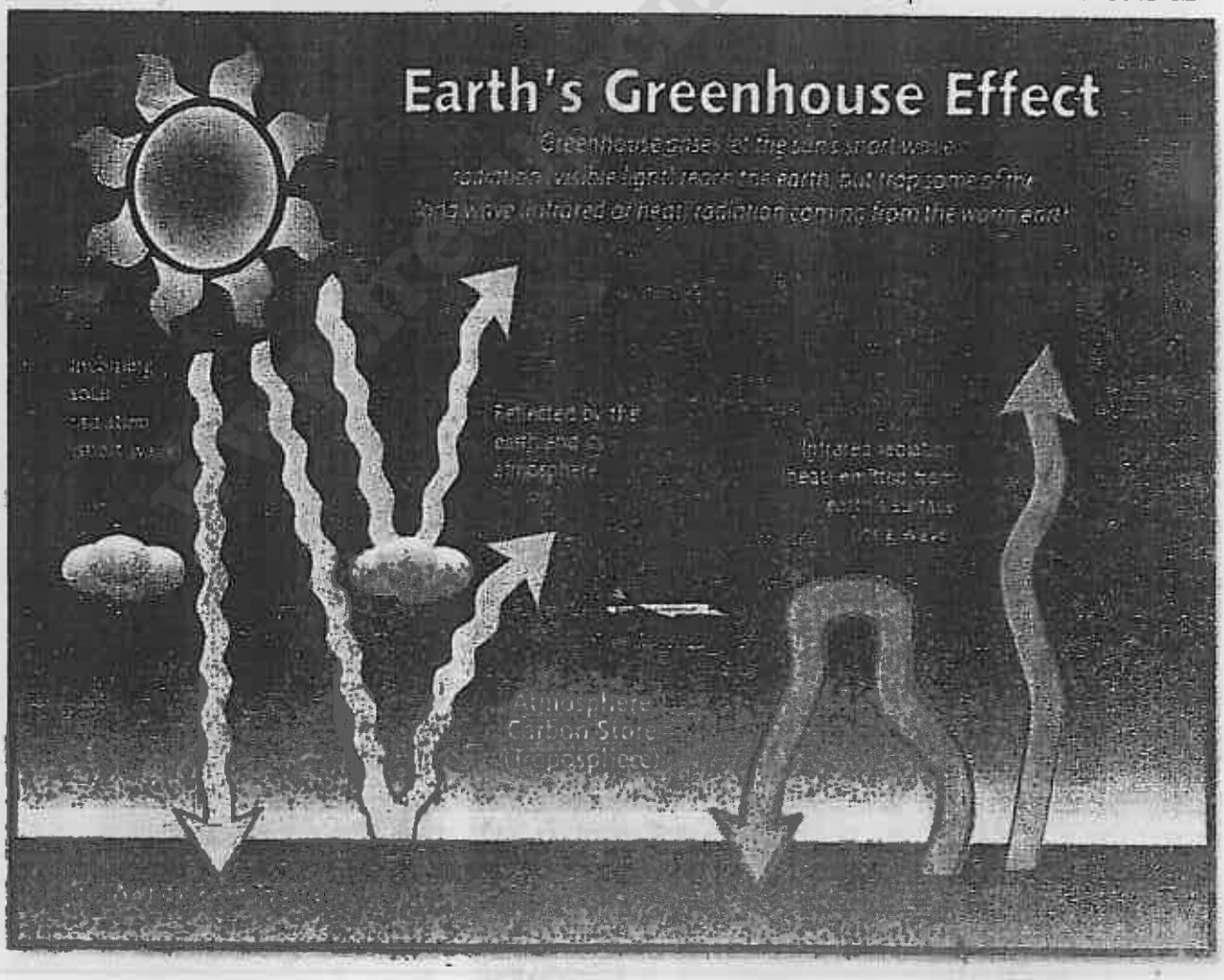


grating at different times, too. As the Earth gets warmer, plants and animals that need to live in cold places, like on mountaintops or in the Arctic, might not have a suitable place to live. If the Earth keeps getting warmer, up to one–fourth of all the plants and animals on Earth could become extinct within 100 years. Every plant and animal plays a role in the ecosystem (for example, as a source of food, a predator, a pollinator, a source of shelter), so losing one species can affect many others.

6. **Forests** – Forests are sensitive to many effects of climate change, including shifting weather patterns, drought, wildfires, and the spread of pests like the mountain pine beetle. Unlike some animals, trees can't just get up and move when the temperature gets too hot or other conditions change! Wildfires are already common in the forests and grasslands of the Tropical places. As the Earth gets warmer and droughts increase, wildfires are expected to occur more often and be more destructive. Wildfires do occur naturally, but the extremely dry conditions resulting from droughts allow fires to start more easily, spread faster, and burn longer.
7. **Coastal Areas** – Global climate change threatens coastlines and the buildings and cities located along them. Hundreds of millions of people around the world live in low–lying areas near the coast that could be flooded as the sea level rises. Rising sea level will also erode beaches and damage many coastal wetlands. Rising sea level and stronger storms caused by warmer oceans could completely wipe out certain beaches and islands.

## GREENHOUSE EFFECT

The greenhouse effect is a natural process that warms the Earth's surface. When the Sun's energy reaches the Earth's atmosphere, some of it is reflected back to space and the rest is ab-




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sorbed and re-radiated by greenhouse gases. The absorbed energy warms the atmosphere and the surface of the Earth. This process maintains the Earth's temperature at around 33 degrees Celsius warmer than it would otherwise be, allowing life on Earth to exist. Greenhouse gases include water vapour, carbon dioxide, methane, nitrous oxide, ozone and some artificial chemicals such as chlorofluorocarbons (CFCs).

A greenhouse is a building made of glass that allows sunlight to enter but traps heat inside, so the building stays warm even when it's cold outside. Because gases in the Earth's atmosphere also let in light but trap heat, many people call this phenomenon the "greenhouse effect." The greenhouse effect works somewhat differently from an actual greenhouse, but the name stuck, so that's how we still refer to it today.

To understand exactly how the greenhouse effect works, imagine the following: a warm, sunny day where the sun shines bright on the Earth. This sunlight (short-wave radiation) passes into the planet's atmosphere and warms the Earth. Part of this energy is absorbed by the Earth's surface, transformed into heat (long wave radiation) and radiated back towards space. But as this heat goes up through the atmosphere, some of it is trapped by the different greenhouse gases and doesn't escape into space. This in turn warms up the Earth's atmosphere; just like the windows of a greenhouse that lets light in and keeps the heat within to warm the plants growing inside. Since some of the heat can't escape into space, it continues to add up which then warms up the Earth. This is what we call the greenhouse effect. So the more green house gases you have in the atmosphere, the more heat stays on Earth. For example - If you open the door of a car that has been left parked in the sun for a couple of hours, you'll notice that the temperature inside the car is much warmer than the temperature outside. This is because the windows of the car allow the sunlight to enter. This light, once inside, is then partially converted into heat. However, these same windows do not allow the heat inside the car to pass through as easily as light, so some of this heat accumulates. The net effect is that more heat remains in than can come out, increasing the temperature inside the car.

> Carbon dioxide, methane, nitrous oxide and the fluorinated gases are all well-mixed gases in the atmosphere that do not react to changes in temperature and air pressure, so the levels of these gases are not affected by condensation. Water vapour on the other hand, is a highly active component of the climate system that responds rapidly to changes in conditions by either condensing into rain or snow, or evaporating to return to the atmosphere. Thus the impact of the greenhouse effect is primarily circulated through water vapour, and it acts as a fast feedback.

## GREENHOUSE GASES

The greenhouse effect is caused by the interaction of the sun's energy with greenhouse gases such as carbon dioxide, methane, nitrous oxide and fluorinated gases in the Earth's atmosphere. The ability of these gases to trap heat is what causes the greenhouse effect. Greenhouse gases are made of three or more atoms. This molecular structure makes it possible for these gases to trap heat in the atmosphere and then re-emit it towards the surface which further warms the Earth. This continuous cycle of trapping heat leads to an overall increase in global temperatures.

> If the amount of energy from the sun and the amount of greenhouse gases in the atmosphere remain the same, then the average temperature on Earth will also be constant. But this is no longer the case. The amount of greenhouse gases in our atmosphere is the highest it has been in the last 3 million years. This is enhancing the greenhouse effect and making the Earth warmer than normal, which is affecting the planet's weather patterns, creating global warming and climate change.

Carbon dioxide and the other non-condensing greenhouse gases are the key gases within the Earth's atmosphere that sustain the greenhouse effect and control its strength. Water vapour is a fast-acting feedback but its atmospheric concentration is controlled by the radiative forcing supplied by the non-condensing greenhouse gases. In fact,

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the greenhouse effect would collapse were it not for the presence of carbon dioxide and the other non-condensing greenhouse gases. Together the feedback by the condensing and the forcing by the non-condensing gases within the atmosphere both play an important role in the greenhouse effect. Each gas's effect on climate change depends on three main factors:

1. **Concentrations these gases are in the atmosphere** – Concentration, or abundance, is the amount of a particular gas in the air. Larger emissions of greenhouse gases lead to higher concentrations in the atmosphere. Greenhouse gas concentrations are measured in parts per million, parts per billion, and even parts per trillion. One part per million is equivalent to one drop of water diluted into about 13 gallons of liquid (roughly the fuel tank of a compact car).
2. **Period of their stay in the atmosphere** – Each of these gases can remain in the atmosphere for different amounts of time, ranging from a few years to thousands of years. All of these gases remain in the atmosphere long enough to become well mixed, meaning that the amount that is measured in the atmosphere is roughly the same all over the world, regardless of the source of the emissions. Approximate time period of their stay in the atmosphere for Carbon dioxide, Methane, Nitrous Oxide and Fluorinated Gas are 100 years, 12 years, 120 years and up to 50,000 years respectively.
3. **Strength to which they impact global temperatures** – Some gases are more effective than others at making the planet warmer and "thickening the Earth's blanket."

**Global Warming Potential (GWP)**

For each greenhouse gas, a Global Warming Potential (GWP) has been calculated to reflect how long it remains in the atmosphere, on average, and how strongly it absorbs energy. GWP for a gas is a measure of the total energy that a gas absorbs over a particular period of time (usually 100 years), compared to Carbon dioxide. Gases with a higher GWP absorb more energy, per pound, than gases with a lower GWP, and thus contribute more to warming Earth.

| Gas | Relative GWP / $CO_2$ (100 years) |
|---|---|
| Carbon dioxide | 1 |
| Methane | 25 |
| Nitrous oxide | 298 |
| Perfluorocarbons | 7400 to 12200 |
| Hydrofluorocarbons | 120 to 14800 |
| Sulfur hexafluoride | 22800 |

The principal forcing gases of the greenhouse effect are :

**Carbon dioxide ($CO_2$)** – The natural production and absorption of carbon dioxide ($CO_2$) is achieved through the terrestrial biosphere and the ocean. However, humankind has altered the natural carbon cycle by burning coal, oil, natural gas and wood and since the industrial revolution began in the mid-1700s, each of these activities has increased in scale and distribution. Carbon dioxide was the first greenhouse gas demonstrated to be increasing in atmospheric concentration with the first conclusive measurements being made in the last half of the 20th century. Prior to the industrial revolution, concentrations were fairly stable at 280ppm. Today, they are around 370ppm (parts per million), an increase of well over 30 percent. The atmospheric concentration has a marked seasonal oscillation that is mostly due to the greater extent of landmass in the northern hemisphere and its vegetation. A greater drawdown of $CO_2$ occurs in the northern hemisphere spring and summer as plants convert $CO_2$ to plant material through photosynthesis. It is then released again in the fall and winter as the plants decomposes.$CO_2$ generates a little over 55% of the human induced greenhouse effect.

**Methane ($CH_4$)** – Methane ($CH_4$) is an extremely effective absorber of radiation, though its atmospheric concentration is less than $CO_2$ and its lifetime in the atmosphere is brief (10-12 years), com-



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pared to some other greenhouse gases (such as $CO_2$, $N_2O$, CFCs). Methane has both natural and anthropogenic sources. It is released as part of the biological processes in low oxygen environments. Over the last 50 years, human activities such as growing rice, raising cattle, using natural gas and mining coal have added to the atmospheric concentration of methane. Direct atmospheric measurement of atmospheric methane has been possible since the late 1970s and its concentration rose from 1.52 ppmv (parts per million volume) in 1978 by around 1 percent per year to 1990, since when there has been little sustained increase. The current atmospheric concentration is approximately 1.77 ppmv. Methane generates a little over 15% of the human induced greenhouse effect. Anthropic Methane contribution has been mainly from following:

- Biomass combustion, especially in the tropical zone. Wood burning is almost always an imperfect combustion, that releases in the atmosphere various un-burnt or partially burnt hydrocarbons, including methane,
- Cattle raising (cows, sheep, goats, yaks, and more generally any ruminant), because the food they ingest ferments in their stomachs, and that leads to methane emissions in the atmosphere).
- Rice paddles, that are humid zones just as swamps (where bits of dead plants fall under water, and decay there in the absence of oxygen),
- Dumpyards (putrefaction once again) and compost production,
- Fossil fuels production, because of leaks (oil and gas production) or ventilation of mines (coal).

**Nitrous oxide ($N_2O$) –**

Concentrations of nitrous oxide also began to rise at the beginning of the industrial revolution and are understood to be produced by microbial processes in soil and water, including those reactions which occur in fertilizer containing nitrogen. Increasing use of these fertilizers has been made over the last century. Global concentration for $N_2O$ in 1998 was 314 ppb, and in addition to agricultural sources for the gas, some industrial processes (fossil fuel-fired power plants, nylon production, nitric acid production and vehicle emissions) also contribute to its atmospheric load. Nitrous oxide generates roughly 5% of the human induced greenhouse effect

**Fluorinated gases –**

Hydro fluorocarbons ($HFC_s$), per fluorocarbons ($PFC_s$), and sulfur hexafluoride ($SF_6$) are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for stratospheric ozone-depleting substances (e.g., chlorofluorocarbons, hydro chlorofluorocarbons, and halons). Due to the discovery that they are able to destroy stratospheric ozone, a global effort to halt their production was undertaken and was extremely successful. So much so that levels of the major CFCs are now remaining level or declining. However, their long atmospheric lifetimes determine that some concentration of the CFCs will remain in the atmosphere for over 100 years making them referred to as High Global Warming Potential gases ("High GWP gases"). These generate a little over 10% of the human induced greenhouse effect. They do not have any natural sources and are solely emitted from anthropic sources such as:

- Fluids for filling fridges and more generally any device that generate cold (air con, domestic or in a car, freezers, etc).
- Emissions then happen because of leaks during use (almost any cold device leaks at least a little) or when dumped.
- As propellants in sprays : the all too famous CFC constitute a subset of halocarbons ; (the Montreal Protocol has decided their progressive ban because, in addition to being potent greenhouse gases, they are also responsible of the destruction of high altitude ozone)



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- In a number of industrial processes (manufacturing of plastic foams and of semiconductors).

**Ozone ($O_3$)**

Ozone acts as a greenhouse gas at ground level, absorbing some of the infrared energy emitted by the earth. Tropospheric, or ground level ozone, is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC). Quantifying the greenhouse gas potency of ozone is difficult because it is not present in uniform concentrations across the globe. However, the most widely accepted scientific assessments relating to climate change suggest that the radiative forcing of tropospheric ozone is about 25% that of carbon dioxide. Ozone ($O_3$) generates roughly 10% of the human induced greenhouse effect.

Since the beginning of the industrial age, that is 1750, all the additional greenhouse gases that we have poured into the atmosphere have created a "radiative forcing" that amounts to roughly 1% of the incoming solar energy. In other words, through its greenhouse gases emissions, man have modified his environment "exactly as if" the incoming solar energy had increased by 1%. 1%, that may seem very little. But, given the considerable energies that are at play, the fragile balance of many subsystems of the climate machine, and the fact that this enhancement, once made, remains for very long periods of time, it is very significant for our future.

**Black Carbon (BC)**

Black Carbon (BC) is a solid particle or aerosol contributing to the warming of the earth. Black carbon is the most strongly light-absorbing component of particulate matter (PM), and is formed by the incomplete combustion of fossil fuels, biofuels, and biomass. BC is emitted directly into the atmosphere in the form of fine particles ($PM_{2.5}$). BC is the most effective form of PM, by mass, at absorbing solar energy: per unit of mass in the atmosphere, BC can absorb a million times more energy than carbon dioxide ($CO_2$). BC is a major component of "soot", a complex light-absorbing mixture that also contains some organic carbon (OC).

BC warms the climate in two ways. When suspended in air, BC absorbs sunlight and generates heat in the atmosphere, which warms the air and can affect regional cloud formation and precipitation patterns. When deposited on snow and ice, it absorbs sunlight, again generating heat and reducing albedo, which warms both the air above and the snow and ice below, thus accelerating melting. Because BC remains in the atmosphere for only one to four weeks, its climate effects are strongly regional. Its short lifetime also means that its climate effects would dissipate quickly if black carbon emissions were reduced, thus benefiting most directly the countries or communities that invest in policies to reduce BC emissions.

**Aerosols**

An aerosol is basically a suspension in the air or liquid or solid particles. For example – Clouds, Dust particles, volcanic ash etc. If we stick to humankind, aerosol emissions include:

- Tiny particles emitted when we burn oil or coal (the famous "black smoke" we can see coming out of the exhaust pipe of a diesel car);
- Tiny particles emitted when we burn wood;
- Dust directly lifted by road traffic, or stone mining.

Aerosols have two effects on the climate system:

- They reflect or absorb light, depending on the colour of the particles they are composed of; and
- They provide "condensation nucleus", which means that the tiny particles they are composed of helps the atmospheric water vapour to condensate into droplets and therefore

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modify the formation of clouds that are themselves, as we have seen, aerosols of a particular kind. Clouds have two opposed effects on, the climatic system –

1. Composed of water and water vapour, they contribute to the greenhouse effect;
2. On the other side, by preventing light to reach the ground, they have a "cooling effect" on the surface.

Hence, Aerosols act as a dampener for solar radiation to reach earth thereby, mitigating the effects of global warming. This is negative Climate Forcing. However, Aerosols have very short period of stay (not more than a fortnight) in the atmosphere making them local in nature, in contrary to the global greenhouse gases.

### Climate Forcing

A climate forcing is any influence on climate that originates from outside the climate system itself. The climate system includes the oceans, land surface, cryosphere, biosphere, and atmosphere. Climate forcings are a major cause of climate change. Alternatively, Climate forcings are factors in the climate system that either increase or decrease the effects to the climate system. Examples of external forcings include Surface reflectivity (albedo), Human induced changes in greenhouse gases, Atmospheric aerosols (volcanic sulphates, industrial output).

Positive (amplified) forcings enhance the warming of the earth as exhibited by Greenhouse gases; whereas, Negative (dampening) forcings cools down the earth as exhibited by aerosols and suspended particles. Historically, in pre-industrial era humans had contributed more towards negative forcings thereby cooling the earth. However, the warming of the earth dues exponential growth in greenhouse gas emissions have surged ahead of the former in recent times contributing to Global Warming.

## ACIDIFICATION

### Definition

"Change in an environment's natural chemical balance caused by an increase in the concentration of acidic elements". Acidification manifests itself as:

### ACID RAIN

"Acid rain" is a broad term referring to a mixture of wet and dry deposition (deposited material) from the atmosphere containing higher than normal amounts of nitric and sulphuric acids. The precursors, or chemical forerunners, of acid rain formation result from both natural sources, such as volcanoes and decaying vegetation, and man-made sources, primarily emissions of sulphur dioxide ($SO_2$) and nitrogen oxides ($NO_x$) resulting from fossil fuel combustion. Acid rain occurs when these gases react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds. The result is a mild solution of sulphuric acid and nitric acid. When sulphur dioxide and nitrogen oxides are released from power plants and other sources, prevailing winds blow these compounds across state and national borders, sometimes over hundreds of miles.

There is a special scale called the pH scale that measures the strength of acids and alkalis. A low pH number means something is acid. A high number means something is alkali. And something in the middle is called neutral.
Acidity can be tested using litmus paper. Usually rain is a little acidic, and has pH of about 5.5, if the pH of rainfall is less than 5.5, then the rain is probably polluted by acid gases.
Acids turn litmus paper red, and alkalis turn it blue. With a special paper called universal indicator, you can test levels of acidity.

### Wet Deposition

It refers to acidic rain, fog, and snow. If the acid chemicals in the air are blown into areas where the weather is wet, the acids can fall to the ground in the form of rain, snow, fog, or mist. As this acidic



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and through the ground, it affects a variety of plants and animals. The strength of the effects depends on several factors, including how acidic the water is; the chemistry and buffering capacity of the soils involved; and the types of fish, trees, and other living things that rely on the water.

**Dry Deposition**

In areas where the weather is dry, the acid chemicals may become incorporated into dust or smoke and fall to the ground through dry deposition, sticking to the ground, buildings, homes, cars, and trees. Dry deposited gases and particles can be washed from these surfaces by rainstorms, leading to increased runoff. This runoff water makes the resulting mixture more acidic. About half of the acidity in the atmosphere falls back to earth through dry deposition.

**Effects**

Acid rain causes acidification of lakes and streams and contributes to the damage of trees at high elevations and many sensitive forest soils. In addition, acid rain accelerates the decay of building materials and paints, including irreplaceable buildings, statues, and sculptures that are part of our nation's cultural heritage. Prior to falling to the earth, sulphur dioxide ($SO_2$) and nitrogen oxide ($NO_x$) gases and their particulate matter derivatives—sulphates and nitrates—contribute to visibility degradation and harm public health. Its effect can be detailed on different things as follows:

**Forests –**

Acid rain can affect trees in several different ways, it may:

- Dissolve and wash away the nutrients and minerals in the soil which help the trees to grow.
- Cause the release of harmful substances such as aluminium into the soil.
- Wear away the waxy protective coating of leaves, damaging them and preventing them from being able to photosynthesise properly.

A combination of these effects weakens the trees which mean that they can be more easily attacked by diseases and Insects or injured by bad weather. It is not just trees that are affected by acid rain, other plants may also suffer.

**Lakes and Rivers –**

Acid rain runs off the land and ends up in streams, lakes and marshes, the rain also falls directly on these areas. As the acidity of a lake increases, the water becomes clearer and the numbers of fish and other water animals decline. Freshwater shrimps, snails, mussels are the most quickly affected by acidification followed by fish. Lakes, rivers and marshes each have their own fragile ecosystem with many different species of plants and animals all depending on one another to survive. If a species of fish disappears, the animals which feed on it will gradually disappear too. If the extinct fish used to feed on a particular species of large insect, that insect population will start to grow, this in turn will affect the smaller insects or plankton on which the larger insect feeds.

**Buildings –**

Every type of material will become eroded sooner or later by the effects of the climate. Water, wind, ice and snow all help in the erosion process but unfortunately; acid rain can help to make this natural process even quicker. Statues, buildings, vehicles, pipes and cables can all suffer. The worst

**Reduction measures**

The main cause of acid rain has been the prevalence of harmful oxides of Sulphur and Nitrogen in the atmosphere. Hence, it must be imperative to control their emission in order to do away with the effects of Acid Rain. Reducing emissions; switching on to cleaner forms of energy; Conserving resources and restoring the damage done by Acid Rain are some of the measure that can be taken to reduce the effects of Acid Rain.



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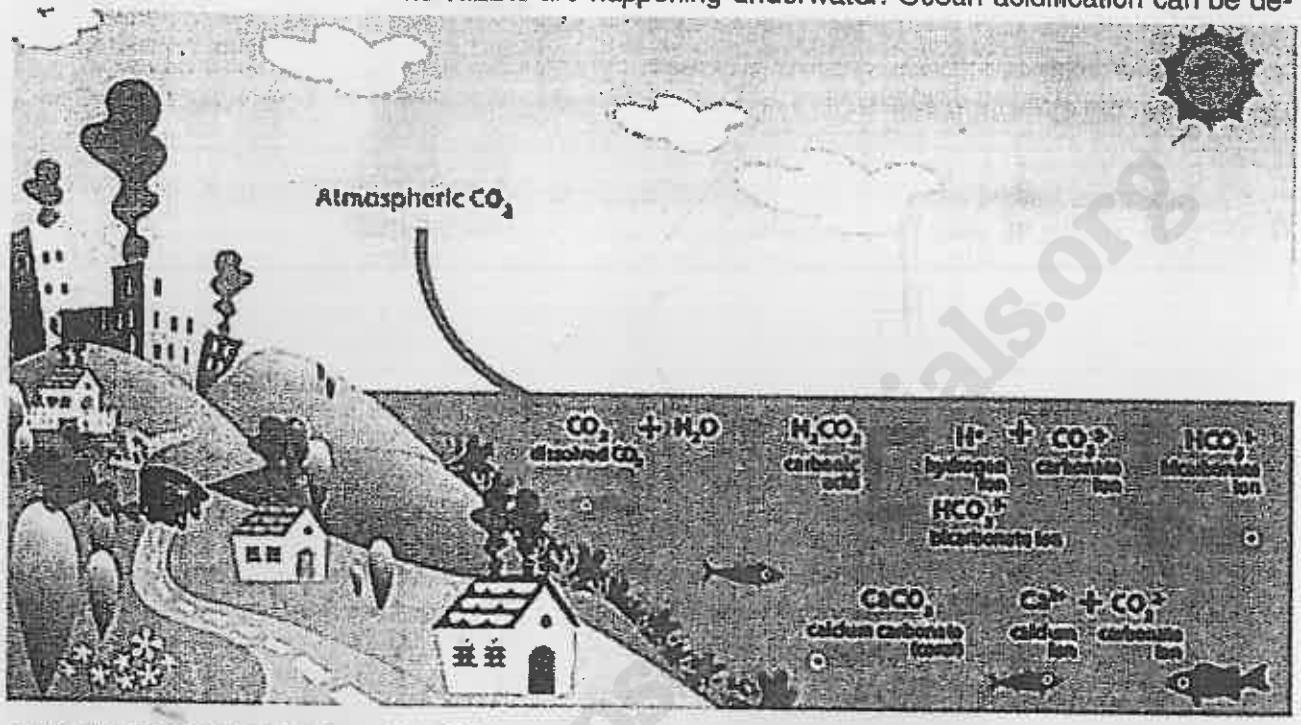
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affected are things made from limestone or sandstone as these types of rock are particularly susceptible and can be affected by air pollution in gaseous form as well as by acid rain.

## OCEAN ACIDIFICATION

Ocean acidification is sometimes called "climate change's equally evil twin," and for good reason: it's a significant and harmful consequence of excess carbon dioxide in the atmosphere that we don't see or feel because its effects are happening underwater. Ocean acidification can be de-




**As $CO_2$ is absorbed by the atmosphere it bonds with sea water forming carbonic acid. This acid then releases a bicarbonate ion and a hydrogen ion. The hydrogen ion bonds with free carbonate ions in the water forming another bicarbonate ion. This free carbonate would otherwise be available to marine animals for making calcium carbonate shells and skeletons.**

fined as long-term decrease in seawater pH, which currently is primarily due to the human-driven increase in atmospheric $CO_2$, which will almost certainly intensify.

When $CO_2$ is absorbed by seawater, a series of chemical reactions occur resulting in the increased concentration of hydrogen ions. This increase causes the seawater to become more acidic and causes carbonate ions to be relatively less abundant. Carbonate ions are an important building block of structures such as sea shells and coral skeletons. Decreases in carbonate ions can make building and maintaining shells and other calcium carbonate structures diffi-

If the amount of carbon dioxide in the atmosphere stabilizes, eventually buffering (or neutralizing) will occur and pH will return to normal. This is why there are periods in the past with much higher levels of carbon dioxide but no evidence of ocean acidification: the rate of carbon dioxide increase was slower, so the ocean had time to buffer and adapt. But in the contemporary times, pH is dropping too quickly. Buffering will take thousands of years, which is way too long a period of time for the ocean organisms affected now and in the near future. So far, the signs of acidification visible to humans are few. But they will only increase as more carbon dioxide dissolves into seawater over time. In light of these, it has become imperative to reduce Carbon dioxide, promote government policies to cap carbon dioxide emissions, eliminate off-shore drilling, advocate energy efficiency, reliance on cleaner energy sources etc. to mitigate the growing nuisance of Ocean Acidification.



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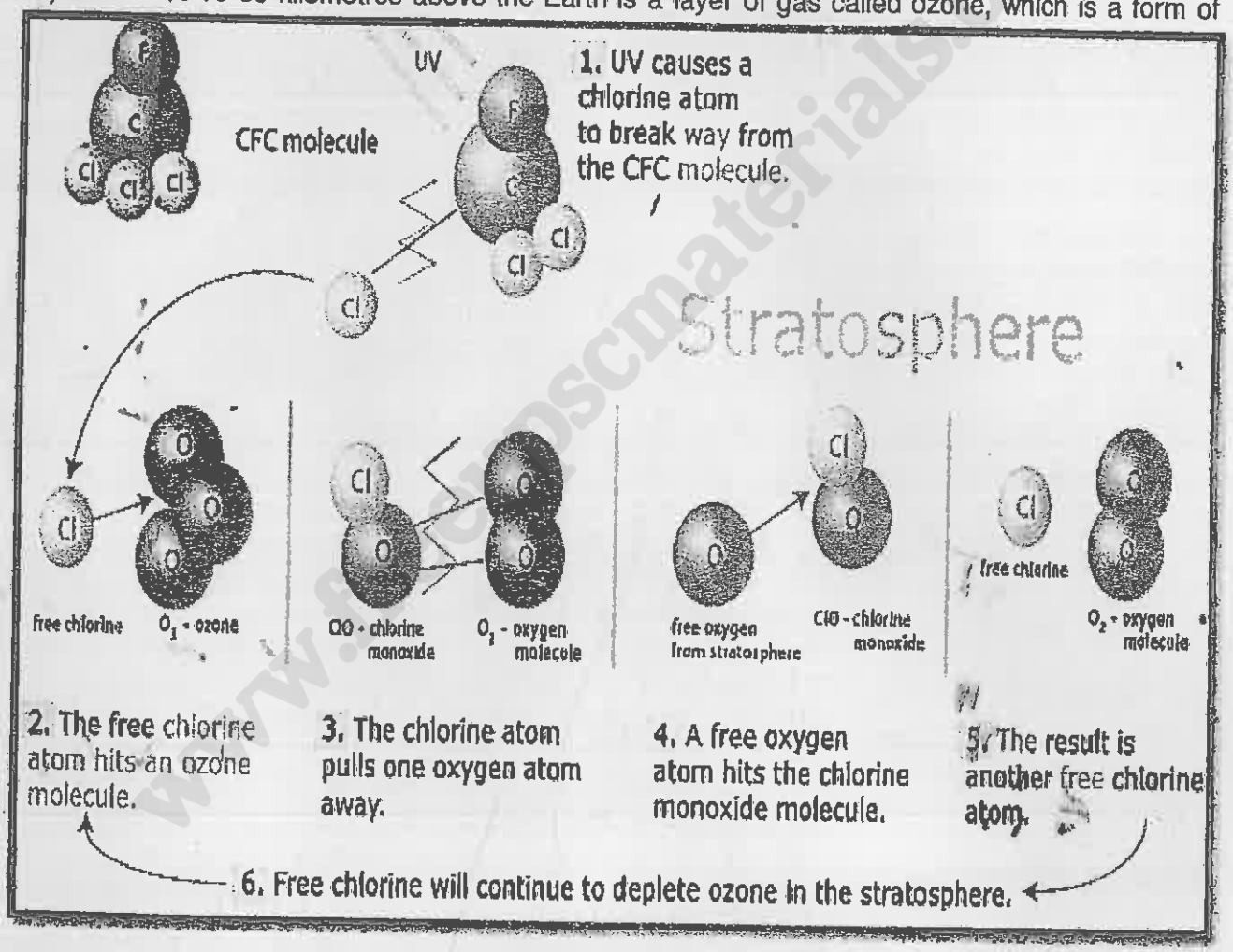


cult for calcifying organisms such as oysters, clams, sea urchins, shallow water corals, deep sea corals, and calcareous plankton. These changes in ocean chemistry can affect the behaviour of non-calcifying organisms as well. Certain fish's ability to detect predators is decreased in more acidic waters. When these organisms are at risk, the entire food web may also be at risk.

Ocean acidification is affecting the entire world's oceans, including coastal estuaries and waterways. Many economies are dependent on fish and shellfish and people worldwide rely on food from the ocean as their primary source of protein. The pH of the ocean fluctuates within limits as a result of natural processes, and ocean organisms are well-adapted to survive the changes that they normally experience. Some marine species may be able to adapt to more extreme changes—but many will suffer, and there will likely be extinctions. Corals, fish, zooplanktons, algae, Oysters and plethora of such marine organisms will be hit tremendously if the ocean acidification persists.

## OZONE HOLE

The Earth is wrapped in a blanket of air called the 'atmosphere', which is made up of several layers. About 19-30 kilometres above the Earth is a layer of gas called ozone, which is a form of




oxygen. Ozone is produced naturally in the atmosphere. The ozone layer is very important because it stops too many of the sun's 'ultra-violet rays' (UV rays) getting through to the Earth - these are the rays that cause our skin to tan. Too much UV can cause skin cancer and will also harm all plants and animals. Life on Earth could not exist without the protective shield of the ozone layer.

The ozone hole is not technically a "hole" where no ozone is present, but is actually a region of exceptionally depleted ozone in the stratosphere over the Antarctic that happens at the beginning of Southern Hemisphere spring. Every spring, a hole as big as the USA develops in the ozone layer



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over Antarctica, in the South Pole. A smaller hole develops each year over the Arctic, at the North Pole. And there are signs that the ozone layer is getting thinner all over the planet. Scientists have discovered that the ozone hole over Antarctica started in 1979, and that the ozone layer generally started to get thin in the early 1980s.The loss of the ozone layer occurs when more ozone is being destroyed than nature is creating.

The ozone depletion process begins when CFCs and other ozone-depleting substances (ODS) are emitted into the atmosphere. Winds efficiently mix the troposphere and evenly distribute the gases. CFCs are extremely stable, and they do not dissolve in rain. After a period of several years, ODS molecules reach the stratosphere, about 10 kilometres above the Earth's surface. Strong UV light breaks apart the ODS molecule. CFCs, HCFCs, carbon tetrachloride, methyl chloroform, and other gases release chlorine atoms and methyl bromide release bromine atoms. It is these atoms that actually destroy ozone, not the intact ODS molecule. It is estimated that one chlorine atom can destroy over 100,000 ozone molecules before it is removed from the stratosphere.

What are CFCs? CFCs, also known as **chlorofluorocarbons** (composed of carbon, fluorine, and chlorine) were invented in the early 1930s. Over the years, they have served many functions, including propellants for aerosols, refrigeration coolants, and electronic circuit board cleaners. There are different types of CFCs. CFC-11 and 12 for example are common refrigeration coolants. CFC-11 is also known under the brand name of Freon.

A question however, naturally arises, if most of the CFCs are released over major industrial countries such as the United States, China and Japan, then why is the ozone hole forming over Antarctica? The answer lies in at least two reasons.

- First, when something (like a CFC molecule) is released into the air, it does not remain in the atmosphere directly above its origin. Because CFCs have a life-span of several decades, they remain intact long enough to make their journey up into the stratosphere. The key to the long life of CFCs is their non-reactivity. They don't react with other substances in the troposphere, and only break apart in the stratosphere when they are exposed to high-

**Montreal Protocol**

Adopted in 1987, the Montreal Protocol on Substances that Deplete the Ozone Layer legally enforces the phase-out of the production and use of ozone depleting substances - chemicals often used in refrigeration, air-conditioning, foam manufacturing, aerosol production, and fire extinguishing. The Montreal Protocol stipulates that the production and consumption of compounds that deplete ozone in the stratosphere--chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform (First generation ODS)--are to be phased out by 2000 (2005 for methyl chloroform) and thereafter, the focus should rely on the HCFC (second generation ODS).Even having unparalleled success, the agreement has failed to directly address some threat associated with these emissions i.e. global warming. Both existing ODSs and their industry substitutes, hydro fluorocarbons (HFCs), have severe global warming potential (GWP)- in some cases more than 10,000 times that of carbon dioxide ($CO_2$), the most prevalent greenhouse gas emitted by human activities. While focusing on the global phase-out of ODS production, the treaty has done little to address existing banks of ODSs or incentivize their controlled destruction. The next 20 years will be crucial in determining the ultimate impact of ODSs on the atmosphere. If ODS banks remain unaddressed, there is a considerable risk that these chemicals will be released into the atmosphere within this timeframe, with significant implications for global warming and ozone depletion. Only if these gases are collected and destroyed or recycled in a controlled, responsible manner can an environmental threat be considered to have been averted. Emissions from ODSs and HFCs threaten to undermine efforts being taken to reduce atmospheric CO2.



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energy ultraviolet radiation - a process that could take up several years. Therefore, winds in the troposphere and stratosphere have sufficient time to distribute CFC molecules around the globe

- Secondly, the weather conditions in the Antarctic are such that they encourage the creation of so-called polar stratospheric clouds (PSCs). These clouds form only under persistently cold conditions, which is why they are usually only found in Antarctica (PSCs can also be found in the Arctic, but because the weather is not as persistently cold, they are less common.)

As mentioned before (in above diagram), when CFCs enter the stratosphere, they are exposed to high-energy ultraviolet rays from the sun, which cause the chlorine (chemical symbol Cl) to break apart from the CFC molecule. One chlorine atom is capable of fragmenting over 1000 ozone molecules (for example via the reaction $Cl + O_3 \rightarrow ClO + O_2$) before it is trapped again in stable molecules (sometimes called reservoir substances), such as chlorine nitrate ($ClONO_2$). This fact is interesting by itself because it explains some of the ozone decrease observed world-wide. Yet it does not explain the ozone hole, which only forms when chlorine is again released from the reservoir substances. This is where the PSCs come into play. At the surface of these icy clouds, the reservoir substances are again transformed into more active forms of chlorine. For example, $ClONO_2$ reacts with hydrochloride acid (HCl) to form chlorine gas ($Cl_2$) and $HNO_3$. During the period of complete darkness during the polar night large quantities of $Cl_2$ can accumulate, but still only little ozone decrease is observed.

The massive destruction of ozone that finally leads to the ozone hole takes place only when the first rays of sunlight are striking the Antarctic atmosphere after the polar night, splitting $Cl_2$ into two atoms of chlorine ($Cl_2 \rightarrow 2\ Cl$). Now ozone destruction can start again via the reaction $Cl + O_3 \rightarrow ClO + O_2$ (It goes without saying that the complete chemistry that is going on is far more complex). This also explains the greater prevalence of Ozone Hole during spring season.

Because the location of the ozone hole is far separated from most of the human population, it would be easy to dismiss it as a phenomenon irrelevant to the rest of the world. It does, however, have a significant impact on the rest of society. First, the oceans around Antarctica are rich in life, which is threatened by increased ultraviolet radiation under the ozone hole. Secondly, when the Polar Vortex, which keeps ozone depleted air trapped over Antarctica during the spring, breaks up, ozone-poor air is dispersed over nearby human-inhabited areas. Such areas include Australia, New Zealand, Southern Argentina, and Southern Chile. And thirdly, there are concerns that the stratosphere over the North Pole could cool down during the next decades. If that were the case, PCS would become more frequent in the northern hemisphere, causing severe ozone depletion over Alaska, Canada, Northern Europe and Siberia. Here human settlements are far more frequent than in the Southern Hemisphere.

Since ozone filters out harmful UV radiation, less ozone means higher UV levels at the surface. The more the depletion, the larger the increase in incoming UV. UV has been linked to skin cancer, cataracts, damage to materials like plastics, and harm to certain crops and marine organisms. Although some UV reaches the surface even without ozone depletion, its harmful effects will increase as a result of this problem.

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# CHAPTER – 11
# CLIMATE CHANGE INSTITUTIONS

## EVOLUTION OF THOUGHT

- ✓ In the 19th century, an awareness began to dawn that accumulated carbon dioxide in the Earth's atmosphere could create a "greenhouse effect" and increase the temperature of the planet (a side-effect of the industrial).
- ✓ By the middle of the 20th century, it was becoming clear that human action had significantly increased the production of these gases, and the process of "global warming" was accelerating.
- ✓ Today, nearly all scientists, as well as nations, agree that we must stop and reverse this process now — or face a devastating cascade of natural disasters that will change life on earth as we know it.

Consequently, in recent decades, several initiatives and procedures have come into place to take care of the newly emerged apprehension as explained below. Pursuing the dissemination of information about challenges posed by climate change, what started off as individual seminars and lectures culminated in the form of institutions.

## UNITED NATIONS CONFERENCE ON THE HUMAN ENVIRONMENT (UNCHE) [STOCKHOLM CONFERENCE]

The first United Nations Conference on the Human Environment (UNCHE) was held in Stockholm, Sweden from June 5 to June 16, 1972. Representatives from 113 countries, as well as representatives from many international non-governmental organizations, intergovernmental organizations, and many other specialized agencies.

This was the first United Nations conference on the environment as well as the first major international gathering focused on human activities in relationship to the environment, and it laid the foundation for environmental action at an international level.

The Conference acknowledged:

1. That the goal of reducing human impact on the environment would require extensive international cooperation, as many of the problems affecting the environment are global in nature.
2. The UNCHE emphasized that defending and improving the environment must become a goal to be pursued by all countries.
3. The Conference indicated that "industrialized" environmental problems, such as habitat degradation, toxicity and acid rain, were not necessarily relevant issues for all countries. In particular, development strategies were not meeting the needs of the poorest countries and communities.
4. Some of the specific issues addressed was the role which industrialized countries should have in the process of protecting the environment, stating that industrial countries should help to close the gap between them and underdeveloped countries while keeping their own priorities and the protection and improvement of the environment in mind.
5. The conference developed a long set of recommendations to act as goals to pursue its mission. Recommendations included that governments communicate about environmental issues that have international implications (such as air pollution), that governments give attention to the training of those who plan, develop, and manage settlement areas, and that



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agencies work together to address many issues, such as access to clean water and population growth.

Result:

- ✓ The United Nations Environmental Programme (UNEP) was launched in order to encourage United Nations agencies to integrate environmental measures into their programs.
- ✓ The Stockholm Declaration and Action Plan defined principles for the preservation and enhancement of the natural environment, and highlighted the need to support people in this process.

**UNITED NATIONS ENVIRONMENT PROGRAMME**

One of the greatest achievements of the UNCHE was the creation of the United Nations Environment Programme (UNEP), based in Nairobi, Kenya. The mission of UNEP is:

- ➢ To provide leadership.
- ➢ Encourage partnership.
- ➢ Inspire, inform, and enable nations and peoples to improve their quality.

UNEP is the voice for the environment within the United Nations system and works toward this mission by:

- Monitoring the status of the global environment and interpreting environmental data collected
- Creating environmental awareness in governments, society, and the private sector
- Coordinating UN activities pertaining to the environment
- Developing regional programs for sustainability
- Helping environmental authorities, especially those in developing countries, form and implement policy
- Helping to develop international environmental law
- Kept pushing the organizations and people in authority to take the onus and devise methods to cope up with emerging environment situations.

Enroute second World Climate Conference in 1990, UNEP managed to formulate various institutional agreements for example, the protection of Ozone layer, Transboundary Air Pollution etc. As the urgency for a stronger international action on the environment, including climate change, gained momentum, the General Assembly decided to convene in 1992 in Rio de Janeiro, Brazil, the United Nations Conference on Environment and Development.

**THE UNITED NATIONS CONFERENCE ON ENVIRONMENT AND DEVELOPMENT (UNCED)**

***Facts:***

*Also known as:* **The Earth Summit.** *Attended by:* 108 heads of countries. *Date:* From June 2-14, 1992. *Place:* Rio de Janeiro, Brazil.

*Central focus:* How to relieve the global environmental system through the introduction to the paradigm of sustainable development?

*Other Issues Discussed:* Poverty, war, and the growing gap between industrialized and developing countries.

**The Earth Summit Agreements**

**Three major agreements** aimed at changing the traditional approach to development were adopted:



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1. **Agenda 21** — a comprehensive programme for global action in all areas of sustainable development;
2. The **Rio Declaration on Environment and Development** — a series of principles defining the rights and responsibilities of States;
3. The **Statement of Forest Principles** — a set of principles to underlie the sustainable management of forests worldwide, which have been depicted as follows:
   - That all countries, notably developed countries, should make an effort to "green the world" through reforestation and forest conservation;
   - That States have a right to develop forests according to their socio-economic needs, in keeping with national sustainable development policies; and
   - That specific financial resources should be provided to develop programmes that encourage economic and social substitution policies.

**In addition, two legally binding Conventions** aimed at preventing global climate change and the eradication of the diversity of biological species were opened for signature at the Summit, giving high profile to these efforts:

1) **The United Nations Framework Convention on Climate Change**
2) **The Convention on Biological Diversity**

NOTE Major Groups include women, youth, indigenous peoples, non-governmental organizations, local authorities, workers and trade unions, business and industry, the scientific community, and farmers.

## UN COMMISSION ON SUSTAINABLE DEVELOPMENT

The United Nations Commission on Sustainable Development (CSD) was established by the UN General Assembly in December 1992 to ensure effective follow-up of United Nations Conference on Environment and Development (UNCED), also known as the Earth Summit. Functions:

- For reviewing progress in the implementation of Agenda 21 and the Rio Declaration on Environment and Development.
- Providing policy guidance to follow up the Johannesburg Plan of Implementation (JPOI) at the local, national, regional and international levels.

The role of the Commission as a high level forum on sustainable development, includes:

- To review progress at the international, regional and national levels in the implementation of recommendations and commitments contained in the final documents of the United Nations Conference on Environment and Development (UNCED), namely: Agenda 21 and the Rio Declaration on Environment and Development
- To elaborate policy guidance and options for future activities to follow up the Johannesburg Plan of Implementation and achieve sustainable development
- To promote dialogue and build partnerships for sustainable development with governments, the international community and the major groups identified in Agenda 21 as key actors outside the central government who have a major role to play in the transition towards sustainable development.

**Furthermore, the Johannesburg Plan of Implementation** called for:

- Renewed emphasis on integration of the three dimensions of sustainable development in a balanced way
- Focus on reviewing and monitoring progress in the implementation through a broad exchange of views and experiences, best practice and lessons learned
- Enhanced linkages between global, regional and national endeavours
- Integrated process that enhances coherence between the implementation of Agenda 21, initia-



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tives and partnerships
- Greater involvement at the regional level
- Opportunity to look at new challenges and opportunities in the context of implementation
- Innovative methods of work
- Broader participation of all stakeholders, particularly UN agencies/international financial institutions and the Major Groups
- Greater consideration to scientific contributions
- Contributions of educators
- Focus on a limited number of issues
- Negotiations once every two years

## THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)

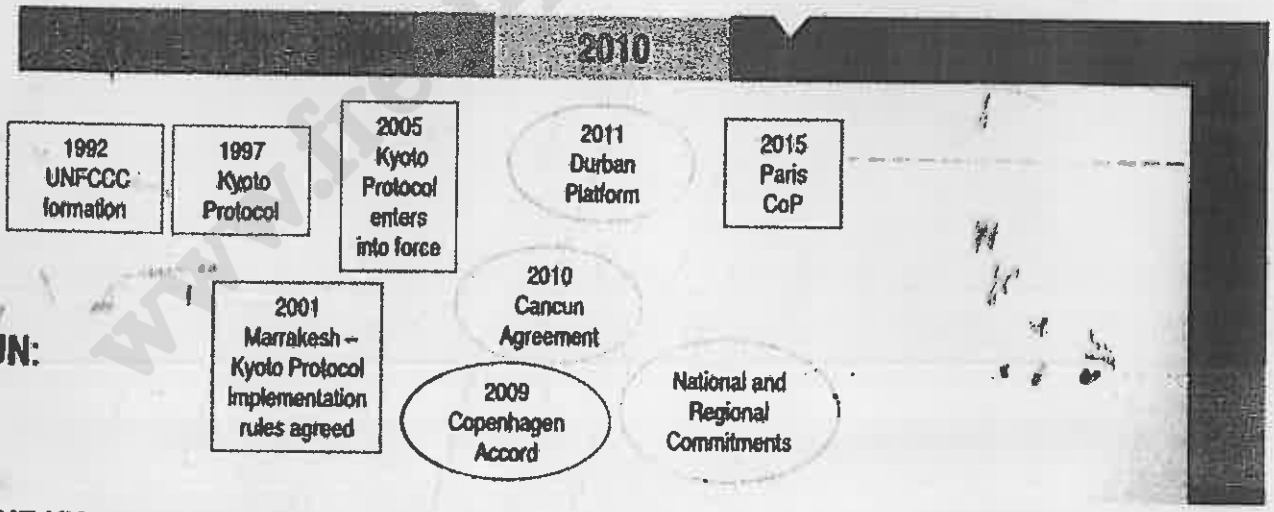
- UNFCCC recognizes that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases.
- It sets an overall framework for intergovernmental efforts to tackle climate change.

The Convention enjoys near "universal membership." Under the Convention, governments:

- ✓ Gather and share information on greenhouse gas emissions, national policies and best practices
- ✓ Launch national strategies for addressing greenhouse gas emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries
- ✓ Cooperate in preparing for adaptation to the impacts of climate change.

NOTE: The Convention entered into force on 21 March 1994.

UNFCCC further led to various conventions and agreements in order to contain climate change.




## THE KYOTO PROTOCOL

→ A protocol linked to UNFCC aimed at fighting global warming.

***Facts***

- The Kyoto Protocol was adopted in Kyoto, Japan, on 11 December 1997.
- Entered into force on 16 February 2005.



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- The detailed rules for the implementation of the Protocol were adopted at COP 7 in Marrakesh, Morocco, in 2001, and are referred to as the "Marrakesh Accords."
- Its first commitment period started in 2008 and ended in 2012.

The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change (UNFCCC) third Conference of the Parties (COP-3), which commits its Parties by setting internationally binding emission reduction targets. Recognizing that developed countries are principally responsible for the current high levels of GHG emissions in the atmosphere as a result of more than 150 years of industrial activity, the Protocol places a heavier burden on developed nations under the principle of "common but differentiated responsibilities (CBDR)."

**Classification of Parties and their commitments**

**Annex I:** There are 43 Parties to the UNFCCC listed in Annex I of the Convention, including the European Union. These Parties are classified as industrialized (developed) countries and "economies in transition" (EITs). The 14 EITs are the former centrally planned (Soviet) economies of Russia and Eastern Europe.

**Annex II:** There are 24 Parties to the UNFCCC listed in Annex II of the Convention, including the European Union. These Parties are made up of members of the OECD. Annex II Parties are required to provide financial and technical support to the EITs and developing countries to assist them in reducing their greenhouse gas emissions (climate change mitigation) and manage the impacts of climate change (climate change adaptation).

**Annex B:** Parties listed in Annex B of the Kyoto Protocol are Annex I Parties with first- or second-round Kyoto greenhouse gas emissions targets. The first-round targets apply over the years 2008–2012. As part of the 2012 Doha climate change talks, an amendment to Annex B was agreed upon containing with a list of Annex I Parties who have second-round Kyoto targets, which apply from 2013–2020. The amendments have not entered into force.

**Least-developed countries (LDCs):** 49 Parties are LDCs, and are given special status under the treaty in view of their limited capacity to adapt to the effects of climate change.

Non-Annex I: Parties to the UNFCCC not listed in Annex I of the Convention are mostly low-income developing countries. Developing countries may volunteer to become Annex I countries when they are sufficiently developed.

**What is CBDR?**

The principle of common but differentiated responsibility includes two elements:

- The first confirms the common responsibility of states for the protection of the environment or parts of it at the national, regional and international levels.
- The second concerns the need to take account of different circumstances, particularly in relation to each state's contribution to the creation of a particular environmental problem and its ability to prevent, reduce and control the danger.

In practical terms, the application of the principle of common but differentiated responsibility has at least two consequences:

- First, it entitles or may require all concerned states to participate in international response measures aimed at addressing environmental problems.
- Secondly, it leads to environmental standards which impose differing obligations on states.

The Kyoto Protocol specifies a quantified emission limitation and reduction commitment for each developed country Party as well as related rules for accounting. Agreed rules are applicable to:

- The assigned amounts of Parties.
- Land-use related activities.



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- Flexibility mechanisms (ET).
- Clean development mechanism (CDM).
- Joint implementation (JI).

## EMISSIONS TRADING (ET)

Emissions trading is one of the three market-based mechanisms under the Kyoto Protocol used by Countries with commitments under the Protocol to limit or reduce their greenhouse gas emissions (GHGs) in order to meet their emission targets.

Since carbon dioxide ($CO_2$) is the principal greenhouse gas, people speak simply of trading in carbon. Carbon is now tracked and traded like any other commodity. This is known as the "carbon market." Parties with commitments under the Kyoto Protocol (Annex B Parties) have accepted targets for limiting or reducing emissions.

Emissions trading, as set out in the Kyoto Protocol, allows countries that have emission units to spare - emissions permitted them but not "used" - to sell this excess capacity to countries that are over their targets. Thus, a new commodity was created in the form of emission reductions or removals.

Renewable energy projects account for nearly two-thirds of CDM projects. The various projects include:

- Hydro, wind and biomass projects.
- Methane avoidance, landfill gas, afforestation and reforestation,
- Energy efficiency projects.

### Criticism

Although the concept of emissions trading seems to be beneficial for all parties, it has received much criticism on some of its fundamental flaws:

- Certain countries had large inefficient industries with high emissions in 1990 that underwent major restructuring during the five years before the Kyoto Protocol was agreed to. Specifically, most of Eastern Europe underwent such a transformation following the collapse of communist governments. Thus, countries such as Russia and Germany (where the former East Germany was merged with West Germany) were said to be able to sell "hot air credits" - because changes taking place for other reasons allowed them to achieve their Kyoto Protocol goals very easily and also be able to make a profit on those emissions reductions.
- Other countries could "purchase" those reductions in order to increase their own emission allotments, thereby actually increasing emissions overall relative to what would have been the case without the Kyoto Protocol, instead of keeping the overall emissions at a neutral status because of the trading.

## THE CLEAN DEVELOPMENT MECHANISM (CDM)

The Clean Development Mechanism (CDM) is one of the market-based mechanisms under the Kyoto Protocol used by Countries with commitments under the Protocol to limit or reduce their greenhouse gas emissions (GHGs) in order to meet their emission targets. It has been operational since the beginning of 2006.

The CDM allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO2, which can be counted towards meeting Kyoto targets. The mechanism is seen by many as a trailblazer. It is the first global, environmental investment and credit scheme of its kind, providing a standardized emissions offset instrument, CERs. A CDM project activity might involve, for example, a rural electrification project using solar panels or the installation of more energy-efficient boilers. A CDM project must provide emission reductions that are additional to what



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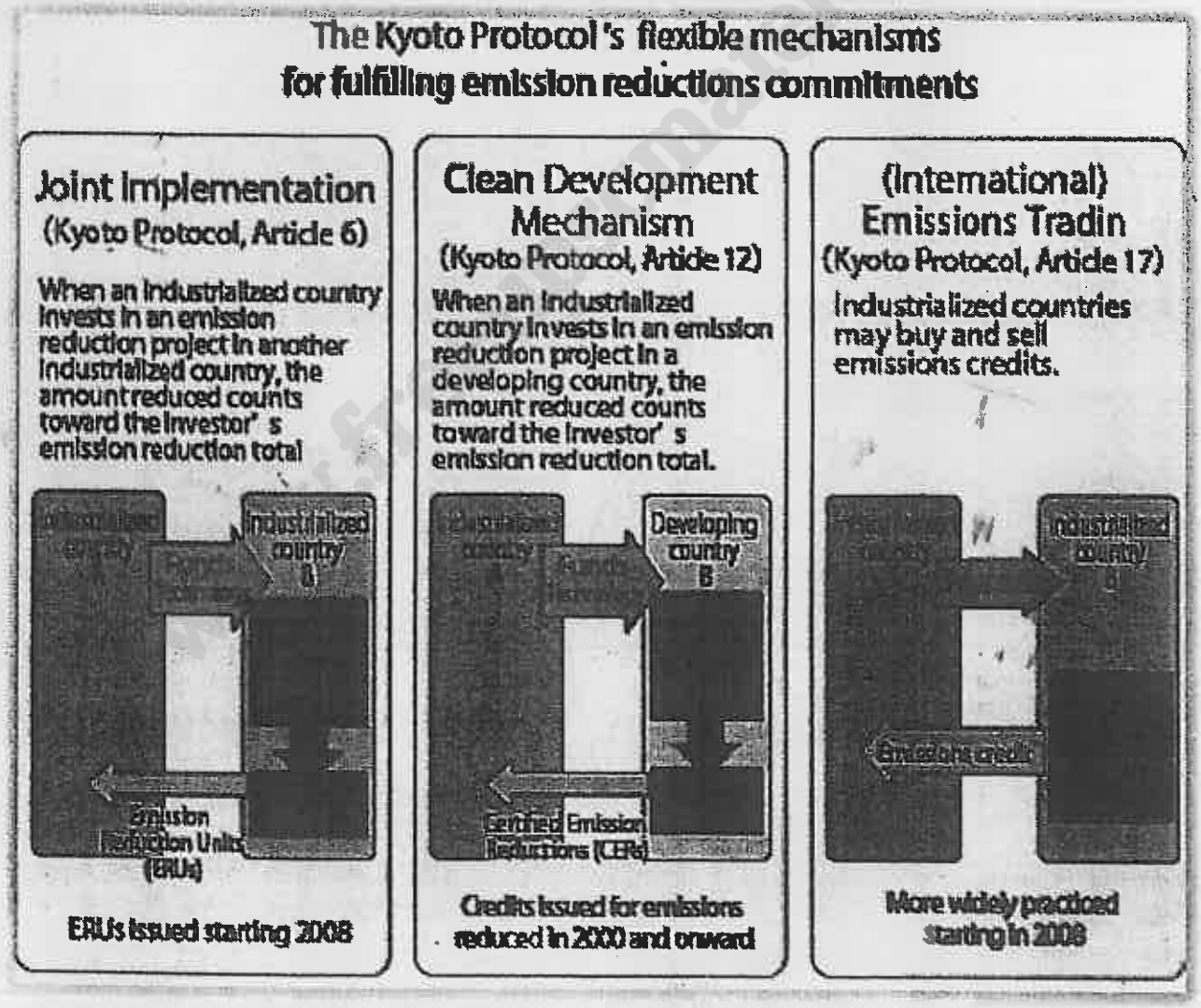
would otherwise have occurred.

## JOINT IMPLEMENTATION (JI)

Joint Implementation (JI) is also one of the market-based mechanisms under the Kyoto Protocol used by Countries with commitments under the Protocol to limit or reduce their greenhouse gas emissions in order to meet their emission targets. JI project examples include renewable energy projects like erection of wind parks, afforestation and reforestation, energy efficiency projects, and reduction of methane emissions. JI is considered to be a "project-based mechanism", similar to the Clean Development Mechanism, which feeds the carbon market.

- The Bali Road Map includes the Bali Action Plan, which charts the course for a new negotiating process designed to tackle climate change.
- The Bali Action Plan is a comprehensive process to enable the full, effective and sustained implementation of the Convention through long-term cooperative action up to and beyond 2012, in order to reach an agreed outcome and adopt a decision.

JI projects are very similar to Clean Development Mechanism (CDM) projects with one important difference. JI projects are between developed (Annex I) country countries, whereas CDM projects are hosted by developing countries. CDM projects are far more common than JI projects.




JI allows a country with an emission reduction or limitation commitment under the Kyoto Protocol (Annex B Party) to earn "emission reduction units" (ERUs) from an emission-reduction or

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emission removal project in another Annex B Party, each equivalent to one tonne of $CO_2$, which can be counted towards meeting its Kyoto target. Joint implementation offers Parties a flexible and cost-efficient means of fulfilling a part of their Kyoto commitments, while the host Party benefits from foreign investment and technology transfer.

## BALI ROAD MAP

The Bali Road Map was adopted at the 13th COP and the 3rd Meeting of the Parties in December 2007 in Bali. The Road Map is a set of a forward-looking decisions that represent the work that needs to be done under various negotiating "tracks" that is essential to reaching a secure climate future.

All Parties to the Convention were involved in crafting the Bali Road Map. The COP decided that the process would be conducted under a subsidiary body under the Convention, the Ad Hoc Working Group on Long-term Cooperative Action (AWG-LCA).

The Bali Action Plan is divided into five main categories:

1. Shared vision.
2. Mitigation.
3. Adaptation,
4. Technology.
5. Financing.

## COPENHAGEN ACCORD

The Copenhagen Climate Change Conference raised climate change policy to the highest political level. COP 15 was a crucial event in the negotiating process. Significant progress was made in narrowing down options and clarifying choices needed to be made on key issues later on in the negotiations. It produced the Copenhagen Accord, which expressed clear a political intent to constrain carbon and respond to climate change, in both the short and long term. The Copenhagen Accord –

> It significantly advanced the negotiations on the infrastructure needed for effective global climate change cooperation, including improvements to the Clean Development Mechanism of the Kyoto Protocol.

- It was put forward by BASIC countries and US
- It was a non-binding agreement
- It included the long-term goal of limiting the maximum global average temperature increase to no more than 2 degrees Celsius above pre-industrial levels, subject to a review in 2015. There was, however, no agreement on how to do this in practical terms.

(The BASIC countries (also Basic countries or BASIC) are a bloc of four large newly industrialized countries – Brazil, South Africa, India and China – formed by an agreement on 28 Nov 2009.)

Copenhagen Accord led to the establishment of four new bodies:

- Mechanism on REDD-plus.
- High-Level Panel under the COP to study implementation of financial provisions.
- Copenhagen Green Climate Fund.
- Technology Mechanism.

## CANCUN AGREEMENTS

The Cancun Agreements were a set of significant decisions by the international community to address the long-term challenge of climate change collectively and comprehensively over time and to take concrete action immediately to speed up the global response to it. The agreements, reached on December 11 in Cancun, Mexico, at the 2010 UNFCCC COP-16, represented key steps



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forward in capturing plans to reduce greenhouse gas emissions. and to help developing nations protect themselves from climate impacts and build their own sustainable futures.

The Cancun Agreements' main objectives cover:

- **Mitigation** – Establish clear goals and a timely schedule for reducing human-generated greenhouse gas emissions over time to keep the global average temperature rise below two degrees
- **Transparency of actions** – Ensure international transparency of the actions which are taken by countries, and ensure that global progress towards the $2^0$C goal is reviewed in a timely way.
- **Technology** – Mobilize the development and transfer of clean technology to boost efforts to address climate change, getting it to the right place at the right time and for the best effect on both adaptation and mitigation.
- **Finance** – Set up the Green Climate Fund to provide support to developing countries to assist them in mitigating climate change and adapting to its impacts
- **Adaptation** – Assist the particularly vulnerable people in the world to adapt to the inevitable impacts of climate change by taking a coordinated approach to adaptation.
- **Forests** – Protect the world's forests, which are a major repository of carbon. Governments agreed to launch concrete action on forests in developing nations, which will increase going forward. The full financing options for the implementation of such mitigation actions in the forest area will be addressed during 2011.
- Capacity **Building** – Build up global capacity, especially in developing countries, to meet the overall challenge

## GREEN CLIMATE FUND (GCF)

* **Resources:** Pledges to GCF by states (43 total including 9 developing countries) and Contributions.
* **Trustee:** UN Framework Convention on Climate Change (UNFCCC) invited the World Bank to serve as interim trustee of the Green Climate Fund. The process to appoint GCF's permanent trustee is scheduled for completion no later than the end of 2017.

The Green Climate Fund (GCF) is a fund within the framework of the UNFCCC founded as a mechanism to redistribute money from the developed to the developing world, in order to assist the developing countries in adaptation and mitigation practices to counter climate change. The Fund will contribute to the achievement of the ultimate objective of the United Nations Framework Convention on Climate Change (UNFCCC). In the context of sustainable development, the Fund will promote the paradigm shift towards low-emission and climate-resilient development pathways by providing support to developing countries to limit or reduce their greenhouse gas emissions and to adapt to the impacts of climate change, taking into account the needs of those developing countries particularly vulnerable to the adverse effects of climate change. The Fund will be guided by the principles and provisions of the Convention.

## ADAPTATION FUND

* The Adaptation Fund is supervised and managed by the Adaptation Fund Board (AFB).
* The World Bank serves as trustee of the Adaptation Fund on an interim basis.

The Adaptation Fund was established to finance concrete adaptation projects and programmes in developing countries that are parties to the Kyoto Protocol and are particularly vulnerable to the adverse effects of climate change. Climate change is predicted to greatly affect the poorest people in the world, who are often hardest hit by weather catastrophes, desertification, and rising sea levels, but who have contributed the least to the problem of global warming. In some parts of the world, climate change has already contributed to worsening food security, reduced the

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predictable availability of fresh water, and exacerbated the spread of disease and other threats to human health. Helping the most vulnerable countries and communities is an increasing challenge and imperative for the international community, especially because climate adaptation requires significant resources beyond what is already needed to achieve international development objectives.

Under the Clean Development Mechanism (CDM), emission-reduction projects in developing countries can earn certified emission reduction (CER) credits. These credits can be traded and sold by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol. Financing for the Adaptation Fund comes mainly from sales of certified emission reductions. The share of proceeds amounts to 2 per cent of the value of CERs issued each year for CDM projects. The fund also receives contributions from governments, the private sector, and individuals.

**DURBAN :**

Towards full implementation of the UN Climate Change Convention (COP-17).

The UN Climate Change Conference in Durban was a turning point in the climate change negotiations. *Road map for Implementation.*

In Durban, governments clearly recognized the need to draw up the blueprint for a fresh universal, legal agreement to deal with climate change beyond 2020, where all will play their part to the best of their ability and all will be able to reap the benefits of success together.

The Durban outcomes looked to address these challenges in a more connected way by embodying a road map for implementation over a longer time horizon than has commonly been the case in the history of the Convention. On this map, four main areas of coordinated and complementary action and implementation, designed also to build and preserve trust among countries, were agreed:

1. Second commitment period of the Kyoto Protocol:
2. Launch of new platform of negotiations
3. Conclusion in 2012 of existing broad-based stream of negotiations
4. Global Review

The Durban outcome recognized, in its spirit and intention that smart government policy, smart business investment, and the demands of an informed citizenry, all motivated by an understanding of mutual self-interest, must go hand in hand in pursuit of the common goal.

**THE DOHA CLIMATE GATEWAY**

At the 2012 UN Climate Change Conference in Doha, Qatar (COP-18), governments consolidated the gains of the last three years of international climate change negotiations and opened a gateway to necessary greater ambition and action on all levels. Among the many decisions taken:

1. **Amendment to the Kyoto Protocol** – The Kyoto Protocol, as the only existing and binding agreement under which developed countries commit to cutting greenhouse gases, has been amended so that it will continue as of 1 January 2013:

   Australia, the EU, Japan, Lichtenstein, Monaco and Switzerland declared that they will not carry over any surplus emissions trading credits (Assigned Amounts) into the second commitment period of the Kyoto Protocol.

   - Governments have decided that the length of the second commitment period will be 8 years.
   - The Kyoto Protocol's Market Mechanisms - the Clean Development Mechanism (CDM), Joint Implementation (JI) and International Emissions Trading (IET) - can continue as of 2013.
   - Access to the mechanisms will be uninterrupted for all developed countries that have accepted targets for the second commitment period.

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- JI will continue to operate, with the agreed technical rules allowing the issuance of credits, once a host country's emissions target has been formally established.

2. **Time table for the 2015 global climate change agreement and increasing ambition before 2020:** Governments agreed to speedily work toward a universal climate change agreement covering all countries from 2020, to be adopted by 2015, and to find ways to scale up efforts before 2020 beyond the existing pledges to curb emissions so that the world can stay below the agreed maximum 2 degrees Celsius temperature rise.
3. **Long-term climate finance:** Developed countries have reiterated their commitment to deliver on promises to continue long-term climate finance support to developing nations, with a view to mobilizing "100 billion USD both for adaptation and mitigation by 2020."
4. **Other key outcomes of COP18 in Doha**
   - Review - Governments have launched a robust process to review the long-term temperature goal. This will start in 2013 and conclude by 2015, and is a reality check on the advance of the climate change threat and the possible need to mobilize further action.
   - Adaptation - Governments have identified ways to further strengthen the adaptive capacities of the most vulnerable, also through better planning .
   - New market mechanisms - A work programme has been agreed to further elaborate the new market-based mechanism under the UNFCCC, and also sets out possible elements for its operation.
   - Actions on forests - In Doha, governments have further clarified ways to measure deforestation, and to ensure that efforts to fight deforestation are supported.
   - Carbon Capture and Storage - Governments meeting in Doha have looked at ways to ensure the effectiveness and environmental integrity of projects under the Kyoto Protocol's Clean Development Mechanism that capture and store carbon emissions
   - Development and transfer of technology - Countries have taken forward work on enabling the development and transfer of technologies that can help developing countries adapt and curb their emissions.
   - Avoiding negative consequences of climate action - In some cases, the implementation of actions that reduce emissions could result in negative economic or social consequences for other countries. In Doha, governments discussed measures to address such consequences in a special forum.

## WARSAW OUTCOMES

The United Nations Climate Change Conference, COP-19 was held in Warsaw, Poland from 11 to 23 November 2013.

***Key points from COP19 –***

- Countries kept talks on track toward a new global climate deal in 2015, but the form and timing of submission of new commitments were weakened, raising fears that the ambition of the new deal will be lowered.
- The role of sub-national governments has been recognized in helping to raise climate action ambitions in the period to 2020, with agreement to facilitate learning from and sharing of sub-national government experiences.
- A 'Loss and Damage' mechanism to help vulnerable developing countries cope with severe climate impacts has been established, but without a clear means of adequate funding.
- Agreement called the "Warsaw international mechanism for loss and damage (IMLD)".



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- As per this agreement, disaster victims in developing country will receive aid from the developed countries. But it will not be linked with any liability /commitment.
- It will also provide expertise and aid, to help developing nations cope with extreme events related to climate change.
- On a positive note, countries agreed to modalities governing 'results-based finance' for developing countries that halt deforestation. Some US$280 million of new funding to support initial efforts was announced by the governments of Norway, the UK and the US.

Discussions on climate finance, in particular the capitalization of the Green Climate Fund and how to mobilize US$100 billion per year by 2020 failed to bridge key divisions, with countries agreeing to continue talks in 2014.

- Overall, Warsaw was procedurally successful, delivering a suite of decisions that keep the UNFCCC process ticking over. But from a climate protection perspective, it joins a growing line of COPs that have fallen short in terms of collective efforts to reduce emissions.

## LIMA CONFERENCE

The 20th Climate Change Conference (COP20) concluded in Peru on 14 December, 2014. Complex negotiations to combat climate change in the sense that the global agreement was not blocked, and that a door has been left open to continue working on the unfinished issues.

***Key highlights:***

A controversial issue which affected negotiations between developed and developing countries was the Common But Differentiated Responsibilities (CBDR). COP20 was unable to define how the emissions reductions would be distributed among the countries. This issue will be addressed at COP21 in Paris.

* For the first time, an agreement was reached in which all countries will specify their objectives, if they are ready, and they will submit their CO2 emissions information by March 2015 (Intended Nationally Determined Contributions).
* The agreement reached is in line with the work that began at COP17 in Durban.
* Funding for the Green Climate Fund slightly exceeded the target, reaching 10.2 billion dollars. The fund will enable developing countries to apply a range of technologies to combat climate change. There are also plans to roll out a Private Sector Facility in 2015 to ensure that private sector entities can be accredited and access the fund.
* The implementation of a new framework for Measurement, Reporting and Verification. The first Multilateral Assessment was held in Lima, providing greater transparency for actions by developed countries, as they can compare their degree of compliance with the emission reduction goals.
* Not much progress was achieved in the main line of negotiations; discussions continue to be hampered by issues of fairness, and the main text, which was promising at first, was devalued by the time an agreement was reached. There are issues pending resolution, but a global agreement was reached for the first time

## PARIS CLIMATE CONFERENCE

The 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21) took place in Paris in November and December 2015. The meeting in Paris was hailed as a one-of-an opportunity to secure an international agreement on approaches to tackling

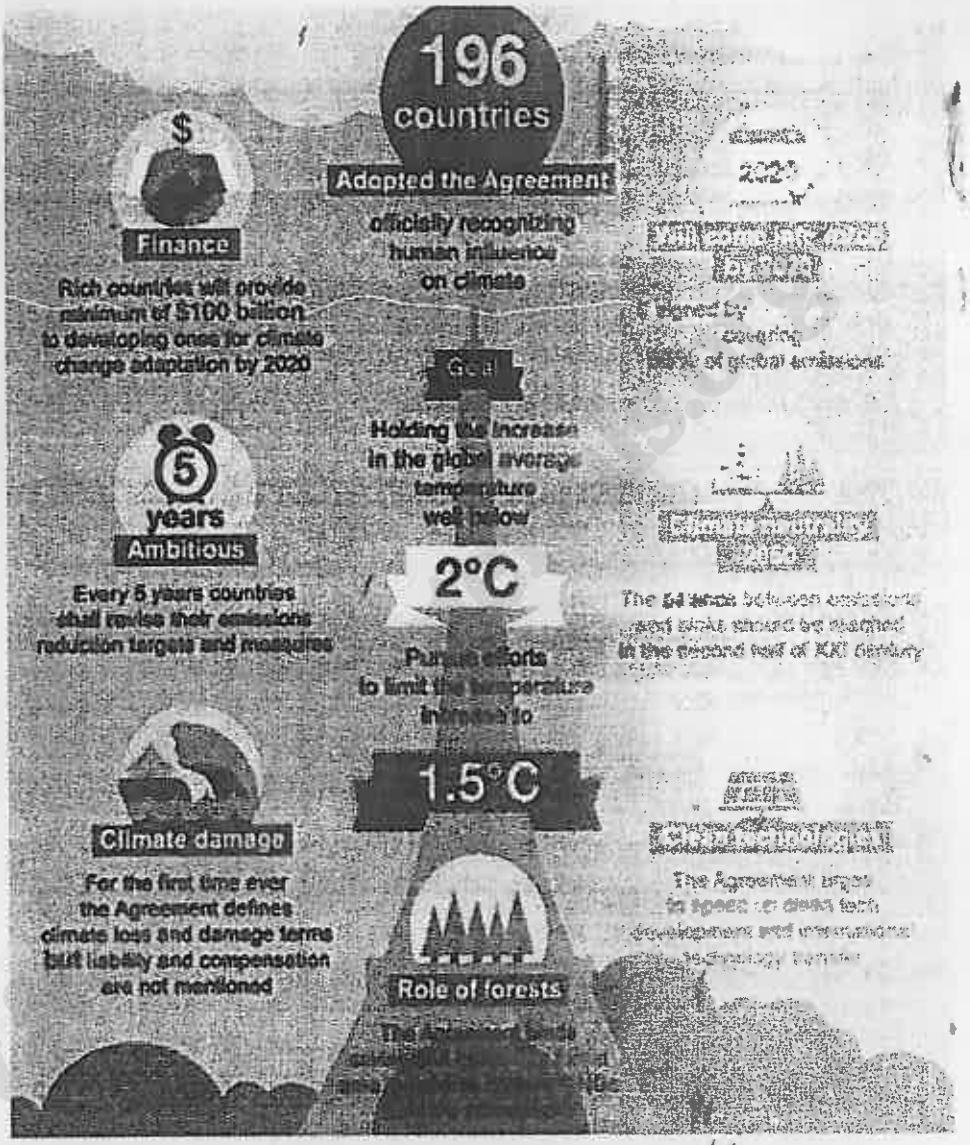
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climate change, a commitment to a longer-term goal of near zero net emissions in the second half of the century, and supporting a transition to a clean economy and low carbon society.

The key highlights of the Paris agreement are summarized below. The agreement is due to come into force in 2020.




**Goals:**

* A long-term goal of keeping the increase in global average temperature to well below 2°C above pre-industrial levels.
* To aim to limit the increase to 1.5°C, since this would significantly reduce risks and the impacts of climate change.
* On the need for global emissions to peak as soon as possible, recognizing that this will take longer for developing countries.
* To undertake rapid reductions thereafter in accordance with the best available science.
* Before and during the Paris conference, countries submitted comprehensive national climate action plans (INDCs). These are not yet enough to keep global warming below 2°C, but the agreement traces the way to achieving this target.

**Performance evaluation:**

* Come together every 5 years to set more ambitious targets as required by science;
* Report to each other and the public on how well they are doing to implement their targets;
* Track progress towards the long-term goal through a robust transparency and accountability system.

**Strategies**

* Strengthen societies' ability to deal with the impacts of climate change.
* Provide continued and enhanced international support for adaptation to developing countries.



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* Recognizes the importance of averting, minimizing and addressing loss and damage associated with the adverse effects of climate change
* Acknowledges the need to cooperate and enhance the understanding, action and support in different areas such as early warning systems, emergency preparedness and risk insurance.

**Support**

- The developed countries will continue to support climate action to reduce emissions and build resilience to climate change impacts in developing countries.
- Other countries are encouraged to provide or continue to provide such support voluntarily.
- Developed countries reiterated their commitment to mobilize USD 100 billion per year until 2025 when a new collective goal will be set

**Nationally Determined Contributions**

- The Paris Agreement requires all Parties to put forward their best efforts through "Nationally Determined Contributions" (NDCs) and to strengthen these efforts in the years ahead. This includes requirements that all Parties report regularly on their emissions and on their implementation efforts.
- In 2018, Parties will take stock of the collective efforts in relation to progress towards the goal set in the Paris Agreement and to inform the preparation of NDCs.
- There will also be a global stock taking every 5 years to assess the collective progress towards achieving the purpose of the Agreement and to inform further individual actions by Parties.

**Status of ratification**

The Paris Agreement on 4 November 2016, thirty days after the date on which at least 55 Parties to the Convention accounting in total for at least an estimated 55 % of the total global greenhouse gas emissions have deposited their instruments of ratification, acceptance, approval or accession with the Depositary.

## MARRAKECH CLIMATE CHANGE CONFERENCE - NOVEMBER 2016

The twenty-second session of the Conference of the Parties (COP 22), the twelfth session of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP 12), and the first session of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA 1) were held in Bab Ighli, Marrakech, Morocco from 7-18 November 2016.



The Paris Agreement set up general climate targets, but the details of the implementation still need to be decided and the process should be completed by 2018, according to what was decided in Marrakech.

***Key highlights:***

* Climate finance was discussed during the last two weeks and in order to reach a good balance between climate adaptation and climate mitigation, countries have been strongly encouraged to strive towards the earlier set target of $100bn a year by 2020.
* Nations have also agreed on a five-year work-plan on "loss and damage" starting from 2017, to address issues beyond climate adaptation like slow-onset impacts of climate change, non-economic losses and migration.
* COP23 will have Fiji as president of the negotiations and will be held in Bonn, Germany, due to the lack of space and capacity on the Pacific Island State.
* COP22 was also the occasion for policy-makers, countries and organizations to announce new strategy plans, initiative and finance changes.



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* Nations notably reaffirmed the global commitment to the Paris Agreement with the Marrakech Action Proclamation.
* The document reads: "We welcome the Paris Agreement...and we affirm our commitment to its full implementation."
* Transparency efforts are being encouraged by countries such as Australia, Germany and Canada with the injection of $50 million in investment.
* Germany, Mexico and Canada set up their roadmap to 2050, and the 2050 Pathways Platform was launched in order to help other countries to do so as well.
* 22 countries – including the UK, 15 cities and 196 businesses have committed to formulate their long-term goals so far.
* The Climate Vulnerable Forum was also created, gathering 47 of the poorest countries in the world, committing to generating 100% of their energy from renewables as soon as possible, as well as to update their NDCs by 2020 and to prepare their long-term strategies.

## REDD (REDUCING EMISSIONS FROM DEFORESTATION AND FOREST DEGRADATION)

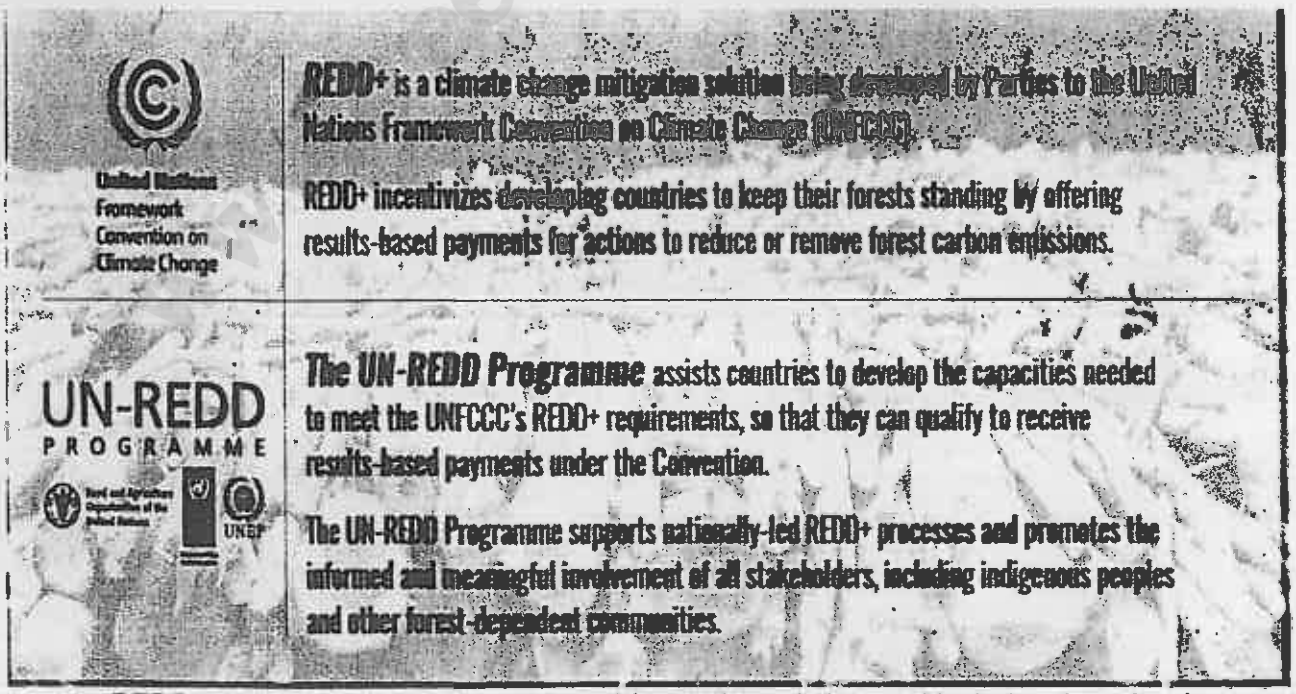
It is a mechanism to create an incentive for developing countries to

1. Protect
2. Better manage
3. Wisely use their forest resources
4. Contributing to the global fight against climate change

REDD mechanism phases:

* Carbon is assessed and quantified.
* Financial value for the carbon stored in trees,
* The final phase of REDD involves developed countries paying developing countries carbon offsets for their standing forests.

REDD is a cutting-edge forestry initiative that aims at tipping the economic balance in favour of sustainable management of forests so that their formidable economic, environmental and social goods and services benefit countries, communities, biodiversity and forest users while also contributing to important reductions in greenhouse gas emissions.




REDD+ goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. REDD+ con-



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ceptualizes flow of positive incentives for demonstrated reduction in deforestation or for enhancing quality and expanse of forest cover.

- It works on the basis of creating a financial value for the carbon stored and enhanced in biomass and soil of standing forests.
- Countries that reduce emissions and undertake sustainable management of forests will be entitled to receive funds and resources as incentives.
- REDD+ approach incorporates important benefits of livelihoods improvement, biodiversity conservation and food security services.

REDD+ is a climate change mitigation solution that many initiatives, including the UN-REDD Programme, are currently developing and supporting.

Other multilateral REDD+ initiatives include:

→ Forest Carbon Partnership Facility (FCPF)

→ Forest Investment Program (FIP),

**GLOBAL ENVIRONMENT FACILITY**

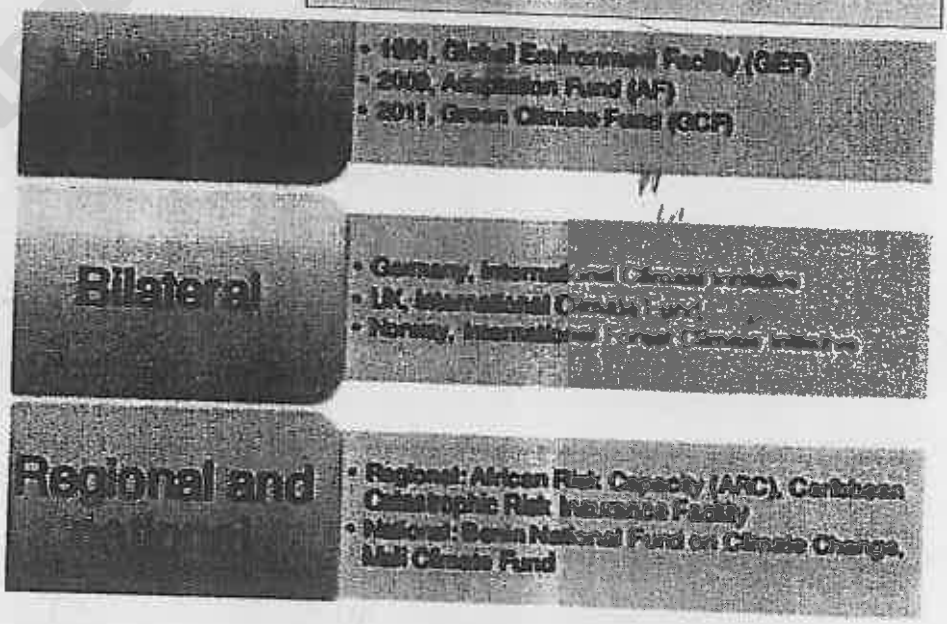
The Global Environment Facility is a partnership for international cooperation where 183 countries work together with international institutions, civil society organizations and the private sector, to address global environmental issues. Among the major results of these investments:

- ✓ The GEF has set up protected areas around the world equal roughly to the area of Brazil
- ✓ Reduced carbon emissions by 2.3 billion tonnes
- ✓ Eliminated the use of ozone depleting substances in Central and Eastern Europe and Central Asia
- ✓ Transformed the management of 33 major river basins and one-third of the world's large marine ecosystems
- ✓ Slowed the advance of desertification in Africa by improving agricultural practices – contributing to better the livelihood and food security of millions of people.

IMPORTANT: The GEF serves as financial mechanism for the following conventions:

- Convention on Biological Diversity (CBD)
- United Nations Framework Convention on Climate Change (UNFCCC)
- Stockholm Convention on Persistent Organic Pollutants (POPs)
- UN Convention to Combat Desertification (UNCCD)
- Minimata Convention on Mercury

NOTE: The GEF, although not linked formally to the Montreal Protocol on Substances That Deplete the Ozone Layer (MP), supports implementation of the Protocol in countries with economies in transition.




The major domains of GEF include:

❖ Biodiversity



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- Climate Change Mitigation and Adaptation
- International Waters
- Land Degradation
- Chemicals
- Cross-cutting Capacity Development

CLIMATE **FINANCING SUMMARY**

Intergovernmental **Panel on Climate Change (IPCC)**

To provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts, the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) established The Intergovernmental Panel on Climate Change (IPCC) in 1988. In the same year, the UN General Assembly endorsed it. The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of Climate Change.

***About IPCC:***

- The IPCC is a scientific panel under the auspices of the United Nations (UN).
- The IPCC is an intergovernmental body. It is open to all member countries of the United Nations (UN) and WMO. Currently 195 countries are members of the IPCC. Governments participate in the review process and the plenary Sessions, where main decisions about the IPCC work programme are taken and reports are accepted, adopted and approved. The IPCC Bureau Members, including the Chair, are also elected during the plenary Sessions.
- It reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change.
- It does not conduct any research nor does it monitor climate related data or parameters.
- Thousands of scientists from all over the world contribute to the work of the IPCC on a voluntary basis. Review is an essential part of the IPCC process, to ensure an objective and complete assessment of current information. IPCC aims to reflect a range of views and expertise.
- Because of its scientific and intergovernmental nature, the IPCC embodies a unique opportunity to provide rigorous and balanced scientific information to decision makers. By endorsing the IPCC reports, governments acknowledge the authority of their scientific content. The work of the organization is therefore policy-relevant and yet policy-neutral, never policy-prescriptive.

IPCC reports and publications follows strict procedures agreed by the Panel.

***IPCC provides:***

- ✓ Assessment Reports at regular intervals of the state of knowledge on climate change.
- ✓ Special Reports.
- ✓ Methodology Reports.
- ✓ Technical Papers.
- ✓ Supporting Material.

"The latest one is the Fifth Assessment Report which was finalized in November 2014. Till now, five AR have been published in 1990, 1995, 2001, 2007 and 2014." These published materials are composed of full scientific and technical assessment of climate change, generally in three volumes, one for each of the Working Groups of the IPCC, plus a Synthesis Report. IPCC 5th Assessment Report (AR5) –



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Three groups are working to prepare this report:

1. On physical science and climate change.
2. Adaption measures [Impact, Adaption and vulnerability].
3. Mitigation measures.

| Region | Examples of observed vegetation increase highlighted in IPCC AR5 WG2 Summary for Policymakers |
|---|---|
| Europe | ➢ Earlier greening, leaf emergence, and fruiting in temperate and boreal trees<br>➢ Upward shift in tree-line in Europe, beyond changes due to land use<br>➢ Positive yield impacts for some crops mainly in northern Europe, beyond increase due to improved technology |
| Asia | ➢ Changes in plant phenology and growth in many parts of Asia (earlier greening), particularly in the north and east<br>➢ Distribution shifts of many plant and animal species upwards in elevation or polewards, particularly in the north of Asia<br>➢ Advance of shrubs into the Siberian tundra |
| Australasia | ➢ Expansion of monsoon rainforest at expense of savannah and grasslands in northern Australia |
| North America | ➢ Phenology changes and species distribution shifts upward in elevation and northward across multiple taxa |
| Polar regions | ➢ Increased shrub cover in tundra in North America and Eurasia<br>➢ Advance of Arctic tree-line in latitude and altitude<br>➢ Increased plant species ranges in the West Antarctic Peninsula and nearby islands over the past 50 years |
| Small Islands | ➢ Upward trend in tree-lines and associated fauna on high-elevation islands |

**Key findings**

- ✓ Changes in climate will cause an increase in the rate of $CO_2$ production. Increased uptake by the oceans will increase the acidification of the oceans.
- ✓ Climate change is inevitable challenge, but if we understand the challenge correctly then we can better tackle it.
- ✓ Decreases are very likely in Arctic sea ice cover, Northern Hemisphere spring snow cover, and global glacier volume.
- ✓ Soil moisture will decline globally.
- ✓ Dry regions will become even drier.
- ✓ Global drought.
- ✓ Food shortage.
- ✓ Temperature has risen $0.2^0$ C since Industrial revolution.
- ✓ The global water cycle will change, with increases in disparity between wet and dry regions, as well as wet and dry seasons, with some regional exceptions.
- ✓ The oceans will continue to warm, with heat extending to the deep ocean, affecting circulation patterns.

**New Findings since the Fourth Assessment Report**

- Increase certainty of human influence on climate
- Improved observations and models and increased understanding of many components of the climate system
- New emission scenarios and projections of climate change beyond 2100 to 2300
- Sea level rise projections include ice-sheet dynamical changes
- Estimates of the total allowable global emissions in order to limit temperature rise to e.g. $2^0$C above pre-industrial

## CONTAINING CLIMATE CHANGE

Unimaginable amount of work and unfathomable public awareness campaigns by scientists and activists made governments come together to combat the environmental issues. Starting off with The United Nations Conference on the Human Environment was held in Stockholm, Sweden from June 5–16 in 1972, here's a timeline of mile stones leading up to the U.N. Climate Conference in Paris:



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| |
|---|
| 1972: STOCKHOLM – United Nations Conference on the Human Environment |
| 1987: MONTREAL – Restrict emissions of chemicals damaging the ozone layer. While it doesn't deal with climate change specifically, the Montreal Protocol becomes a model for how to rein in man-made emissions through international agreements. |
| 1988: NEW YORK – The U.N. General Assembly endorses the creation of the Intergovernmental Panel on Climate Change, also set up the same year two U.N. agencies, the World Meteorological Organization and the U.N. Environmental Program. |
| 1990: LONDON – The IPCC releases its first scientific assessment of climate change. warming of the Earth's surface. |
| 1992: RIO DE JANEIRO – World leaders gathering for the first Earth Summit sign the United Nations Framework Convention on Climate Change, the first international treaty aimed at limiting greenhouse gas emissions. However, it sets no binding emissions targets. |
| 1997: KYOTO – The Kyoto Protocol is adopted, setting binding emissions targets for wealthy countries. |
| 2004: MOSCOW – President Vladimir Putin signs a bill confirming Russia's ratification of the Kyoto Protocol. The move means countries representing more than 55 percent of global emissions support the treaty, a condition for it to take effect. |
| 2009: COPENHAGEN – The first attempt to craft a global emissions treaty to replace Kyoto, which is set to expire in 2012, falls apart amid disputes between rich and poor countries over who should do what. Acrimonious negotiations end with a voluntary deal inviting countries to present nonbinding emissions targets for 2020. |
| 2011: DURBAN – U.N. climate talks produce a major breakthrough as countries agree to adopt a universal agreement on climate change in 2015 that would take effect five years later and apply to all of them. |
| 2013: STOCKHOLM – The IPCC says it's "extremely likely" that human influence is the dominant reason for warming temperatures recorded since the mid-20th century. |
| 2015: PARIS – More than 190 governments meet in the French capital to finish what's envisioned as a landmark deal to rein in greenhouse gas emissions after 2020. |

To slow and reverse climate change or prevent the damages climate change can unleash, over decades scientists have come up with measures ranging from modifications in individuals' lifestyles to a whole hosts of strategies and operations taken up by nations and international climate agencies. **A few important ones are :**

ADAPTATION

Adaptation is the pre-emptively taken appropriate action to prevent or minimise the damage the "change in climate" can cause. Well planned, early adaptation action can forestall human tragedies and also adds some stability to an economy. Examples of adaptation measures include:

*Agriculture and Food Supply –*

- Breed crop varieties that are more tolerant of heat, drought, and water logging from heavy rainfall or flooding
- Protect livestock from higher summer temperatures by providing more shade and improving air flow in barns

*Coasts –*

- Promote shore protection techniques and open space preserves that allow beaches and coastal wetlands to gradually move inland as sea level rises.



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- Identify and improve evacuation routes and evacuation plans for low-lying areas, to prepare for increased storm surge and flooding.

*Ecosystems –*

- Protect and increase migration corridors to allow species to migrate as the climate changes.
- Promote land and wildlife management practices that enhance ecosystem resilience.

*Energy –*

- Increase energy efficiency to help offset increases in energy consumption.
- Harden energy production facilities to withstand increased flood, wind, lightning, and other storm-related stresses.

*Human Health –*

- Implement early warning systems and emergency response plans to prepare for changes in the frequency, duration, and intensity of extreme weather events.
- Plant trees and expand green spaces in urban settings to moderate heat increases.

*Water Resources –*

- Improve water use efficiency and build additional water storage capacity.
- Protect and restore stream and river banks to ensure good water quality and safe guard water quantity.

**MITIGATION**

The Intergovernmental Panel on Climate Change (IPCC) defines climate change mitigation as technological change and substitution that reduce resource inputs and emissions per unit of output.

Climate Change Mitigation refers to efforts to reduce or prevent emission of greenhouse gases. Mitigation can mean using new technologies and renewable energies, making older equipment more energy efficient, or changing management practices or consumer behaviour. Efforts underway around the world range from high-tech subway systems to bicycling paths and walkways. Protecting natural carbon sinks like forests and oceans, or creating new sinks through silviculture or green agriculture are also elements of mitigation.

Mitigation strategies will be prudent enough through following domains:

*Agriculture –*

- Type of agriculture, which emits a very low carbon and related contents, will be a definite mitigation strategy and this can be achieved through sustainable and Climate Smart Agriculture.
- Turning agriculture into a brighter shade to ease pressure on the environment.
- Will create opportunities to diversify economies, increase yields, reduce costs, and generate jobs.

*Energy –*

- Shifting to the renewable form of energy such as Solar, Wind, Wave, Tidal and OTEC.
- Renewable energy neither produces Carbon nor the poisonous matters like Nitrous Oxide, Sulphur Oxide, Ozone, Lead and Ammonia.

**NOTE:** Reducing Emissions from Deforestation and forest Degradation (REDD) may offer one of the best possibilities for establishing this type of regime. REDD aims to create financial value for forest carbon storage, while REDD+ goes beyond the programme's initial mission and includes conservation, sustainable forest management, and enhancing forest stocks.



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*Forest –*

- The massive carbon sink of the planet earth must be preserved.
- Halting deforestation.
- Investment in forest-derived goods and assure their equitable and sustainable production.
- Reducing Emissions from Deforestation and forest Degradation (REDD) may offer one of the best possibilities for establishing this type of regime.
- Social forestry, urban forestry, community forestry, and other afforestation measures.

Waste –

Pragmatic waste disposal, recycling and eco-friendly waste to:

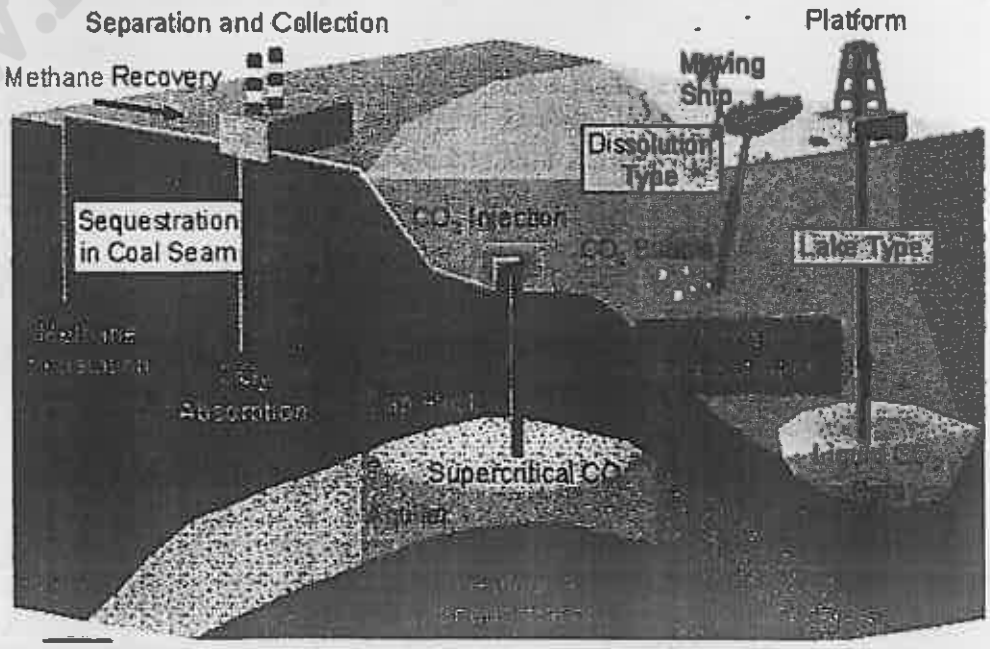
- Recycling will grow with a greening of the waste management sector creates more jobs than it replaces.
- Investment in greener waste management can produce many environmental and economic benefits, including resource savings, nature protection, and employment and business opportunities.

| Adaptation | Mitigation |
|---|---|
| Most common strategies aimed *to cope* with the impact of climate change | Most common strategies *to reduce* with the impact of climate change |
| A focus on adaptation now is sometimes perceived as an acknowledgement of allocating scarce resources to a threat that is not yet perceived as imminent | Includes technical and infrastructural investments in order to reduce the impact of climate change. e.g. turning off lights in empty rooms |
| Requires long-term strategies that may not be popular with government systems which prefer to focus on shorter time frames and quick fixes | Mitigation is a global responsibility, e.g. limiting greenhouse emissions is a global responsibility because the benefits are global, not necessarily regional |
| Can be more localised and region specific where specific realities of climate change occur | Is global and not localised |

- Handling the wastes properly will have substantial negative impact on Methane production.
- Will help in prevention of diseases.
- Prevent pollution of waterbodies and soil.

**CARBON SEQUESTRATION**

Carbon sequestration means capturing carbon dioxide or any other form of carbon from the atmosphere or capturing $CO_2$ from large-scale stationary sources like power plants before it is released to the atmosphere and putting it into storage permanently. The CO2 captured






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and stored (CSS) is rendered unavailable to cause climate changes.

Carbon dioxide is the gas that is usually used to make the "fizz" in soda drinks. It is most soluble at high pressures and low temperatures (eg. soda is normally served cold from cans or bottles). Some $CO_2$ will remain dissolved with the can or bottle open and at room temperature. This is also why colder oceans can absorb more $CO_2$ than warmer waters.

Major types of $CO_2$ sequestration:

- **Ocean Sequestration:** Carbon stored in oceans through direct injection or fertilization.
- **Terrestrial Sequestration:** A large amount of carbon is stored in soils and vegetation, which are our natural carbon sinks. Increasing carbon fixation through photosynthesis, slowing down or reducing decomposition of organic matter, and changing land use practices can enhance carbon uptake in these natural sinks.
- Geologic Sequestration: Natural pore spaces in geologic formations serve as reservoirs for long-term carbon dioxide storage.

Geologic Sequestration Trapping Mechanisms

**Hydrodynamic Trapping:** Carbon dioxide can be trapped as a gas under low-permeability cap rock (much like natural gas is stored in gas reservoirs).

**Solubility Trapping:** Carbon dioxide can be dissolved into a liquid, such as water or oil.

**Mineral Carbonation:** Carbon dioxide can react with the minerals, fluids, and organic matter in a geologic formation to form stable compounds/minerals; largely calcium, iron, and magnesium carbonates.

## CARBON SINKS

A carbon sink is anything that absorbs more carbon that it releases.

SINKS: Forests, soils, oceans and the atmosphere all store carbon and moves between them in a continuous cycle.

Oceans and Forests are the two most important Carbon Sinks on this planet. Alternatively, they are also known as Blue Carbon and Green Carbon.

- Forests act as sources or sinks at different times.
- This separation ends when humans burn coal, oil and natural gas, turning fossil carbon stores into atmospheric carbon.
- This release of carbon from fossil fuel has caused greenhouse gas (GHG) concentrations in the atmosphere to soar to levels more than 30 per cent higher than at the beginning of the industrial revolution.
- We are still adding roughly 6 billion tonnes of carbon per year to the atmospheric carbon cycle, significantly altering the intricate web of carbon fluxes, and as a consequence, altering the global climate.

**NOTE:** Molecules of carbon dioxide are continuously being exchanged between the atmosphere and water through a process called diffusion. Diffusion of carbon dioxide into the oceans accounts for nearly half of the carbon extracted from the atmosphere.

## BLUE CARBON

Blue carbon is the carbon captured by living coastal and marine organisms and stored in coastal ecosystems, i.e. Salt marshes, mangroves, and sea-grass beds.

- They sequester atmospheric CO2 through primary production, and then deposit it in their sediments.
- Most blue carbon is found in the soils or sediments beneath the vegetation.
- Many forms of sea life extract carbon and oxygen from seawater and combine them with calcium to produce calcium carbonate ($CaCO_3$). This is used to produce shells and other



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hard body parts by a variety of organisms, such as coral, clams, oysters, and some microscopic plants and animals.

- Organisms die, their shells and body parts sink to the seabed. Over very long periods of time, enormous numbers of dead organisms can create thick layers of carbonate-rich deposits on the ocean floor.
- Over millions of years, the deposits become buried by more and more carbonates and/or sand or mud, creating heat and pressure that physically and chemically changes them into sedimentary rocks such as limestone, marble, and chalk.

**NOTE:** In the context of climate change, the most important carbon stores are fossil fuel deposits as they have the unique benefit of being buried deep inside the earth, naturally separated from the carbon cycling in the atmosphere.

Although coastal habitats provide a great service in capturing carbon, their destruction affects in two ways

- Carbon sequestration capacity lost.
- Stored carbon is released.

As a result, damaged or destroyed coastal habitats change from being net carbon sinks to net carbon emitters. Unfortunately, coastal habitats around the world are being lost at a rapid rate, largely due to coastal development for housing, ports, and commercial facilities.

## GREEN CARBON

Green carbon is the carbon stored in the **plants and soil of natural ecosystems** and is a vital part of the global carbon cycle.

- Forests, along with their associated soils contain two to three times the amount of carbon in the atmosphere.
- Forests as a carbon sink are often overlooked as a major source of carbon removal from the atmosphere, a process known as carbon sequestration.
- Conversely, deforestation, whether removal of forests by logging or burning, has been a major contribution to atmospheric carbon addition since the mid-Holocene, when the ascent of man to planetary dominance began.
- Massive deforestation at present is most prevalent in places such as the Amazon, Indonesia, Brazil and Borneo. There are two main reasons for land use conversion by deforestation; ranching and agriculture.
- These conversions are done in an attempt to produce short term economic benefit by forcing immediate environmental change.

**BACKGROUND**

At the Kyoto Protocol, emission ticipating country. The intention highlighted in this treaty was to reduce the overall emissions to 1990 levels by the end of 2012. It was stated that countries with high emissions levels can purchase carbon credits from nations that have less of a negative impact on the environment. The reasoning for this is to make an effort to offset the quantity of greenhouse gases released into the air.

## CARBON CREDIT

A carbon credit (often called a carbon offset) is a financial instrument that represents a tonne of $CO_2$ (carbon dioxide) or $CO_2e$ (carbon dioxide equivalent gases) removed or reduced from the atmosphere from an emission reduction project, which can be used, by governments, industry or private individuals to offset damaging carbon emissions that they are generating. Carbon credits are associated with either

- Removing existing $CO_2$ or $CO_2e$ emissions from the atmosphere in the case of carbon sequestration from forests and planting of trees
- Or the reduction of future CO2 or CO2e emissions from



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renewable energy and energy efficiency projects that displace fossil fuel power generation production or industrial processes.

**CARBON FOOTPRINT**

A carbon footprint is the measure of the amount of greenhouse gases, measured in units of carbon dioxide, produced by human activities. A carbon footprint can be measured for an individual or an organization, and is typically given in tons of $CO_2$-equivalent ($CO_2$-eq) per year. The global average carbon footprint is about 4 tons of $CO_2$-eq per year.

An individual's or organization's carbon footprint can be broken down into the primary and secondary footprints.

- The **primary footprint** is the sum of direct emissions of greenhouse gases from the burning of fossil fuels for energy consumption and transportation. More fuel-efficient cars have a smaller primary footprint, as do energy-efficient light bulbs in your home or office. Worldwide, 82% of anthropogenic greenhouse gas emissions are in the form of $CO_2$ from fossil fuel combustion.
- The **secondary footprint** is the sum of indirect emissions of greenhouse gases during the life-cycle of products used by an individual or organization. For example, the greenhouse gases emitted during the production of plastic for water bottles, as well as the energy used to transport the water, contributes to the secondary carbon footprint. Products with more packaging will generally have a larger secondary footprint than products with a minimal amount of packaging.

Although carbon footprints are reported in annual tons of $CO_2$ emissions, they actually are a measure of total greenhouse gas emissions. Each greenhouse gas—carbon dioxide, methane, CFCs, etc.—has a different atmospheric concentration, and a different strength as a greenhouse gas. A potent greenhouse gas with a very small atmospheric concentration can contribute to the overall greenhouse effect just as much as a weaker greenhouse gas with a much larger atmospheric concentration. Because of this variability, carbon footprints are measured in tons of $CO_2$-eq, or the tons of $CO_2$ that would cause the same level of radiative forcing as the emissions of a given greenhouse gas.

**An individual's carbon footprint** is the direct effect their actions have on the environment in terms of greenhouse gas emissions, generally due to transportation, Food, Home heating and cooling etc.

The idea for carbon credits came from the Kyoto Protocol of 1997. This is placing a monetary value on the cost of polluting the air. **A credit is a measure representing one megatonne (a mass equal to 1,000 kilograms) of carbon dioxide.** This is either saved from being emitted or removed from the Earth's atmosphere.

Basically, what these credits do are two-fold, one, they reduce greenhouse emissions and second they help fight climate change or Global Warming .

Carbon credits are a vital component of national and international emissions trading strategies that have been stressed to lessen global warming.

- ❖ They **provide a way** to reduce greenhouse effect emissions on an industrial scale.
- ❖ This is accomplished by capping total emissions every year and letting the market place a monetary value to any shortfall through trading.
- ❖ Credits can be exchanged between national and international businesses.
- ❖ Credits may also be bought and sold in international markets at the current market price. These credits can be used to finance carbon reduction schemes between trading partners.

**CARBON OFFSETTING**

Carbon offsetting is the use of carbon credits to enable businesses to compensate for their emissions, meet their carbon reduction goals and support the move to a low carbon economy.



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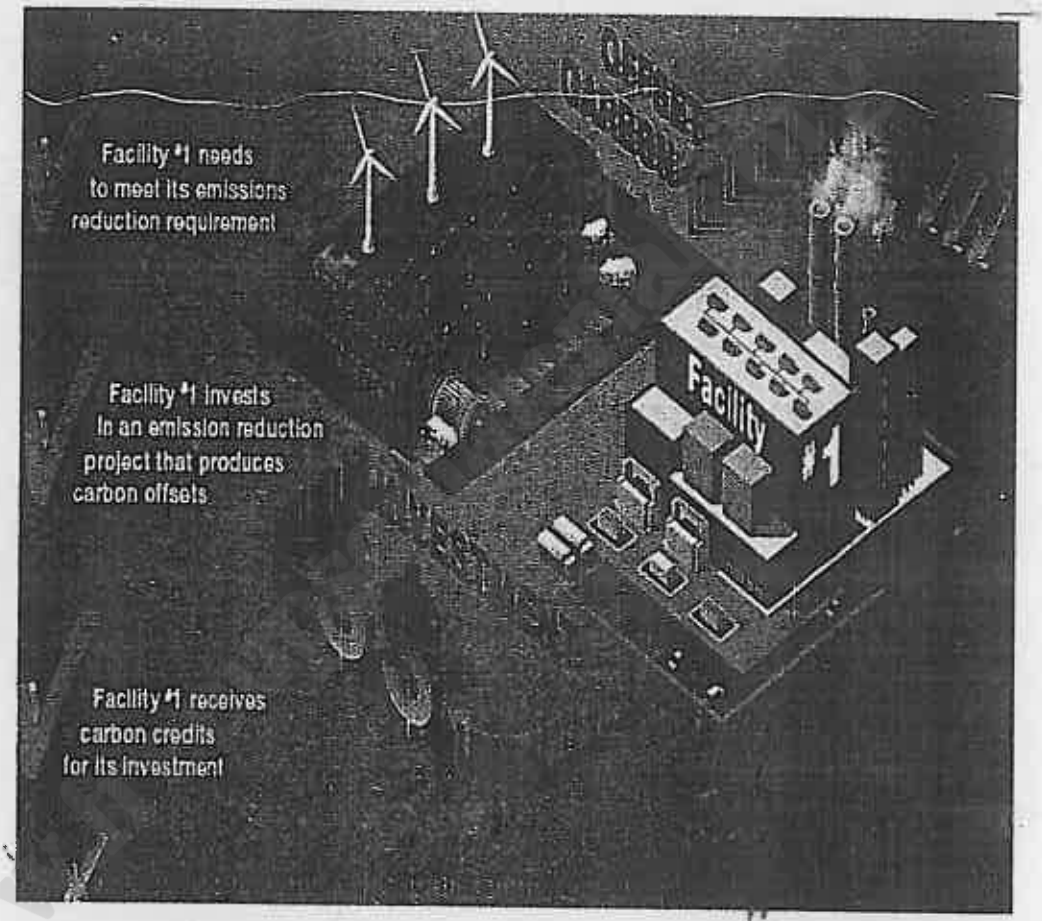
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Businesses compensate for their environmental impact in order to meet increasing stakeholder pressure and are able to demonstrate leadership, differentiate from competitors and engage internal and external stakeholders in their action.

By purchasing carbon credits to offset their emissions, businesses contribute essential finance to renewable energy, forest protection and reforestation projects around the world that would not otherwise be financially viable. These projects play an important role in the mitigation of climate change.

Carbon offsetting works by purchasing carbon credits which are sold in metric tonnes of carbon dioxide equivalent (tonnes $CO_2e$).




- Projects which sell carbon credits include
- wind farms which displace fossil fuel,
- household device projects which reduce fuel requirements for cookstoves and boiling water in low-income households,
- forest protection from illegal logging,
- methane capture from landfill gas and agriculture,
- reforestation for small-hold farmers and
- Run-of-river hydro power and geothermal energy.

## GEO-ENGINEERING

Geoengineering schemes are projects designed to tackle the effects of climate change directly, usually by removing CO2 from the air or limiting the amount of sunlight reaching the planet's surface. Although large-scale geoengineering is still at the concept stage, advocates claim that it may eventually become essential if the world wants to avoid the worst effects of climate change. Critics, by contrast, claim that geoengineering isn't realistic – and may be a distraction from reducing emissions.

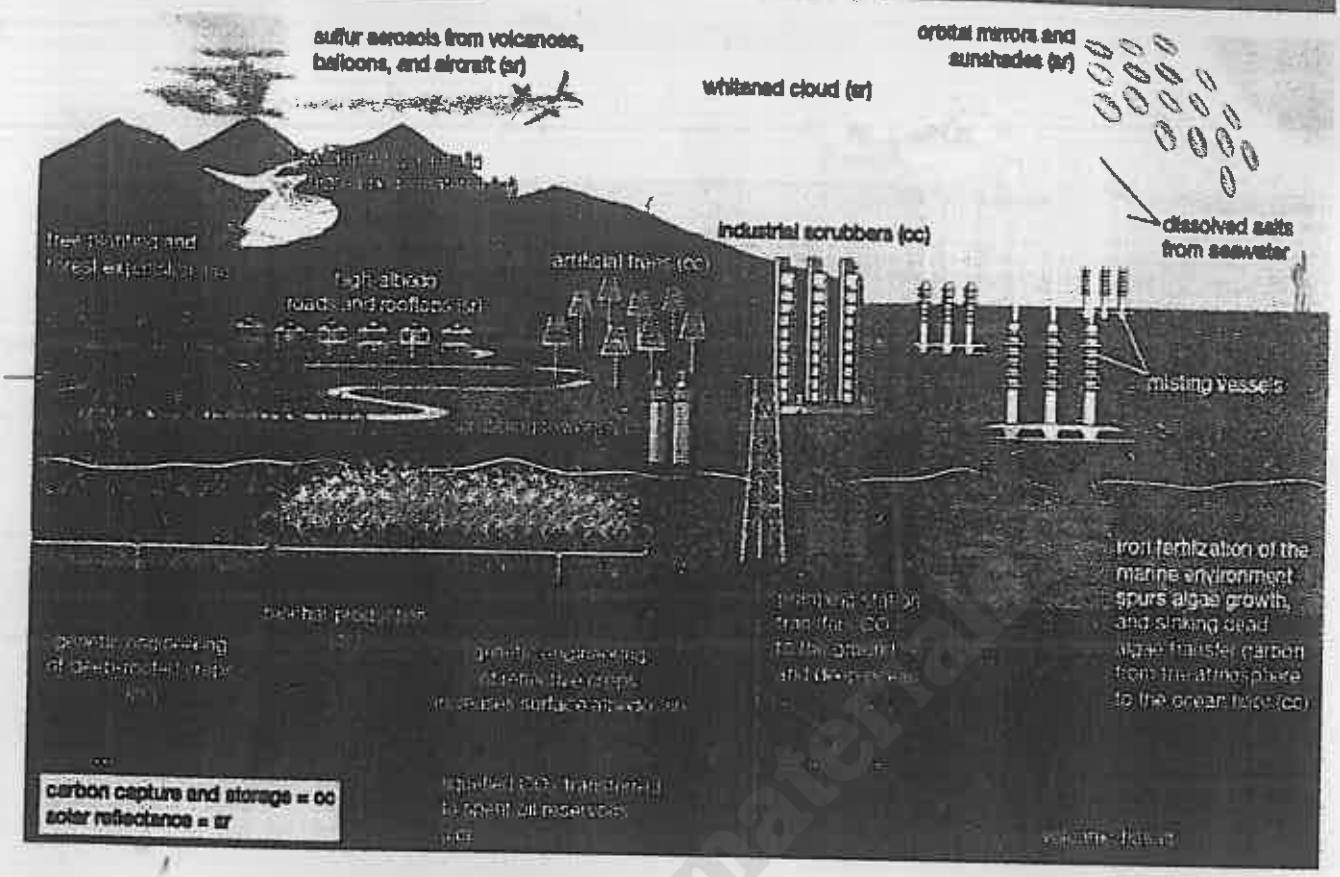


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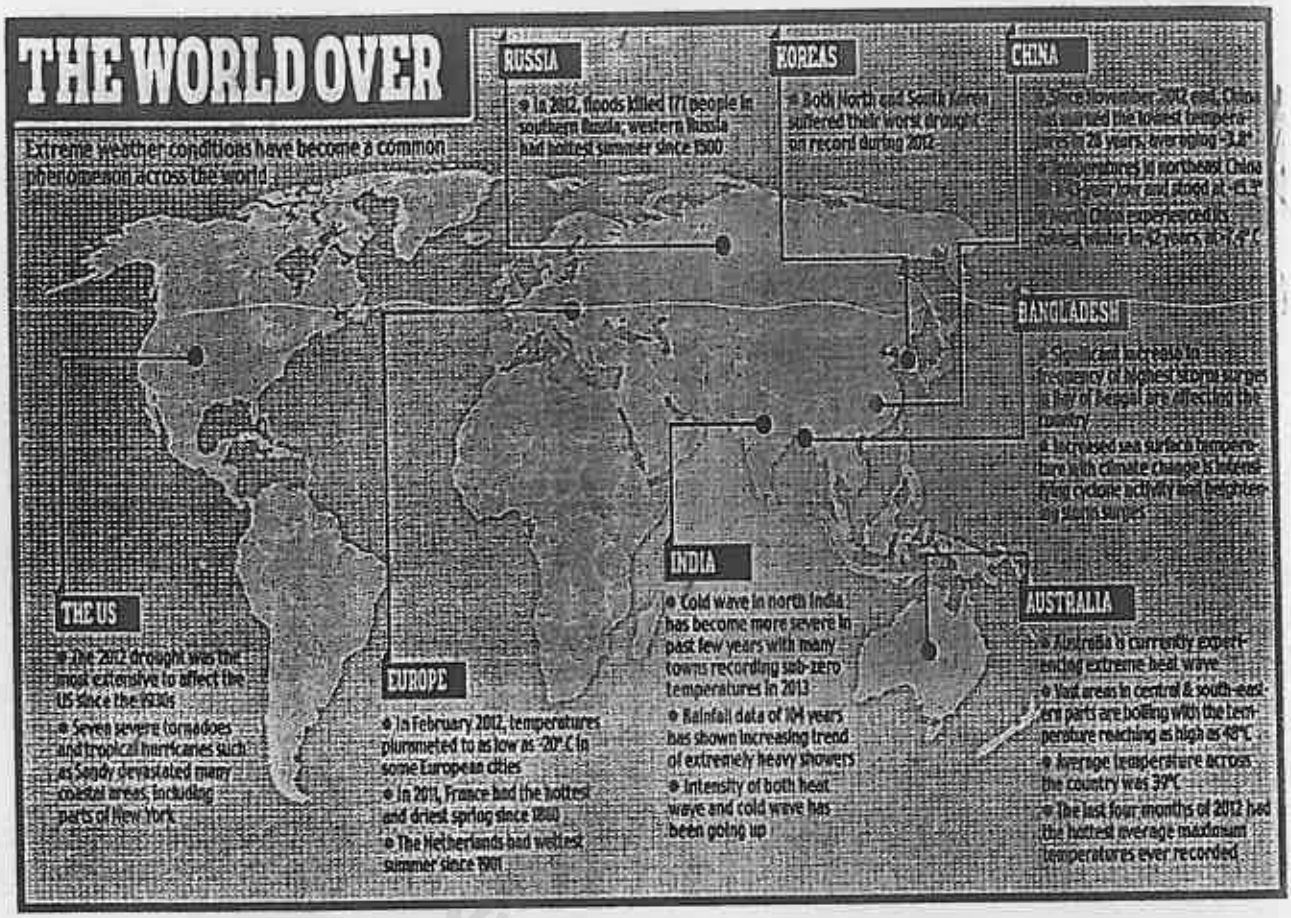


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# CHAPTER – 12
# INDIA AND CLIMATE CHANGE




* India is faced with the challenge of sustaining its rapid economic growth while dealing with the global threat of climate change. This threat emanates from accumulated greenhouse gas emissions in the atmosphere, anthropogenically generated through long-term and intensive industrial growth and high consumption lifestyles in developed countries. While engaged with the international community to collectively and cooperatively deal with this threat, India needs a national strategy to firstly, adapt to climate change and secondly, to further enhance the ecological sustainability of India's development path.
* Climate change may alter the distribution and quality of India's natural resources and adversely affect the livelihood of its people. With an economy closely tied to its natural resource base and climate sensitive sectors such as agriculture, water and forestry, India may face a major threat because of the projected changes in climate.
* Recognizing that climate change is a global challenge, India has engaged actively in multilateral negotiations in the UN Framework Convention on Climate Change, in a positive, constructive and forward-looking manner. India's objective has been to establish an effective, cooperative and equitable global approach based on the principle of common but differentiated responsibilities and respective capabilities, enshrined in the United Nations Framework Convention on Climate Change (UNFCCC). Such an approach must be based on a global vision inspired by Mahatma Gandhi's wise dictum – "The earth has enough resources to meet people's needs, but will never have enough to satisfy people's greed."

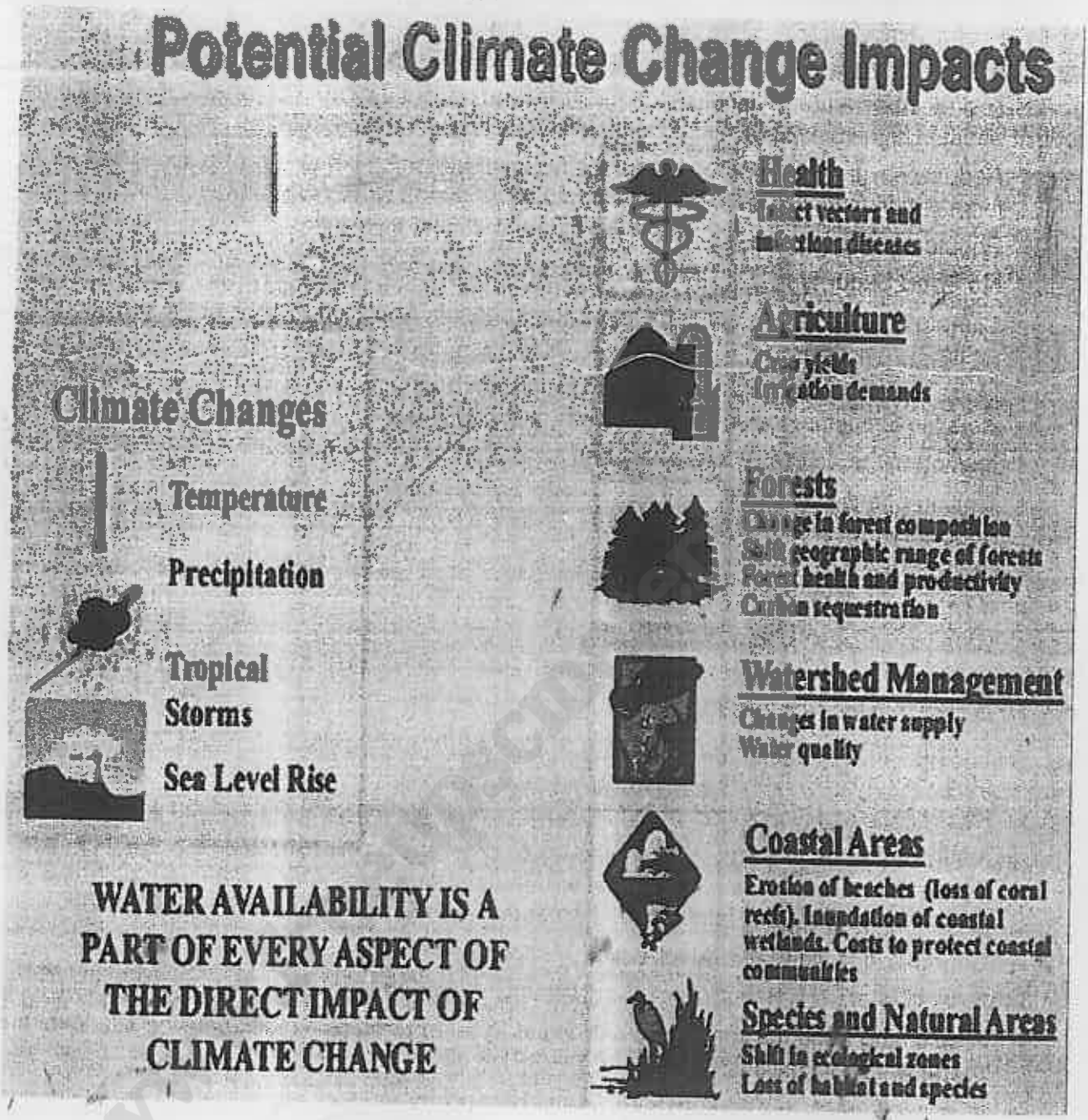


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IMPACT OF CLIMATE CHANGE ON INDIA




- Widespread displacement and extinction of animal populations due to habitat loss will add more species to the 'threatened' and 'extinct' list.
- Thermal expansion also contributes to sea level rise.
- There is evidence that some Himalayan glaciers have retreated significantly since the 19th century.
- The Himalayan glaciers are a source of fresh water for perennial rivers, in particular the Indus, Ganga, and Brahmaputra river systems.
- Spread of diseases (like malaria, etc.) in tropics will put more pressure on the health care sector.
- Scarcity of freshwater during droughts and contamination of freshwater supplies during floods compromise hygiene, thus increasing rates diseases like cholera, diarrhoea etc.



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**Biodiversity Loss**

- Rising temperatures will further affect the physical, chemical and biological properties of fresh water lakes and rivers, with adverse impacts on many individual fresh water species.
- Rising temperature would increase fertilizer requirement for the same production targets and result in higher GHG emissions, ammonia volatilization and cost of crop production.
- Reduced hydroelectric power generation due to abnormal behaviour of glaciers will further increase dependence on fossil fuels.
- Populous cities lying on the coasts will be submerged under the sea.

**No Food Security**

- Climate Change affects crops by impacting irrigation, insolation as well as the prevalence of pests.
- Moderate warming (increase of 1 to 3°C in mean temperature) is expected to benefit crop yields in temperate regions, while in lower latitudes the crops will take a hit.
- Melting of the ice caps and glaciers and subsequent rise in sea level.
- Melting of snow, the amount of arable land in high-latitude region is likely to increase by reduction of the amount of frozen lands.
- Loss of Plankton due to warming of seas will adversely affect marine food chain.
- Increased likelihood of extreme events such as heat wave, flooding, hurricanes, etc. will offset all the economic advancements made.
- Increased frequencies of droughts, floods, storms and cyclones are likely to increase agricultural production variability.
- Increase in the number of deaths due to greater frequency and severity of heat waves and other extreme weather events.
- Flashfloods and Flooding of plains in wet season and drought in dry season will severely affect the country.
- Fertile agricultural lands on the coast will be submerged and saline water intrusions will degrade the neighbouring land. Ground water in such regions will become useless.
- Changes in rainfall patterns will severely impact agriculture.
- Bleaching of Coral Reefs will cause great loss of marine biodiversity.
- Arable land along the coast lines are bound to be reduced as a result of rising sea level and saline water inundations.
- In coastal areas, sea level rise will exacerbate water resource constraints due to increased salinization of groundwater supplies.
- High latitude forests store more carbon than tropical rainforests.
- One third of the world's soil-bound carbon is in taiga and tundra areas.
- When the permafrost melts due to global warming, it releases carbon in the form of carbon dioxide and methane.
- In the 1970s the tundra was a carbon sink, but today, it is a carbon source, thanks to global warming [Global warming leads to more global warming .]

**World Bank Summarizes the extent of impact of climate change as:**

*Extreme Heat*

**What we know** India is already experiencing a warming climate.



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|---|---|
| **What could happen** | Unusual and unprecedented spells of hot weather are expected to occur far more frequently and cover much larger areas.<br>Under 4°C warming, the west coast and southern India are projected to shift to new, high-temperature climatic regimes with significant impacts on agriculture. |
| **What can be done** | With built-up urban areas rapidly becoming "heat-islands", urban planners will need to adopt measures to counteract this effect. |

*Changing Rainfall Patterns*

| | |
|---|---|
| **What we know** | A decline in monsoon rainfall since the 1950s has already been observed. The frequency of heavy rainfall events has also increased. |
| **What could happen** | A 2°C rise in the world's average temperatures will make India's summer monsoon highly unpredictable.<br>At 4°C warming, an extremely wet monsoon that currently has a chance of occurring only once in 100 years is projected to occur every 10 years by the end of the century.<br>An abrupt change in the monsoon could precipitate a major crisis, triggering more frequent droughts as well as greater flooding in large parts of India.<br>India's northwest coast to the south eastern coastal region could see higher than average rainfall.<br>Dry years are expected to be drier and wet years wetter. |
| **What can be done** | Improvements in hydro-meteorological systems for weather forecasting and the installation of flood warning systems can help people move out of harm's way before a weather-related disaster strikes.<br>Building codes will need to be enforced to ensure that homes and infrastructure are not at risk. |

*Droughts*

| | |
|---|---|
| **What we know** | Evidence indicates that parts of South Asia have become drier since the 1970s with an increase in the number of droughts.<br>Droughts have major consequences. In 1987 and 2002-2003, droughts affected more than half of India's crop area and led to a huge fall in crop production. |
| **What could happen** | Droughts are expected to be more frequent in some areas, especially in northwestern India, Jharkhand, Odisha and Chhattisgarh. Crop yields are expected to fall significantly because of extreme heat by the 2040s. |
| **What can be done** | Investments in R&D for the development of drought-resistant crops can help reduce some of the negative impacts. |

*Groundwater*

| | |
|---|---|
| **What we know** | More than 60% of India's agriculture is rain-fed, making the country highly dependent on groundwater.<br>Even without climate change, 15% of India's groundwater resources are over- |

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exploited.

**What could happen** Although it is difficult to predict future ground water levels, falling water tables can be expected to reduce further on account of increasing demand for water from a growing population, more affluent life styles, as well as from the services sector and industry.

**What can be done** The efficient use of ground water resources will need to be incentivized.

*Glacier Melt*

**What we know** Glaciers in the northwestern Himalayas and in the Karakoram range - where westerly winter winds are the major source of moisture - have remained stable or even advanced.

On the other hand, most Himalayan glaciers - where a substantial part of the moisture is supplied by the summer monsoon - have been retreating over the past century.

**What could happen** At 2.5°C warming, melting glaciers and the loss of snow cover over the Himalayas are expected to threaten the stability and reliability of northern India's primarily glacier-fed rivers, particularly the Indus and the Brahmaputra. The Ganges will be less dependent on melt water due to high annual rainfall downstream during the monsoon season.

The Indus and Brahmaputra are expected to see increased flows in spring when the snows melt, with flows reducing subsequently in late spring and summer.

Alterations in the flows of the Indus, Ganges, and Brahmaputra rivers could significantly impact irrigation, affecting the amount of food that can be produced in their basins as well as the livelihoods of millions of people (209 million in the Indus basin, 478 million in the Ganges basin, and 62 million in the Brahmaputra basin in the year 2005).

**What can be done** Major investments in water storage capacity would be needed to benefit from increased river flows in spring and compensate for lower flows later on.

*Sea level rise*

**What we know** Mumbai has the world's largest population exposed to coastal flooding, with large parts of the city built on reclaimed land, below the high tide mark. Rapid and unplanned urbanization further increases the risks of sea water intrusion.

**What could happen** With India close to the equator, the sub-continent would see much higher rises in sea levels than higher latitudes.

Sea-level rise and storm surges would lead to saltwater intrusion in the coastal areas, impacting agriculture, degrading groundwater quality, contaminating drinking water, and possibly causing a rise in diarrhoea cases and cholera outbreaks, as the cholera bacterium survives longer in saline water.

Kolkata and Mumbai, both densely populated cities, are particularly vulnerable to the impacts of sea-level rise, tropical cyclones, and riverine flooding.



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**What can be done** Building codes will need to be strictly enforced and urban planning will need to prepare for climate-related disasters.

Coastal embankments will need to be built where necessary and Coastal Regulation Zone codes enforced strictly.

*Agriculture and food security*

**What we know** Even without climate change, world food prices are expected to increase due to growing populations and rising incomes, as well as a greater demand for biofuels.

**Rice:** While overall rice yields have increased, rising temperatures with lower rainfall at the end of the growing season have caused a significant loss in India's rice production. Without climate change, average rice yields could have been almost 6% higher (75 million tons in absolute terms).

**Wheat:** Recent studies shows that wheat yields peaked in India and Bangladesh around 2001 and have not increased since despite increasing fertilizer applications. Observations show that extremely high temperatures in northern India - above 34°C - have had a substantial negative effect on wheat yields, and rising temperatures can only aggravate the situation.

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9540720216, 9650843448

**What could happen** Seasonal water scarcity, rising temperatures, and intrusion of sea water would threaten crop yields, jeopardizing the country's food security.

Should current trends persist, substantial yield reductions in both rice and wheat can be expected in the near and medium term?

Under 2°C warming by the 2050s, the country may need to import more than twice the amount of food-grain than would be required without climate change.

**What can be done** Crop diversification, more efficient water use, and improved soil management practices, together with the development of drought-resistant crops can help reduce some of the negative impacts.

*Energy Security*

**What we know** Climate-related impacts on water resources can undermine the two dominant forms of power generation in India - hydropower and thermal power generation - both of which depend on adequate water supplies to function effectively.

To function at full efficiency, thermal power plants need a constant supply of fresh cool water to maintain their cooling systems.

**What could happen** The increasing variability and long-term decreases in river flows can pose a major challenge to hydropower plants and increase the risk of physical damage from landslides, flash floods, glacial lake outbursts, and other climate-related natural disasters.

Decreases in the availability of water and increases in temperature will pose major risk factors to thermal power generation.

**What can be done** Projects will need to be planned taking into account climatic risks.



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*Water Security*

| | |
|---|---|
| **What we know** | Many parts of India are already experiencing water stress. Even without climate change, satisfying future demand for water will be a major challenge.<br>Urbanization, population growth, economic development, and increasing demand for water from agriculture and industry are likely to aggravate the situation further. |
| **What could happen** | An increase in variability of monsoon rainfall is expected to increase water shortages in some areas.<br>Studies have found that the threat to water security is very high over central India, along the mountain ranges of the Western Ghats, and in India's north-eastern states. |
| **What can be done** | Improvements in irrigation systems, water harvesting techniques, and more-efficient agricultural water management can offset some of these risks. |

*Health*

| | |
|---|---|
| **What we know** | Climate change is expected to have major health impacts in India- increasing malnutrition and related health disorders such as child stunting - with the poor likely to be affected most severely. Child stunting is projected to increase by 35% by 2050 compared to a scenario without climate change.<br>Malaria and other vector-borne diseases, along with and diarrheal infections which are a major cause of child mortality, are likely to spread into areas where colder temperatures had previously limited transmission.<br>Heat waves are likely to result in a very substantial rise in mortality and death, and injuries from extreme weather events are likely to increase. |
| **What could happen** | Health systems will need to be strengthened in identified hotspots. |
| **What can be done** | Improvements in hydro-meteorological systems for weather forecasting and the installation of flood warning systems can help people move out of harm's way before a weather-related disaster strikes.<br>Building codes will need to be enforced to ensure that homes and infrastructure are not at risk. |

*Migration and conflict*

| | |
|---|---|
| **What we know** | South Asia is a hotspot for the migration of people from disaster-affected or degraded areas to other national and international regions.<br>The Indus and the Ganges-Brahmaputra-Meghna Basins are major trans boundary rivers, and increasing demand for water is already leading to tensions among countries over water sharing. |
| **What could happen** | Climate change impact on agriculture and livelihoods can increase the number of climate refugees. |
| **What can be done** | Regional cooperation on water issues will be needed. |



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***Economic survey 2015-16 listed some growing concerns as:***

1. Climate change and emerging scarcities will necessitate a focus on "more for less", and hence redressing the current system of incentives and subsidies, which encourages using more inputs such as fertilizer, water, and power, to the detriment of soil quality, health and the environment.
2. Rapid industrialization and climate change are raising the scarcity value of land and water, respectively.

## INDIA AND UNFCCC

*As per the Second National Communication (NATCOM) to the UNFCCC in 2012, it was projected:*

- The emissions indicate an annual growth of 4.2% from the levels in 1994. Whereas India's CO2 emissions are only about 4% of total global CO2 emissions and much less if the historical concentrations are taken into account.
- That the annual mean surface air temperature rise by the end of the century ranges from 3.5 c to 4.3 c.
- The sea level along the Indian coast has been rising at the rate of about 1.3 mm/year on an average.
- Climate change projections are likely to impact human health, agriculture, water resources, natural ecosystems, and biodiversity.

## UPDATE TO NATCOM

India submitted its first Biennial Update Report (BUR) to the United Nations Framework Convention on Climate Change (UNFCCC), towards fulfilment of the reporting obligation under the Convention. As per the provisions of the Convention, countries need to periodically provide information in the form of their National Communication.

BUR contains national GHG inventory of India for the year 2010, prepared in accordance with the guidelines of Intergovernmental Panel on Climate Change (IPCC).

The inventory covers:

**Five categories** :

a) Agriculture.
b) Energy.
c) Industrial processes and Product use (IPPU).
d) Land-use, Land-use, Change and Forestry (LULUCF).

***WHAT'S NATCOM***

Parties submit their national reports to the UNFCCC secretariat in Bonn, Germany, which makes them publicly available. Following a request from the COP, the secretariat synthesizes the most important information from submitted national communications in separate reports for Annex I and non-Annex I Parties, and in turn submits these reports to the Subsidiary Bodies and the COP for consideration.

1) BUR has been prepared by the Ministry of Environment, Forest and Climate Change under its NATCOM project funded by Global Environment Facility (GEF) through UNDP.
2) Several studies were carried out by 17 national-level institutions, including CSIR laboratories (CIMFR, CRRI, IIP, NEERI and NPL), ICAR institutes (CRIDA, IARI, NDRI), organizations of the MoEFCC (FSI and ICFRE), premier educational institutions (IIM Ahmedabad and IISc), Non-governmental research organizations (TERI and IRADe) and other institutions (CII, EESL and NRSC) involving more than 60 researchers along with inputs from various Ministries, Government departments and independent experts.
3) BUR has also undergone multitier review process and has been approved by the Union Cabinet.



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e) Waste.

**Six greenhouse gases** :

a) Carbon dioxide (CO2).
b) Hydrofluorocarbons (HFCs).
c) Methane (CH4).
d) Nitrous Oxide (N2O).
e) Perfluorocarbons (PFCs)
f) Sulphur Hexafluoride(SF6)

***As per BUR***

- ✓ India emitted 2,136.84 million tonnes of CO2 equivalent greenhouse gases in 2010. Energy sector was the prime contributor to emissions and with 71% of total emissions in 2010.
- ✓ Energy sector includes - electricity production, fuel combustion in industries, transport and fugitive emissions. Industrial processes and product use contributed 8%; agriculture and waste sectors contributed 18% and 3% respectively to the national GHG inventory.
- ✓ About 12% of emissions were offset by carbon sink action of forests and croplands, considering which the national GHG emissions are arrived at a total of 1,884.31 million tonnes of CO2 equivalent.
- ✓ India's per capita GHG emission in 2010 was 1.56 tco2 equivalent, which is less than one- third of the world's per capita emissions and far below than many developed and developing countries. A reduction of emission intensity of GDP by about 12% between 2005 and 2010 has been achieved against our voluntary pledge to reduce the emission intensity of its GDP by 20–25 per cent by 2020, compared with the 2005 level.

*Summary of GHGs* :

BUR has different sections elaborating various aspects on climate change in the country, such as institutional arrangements to implement the reporting process, national circumstances in which country is responding to climate change, national greenhouse gas inventory for 2010; initiatives of the government to tackle the problem of climate change along with domestic arrangements to measure, report and verify these programs. A section on finance, technology and capacity-building needs and support received has also been provided.

**As per the rules of UNFCCC**

- ✓ BURs are subjected to an international process known as International Consultation and Analysis (ICA). It is a process that includes international scrutiny of BUR in a manner that is non-intrusive, non-punitive and respectful of national sovereignty. All BURs are subjected to ICA process.
- ✓ Developed countries are required to submit a report known as the Biennial Report (BR), which is to be submitted every alternate year and is subjected to International Analysis and Review (IAR). Paris Agreement calls for developing country Parties to submit their first biennial update reports as soon as possible.
- ✓ India had submitted its first national communication in 2004 and second national communication in 2012. The UNFCCC in its sixteenth session of conference of Parties (COP) had decided that the developing countries will submit updates to their national communication on biennial basis in the form of 'Biennial Update Report'. The scope of a BUR is to provide an update to the latest National Communication submitted by the country to the UNFCCC. Accordingly, India's first BUR is an update to the Second National Communication. China, world's largest emitter of greenhouse gases is yet to submit its BUR.



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| | $CO_2$ emission | $CO_2$ removal | $CH_4$ | $N_2O$ | HFC-134a | HFC 23 | $CF_4$ | $C_2F_6$ | $SF_6$ | $CO_2$ equivalent |
|---|---|---|---|---|---|---|---|---|---|---|
| TOTAL without LULUCF (Gg) | 1574362.14 | 0.00 | 19823.15 | 368.92 | 0.00 | 1.43 | 2.13 | 0.58 | 0.0042 | 2136841.24 |
| TOTAL with LULUCF (Gg) | 1632623.84 | 314586.77 | 19776.18 | 370.79 | 0.00 | 1.43 | 2.13 | 0.58 | 0.0042 | 1884309.46 |
| 1. ENERGY | 1441882.67 | 0.00 | 2534.30 | 48.44 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1510120.76 |
| A. Fuel Combustion Activities | 1441882.67 | 0.00 | 204.36 | 48.44 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1461192.10 |
| B. Fugitive Emission from fuels | 0.00 | 0.00 | 2329.94 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 48928.66 |
| 2. Industrial Processes and Product Use | 132479.47 | 0.00 | 22.97 | 8.11 | 0.00 | 1.43 | 2.13 | 0.58 | 0.0042 | 171682.87 |
| A. Minerals | 104545.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 104545.23 |
| B. Chemicals | 19906.71 | 0.00 | 21.46 | 8.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 22470.76 |
| C Metal Production | 6824.27 | 0.00 | 1.52 | 0.00 | 0.00 | 0.00 | 2.13 | 0.58 | 0.0042 | 26171.33 |
| D. Other Production | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.43 | 0.00 | 0.00 | 0.00 | 16712.28 |
| E. Non energy product use | 1003.27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1003.27 |
| 3. AGRICULTURE | 0.00 | 0.00 | 14612.78 | 268.70 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 399165.14 |
| A. Enteric Fermentation | | | 10811.12 | | | | | | | 227033.52 |
| B. Manure Management | | | 130.60 | 0.00 | | | | | | 2768.11 |
| C. Rice Cultivation | | | 3398.47 | | | | | | | 71367.95 |
| D. Agricultural Soils | | | | 261.55 | | | | | | 81080.50 |
| F. Field Burning of Agricultural Residues | | | 272.59 | 7.07 | | | | | | 7015.06 |
| 4. LULUCF | 58261.70 | 314586.77 | 153.02 | 1.87 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -252531.78 |
| A. Forestland | | 203829.60 | 153.02 | 1.87 | | | | | | -200036.31 |
| B. Cropland | | 110757.17 | | | | | | | | -110757.17 |
| C.Grassland | 55646.16 | | | | | | | | | 55646.16 |
| D. Settlement | 2615.54 | | | | | | | | | 2615.54 |
| 6. WASTE | 0.00000 | 0.0000 | 2453.10 | 43.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 66052.47 |
| A. Solid Waste Disposal on Land | 0.00 | 0.00 | 664.94 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 13963.74 |
| B. Waste water Handling | 0.00 | 0.00 | 1788.16 | 43.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 51088.73 |
| Memo Item (not accounted in total emissions) | 589760.13 | 0.00 | 0.05 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 589793.42 |
| International Bunkers | 3627.13 | 0.00 | 0.05 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3660.42 |
| $CO_2$ from Biomass | 586,133.00 | | | | | | | | | 586,133.00 |

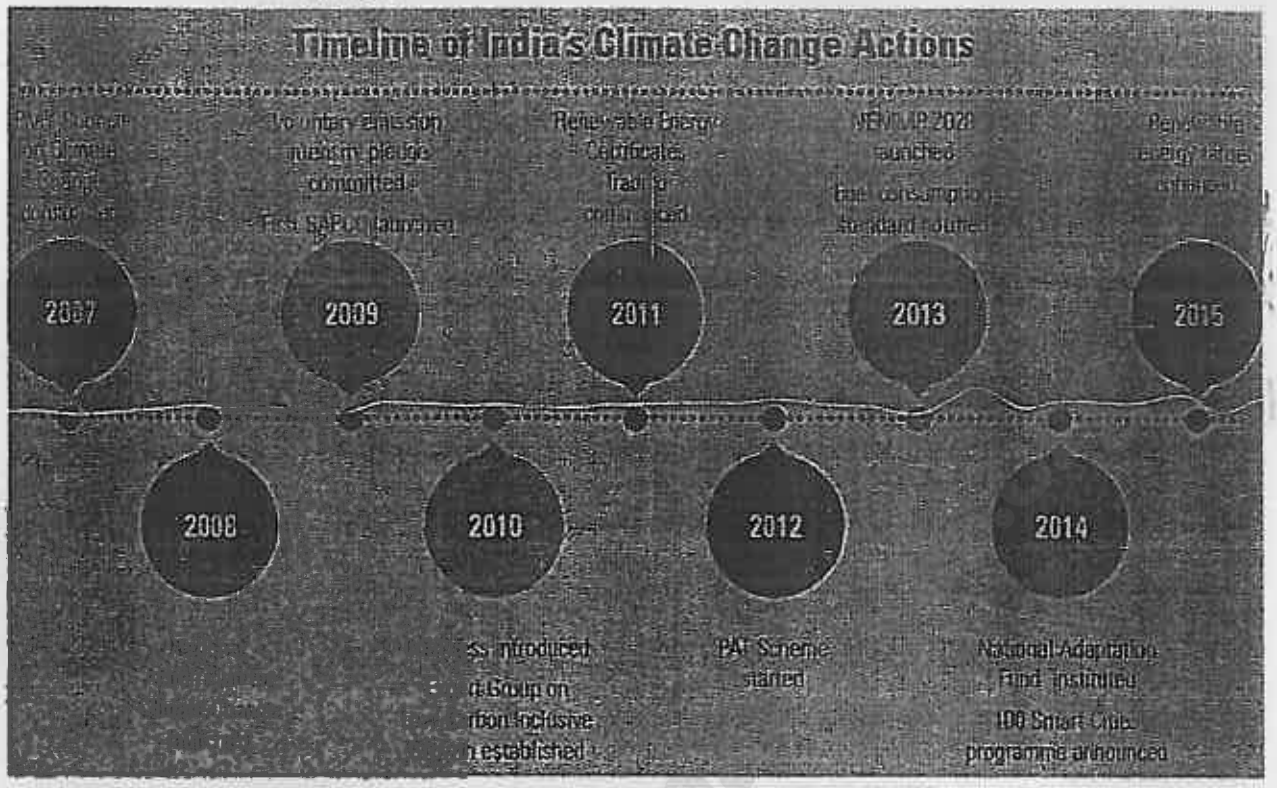


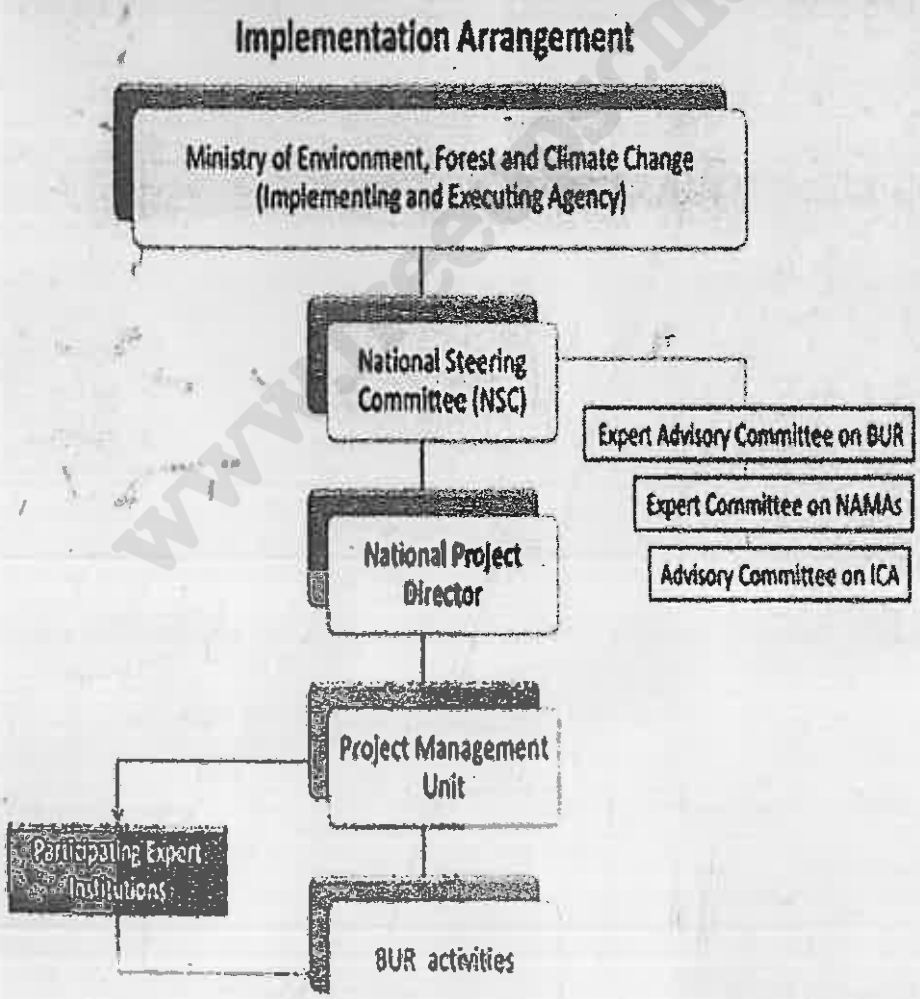
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## ACTIONS FOR ADAPTATION AND MITIGATION:




In order to keep its pace with the global efforts India has made her presence . felt in shouldering the responsibility of conserving the environment. India has also pledged both at the national as well as international platforms to volunteer itself to be a part of the solution for climate change phenomenon. BUR showcases a range of climate-friendly measures initiated through eight National Missions under National Action Plan on Climate Change and other programs such as Integrated Power Development Scheme, Renewable Purchase Obligations, enhancement of cess on coal, Perform Achieve and Trade Scheme and National



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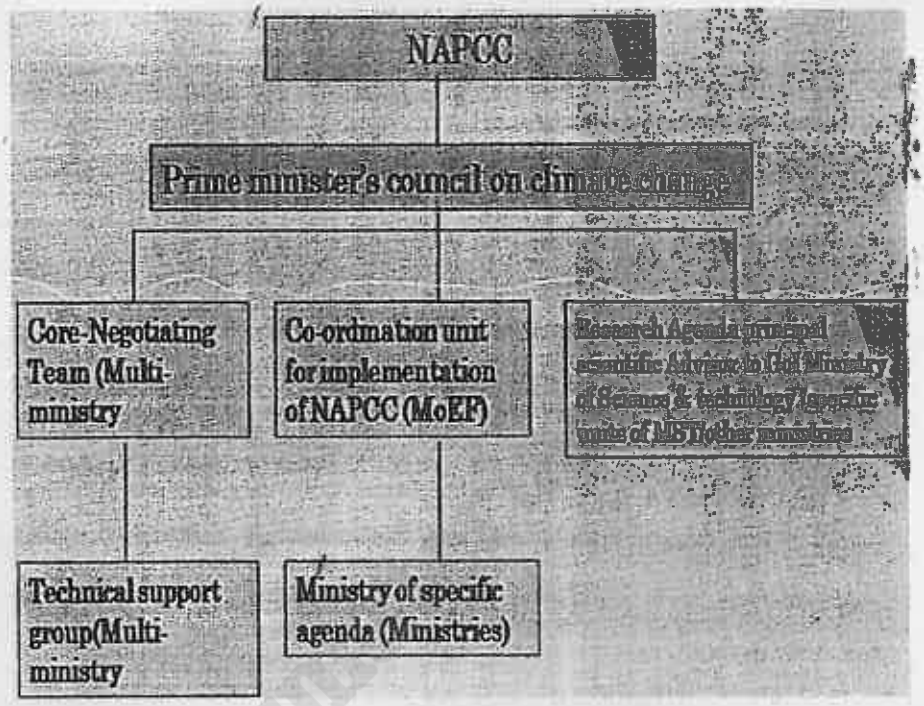
Program for LED based lighting. At the national level, 137 and at state level 286 policies and measures relevant to climate change have been mapped in the report on non-exhaustive basis.

## GOVERNMENTAL SETUP

### Prime Minister's Council on Climate Change

The former Prime Minister, Dr. Manmohan Singh, had set up a High Level advisory group on climate change issues which included:

1. Government Representatives
2. Non-Government Members.




**Functions of council:**

- The Council coordinates National Action Plans for assessment, adaptation and mitigation of Climate Change.
- It also advises the Government on proactive measures that can be taken by India to deal with the challenge of Climate Change.
- It will also facilitate inter-ministerial coordination and guide policy in relevant areas.

### Twelfth Five-Year Plan and Climate Change

The Government has a domestic mitigation goal of reducing emissions intensity of Gross Domestic Product (GDP) by 20-25% by 2020 in comparison with 2005 level. The energy intensity of India's output has shown a declining trend owing to improvements in energy efficiency, autonomous technological changes and economical use of energy. This domestic goal and the objectives of the National Action Plan on Climate Change are proposed to be achieved through a sustainable development strategy under the Twelfth Five-Year Plan. Several thrust areas have been identified in the Twelfth Five-Year Plan for this purpose and a coordinated initiative to identify Nationally Appropriate Mitigation Actions and implement them towards this end will be taken during the Plan period. At the initiative of the Ministry, Planning Commission has recognized Climate Change as a major area of environmental intervention.

**Climate Change Action Programme (CCAP)** - a new thematic/umbrella Scheme has been approved by the Planning Commission for implementation during the 12th Five year Plan. The scheme aims at advancing scientific research, information and assessment of the phenomenon of Climate Change, building an institutional and analytical capacity for research and studies in the area of Climate Change, and supporting domestic actions to address Climate Change through specific programmes and actions at the national and state level. The scheme comprises of eight activities, of which, three relate to scientific studies on Climate Change, two to institution and capacity building and three others to domestic and international actions



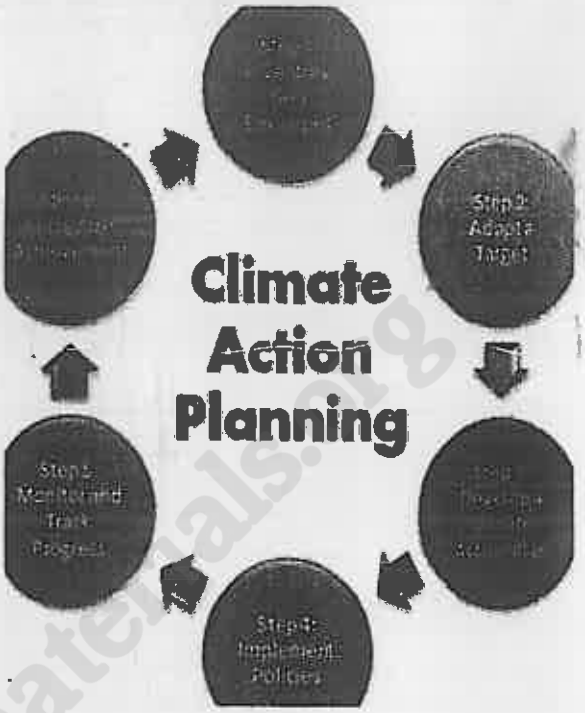
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## MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE:

Taking into account the contemporary trends related to issues pertaining to climate change the term "Climate Change" has been added to the Ministry changing its nomenclature to "Ministry of Environment, Forest and Climate Change" (MoEFCC).




The Ministry is the nodal agency for

1. The United Nations environment programme (UNEP).
2. South Asia co-operative environment programme (SACEP).
3. International centre for integrated Mountain development (ICIMOD).
4. The United Nations conference on environment and Development (UNCED).

The Ministry also coordinates, on matters pertaining to environment, with bodies such as the

a) Multilateral
   1. Commission on Sustainable Development (CSD),
   2. Global Environment Facility (GEF)

b) Regional
   1. Economic and Social Council for Asia and Pacific (ESCAP) and
   2. South Asian Association for Regional Cooperation (SAARC)

**Key Focuses**

1. **Water:** The National Water Policy (2002) stresses that non-conventional methods for utilization of water, including inter-basin transfers, artificial recharge of groundwater, and desalination of brackish or sea water, as well as traditional water conservation practices like rainwater harvesting, including roof-top rainwater harvesting, should be practised to increase the utilizable water resources.
2. **Health:** The prime objective present of health programmes is the surveillance and control of vector borne diseases such as Malaria, Kala-azar, Japanese Encephalitis, Filaria and Dengue.
3. **Forestry:** Forest Conservation Act of 1980, which aimed at stopping the clearing and degradation of forests through a strict, centralized control of the rights to use forest land and mandatory requirements of compensatory afforestation in case of any diversion of forest land for any non-forestry purpose. An aggressive afforestation and sustainable forest management program, resulted in annual reforestation of 1.78 mha during 1985-1997, and is currently 1.1 mha annually.
4. **Disaster Management:** The National Disaster Management programme provides grants-in-aid to victims of weather related disasters, and manages disaster relief operations. It also supports proactive disaster prevention programmes, including dissemination of information and training of disaster-management staff. Programmes also provide for emergency medical relief in the case of natural calamities, and to train and develop human resources for these tasks.



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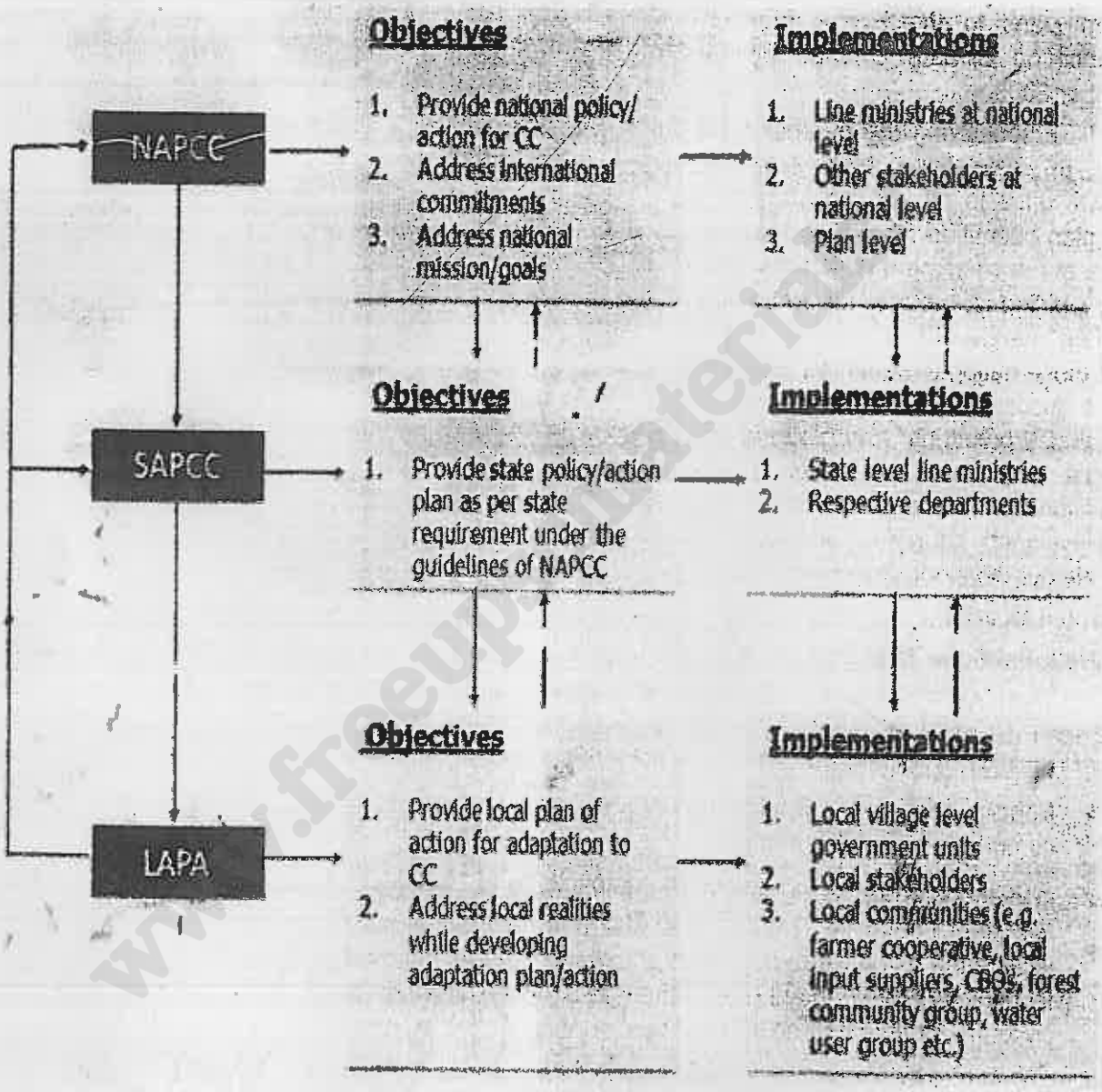
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5. **Coastal Regions:** in coastal regions, restrictions have been imposed in the area between 200m and 500m of the HTL (high tide line) □ special restrictions have been imposed in the area up to 200m to protect the sensitive coastal ecosystems and prevent their exploitation.
6. **Agriculture:** Two risk-financing programs support adaptation to climate impacts. The Crop Insurance Scheme- supports the insurance of farmers against climate risks, and the Credit Support Mechanism- facilitates the extension of credit to farmers, especially for crop failure due to climate variability

## INDIA'S STRATEGY FOR ADDRESSING CLIMATE CHANGE




### National Environment Policy National Environment Policy, 2006

It outlines essential elements of India's response to Climate Change:

- Adherence to principle of common but differentiated responsibility and respective capabilities of different countries.
- Identification of key vulnerabilities of India to Climate Change, in particular impacts on water resources, forests, coastal areas, agriculture and health.



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- Assessment of the need for adaptation to Climate Change and encouragement to the Indian Industry to participate in the Clean Development Mechanism (CDM).

**National Action Plan on Climate Change (NAPCC)**

On June 30, 2008, the then Prime Minister Manmohan Singh released India's first National Action Plan on Climate Change (NAPCC) outlining existing and future policies and programs addressing climate mitigation and adaptation. The plan identified **eight core "national missions"** running through 2007 and directed Ministries to submit detailed implementation plans to the Prime Minister's Council on Climate Change by December 2008.




Emphasizing the overriding priority of maintaining high economic growth rates to raise living standards, the plan "identified measures that promote our development objectives while also yielding co-benefits for addressing climate change effectively." It asserted that these national measures would be more successful with assistance from developed countries, and pledged that India's per capita greenhouse gas emissions "will at no point exceed that of developed countries even as we pursue our development objectives."

**National Missions**

**1. National Solar Mission:**

The NAPCC aims to promote the development and use of solar energy for power generation and other uses with the ultimate objective of making solar competitive with fossil-based energy options. The plan includes:

- Specific goals for increasing use of solar thermal technologies in urban areas, industry, and commercial establishments;
- A goal of increasing production of photovoltaics to 1000 MW/year; and
- A goal of deploying at least 1000 MW of solar thermal power generation. Other objectives include the establishment of a solar research centre, increased international collaboration on technology development, strengthening of domestic manufacturing capacity, and increased government funding and international support.
- The country's National solar Mission is being scaled up five-fold to 1,00,000 megawatts by 2022 from 2015

**2. National Mission for Enhanced Energy Efficiency:**

Current initiatives are expected to yield savings of 10,000 MW by 2012. Building on the Energy Conservation Act 2001, the plan recommends:

- Mandating specific energy consumption decreases in large energy-consuming industries, with a system for companies to trade energy-savings certificates;
- Energy incentives, including reduced taxes on energy-efficient appliances; and



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- Financing for public-private partnerships to reduce energy consumption through demand-side management programs in the municipal, buildings and agricultural sectors.

**3. National Mission on Sustainable Habitat :**

To promote energy efficiency as a core component of urban planning, the plan calls for:

- Extending the existing Energy Conservation Building Code;
- A greater emphasis on urban waste management and recycling, including power production from waste;
- Strengthening the enforcement of automotive fuel economy standards and using pricing measures to encourage the purchase of efficient vehicles; and
- Incentives for the use of public transportation.

**4. National Water Mission :**

With water scarcity projected to worsen as a result of climate change, the plan sets a goal of a 20% improvement in water use efficiency through pricing and other measures.

**5. National Mission for Sustaining the Himalayan Ecosystem :**

The plan aims to conserve biodiversity, forest cover, and other ecological values in the Himalayan region, where glaciers that are a major source of India's water supply are projected to recede as a result of global warming.

**6. National Mission for a "Green India" :**

Goals include the afforestation of 6 million hectares of degraded forest lands and expanding forest cover from 23% to 33% of India's territory.

***National Seabuckthorn Initiative***

The Ministry of Environment & Forests and the Defence Research and Development Organisation have jointly launched a major new national initiative for seabuckthorn cultivation in the high altitude, cold desert ecosystems of the country. Seabuckthorn (local name in Ladakh: Tsemarang; Himachal Pradesh: Chharma; Uttarakhand: Ames/Chuk; NE region: Tare/Taroobo has multipurpose medicinal and nutritional properties, besides being useful for soil conservation and nitrogen fixation (see below) but has for long been considered a humble shrub of the Himalayas. This workshop brought together for the first time various stakeholders under one platform to discuss strategies for cultivation and commercialisation of seabuckthorn. This will not only benefit the local community secure livelihoods but will ensure conservation of the fragile ecosystem in the high altitudes. It is noteworthy that India currently has only 11,500 ha under seabuckthorn cultivation, compared to 1.1 million ha in China, 30,000 ha in Mongolia and 47,000 ha in Russia. ***A Leh Declaration*** was adopted at the conclusion of the workshop, and the following important decisions were taken:

- A National Seabuckthorn Initiative was established. This was based on a consortium approach, bringing together the existing work being done by various agencies including DIHAR, ICFRE, CSIR, ICAR, DBT, the National Horticulture Board and the National Medicinal Plants Board. Specific, complementary 'work programmes' was identified for each institute, so that there is an integrated programme and no duplication of work.
- An overarching national objective of the initiative was to bring one million hectares of land area under seabuckthorn cultivation by the year 2020.
- An Action Plan was prepared over the next 2 months, under the leadership of DIHAR and Ministry of Environment & Forests (MoEF). A website to facilitate collaboration was launched within 30 days.
- An initial allocation of Rs. 25 crores was made for the initiative in 2011 for initial preparatory work, awareness and pilot programmes.



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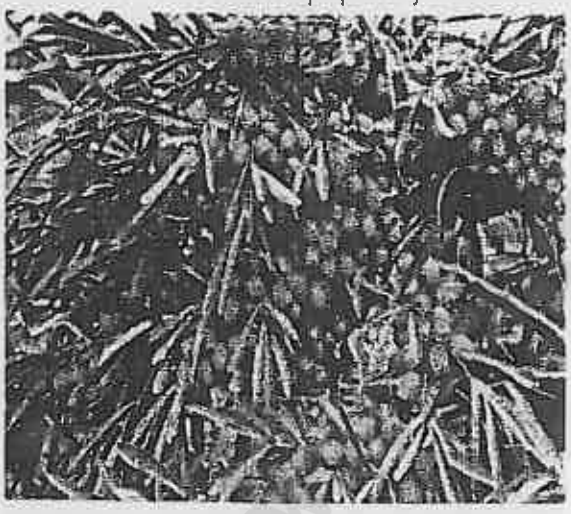
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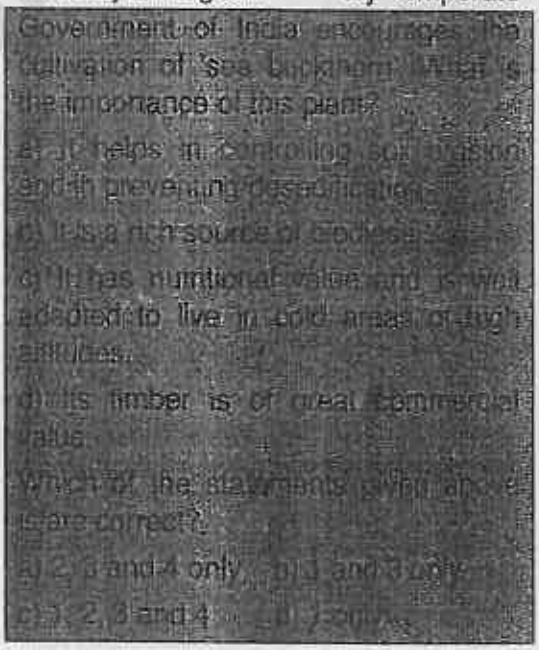


- An initial pilot was launched in five districts: Leh and Kargil in J&K, Lahaul Spiti and Kinnaur in Himachal Pradesh and Chamoli in Uttarakhand. Riverbanks and hill slopes was prioritised for cultivation.
- Engaging the private sector, especially in the commercialisation of seabuckthorn products, through public-private partnership, was a key focus of the Initiative.
- Eco Task Force Battalions were mobilised for plantation of seabuckthorn in remote areas. A Meeting was convened with the Territorial Army to discuss modalities in the near future.
- Women's Self-Help Groups will also be mobilised to scale up the Initiative in the focus areas.
- Programme for international cooperation on seabuckthorn R&D was initiated under the Initiative. This could include collaboration on research and cultivation with China, Mongolia, Russia and Pakistan and collaboration on processing and commercialisation with Germany and Finland. The recent regional collaboration project involving India, China and Nepal for the Mt. Kailash Landscape, initiated by ICIMOD, could serve as a model for this partnership.
- A Sub-Mission on Cold Desert Ecosystems was established **under the Green India Mission**, a key Mission under India's National Action Plan on Climate Change. This Sub-Mission includes the National ***Seabuckthorn Initiative***.

**About Seabuckthorn**

Seabuckthorn – popularly known as Leh berry, is indigenous to the high altitudes and grows widely in the Himalayan region. The dry temperate and cold desert of the Himalayas is an ideal place for the Seabuckthorn to flourish, and as such Seabuckthorn is found extensively in Jammu & Kashmir, Himachal Pradesh, Uttatrakhand, Sikkim and Arunachal Pradesh. Seabuckthorn not only provides nourishment but has multipurpose value. This is indeed the golden berry, with every part of the plant (twig, leaf, root, and thorn) being traditionally used as medicine, nutritional supplements, fire wood and fence shrub. Being a nitrogen fixing deciduous plant, it can be used for commercial purposes and well as for environment protection especially through afforestation. Since this is the only plant that can grow in high altitude regions it can be easily used for water and soil conservation. With climate variations on the increase, it was of importance to conserve this species that can aid in climate change mitigation and provide livelihoods support thereby reducing pressures on the ecosystem. Seabuckthorn is the ideal plant for desertification control. There are 6 species and 12 subspecies native over a wide area of Europe and Asia, including China, Mongolia, India, Nepal, Pakistan, Russia, Great Britain, France, Denmark, Netherlands, Germany, Poland, Finland, Sweden and Norway. In India, it is distributed in Ladakh region of Jammu & Kashmir; Kukumsari, Lahaul, Kaza








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and Tabo in Himachal Pradesh; and Nathula in Sikkim. It has silvery deciduous leaves and colourful red, orange or yellow berries that remain on the shrub most of the winter. The plant is hardy and usually cold tolerant. It can withstand extreme temperatures from -43ºC to +40ºC and considered to be drought resistant. The shrub develops extensive root system having ability to fix atmospheric nitrogen. It is therefore an ideal plant for environmental conservation, soil erosion control, land reclamation, wildlife habitat enhancement, and farm stand protection. Every part of the plant viz. fruit, leaf, twig, root and thorn has been traditionally used as medicine, nutritional supplement, fuel and fence, and therefore, seabuckthorn is popularly known as 'Wonder Plant', 'Ladakh Gold', 'Golden Bush' or 'Gold Mine'.

**7. National Mission for Sustainable Agriculture :**

The plan aims to support climate adaptation in agriculture through the development of climate-resilient crops, expansion of weather insurance mechanisms, and agricultural practices.

**8. National Mission on Strategic Knowledge for Climate Change :**

To gain a better understanding of climate science, impacts and challenges, the plan envisions a new Climate Science Research Fund, improved climate modelling, and increased international collaboration. It also encourages private sector initiatives to develop adaptation and mitigation technologies through venture capital funds.

Government of India has introduced **ninth mission under NAPCC.** This new mission is called as National Bio-energy Mission.

**9. National Bio-energy Mission:**

It is being developed to push sustainable development of the renewable energy sector. The Bio Energy Mission will:

1. Aim at improving energy efficiency in traditional biomass consuming industries.
2. Seek to develop a bio-energy city project.
3. Provide logistics support to biomass processing units.
4. It will also propose a GIS-based National Biomass Resource Atlas to map potential biomass regions in the country.

**INDIA'S INDC OBJECTIVES**

1. ***Reduce emission intensity by 33 to 35 per cent by 2030 compared to 2005 levels***
   - Introduce new, more efficient and cleaner technologies in thermal power generation
   - Reducing emissions from transportation sector
   - Promote energy efficiency, mainly in industry, transportation, buildings and appliances
   - Develop climate resilient infrastructure
   - Pursue Zero Effect, Zero Defect policy under Make in India programme
2. ***Produce 40 per cent of electricity from non-fossil fuel based energy resources by 2030, if international community helps with technology transfer and low cost finance.***
   - Install 175 GW of solar, wind and biomass electricity by 2022, and scale up further in following years
   - Aggressively pursue development of hydropower
   - Achieve the target of 63 GW of installed nuclear power capacity by 2032
3. ***Create an additional carbon sink of 2.5 to 3 billion tonnes of carbon dioxide equivalent by 2030 through additional forest and tree cover.***
   - Full implementation of Green India Mission and other programmes of afforestation



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- Develop 140,000 km long tree line on both sides of national highways

4. ***Develop robust adaptation strategies for agriculture, water and health sectors***
   - Redesign National Water Mission and National Mission on Sustainable Agriculture
   - Active implementation of ongoing programmes like National Initiative on Climate Resilient Agriculture, setting up of 100 mobile soil-testing laboratories, distribution of soil health cards to farmers.
   - Additional impetus on watershed development through Neeranchal scheme
   - Effective implementation of National Mission on Clean Ganga
   - Early formulation and implementation of National Health Mission
   - Complete Integrated Coastal Zone Management plan. Mapping and demarcation of coastal hazard lines

**Money Matters**

- At least USD 2.5 trillion (at current prices) required between now and 2030 to implement all planned actions. USD 206 million required for adaptation actions. Much more needed for strengthening resilience and disaster management.
- About USD 834 billion, at 2011 prices, required for mitigation actions till 2030.A total of INR 170.84 billion collected through cess on coal production. Being used for funding clean energy projects

***National Adaptation Fund*** has been created with initial allocation of Rs 3500 million

- Tax free infrastructure bonds of INR 50 billion being introduced for funding renewable energy projects.

**National Adaptation Fund for Climate Change (NAFCC) by Government of India**

**Objectives**

- **Funding concrete adaptation projects/programmes aligned with the relevant Missions under NAPCC and the SAPCCs in agriculture, horticulture, agro-forestry, environment, allied activities, water, forestry, urban, coastal and low-lying system, disaster management, human health, marine system, tourism, habitat sector and other rural livelihood sectors to address climate change related issues.**
- **Preparing and updating climate scenario, assessing vulnerability and climate impact assessment**
- **Capacity building of various stakeholders on climate change adaptation and project cycle management and developing knowledge network**
- **Mainstreaming the approaches/ learnings from project/programme implementation through knowledge Management**

**The Indian Network for Climate Change Assessment (INCCA)**

The Minister for Environment and Forests on October 14, 2009 announced the launch of the Indian Network for Climate Change Assessment (INCCA), which has been conceptualized as a Network-based Scientific Programme designed to:

- Assess the drivers and implications of climate change through scientific research
- Prepare climate change assessments once every two years
- Develop decision support systems
- Build capacity towards management of climate change related risks and opportunities.

INCAA has been launched to have an independent body of Indian scientists who could "prepare scientific reports at the domestic level about the impact of climate change on various sectors,



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which can give a real picture and influence the world debate." Reports prepared by the INCAA will form a part of India's National Communication (Nat Com) to UNFCCC.

**INCCA – First Assessment 'India: Greenhouse Gas Emission 2007'**

This Report, being brought out by the Indian Network of Climate Change Assessment (INCCA), provides updated information on India's Greenhouse Gas Emissions for the year 2007. Hitherto, the only official emissions estimates available were for the year 1994. This was very inadequate.

**INCCA – Second Assessment '"Climate Change and India: A 4X4 Assessment A sectoral and regional analysis for 2030s'**

This report provides an assessment of impact of climate change in 2030s on four key sectors of the Indian economy, namely Agriculture, Water, Natural Ecosystems & Biodiversity and Health in four climate sensitive regions of India, namely the Himalayan region, the Western Ghats, the Coastal Area and the North-East Region. It was for the first time that such a comprehensive, long term assessment had been undertaken based on rigorous scientific analysis. The 4 region, 4 sectors assessment in short has been referred to as a 4x4 assessment.

**India and REDD & REDD+**

India believes REDD needs to be seen in the broader context of REDD+, not in isolation or in a truncated form since reduction of deforestation, and conservation and improvement of forests are two sides of the same coin, and so should be treated at par.

- Fairness requires that a unit of carbon saved by checking deforestation should be treated the same as a unit of carbon added due to conservation and afforestation measures. In essence, India has been insisting on following a comprehensive and holistic approach in realizing the full potential of mitigation in forestry sector.
- India's stand was finally accepted in 13th Meeting of the Conference of the Parties (COP 13) at Bali when elements of conservation, sustainable management of forests and enhancement of forest carbon stocks were added to the then existing text of reducing deforestation and forest degradation as part of Bali Action Plan.

India stands to gain a lot from a global REDD+ mechanism. It has specifically opened the possibilities for the country to expect compensation for its pro-conservation approach and sustainable management of forests resulting in even further increase of forest cover and thereby its forest carbon stocks.

India is playing a positive role and has taken a firm stance in favour of a comprehensive REDD+ approach. It has presented an ambitious Green India Mission programme under its National Action Plan on Climate Change. India is underlying the following initiatives related to REDD+.

- India has made a submission to UNFCCC on "REDD, Sustainable Management of Forest (SMF)

With reference to "Forest Carbon Partnership Facility", which of the following statements is/are correct?

1) It is global partnership of governments, businesses, civil society and indigenous peoples

2) It provides financial aid to universities, individual scientists and institutions involved in scientific forestry research to develop eco friendly and climate adaptation technologies for sustainable forest management

3) It assists the countries in their 'REDD+ (Reducing Emission from Deforestation and Forest Degradation+)' efforts by providing them with financial and technical assistance.

Select the correct answer using the code given below

a) 1 only

b) 2 and 3 only

c) 1 and 3 only

d) 1, 2 and 3



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and Afforestation and Reforestation (A&R)" in December 2008

- A Technical Group has been set up to develop methodologies and procedures to assess and monitor contribution of REDD+ actions
- A National REDD+ Coordinating Agency is being established
- A National Forest Carbon Accounting Programme is being institutionalized

**National Initiative on Climate Resilient Agriculture (NICRA)**

It is a network project of the Indian Council of Agricultural Research (ICAR) launched in February 2011. The project aims to enhance resilience of Indian agriculture to climate change and climate vulnerability through strategic research and technology demonstration. The research on adaptation and mitigation covers crops, livestock, fisheries and natural resource management. The project consists of four components viz. Strategic Research, Technology Demonstration, Capacity Building and Sponsored/Competitive Grants. NICRA was launched in XI plan with following objectives:

**National Innovations on Climate Resilient Agriculture (NICRA)**

**Objectives**

- To enhance resilience of Indian agriculture (including crops, livestock and fisheries) to climatic variability and climate change
- To demonstrate site specific technology packages on farmers' fields to cope with current climatic variability
- To enhance the capacity of scientists, farmers and other stakeholders in climate resilient agricultural research and awareness of impacts




**PROGRAM AREAS**

- Rainfed crop production systems
- Irrigated crop production systems
- Horticultural production systems
- Soil, water and nutrient management
- Monitoring of GHGs
- Resource use efficiency in agriculture
- Improved machinery for adaptation and mitigation
- Livestock and Dairy sector
- Fisheries including Aquaculture

- Critical assessment of different crops/zones in the country for vulnerability to climatic stresses and extreme events, in particular, intra seasonal variability of rainfall.
- Installation of the state-of-the-art equipment like flux towers for measurement of green house gases in large field areas to understand the impact of management practices and contribute data on emissions as national responsibility.
- Rapid and large scale screening of crop germplasm including wild relatives for drought and heat tolerance through phenomics platforms for quick identification of promising lines and early development and release of heat/drought tolerant varieties.
- Comprehensive field evaluation of new and emerging approaches of paddy cultivation like aerobic rice and SRI for their contribution to reduce the GHG emissions and water saving.
- Special attention to livestock and fishery sectors including aquaculture which have not received enough attention in climate change research in the past. In particular, the documentation of adaptive traits in indigenous breeds is the most useful step.
- Thorough understanding of crop-pest/pathogen relationship and emergence of new biotypes due to climate change.



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- Simultaneous up-scaling of the outputs both through KVKs and the National Mission on Sustainable Agriculture for wider adoption by the farmers

**Energy Conservation Building Code (ECBC)**

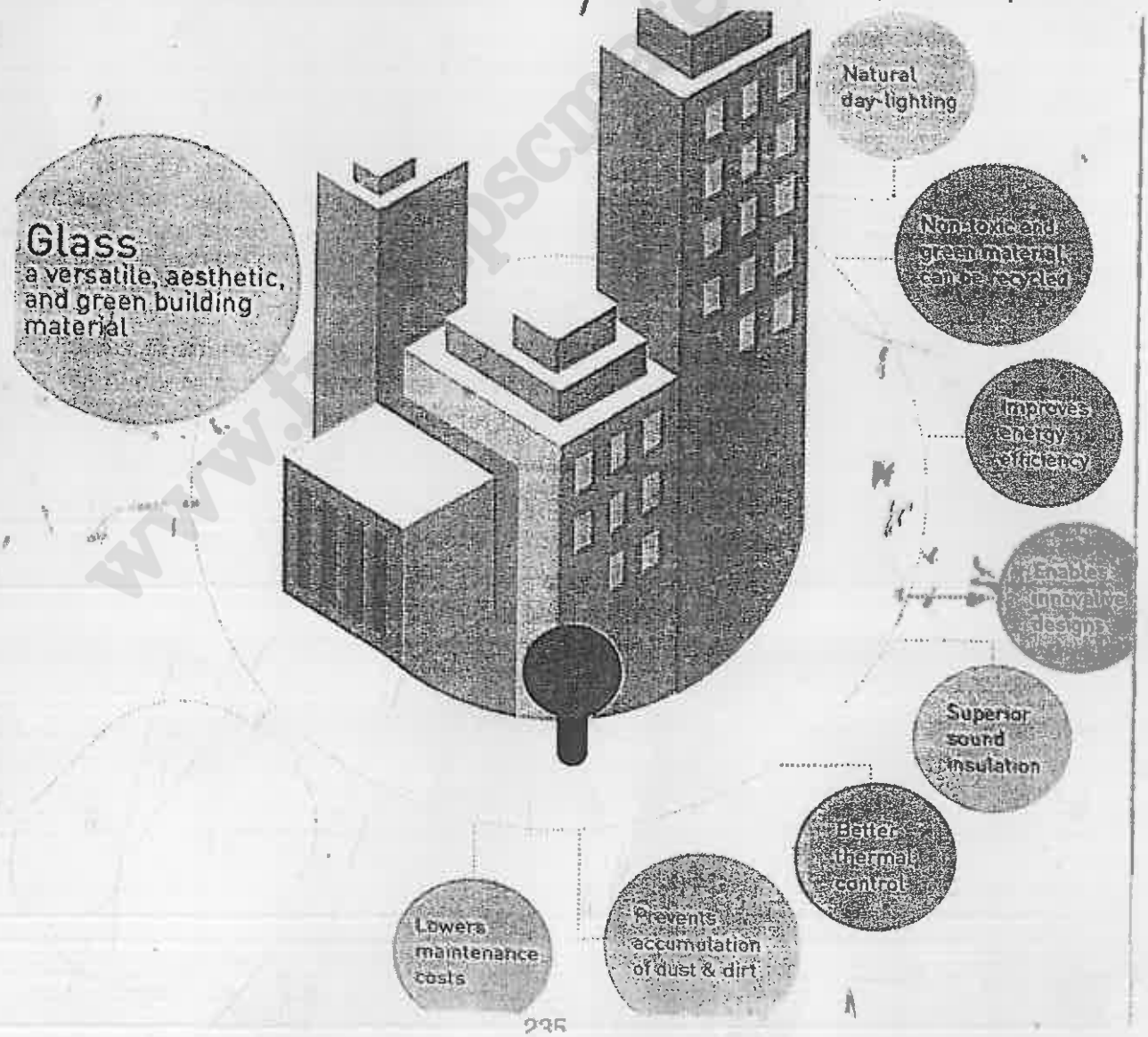
The Energy Conservation Building Code (ECBC) was launched by Ministry of Power, Government of India in May 2007, as a first step towards promoting energy efficiency in the building sector. It is estimated that the nationwide mandatory enforcement of the Code will yield considerable annual energy savings. This, coupled with the fast growing building sector, is likely to result in a big leap towards achieving nation's energy efficiency goals.

**Objectives**

- Provide technical support to BEE to implement the ECBC in a rigorous manner
- Develop reference material and documentation to support the Code
- Develop ECBC Training material for workshops and training programs
- Develop a road map for ECBC implementation

**Green Building**

Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and






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complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high performance building. Green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by:

- Efficiently using energy, water, and other resources
- Protecting occupant health and improving employee productivity
- Reducing waste, pollution and environmental degradation

**GRIHA (Green Rating for Integrated Habitat Assessment)**

GRIHA is an acronym for Green Rating for Integrated Habitat Assessment. GRIHA is a Sanskrit word meaning – 'Abode'. Human Habitats (buildings) interact with the environment in various ways. GRIHA attempts to minimize a building's resource consumption, waste generation, and overall ecological impact to within certain nationally acceptable limits / benchmarks.

GRIHA is a rating tool that helps people assesses the performance of their building against certain nationally acceptable benchmarks. It evaluates the environmental performance of a building holistically over its entire life cycle, thereby providing a definitive standard for what constitutes a 'green building'. The rating system, based on accepted energy and environmental principles, will seek to strike a balance between the established practices and emerging concepts, both national and international.

**SVAGRIHA (Small Versatile Affordable GRIHA)**

It was jointly developed by GRIHA Council and TERI. SVAGRIHA is a significantly simplified, faster, easier and more affordable rating system and will eventually function as a demand driven rating tool. It was required that attention be paid to smaller buildings in India which although have small individual environmental footprints but their cumulative effect is far bigger. SVAGRIHA has been designed as an extension of GRIHA and has been specifically developed for projects with built-up area less than 2500 sq. mtr.

**BSE-GREENEX**

It is India's first carbon-efficient live index developed by the BSE in collaboration with IIM Ahmedabad. BSE-Greenex measures the performances of companies in terms of carbon emissions. The index will target socially-aware investors. There are many investors willing to pay a premium for green investments in companies to get better returns. Key points:

- The top-ranking companies from each sector like power, steel, cement have made it to the new index called BSE-GREENEX
- Greenex has 20 companies from the broader BSE 100 index that meet energy efficiency norms, allowing investors to derive benefit from the related cost savings.
- gTrade Carbon Ex Ratings Services Private Limited (gTrade) is a company based in India which has co-developed the BSE-GREENEX Index in close association with the BSE
- The company with the biggest weightage in this index is Tata Steel at 6.5 per cent. ICICI Bank, State Bank of India, HDFC, Sun Pharma and BHEL are the other major stocks in the basket of the Index
- The index will allow investors to track companies that invest in energy efficient practices
- Investors can invest in a mutual fund that invests in companies that form the Greenex
- The Greenex will allow asset managers to create products to help investors put their money in green enterprises.



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# CHAPTER – 13
# WASTE MANAGEMENT

**Overview**
1. Definition
2. Types Of waste
3. Management of Waste
4. E-waste management Rules 2016

## DEFINITION

"Material discharged to, deposited in, or emitted to an environment in such amount or manner that causes a harmful change".

Waste includes all items that people no longer have any use for, which they either intend to get rid of or have already discarded. Additionally, wastes are such items which people are require to discard, for example by lay because of their hazardous properties. Many items can be considered as waste e.g., household rubbish, sewage sludge, wastes from manufacturing activities, packaging items, discarded cars, old televisions, garden waste, old paint containers etc. Thus, all our daily activities can give rise to a large variety of different wastes arising from different sources.

## TYPES OF WASTES

**1. Municipal Waste (including Household and Commercial) –**

- Municipal waste is generated by households, commercial activities and other sources whose activities are similar to those of households and commercial enterprises.
- Municipal waste is made up to residual waste, bulky waste, secondary materials from separate collection, household hazardous waste, street sweepings and litter collections. It is made up of materials such as paper, cardboard, metals, textiles, organics (food and garden waste) and wood.

Garbage: the four broad categories
1. Organic waste: kitchen waste, vegetables, flowers, leaves, fruits.
2. Toxic waste: old medicines, paints, chemicals, bulbs, spray cans, fertilizer and pesticide containers, batteries, shoe polish.
3. Recyclable: paper, glass, metals, plastics.
4. Soiled: hospital waste such as cloth soiled with blood

**2. Hazardous waste –**

- Industrial and hospital waste is considered hazardous as they may contain toxic substances. Certain types of household waste are also hazardous.
- Hazardous wastes could be highly toxic to humans, animals, and plants; are corrosive, highly inflammable, or explosive; and react when exposed to certain things e.g. gases.
- Household wastes that can be categorized as hazardous waste include old batteries, shoe polish, paint tins, old medicines, and medicine bottles.
- Hospital waste contaminated by chemicals used in hospitals is considered hazardous. These chemicals include formaldehyde and phenols, which are used as disinfectants, and mercury, which is used in thermometers or equipment that measure blood pressure.
- In the industrial sector, the major generators of hazardous waste are the metal, chemical, paper, pesticide, dye, refining, and rubber goods industries.

**3. Hospital waste –**

- Hospital waste is generated during the diagnosis, treatment, or immunization of human beings or animals or in research activities in these fields or in the production or testing of biological
- It may include wastes like sharps, soiled waste, disposables, anatomical waste, cultures, discarded medicines, chemical wastes, etc



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- These are in the form of disposable syringes, swabs, bandages, body fluids, human excreta, etc.

**4. E-waste** – Electrical and electronic equipment contain different hazardous materials which are harmful to human health and the environment if not disposed of carefully. While some naturally occurring substances are harmless in nature, their use in the manufacture of electronic equipment often results in compounds which are hazardous. The following list gives a selection of the mostly found toxic substances in e-waste.

| Substance | Occurrence in e-waste | Health Effects |
|---|---|---|
| **Halogenated compounds** | | |
| PCB (polychlorinated biphenyls) | Condensers, Transformers | Polychlorinated biphenyls (PCBs) are a class of organic compounds use in a variety of applications, including dielectric fluids for capacitors and transformers, heat transfer fluids and as additives in adhesives and plastics. PCBs have been shown to cause cancer in animals. PCBs have also been shown to cause a number of serious non-cancer health effects in animals, including effects on the immune system, reproductive system, nervous system, endocrine system and other health effects. PCBs are persistent contaminants in the environment. Due to the high lipid solubility and slow metabolism rate of these chemicals, PCBs accumulate in the fat-rich tissues of almost all organisms (bioaccumulation). |
| Dioxins | | Dioxins and furans are a family of chemicals comprising 75 different types of dioxin compounds and 135 related compounds known as furans. Dioxins is taken to mean the family of compounds comprising polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). **Dioxins have never been intentionally manufactured, but form as unwanted by-products in the manufacture of substances like some pesticides as well as during combustion.** Dioxins are known to be highly toxic to animals and humans because they bio-accumulate in the body and can lead to malformations of the foetus, decreased reproduction and growth rates and cause impairment of the immune system among other things. |
| TBBA (tetra-bromo-bisphenol-A)<br>PBB (poly-brominated bi-phenyls)<br>PBDE (poly-brominated di-phenyl ethers) | Fire retardants for plastics (thermoplastic components, cable insulation)<br>TBBA is presently the most widely used flame retardant | The 3 main types of BFRS used in electronic and electrical appliances are Poly-brominated biphenyl (PBB), Poly-brominated diphenyl ether (PBDE) and Tetra-bromobisphenol - A (TBBPA). Flame retardants make materials, especially plastics and textiles, more flame resistant. They have been found in indoor dust and air through migration and evaporation from plastics. Combustion of halogenated case material and printed wiring boards at lower temperatures releases toxic emissions including dioxins |



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| | in printed wiring boards and casings. | which can lead to severe hormonal disorders |
| Chlorofluorocarbon (CFC) | Cooling unit, Insulation foam | Chlorofluorocarbons are compounds composed of carbon, fluorine, chlorine, and sometimes hydrogen. Used mainly in cooling units and insulation foam, they have been phased out because when released into the atmosphere, they accumulate in the stratosphere and have a deleterious effect on the ozone layer. This results in increased incidence of skin cancer in humans and in genetic damage in many organisms. |
| PVC (polyvinyl chloride) | Cable insulation | Polyvinyl chloride (PVC) is the most widely-used plastic, used in everyday electronics and appliances, household items, pipes, upholstery etc. PVC is hazardous because contains up to 56 percent chlorine which when burned produces large quantities of hydrogen chloride gas, which combines with water to form hydrochloric acid and is dangerous because when inhaled, leads to respiratory problems. |
| **Heavy metals and other metals** | | |
| Arsenic | Small quantities in the form of gallium arsenide within light emitting diodes | Arsenic is a poisonous metallic element which is present in dust and soluble substances. Chronic exposure to arsenic can lead to various diseases of the skin and decrease nerve conduction velocity. Chronic exposure to arsenic can also cause lung cancer and can often be fatal. |
| Barium | Getters in CRT | Barium is a metallic element that is used in sparkplugs, fluorescent lamps and "getters" in vacuum tubes. Being highly unstable in the pure form, it forms poisonous oxides when in contact with air. Short-term exposure to barium could lead to brain swelling, muscle weakness, damage to the heart, liver and spleen. |
| Beryllium | Power supply boxes which contain silicon controlled rectifiers and x-ray lenses | Beryllium has recently been classified as a human carcinogen because exposure to it can cause lung cancer. The primary health concern is inhalation of beryllium dust, fume or mist. Workers who are constantly exposed to beryllium, even in small amounts, and who become sensitised to it can develop what is known as Chronic Beryllium Disease (berylicosis), a disease which primarily affects the lungs. Exposure to beryllium also causes a form of skin disease that is characterised by poor wound healing and wart-like bumps. |
| Cadmium | Rechargeable Ni-Cd batteries, fluorescent layer (CRT screens), | Cadmium components may have serious impacts on the kidneys. Cadmium is adsorbed through respiration but is also taken up with food. Due to the long half-life in the body, cadmium can easily be accumulated in amounts that cause |



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| | | |
|---|---|---|
| | printer inks and toners, photo-copying-machines (printer drums) | symptoms of poisoning. Cadmium shows a danger of cumulative effects in the environment due to its acute and chronic toxicity. Acute exposure to cadmium fumes causes flu-like symptoms of weakness, fever, headache, chills, sweating and muscular pain. The primary health risks of long term exposure are lung cancer and kidney damage. Cadmium also is believed to cause pulmonary emphysema and bone disease (osteomalacia and osteoporosis) |
| Chromium VI | Data tapes, floppy-disks | Chromium and its oxides are widely used because of their high conductivity and anti-corrosive properties. While some forms of chromium are non-toxic, Chromium (VI) is easily absorbed in the human body and can produce various toxic effects within cells. Most chromium (VI) compounds are irritating to eyes, skin and mucous membranes. Chronic exposure to chromium (VI) compounds can cause permanent eye injury, unless properly treated. Chromium VI may also cause DNA damage |
| Lead | CRT screens, batteries, printed wiring boards | Lead is the fifth most widely used metal after iron, aluminium, copper and zinc. It is commonly used in the electrical and electronics industry in solder, lead-acid batteries, electronic components, cable sheathing, in the glass of CRTs etc. Short-term exposure to high levels of lead can cause vomiting, diarrhoea, convulsions, coma or even death. Other symptoms are appetite loss, abdominal pain, constipation, fatigue, sleeplessness, irritability and headache. Continued excessive exposure, as in an industrial setting, can affect the kidneys. It is particularly dangerous for young children because it can damage nervous connections and cause blood and brain disorders |
| Lithium | Li-batteries | |
| Mercury | Fluorescent lamps that provide backlighting in LCDs, in some alkaline batteries and mercury wetted switches | Mercury is one of the most toxic yet widely used metals in the production of electrical and electronic applications. It is a toxic heavy metal that bio-accumulates causing brain and liver damage if ingested or inhaled. In electronics and electrical appliances, mercury is highly concentrated in batteries, some switches and thermostats, and fluorescent lamps. |
| Nickel | Rechargeable Ni-Cd batteries or NiMH-batteries, electron gun in CRT | |
| Rare Earth elements (Yttrium, | Fluorescent layer (CRT- | |



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| | | |
|---|---|---|
| Europium) | screen) | |
| Selenium | Older photo-copying-machines (photo drums) | Exposure to high concentrations of selenium compounds cause selenosis. The major signs of selenosis are hair loss, nail brittleness, and neurological abnormalities (such as numbness and other odd sensations in the extremities). |
| Zinc sulphide | Interior of CRT screens, mixed with rare earth metals | |
| **Others** | | |
| Toner Dust | Toner cartridges for laser printers / copiers | |
| Radio-active substances Americium | Medical equipment, fire detectors, active sensing element in smoke detectors | |

## MANAGEMENT OF WASTE

Waste management is the "generation, prevention, characterization, monitoring, treatment, handling, reuse and residual disposition of solid wastes. It can be done by following ways:

1. Reuse: Instead of being disposed of, materials that are recovered from an incident and decontaminated may be able to be reused. Reusing these materials protects the environment by saving resources, including energy, virgin materials, and landfill space as well as reduces the economic impact of the affected site.
2. **Recycling:** Recycling involves making materials that would otherwise be disposed of as waste into valuable resources for new products. Recycling these materials protects the environment by saving resources, including energy, virgin materials, and landfill space.
3. **Composting:** Composting is the controlled biological decomposition of organic material in the presence of air to form a humus-like material. Controlled methods of composting include mechanical mixing and aerating, ventilating the materials by dropping them through a vertical series of aerated chambers, or placing the compost in piles out in the open air and mixing it or turning it periodically. This treatment option is distinct from backyard composting that is conducted by individuals on their own properties. Instead, composting, as a treatment option, is used to decompose large quantities of waste either on-site (e.g., on a farm in association with animal disease control activities) or off-site (e.g., composting facilities). Off-site composting will trigger transportation considerations.
4. **On-Site Burial:** This disposal option refers to the placing of the waste within the ground at the site of the incident. This option should only be used when site characteristics allow it (e.g., depth to water table) and proper environmental controls to protect groundwater, surface water, and soil are put into place.
5. **Landfill Disposal:** This is a disposal option involving carefully designed structures built into or on top of the ground in which waste is isolated from the surrounding environment. Gener-



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ally, each landfill is permitted or licensed for particular kinds of waste. A landfill generally cannot accept waste that falls outside the scope of its permit.

6. **Open Burning:** This disposal option refers to the deliberate outdoor burning of waste. It can be done in open drums, in fields, and in large open pits or trenches. Open burning should only be done when and where it is appropriate and if there are no other alternatives available.
7. **Incineration:** Also called combustion, this treatment option burns waste under controlled conditions. As with landfills, different incinerators are permitted for different kinds of waste. Hazardous waste must be brought to an incinerator permitted to accept hazardous waste. Municipal solid waste incinerators are permitted to burn municipal solid waste, with some units having the ability to recover energy. Medical waste incinerators are designed to handle pathogenic wastes.
8. **Pyrolysis:** Pyrolysis is a form of treatment that chemically decomposes organic materials by heat in the absence of oxygen. Pyrolysis typically occurs under pressure and at operating temperatures above $430^0$ C. In practice, it is not possible to achieve a completely oxygen-free atmosphere. Because some oxygen is present in any pyrolysis system, a small amount of oxidation occurs. If volatile or semi-volatile materials are present in the waste, thermal desorption will also occur.
9. Rendering: This treatment option converts animal carcasses or animal by-products into economically valuable products. During the rendering process, as the animal material is heated, water is driven off, and the animal material separates into a fat-containing material called "tallow" and a solid material called "meat and bone meal."
10. **Alkaline Hydrolysis:** This treatment option uses an alkaline solution such as sodium hydroxide, pressure, and heat to convert animal carcasses into an aqueous solution. The resulting aqueous solution must be neutralized and properly managed.
11. **Digestion Methods:** This treatment option for animal carcasses involves a process that uses bacteria to break down organic matter. The digestion process produces bio-solids and methane gas, which are potentially useful products.
12. Autoclaving: This treatment option sterilizes waste through the use of high temperatures (up to 150° C) and high pressure steam. It is a commonly used treatment process for medical waste.
13. **Bioremediation:** This treatment option naturally degrades chemicals in soil and groundwater using biological processes that involve the conversion of chemicals into water and harmless gases by microbes. The right conditions (e.g., temperature, nutrients, amount of oxygen) must be present or created in order for bioremediation to be successful.

| E-WASTE (MANAGEMENT) RULES, 2016 |
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| 1. Manufacturer, dealer, refurbisher and Producer Responsibility Organization (PRO) have been introduced as additional stakeholders in the rules. |
| 2. The applicability of the rules has been extended to components, Consumables, spares and parts of EEE in addition to equipment as listed in Schedule I. |
| 3. Compact Fluorescent Lamp (CFL) and other mercury containing lamp brought under the purview of rules. |
| 4. Collection mechanism based approach has been adopted to include collection centre, collection point, take back system etc. for collection of e-waste by Producers under Extended Producer Responsibility (EPR). |



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| 5. Option has been given for setting up of PRO, e-waste exchange, e- retailer, Deposit Refund Scheme as additional channel for implementation of EPR by Producers to ensure efficient channelization of e-waste. |
| 6. Provision for Pan India EPR Authorisation by CPCB has been introduced replacing the state wise EPR authorization. |
| 7. Collection and channelization of e-waste in Extended Producer Responsibility - Authorisation shall be in line with the targets prescribed in Schedule III of the Rules. The phase wise Collection Target for e-waste, which can be either in number or Weight shall be 30% of the quantity of waste generation as indicated in EPR Plan during first two year of implementation of rules followed by 40% during third and fourth years, 50% during fifth and sixth years and 70% during seventh year onwards. |
| 8. Deposit Refund Scheme has been introduced as an additional economic instrument wherein the producer charges an additional amount as a deposit at the time of sale of the electrical and electronic equipment and returns it to the consumer along with interest when the end-of life electrical and electronic equipment is returned. |
| 9. The e-waste exchange as an option has been provided in the rules as an independent market instrument offering assistance or independent electronic systems offering services for sale and purchase of e-waste generated from end-of-life electrical and electronic equipment between agencies or organizations authorised under these rules. |
| 10. The manufacturer is also now responsible to collect e-waste generated during the manufacture of any electrical and electronic equipment and channelize it for recycling or disposal and seek authorization from SPCB. |
| 11. The dealer, if has been given the responsibility of collection on behalf of the producer, need to collect the e-waste by providing the consumer a box and channelize it to Producer. |
| 12. Dealer or retailer or e-retailer shall refund the amount as per take back system or Deposit Refund Scheme of the producer to the depositor of e-waste . |
| 13. Refurbisher need collect e-waste generated during the process of refurbishing and channelize the waste to authorised dismantler or recycler through its collection centre and seek one time authorization from SPCB. |
| 14.The roles of the State Government has been also introduced in the Rules in order to ensure safety, health and skill development of the workers involved in the dismantling and recycling operations. |
| 15. Department of Industry in State or any other government agency authorised in this regard by the State Government is to ensure earmarking or allocation of industrial space or shed for e-waste dismantling and recycling in the existing and upcoming industrial park, estate and industrial clusters. |
| 16. Department of Labour in the State or any other government agency authorized in this regard by the State Government need to ensure recognition and registration of workers involved in dismantling and recycling; assist formation of groups of such workers to facilitate setting up dismantling facilities; undertake industrial skill development activities for the workers involved in dismantling and recycling; and undertake annual monitoring and to ensure safety & health of workers involved in dismantling and recycling. |
| 17. State Government to prepare integrated plan for effective implementation of these provisions, and to submit annual report to Ministry of Environment, Forest and Climate Change. |
| 18. The transportation of e-waste shall be carried out as per the manifest system whereby the |



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| transporter shall be required to carry a document (three copies) prepared by the sender, giving the details. |
| 19. Liability for damages caused to the environment or third party due to improper management of e-waste including provision for levying financial penalty for violation of provisions of the Rules has also been introduced. |
| 20. Urban Local Bodies (Municipal Committee/Council/Corporation) has been assign the duty to collect and channelized the orphan products to authorized dismantler or recycler. |

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