

**Environmental Studies**  
**Non-credit PG course (CBSC regulation)**  
**Skill Enhancement Course**

**2 Credit**

**50 Marks**

**Unit-I:**

**1 Credit (25 Marks)**

**Fundamentals of Environment**

**(2 Lectures)**

- Definition, Principles and Scope of Environment, Interaction between Earth, Man and Environment.
- Remote Sensing and GIS and Environmental studies

**Environment and education**

- Environmental ethics, environmental education, Education for Sustainable Development, UN 2030 Agenda , UCLG  
**( 1 Lecture)**

**Environmental Chemistry**

**(3 Lectures)**

- Composition of air. Particles, ions and radicals in the atmosphere, Oxygen and Ozone chemistry. Photochemical smog.
- Hydrological cycle. Concept of DO, BOD and COD. Sedimentation, coagulation, flocculation, filtration, pH.
- Toxic chemicals: Pesticides and their classification and effects. Biochemical aspects of heavy metals (Hg, Cd, Pb, Cr) and metalloids (As, Se). CO, O<sub>3</sub>, PAN, VOC and POP. Carcinogens in the air.

**Environmental Biology**

**(6 Lecturers)**

- Ecology and Ecosystem (energy flow in ecosystems, energy flow models, food chains and food webs. Biogeochemical cycles, Ecological succession. Species diversity, ecotone, edge effects, ecological habitats and niche, Ecosystem stability and factors affecting stability.
- Biomes, Population ecology (Population fluctuations, dispersion and metapopulation. Concept of 'r' and 'k' species. Keystone species).
- Community ecology, Biological invasions.
- Biodiversity ('Hotspots'; hotspots, situ, ex situ and vitro conservation. National parks, Sanctuaries, Protected areas and Sacred groves, gene pool, biopiracy and bioprospecting, restoration ecology. Extinct, Rare, Endangered and Threatened species), Industrial Ecology.

**Environment and Economics**  
**Lecture)**

**(1**

Environmental economics, Economics for environment

**Environment and ICT**

**(1 Lecture)**

Application of ICT in Environmental Management

**Environment and Geography**

**(3 Lectures)**

- Origin of earth, formation of landforms, Weathering , Soil formation, Mineralogical controls.
- Geochemical classification, Paleoclimate, hydrology and hydrogeology, groundwater provinces, Natural resource exploration and exploitation
- Natural Hazards Air, Noise, Water, Soil Pollution, Thermal, Marine Pollution and Radioactive

- Waste Management : Solid Waste, Solid waste processing and recovery, Hazardous waste, e-waste, Plastic waste

**Environmental Laws, Assessment and Management (4 Lectures)**

- EIA, EIS, EMP, Environmental Audit, ISO 14000 series, Eco-labeling schemes.
- Risk Assessment
- Environmental Laws and Protocols
- IPCC, Rain water harvesting and ground water recharge, Conservation of wetlands, Ramsar sites, Soil erosion, reclamation of degraded land, desertification and its control.
- Chipko movement, Appiko movement, Silent Valley movement and Gandhamardan movement. People Biodiversity register, Project tiger, Project Elephant, Crocodile Conservation, GOI-UNDP Sea Turtle project, Indo-Rhino vision.
- Carbon sequestration and carbon credits, Swachh Bharat Abhiyan. Sustainable Habitat: Green Building, GRIHA Rating Norms

**Environment and Statistics: (3 Lectures)**

- Application of Statistics in Environmental Studies and science (types of variables, scales of measurement, measurement of Central tendency and Dispersion, Standard error, Moments – measure of Skewness and Kurtosis, Basic concept of probability theory, Sampling theory, Distributions – Normal, log-normal, Binomial, Poisson, t, X<sup>2</sup> and F-distribution. Correlation, Regression, tests of hypothesis (t-test, X<sup>2</sup> -test ANOVA)

**Literature, Environmental Thinkers and Sustainable Development (1 Lecture)**

**Contemporary Environmental Issues (4 Lectures)**

- Biodiversity loss, Climate change, Ozone layer depletion, Sea level rise
- Plastic pollution, Drinking water scarcity, Forest Fire (Amazon, Kongo)
- Water resource projects – Narmada dam, Tehri dam, Almatti dam
- Environmental Disasters: Minamata Disaster, Love Canal Disaster, Bhopal Gas Disaster, 1984, Chernobyl Disaster, 1986, Fukushima Daiichi nuclear disaster, 2011.

**Unit II:**

**Field Work / Project / Term Paper /Assignment/ case Study**

**1 Credit (15 in Project + 5 in viva-voce = 25 marks)  
(10 Lectures)**

Topic of the project must be syllabus oriented.

Project can be prepared based on both or either Primary and Secondary data. Both the Computer typed of Hand writing are allowed to submit it. Viva-voce may be conducted by both subject teacher and one external teacher from any department of Raiganj University or else.

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# FUNDAMENTALS OF ENVIRONMENT

## *Structure 1. Introduction*

### *1.1 Definition and Scope*

### *1.2 Types of Environment*

#### *1.2.1 Physical/abiotic environment*

#### *1.2.2 Biotic environment*

## *2. Components of Environment*

### *2.1 Abiotic Components*

#### *2.1.1 Responses to change in abiotic factors*

### *2.2 Biotic Components*

## *3. Man Environment Relationship*

## **1. Introduction**

Everything that surrounds or affects an organism during its life time is collectively known as its environment or simply put everything surrounding a living organism like people; place and things constitute its environment which can be either natural or man-made. The word environment has been derived from a French word 'environner' meaning to encircle or to surround. In the beginning, environment of early man consisted of only physical aspects of the planet earth such as land (lithosphere), air (atmosphere) and water (hydrosphere) along with biotic communities but, with the passage of time and advancement of society man extended his environment to include his social, economic and political functions too. At the organismic level it is essentially physiological interaction which tries to understand that how different organisms are adapted to their environment in terms of not only survival but also reproduction and propagation of their population. All organisms (from virus to man) are obligatorily dependent

on the environment for various essential needs such as food, shelter, water, oxygen etc. The surrounding that affects an organism during its lifetime is collectively known as its environment. In another words “Environment is sum total of water, air and land inter-relationships among themselves and also with the human being, other living organisms and material goods”. It comprises all the physical and biological surrounding and their connections. Environmental studies give an approach towards understanding the environment of our globe and the impact of human life upon the environment and vice-versa. Thus, environment is actually universal in nature and it is a multidisciplinary subject counting physics, chemistry, geology, geography, history, economics, physiology, biotechnology, remote sensing, geophysics, soil science and hydrology etc. Environment belongs to all the biotic and abiotic components and therefore is, vital for all. Consequently, everyone is affected by environmental issues like global warming, depletion of ozone layer, dwindling forest, depleting energy resources, loss of biodiversity etc. Environment also deals with the analysis of the processes in hydrosphere, atmosphere, lithosphere, and organisms which leads to pollute biosphere. Environment helps us for setting benchmark for safe and healthy natural ecosystem.

### 1.1 Definition and Scope

The surroundings or settings in which a human being, animal, or plant lives or operates or it is a set of conditions of a living being all the natural forces which provide settings for development and growth as well as danger and damage. In a comprehensive form the environment may be defined as “sum total of living, non-living components; influences and events, surrounding an organism.” Environment is defined more comprehensively by others ‘as a holistic view of the world as its functions at any point of time, with a multitude of spatial elemental and socio-economic systems distinguished by quality and attributes of space and mode of behaviour of abiotic and biotic forms.’ (K.R. Dikshit, 1984).

**Environment means:**

‘The term environment is used to describe, in the aggregate, all the external forces, influences and conditions, which affect the life, nature behaviour and the growth, development and maturity of living organisms’ (Douglas and Holland).

Environment refers to the sum total of all conditions which surround man at a given point in space and time’ (C.C.Park)

The entire range of external influence acting on an organism, both the physical and biological, and other organisms, i.e. forces of nature surrounding an individual. (Encyclopedia Britannica).  
Total environmental system including not only the biosphere, but also his interactions with his natural and man made surroundings (US Council on Environmental quality).

Environment is argued as an inseparable whole and is constituted by the interacting systems of physical, biological and cultural elements, which are interlinked individually as well as collectively in myriad ways. Physical elements (space, landforms, waterbodies, climate, soils, rocks and minerals) determine variable character of the human habitat, its opportunities as well as limitations. Biological elements (plants, animals, micro-organisms and man) constitute the biosphere. Cultural elements (economic, social, political) are essentially manmade features which go into the making of cultural milieu (Savindra Singh and A. Dubey, 1983). Thus, environment is defined as '(1) the circumstances and conditions (physical conditions) that surround an organism or group of organisms, or (2) the social and cultural conditions that affect an individual or community. Since human inhabit the natural world as well as the 'built' or technological, social, and cultural world, all constitute part of our environment' (W.P.Cunnigham and M.A. Cunnigham, 2004).

Environmental knowledge is a multidisciplinary knowledge whose fundamental aspects have a direct significance to every segment of the planet. Its main characteristics include:

- Conservation and natural resources.
- Maintenance and management of biological diversity.
- Controlling and managing environmental pollution to permissible limit
- Stabilisation of human population and environment.
- Development of alternate sources of renewable energy systems
- Providing new dimension to nation's security through conservation, protection, management and maintenance of environment

It also deals with vital issues like safe and clean drinking water, hygienic living conditions and pollution free fresh air, fertility of land, healthy food and development of sustainable environmental laws, administration, environmental protection, management and environmental business are coming up as new opportunities for environment protection and managements. The relationship and interaction between organism and environment are highly complex and multidimensional. No organism can live alone without interacting with other organisms or other biotic/abiotic forms. So each organism has other organisms as a part of its environment. Each and everything with which we interact or which we need for our sustenance forms our environment. In fact, environment is visualised in different ways with different angles by different groups of people but it may be safely argued that ‘environment is an inseparable whole and is constituted by the interacting system of physical, biological and cultural elements which are interlinked individually as well as collectively in myriad ways. The environment is not static; rather it’s a very dynamic entity. Various factors (biotic & abiotic) are in a flux and keep changing the environment continuously.

**1.2 Types of Environment** On the basis of basic structure the environment may be divided into

- Physical/abiotic environment
- Biotic environment
- Cultural environment

**1.2.1 Physical/abiotic environment-** on the basis of physical characteristics and state, abiotic or physical environment is subdivided into:

- i. Solid i.e lithosphere (solid earth)
- ii. Liquid i.e hydrosphere (water component)
- iii. Gas i.e atmosphere (gaseous component) These environment can be termed as lithospheric, hydrospheric, atmospheric environment which can be further broken into smaller units based on different spatial scales like mountain environment, plateau, plain, lake, river maritime, glacier, desert environment etc. The physical environment may also be viewed in terms of climatic conditions providing certain suits of habitat for biological communities like tropical, temperate and polar environment etc.

**1.2.2 Biotic environment:** biotic environment consists of flora and fauna including man as an important factor. Thus the biotic environment may be divided into:

- i. Floral environment
- ii. Faunal environment

Further all the organisms work to form their social groups And organisations at several levels and thus is formed social environment, where in, the organisms work to derive matter from the physical environment for their sustenance and development. This process generates economic environment. It may be pointed out that of all the organisms man is the most skilled and civilized and hence his social organisation is most systematic. It is significant to note that three aspects of man, physical, social and economic have different characteristics and functions in the biotic environment. As 'physical man' is one of the organismic populations or biological community and thus requires basic elements of physical environment (habitat, air, water, food etc) like other biological populations and releases wastes into the ecosystem; 'social man' establishes social institutions forms social organisations, formulates laws and policies to safeguard his existence, interest and social welfare and 'economic man' derives and utilises resource from the physical and biotic environments with his skills and technologies. These may be termed as physical, social and economic functions of man. It is the third function which makes the man and environmental process because he transports matter and energy from one component of the ecosystem to the other.

## **2. Components of Environment**

The basic components of the environment are atmosphere or the air, lithosphere or the rocks and soil, hydrosphere or the water, and the living component of the environment or the biosphere.

### **Atmosphere:**

- the thick gaseous layer surrounding the earth.
- It spreads up to 300 km. above the earth's surface.
- Apart from gases there are water vapor, industrial gases, dust and smoke particles in suspended state, micro organism etc.

### **Lithosphere:**

The word lithosphere originated from a Greek word mean "rocky" + "sphere" i.e. the solid outmost shield of the rocky planet.

The Earth is an oblate spheroid. It is composed of a number of different layers.

These layers are:

- The Core which is around 7000 kilometers in diameter (3500 kilometers in radius) and is situated at the Earth's center.
- The Mantle which environs the core and has a thickness of 2900 kilometers.
- The Crust floats on top of the mantle and is composed of basalt rich oceanic crust and granitic rich continental crust.

### **Hydrosphere :**

- The hydrosphere includes all water on or near earth surface and includes oceans, lakes, rivers, wetlands, icecaps, clouds, soils, rock layers beneath surface etc.
- water exist in all three states: solid (ice), liquid (water), and gas (water vapor)
- 71%of planet surface is covered with water • Freshwater- 2.53%
  - Freshwater in glaciers-1.74%
- Water as water vapour in atmosphere-12,900 km<sup>3</sup>
- living organism contain- 1100 km<sup>3</sup>

Since the environment includes both physical and biological concept, it embraces both the abiotic (non-living) and biotic (living) components of planet earth. Thus, on account of basic structure the components of environment may be classified into two basic types:



**Fig. Components of Environment**

**21 Abiotic Components** (Non living): these are the most important determining factor of where and how well an organism exists in the environment. Although these factors interact with each other, one single factor can limit the range of an organism thus acting as the limiting factor.

These factors can be categorised into following groups:

**a. Physical factors:** the major components are temperature, Water (Rainfall), Light (Energy), Soil, Atmospheric pressure. Temperature:

Temperature is the most ecologically germane environmental factor. It's a very well-known and an established fact that the average temperature on land varies seasonally, decreasing progressively from the equator towards the poles and from plains to the top of mountains

ranging from sub-zero levels to  $>50^{\circ}\text{C}$  in polar areas/high altitudes and tropical deserts in summer respectively. There are, however, unique habitats like thermal springs and deep-sea hydrothermal vents where average temperatures exceed  $100^{\circ}\text{C}$ . It is commonly known fact that mango trees do not and cannot grow in temperate countries like Canada and Germany, snow leopards are not found in Kerala forests and tuna fish are rarely caught beyond tropical latitudes in the ocean. A few organisms can tolerate and thrive in a wide range of temperatures without having effect on their internal environment (they are called eurythermal), but, a vast majority of them operate within a narrow range of temperatures (such organisms are called stenothermal).

**Water (Rainfall):** Subsequent to temperature, water is another most important factor influencing the life of organisms. In fact, genesis of life on earth is attributed to water without which life is unsustainable. Its availability is too scarce in deserts. Due to this scarcity only special adaptations by plants and animals of this region make it possible to survive there in such an unusual living conditions. The productivity and distribution of plants is also profoundly dependent on water. One might believe that organisms living in oceans, lakes, rivers and other water bodies should not face any water-related problems, but it doesn't hold true. For aquatic organisms the quality (chemical composition, pH) of water becomes crucial and one of the most determining factor for their survival. The saline concentration (measured as salinity in parts per thousand), is less than 5 % in inland waters, 30-35 % in the sea and  $>100$  % in some hypersaline lagoons. Some organisms are tolerant to a wide range of salinity (referred as euryhaline) while others are restricted to a much narrow range of salinity (referred as stenohaline). Many freshwater animals cannot survive for long in sea water and vice versa because of the osmotic problems which would subsequently lead to their death.

**Light (Energy):** One can quickly and easily understand the importance of light/energy for living organisms, particularly autotrophs since they produce/manufacture food through photosynthesis, a specialised process which is only possible with the availability of sunlight as a source of energy. Many plants are also dependent on sunlight to meet their photoperiodic requirement for flowering. For many animals too, light is essential as they use the diurnal and seasonal variations in light intensity and duration (photoperiod) as cues for timing their searching food, reproductive and migratory activities. The availability of light on land is in close association with that of temperature since the sun is the source for both. But, deep ( $>500\text{m}$ ) in the oceans, the environment is perpetually dark and its inhabitants are unaware of the existence of a celestial source of energy called Sun.

**Soil:** The nature and properties of soil in various places vary to a great extent depending upon the climate which includes temperature and humidity, the weathering process, whether soil is transported or sedimentary and how soil development occurred. Various physical characteristics of the soil such as soil composition, grain size and aggregation determine the percolation and water holding capacity of the soil. These features along with chemical parameters such as pH, mineral composition and also topography determine to a large extent the vegetation in any area. This in turn indicates or rather determines the type of animals that can be supported on a particular soil area. Similarly, in an aquatic environment, the sediment-characteristics often determine the type of benthic animals that can thrive there optimally.

### **2.1.1 Responses to change in abiotic factors**

Abiotic conditions of many habitats may vary drastically in time, which raises an essential question –how do the organisms living in such changing habitats adapt themselves with stressful conditions? But, prior to delving into answering this inevitable question, one should perhaps ask first why a highly variable and ever changing external environment should create an inconvenience to an organism afterall. One would expect that during the course of millions of years of their existence, many species would have evolved a relatively constant internal (within the body) environment that enables all biochemical reactions and physiological functions to progress with maximal efficiency and thus, enhance the overall ‘fitness’ of the species.

**Regulate:** Some organisms are able to achieve and stabilise homeostasis by physiological (sometimes behavioural also) means which ensures constant body temperature, constant osmotic concentration, etc. All birds and mammals, and a very few lower vertebrate and invertebrate species are indeed capable of such regulation (thermoregulation and osmoregulation). Evolutionary biologists are of the opinion that the mammalian success is largely owing to their ability to adhere to a constant body temperature and thrive successfully whether they live in frigid Antarctica or in the blazing Sahara desert. The mechanisms used by most mammals to regulate or stabilise their body temperature are similar to those of human beings. We, the humans, maintain a constant body temperature of 37°C. In summer, when external temperature is more than our body temperature, we sweat profusely resulting in evaporation which leads to external body cooling thus lowering the overall body temperature. Likewise, in winter when the temperature is much lower than 37°C, we start to shiver, leading to heat generation and thus raising the body temperature and thereby maintaining homeostasis

around 37°C. Plants, on the other hand, do not possess such mechanisms to maintain internal temperatures and are thus unable to regulate homeostasis.

**Conform:** In literal English term it means to obey or agree to something. An overwhelming majority (99%) of animals and nearly all plants are unable to maintain a constant internal environment, thus inefficient in maintaining homeostasis. Their body temperature varies with the ambient temperature, rise with increasing temperature and fall with decreasing temperature most of the times. In aquatic animals, the osmotic concentrations of the body fluids change with that of the ambient water osmolality which itself depends upon the salinity of the surrounding water. Such animals and plants are simply conformers, meaning thereby that they just agree to the surrounding conditions rather than adopting any mechanism to stabilise their internal environment.

**Migrate:** The organisms can shift away temporarily from the stressful habitat to a more hospitable area and return when stressful period is over. In human analogy, this strategy is like a person moving from Delhi to Shimla for the duration of summer to avoid the stressful conditions of severe heat and return back to Delhi when temperature is more comfortable. Likewise, many animals, particularly birds, during winter undertake long-distance migrations to more hospitable areas and avoid the frigid conditions of their true environment. Every winter the famed Keoladeo National Park (Bharatpur) in Rajasthan host thousands of migratory birds coming from Siberia and other extremely cold northern regions which become temporarily inhospitable for them. Thus migration is a form of temporary shift of organism from its true habitat to an ecologically friendlier habitat due to more stressful conditions of true habitat.

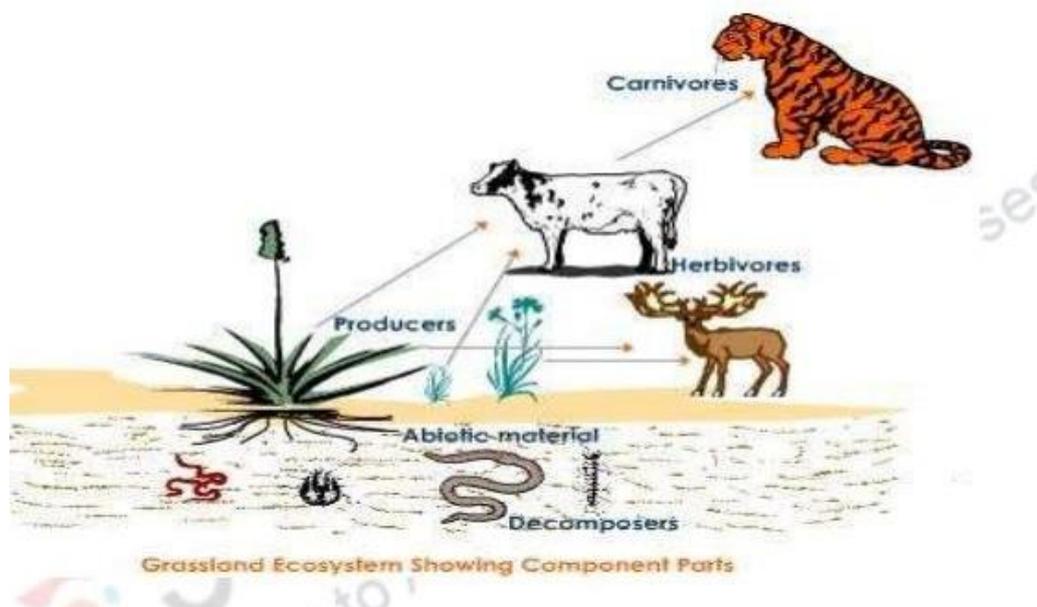
**Suspend:** In bacteria, fungi and lower plants, various types of thick walled spores are formed which help them to survive unfavourable/extreme conditions – which subsequently germinate on availability of suitable environment. In higher plants, seeds and some other vegetative reproductive structures serve as means to resist the periods of stress besides helping in its dispersal – they germinate to form new plants under favourable moisture and temperature conditions. They do so by reducing their metabolic activity and going into a stage of ‘dormancy’.

In animals, the organism, if unable to migrate, might avoid the stress by escaping in time through the two phenomenon. The familiar case of bears going into hibernation during winter is an example of escape in time to avoid extreme of cold.

Some snails and fish go into aestivation (a state of animal dormancy characterized by inactivity and a lowered metabolic rate) to avoid extreme summer heat and desiccation.

Similarly, under unfavourable conditions many zooplankton species in lakes and ponds are known to enter diapause, (a stage of suspended/deferred development). Diapause, when referencing animal dormancy, is the delay in development in response to regularly and recurring periods of adverse environmental conditions.

**Inorganic and organic substances:** Water, Oxygen, Carbon, Nitrogen, Sulphur, Nitrates, Phosphates and ions of various metals etc are inorganic substances essential for organisms to survive while proteins, Carbohydrates, Lipids etc are essential Organic substances:



**Fig. 2 Components of biotic community**

**22 Biotic Components (Living):** It consists of the living parts of the environment, including the association of a lot of interrelated populations that belong to different species inhabiting a common environment. The populations are those of the animal community, the plant community and the microbial community.

The biotic community is divided into:

- a. Autotrophs,

b. Saprotrophs, and

c. Heterotrophs

**Autotrophs** (from Greek : auto - self, trophos - feeder) are called producers, transducers or convertors, as well. Those are photosynthetic plants, normally chlorophyll bearing, which synthesize a high-energy complex organic compound (food) from the inorganic raw materials utilizing the aid of the sun, and this process is called photosynthesis. Autotrophs form the core of all biotic systems. In terrestrial ecosystems, autotrophs are usually rooted plants. In the aquatic ecosystems, the floating plants referred to as phytoplankton and the shallow water rooted plants – macrophytes - are the main producers.

**Heterotrophs** (from Greek: heteros - other; trophos - feeder) are the consumers, normally animals that feed on the other organisms. Consumers are also referred to as phagotrophs (phago - to swallow or ingest) while macroconsumers are normally herbivores and carnivores. Herbivores are called First order or primary consumers, for they feed directly on green plants. For example, Terrestrial ecosystem consumers are cattle, deer, grass hopper, rabbit, etc. Aquatic ecosystem consumers are protozoans, crustaceans, etc.

Carnivores are animals that prey or feed on other animals. Second order consumers or Primary carnivores include those animals that feed on herbivorous animals. For example, fox, frog, smaller fishes, predatory birds, snakes, etc.

Third order consumers or Secondary carnivores are the animals that feed on primary carnivores. For example, wolf, owl, peacock, etc. Some larger carnivores prey on Secondary carnivores. Quaternary consumers or Tertiary carnivores include those animals which feed upon secondary carnivores. For example, the lion, the tiger, etc. Those are not eaten by any other animal. The larger carnivores which cannot be preyed on further are also called the top carnivores.

**Saprotrophs** (from Greek again: sapos - rotten; trophos - feeder) are called the reducers or decomposers or osmotrophs. They break the complex organic compounds in dead matter down (dead plants and animals). Decomposers don't ingest the food. Instead they secrete a digestive enzyme into the dead, decaying plant or animal remains and digest this organic material. The enzymes act on the complex organic compounds in the dead matter. Decomposers absorb a bit of the decomposition products to provide themselves with nourishment. The remaining

substance is added as minerals in the process of mineralisation to the substratum. Released minerals are utilised or reused as nutrients by plants - the producers.

## MAN AND ENVIRONMENT RELATIONSHIP

### 1. Introduction

Geography as a discipline always had the purpose of gaining logical and useful information about the man and his habitat. This has been from the beginning of the philosophical scholarship of man. To establish my point I would initiate from Eratosthenes, the Greek scholar in the third century B.C who coined the term 'geography'. The word 'geography' can be divided into two parts, '*geo*' and '*graphy*.' 'Geo' comes from the Greek word 'go', meaning '**Earth**,' and '*graphy*' comes from '*graphein*', which means '**to describe**.' What is more important to know that in what spirit did Eratosthenes coined the term geography? For him, geography was a discipline that studies earth as the home of a man (James and Martin, 1972). This sets the roots for the theme of man-environment relationship within the geographical thinking. The theme became so popularise that it still persists; in the words of Broek (1965) '*..... to understand the earth as the world of man.....*'.

The history of geographical ideas clearly depicts how through ages, the manenvironment relationship as been perceived, deliberated upon and established as one of the focal themes in the geographical thinking. The whole idea is to get more and more logical and useful knowledge of the human habitat and human spread over the earth surface. Before we look into the historical background and doctrines established on this theme we need to have a clear perspective on a man-environment relationship which is discussed in the next section. focal themes in the geographical thinking. The whole idea is to get more and more logical and useful knowledge of the human habitat and human spread over the earth surface. Before, we look into the historical background and doctrines established on this theme we need to have a clear perspective on a man-environment relationship which is discussed in the next section.

### 2. Man and Environment Relationship – A Perspective

For the understanding of this relationship, one has set the limits how one defines the environment. The most basic definition was given by Einstein who states that *the environment*

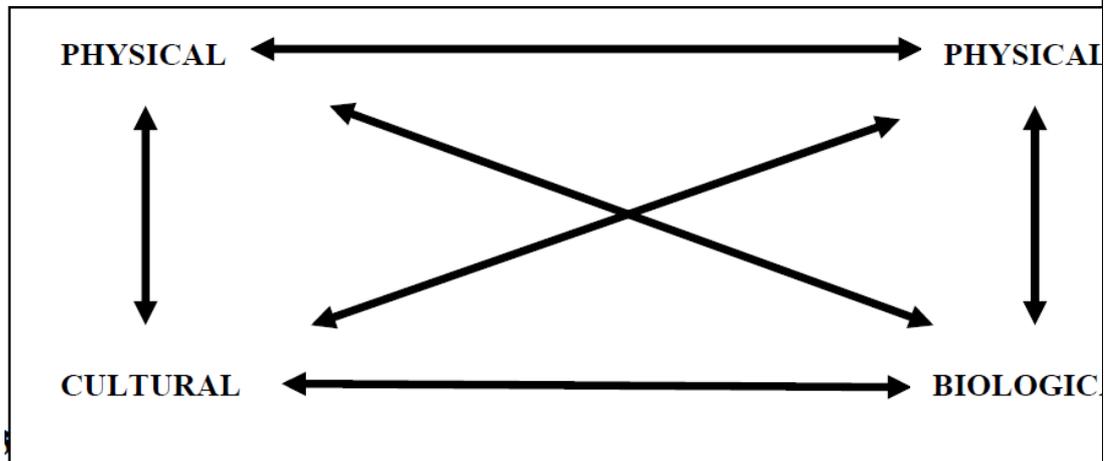
*is everything that isn't me.* In simpler words, everything beyond me is the environment. Thus one should not debate on the dualism of physical and cultural environment rather take both as two equal halves of the same whole. Both physical (biotic, abiotic and energy) and cultural (mentifacts, socio facts, and artifacts) components influence man's actions in adapting to the environment to transforming it for satisfying his needs. The basic premise is that this relationship is not direct or static rather it is dynamic and multifaceted as explained in the diagram given below (Figure 1)

MAN

ENVIRONMENT

1. The environment acts directly on man.

2. ~~The man acts directly on the environment.~~

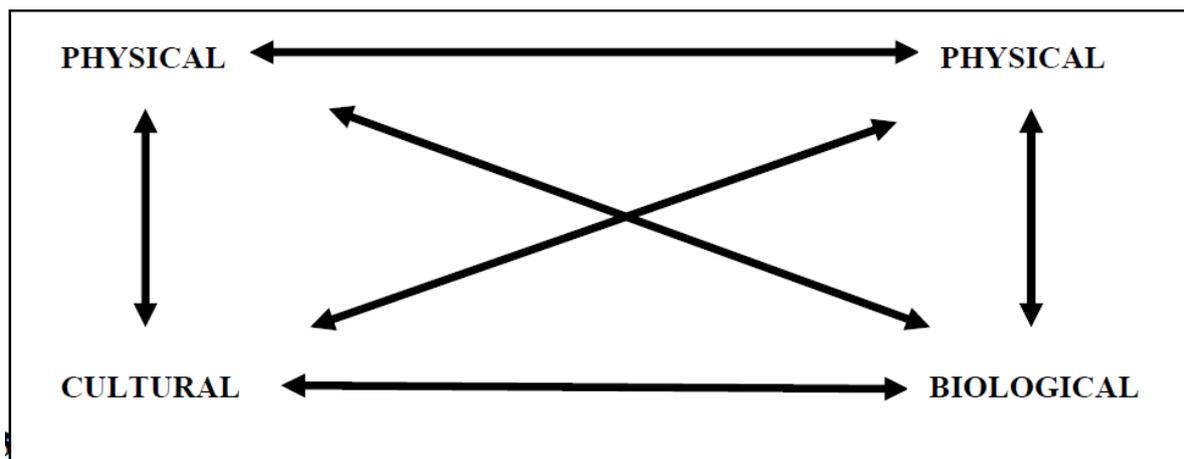


3. Each acts directly on the other

4. The reciprocal action is indirect because it is conditioned by man's culture and

knowhow

5. In reality, the situation is complicated because a large number of factors and their association among themselves influences this relationship.



In the ancient and middle ages, Greek, Roman, Indian, Chinese and Arab geographers attempted to establish a relationship between man and natural environment. Kant, in the latter half of the 18th century, advocated the impact of environment on the lifestyle and physical constitution and lifestyle the equatorial, hot deserts, Mediterranean, coastal and mountainous regions. According to Kant, the inhabitants of Torrid Zone are exceptionally lazy and timid, while the people of the Mediterranean region living in the mild temperature conditions are industrious, hardworking and progressive.

The environmental causation continued throughout the 19th century. Humboldt asserted that the mode of life of the inhabitants of the mountainous countries of the Andes mountains differs from that of the people of Amazon basin, coastal plains, and islands like Cuba and West Indies. Ritter attempted to establish the cause variations in the physical constitution of body, physique, and health of people living in the different physical environmental conditions

### **A. Impact of Darwinism**

The idea of defining geography in terms of man and environment relationship developed on scientific lines in the latter part of the 19th century after the publication of *The Origin of Species* (1859) by Charles Darwin. This seminal work gave a new direction to the discipline of geography. The theory of evolution held that all living species have evolved from pre existing forms. His geological observations and theories had one thing in common: the idea that things in nature change with time

Most of the writers in the pre-Darwinian period discussed the man-environment relationship as a cause-effect relationship. They did not ponder into the processes involved in this relationship. Ratzel for the first time took up this issue in the first volume of *Anthropogeographie* (1882) which was later developed by his students Semple and Demolins. In France, Blache's ideas

dominated so this rigid framework of harmony and relationship was not accepted. But in America, this was carried out by Davis who tried to incorporate this idea of causality into the definition of geography itself. This notion was not accepted by many scholars as they were of opinion that no science can be confined to the study of a specific relationship. Moreover, this causal relationship provides an unsound methodological approach as the intensity of the influence of environment becomes a major problem.

Fluere was deeply influenced by Darwinism and opined that the man-environment relationship should be studied from the physiological point of view and while delineating human regions; he applies Darwin's ideas of natural selection through environmental influence to human groups. Huntington too looked into this theme and applied it to human population while studying it at the global level. Taylor investigated this idea in his studies on race, population, states, and cities. He concluded that these are directly influenced by environmental factors as their development over time is regulated by these conditions. Determinists, therefore, raised certain questions but could not possibly find suitable answers within the geographical framework. Hartshorne tries to seek answers by stating that the whole determinist-possibilist debate within the discipline was unreal and futile which led the whole debate on a philosophical level rather than at an empirical level.

In America, the concepts of Spencer and Darwin, the survival of the fittest and the struggle for life, respectively were positively used in the disciplines of political science and economics to justify *laissez-faire*. Darwinism, though, had a limited influence on the classical equilibrium economics.

In geography, particularly, political geography, these ideas of struggle and selection were used significantly. Ratzel (1896) applied this concept to his seven laws for the growth of state which later developed as the concept of *Lebensraum*. He states that as plants and animals struggle for their existence, a nation too, clash for their struggle to capture more territory. The organic analogy derived by Ratzel along with the theme of struggle and selection provided a strong model in analytical political geography which had scientific justification in man's political behaviour. Semple tried to omit the concept of organic analogy in her writings but it seemed that she was still touched by it, as these themes penetrated in her writings

Kjellen (1942) in his work on states was highly influenced by Ratzelian ideas. His *Geopolitik* is an example where he writes that states are biological manifestations not only morally but also organically as they experience lust. He was also supportive of Spencer's writings which

are visible in his *Staten sam Lifsfarm* (1944). The over-dependence of political geography on the organic analogy, the ideas of struggle and *Lebensraum* brought disgrace to this branch, especially in the 1930s.

To sum up, Darwin contributed by making science more empirical and inductive in nature; this dismisses the role of teleology also. The biggest contribution of Darwinism in geography is in establishing man's place in nature and at the same time making a study of man a scientific learning.

### **b. The Deterministic Perspective**

In the history of geographical thinking, human – nature dialogue has been studied and analyzed from a number of different perspectives and views. The first amongst these approaches to deliberate on the human-nature relationship was determinism. In the words of Platt (1948) determinism, refers to the idea that everything in human life is caused certainly by preceding events or conditions. The primary initial source of determinists for an explanation was the physical environment, and the theoretical order was centered on the belief that the human activity was solely regulated and controlled by their environment. Determinism, as a paradigm is one of the most significant beliefs, which still continues in one form or other. In the context of this concept, it is believed that due to the difference in the natural environment, the variations in human behavior in different parts of the world can be described. The spirit of deterministic ideology is that the level of development of history, culture, lifestyle and social group or nation is solely ruled by the physical components of the environment at any scale.

Determinists consider humans as a passive agent on whom physical factors are working continuously determining their approach and decision-making process. In short, they believe that most of the activities of man can be elucidated as a response to the environment.

In the context of the effect of natural conditions, the first attempt was made by Greek and Roman scholars explaining the physical characteristics and character traits of different people and their culture. At that time, this effort was not contained only among geographers rather included scholars from different fields like the doctor Hippocrates, philosopher Aristotle, and Historians Thucydides, Polybius, and Herodotus. In the Greco-Roman era, regional studies were closely tied with the study of history; Thucydides and Polybius saw Athens's natural conditions and geographical position as factors for its greatness. For example, Aristotle explained the difference between Northern Europe and Asian people in the context of climate causes, while explaining the greatness of Rome, while mentioning similar incidents of Strabo

Strabo argued that the cold weather in Europe was the reason for their bravery. Aristotle thought that people living in hot weather in Asia were wise but there was a lack of soul and therefore time to time subjected to slavery. Because humans often consider their home as the best place, it is not surprising that Aristotle believed that the best combination of all possible worlds was in the center of space, Greece (Glacon, 1967). Aristotle strongly advocated the progress of some countries is the result of their favorable environmental conditions.

In the Middle Ages, Montesquieu explained that in cold weather people are less physically strong, more courageous, clear, less susceptible and less cunning than those in hot weather. He quotes that people in hot weather are terrible, weak in body, dull and inactive. Deterministic approach dominated the writings of Arab scholars. They divided the world into seven terrestrial zones on the basis of climate and highlighted the physical and cultural characteristics of the castes and castes of these regions. Al-Baruni, Al-Masudi, IbnHawkal, Al-Idrisi and Ibn Khaldun attempted to correlate the environment with human activities and living conditions within the conceptual domain of determinism.

Deterministic reasoning continued in the 19th century when geography itself was related to other sciences. Carl Ritter, a German geographer adopted an anti-human approach and laid the philosophical base of determinism in geography. Ritter tried to make a difference in the physical constitution of the body, body, and health of men living in the different physical environment. Many of his students considered geography as "a study of the relationship between people's density and the nature of their land". Many geographers of their school had declared that their main task was to identify the influence of physical cultural geographical conditions and the political fortunes of residents of any area in both East and present. Alexander von Humboldt, one of the founders of 'Modern Geography' and a contemporary of Ritter, also said that the life of the residents of a hill country is different from those in the plains.

Friedrich Ratzel, the founder of 'new' determinism, supplemented the 'classical' geographical determinism with the elements of 'Social Darwinism' and developed the state's theory as an organism. He believed in the existence of a qualification and saw the 'man' as the end product of development - a development which was natural selection of type according to the ability to adjust itself to the physical environment of the environment. He along with his disciple Ellen Churchill Semple became the most vocal expression of the deterministic approach in geography.

Semple in her book *Influences of Geographical Environment* (1911) writes: Man is a product of the surface of the Earth; this book had a widespread, long-lasting use in geographic education (Wright 1966). She dominated the environmentalist period of the discipline in the early twentieth century (Hartshorne 1939) and "trained a large proportion of those who became leaders of the profession during the period between the two World Wars" (James, Bladen and Karan 1983). Her methodological statement cannot be questioned as at one time she points out that the influence of climate on man both as a direct and indirect effect cannot be questioned. She further elaborates that man was a passive subject who bears direct environmental influence at early stages of development

### **c. The Possibilistic Perspective**

The doctrine of possibilism tries to explain the relationship of a human being with the environment in a different way; it puts human at a higher level and regards it as an active agent. It is a principle which claims that environment provides opportunities and man being an economic man chooses from those possibilities. Febvre (1932) in 'A Geographical Introduction to History' stated 'there are no necessities, but everywhere possibilities; and man, as the master of these possibilities, is the judge of their users'.

The roots of possibilism can be traced back to the works of Plato, who is considered the master of deductive reasoning. Though his idea went into gloom for hundreds of years; the contrasting doctrine of determinism continued to grow and flourished. It got support in the writings of French scholar of the eighteenth century – Montesquieu, who is credited with developing a doctrine analogous to modern paradigm of possibilism. He opined that man possesses free will and has the ability to choose from a series of opportunities. Similar thoughts were also put forward by another eighteenth-century French philosopher, Comte de Buffon. He believed that man was ordered to conquer the earth and even transform it. Their views laid the base for crypto-possibilistic hypothesis (Adhikari, 2010).

It was only in the latter half of the nineteenth century that under the leadership of Vidal De la Blache (1845 – 1918), a possibilistic view of man-environment developed. The focus of this philosophy was "Nature has set boundaries and has provided possibilities for human settlement, but the way a person responds to these conditions or adjusts it depends on the traditional way of life." Vidal rejected the concept of material determinism and advocated favourability. He even rejected Durkheim's opinion of human geography as social morphology rather insisted that man was a partner and not a slave of the environment (Dikshit, 2009). He was critical of

Darwinian-Ratzelian heritage which proposed environmental determinism and put forth the concept of possibilism. He sought a scheme for understanding the interaction of nature and culture that eschewed both environmental determinism and radical possibilism to seek answers or solution for the dichotomy between the human and the environment.

In the twentieth century, possibilism got stronghold after the publication of Blache's article in 1913 where he categorically states that geography as a discipline seeks to measure and role of man in modifying the earth surface. This was further strengthened when his book was published in 1921 (English translation in 1926), though posthumously. He observes that nature gives man materials which have their inherent needs as well as limitations thus leading them to limited uses.

Possibilism was further flourished by acclaimed historian Lucien Febvre (1878- 1956). He puts forward - "Whatever the men do in their own environment, they cannot completely get rid of themselves completely." Febvre emphasized human initiative and motivation against the environment, destroying the environmental deterministic reasoning and as part of the environment of any group, as well as other humans, because they belong to the next group's cultural surroundings, or the constraints of the environment are influenced by such thinking. He stated that in the view of possibilists, a homogeneous region does not necessarily result in a homogeneous society. This is because people residing in any area have the choice of possibilities time to time and also in the quantity they want.

Bruhnes followed Blache's ideas and took it to next step, he not only transmitted Blache's philosophy in France but also disseminated it to different parts of the world. In 1910, his monumental work *La Geographie de L'Histoire* was published.

Barrows, in his presidential address (1922), recommended that relationships in geography should be studied "from man's adjustment to environment, rather than the reverse". Hettner (1907) also supported the concept of geography as the study of relationship. Thus, both the physical factors and the human factors (cultural environment) are to be studied in their relations to each other.

**d. Probabilism:** The concept of probability was put forward by the O H K. Spat (1957) is the idea that the physical environment does not specifically determine human activities, yet it gives some reaction to others. This word was proposed as a mid-route between Ratzel's complete environmental determinism and a revolutionary prospect of Febvre, Lablache, and Sauer. While the environmental determinants, influenced by the cause and effect of Darwin, said that

human activities are controlled by the physical environment, according to the possibilities, the physical environment provides the opportunity for many possible human reactions and enough conscience to choose people is among them.

According to Spate, "human action was not said in the case of all or some kind of compulsion, but rather the balance of the possibilities". For example, there is a possibility that the use of land in the Sutlej-Ganga field decreases intensity from market centers; Population density decreases away from metropolitan centers in all directions; With the settlement of the village, the crop yields less than a few walking distances

However, there can be exceptions for each of these generalizations, and in many cases, there is a limit to the boundaries that they keep right. Exception and boundary demand details After this concept, probability theory is considered as an essential component of geographic analysis because "a general mode of discussion" was provided for " the scientific study of the scenario". This view, in fact, is completely consistent with the original Vitalian concept. Geologists started using probability theory to determine human and environmental relations and also carried scientific studies of the landscape.

The probability theory was criticized on many grounds. For example, a complete knowledge about the environment cannot be available; The available data about resources and their use cannot be reliable; The perception about resources (environment) differs from humans to community, community to region, and country to country, prospective model's application, due to these constraints, can be difficult and thus the results obtained cannot be authentic Are close to the ground reality.

**e. Cultural or Social Determinism:** Cultural or social determinism emphasizes the human element: "Our thoughts determine our actions, and our actions determine the nature of the world's last" (James, 1932: 318). Since there is a difference in human interest, desires, prejudices and group values, therefore there is a difference in the level of cultural landscape and socio-economic development. The amendment of an environment depends on our perception, thoughts and decision-making processes

This philosophy made by American scholars can be explained in principle, according to which "the significance of man's physical and biological features of his residence is an act of man's own views, objectives, and technical skills". For example, a country that is financed by a hunter's perspective can be poor for an agricultural person; The importance of coal is not the same as those who can not use it. All these truths are self-evident. It is also true that as

technology develops, the importance of the environment is not reduced, but the change becomes more complex

The philosophy of cultural determinism is quite broad among American geographers. For example, Eduard Wellman wrote that "the environment is essentially neutral, its role depends on the level of technology, the type of culture and the other characteristics of the changing society". For example, mountain pass estimation, which is for horses, automobiles, airplanes, will be different for them; Assessment of fertility of soil will not be similar to the perspective of a Japanese farmer, on the other hand, or an Amazonian Indian. Similar natural conditions can say different reactions on human part, and in similar circumstances, different cultures can occur. George Carter is out of three fundamental factors in human geography, he has given more emphasis on cultural forces and wrote that "staying as a primary reason for changing the ideas ..., these are the ideas that determine the human use of the physical world We do". He also said that human beings are the decisive factor.

After World War II, schools of social determinism became very popular in Austria, Holland, and Sweden. Social geography relates to the spatial distribution of society. This, however, is not able to gain a deeper understanding of social relations or landscape. Social groups can be isolated in the context of ethnic, religious, professional and some other characteristics, whereas social change is only mentioned, but seldom is associated with any fundamental economic causes or society's class structure.

The study of the effect implemented by these groups on the scenario reduces in the definition of purely external factors of the cultural landscape (deployment and deployment of homes, land uses, type patterns etc.), which in the form of morphology and Under the functional changes, boundaries of the same road are infinitely the use of such 'macroregional' research is usually used in the character. Motivated and cannot provide any basis of scientific findings of real importance. Thus social or cultural determinism does not adequately assess environmental factors, that is, the effect of the natural environment on 'cultural geographical differences'. Thus, social determinism is thus rigorous as the environmental fatalism and therefore cannot be accepted in its raw form.

To sum up, the major debate among the geographical thinkers is whether people are an active or passive agent in the man-nature relationships. The entire debate revolves around two issues – Firstly, resource exploitation is inevitable for the survival of human beings which means that he will take more and return less. Secondly, there is hope that morality will win as human

beings will vote for greater gains than meager personal benefits. The doctrine of sustainable development leads towards both these issues as it is based on the theme that development means meeting the needs of the present without compromising the ability of the future generations to meet their own needs (Report on World Commission on Environment and Development, 1987).

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1. Explain the definition and scope of environment
2. Recognize different types and components of environment
3. Explain the difference between biotic and abiotic environment
4. Explain the concepts of determinism and possibilism

## **Ecology**

Ecology is the branch of science that deals with the relationship of organisms with one another and with their physical surroundings. **The word “ecology” (oekologie), was first coined in 1866 by the German Scientist Ernst Haeckel (1834-1919) is derived from Greek word *oikos* meaning home and *logos* meaning the discourse or study.**

- According to Haeckel “*ecology is the study of the reciprocal relationship between living organisms and their environments*”.
- Recently Odum has defined ecology as “*the study of the structure and function of nature*”.

It is studied at various levels such as organism, population, community, biosphere, and ecosystem.

### Levels of study

**Individual-** study of a single organism

**Species-** Plants have similar genetic makeup

**Population** – similar organisms living in the same area that can interbreed each other and make fertile offspring

**Community** – different populations living in a certain area

**Ecosystem** – all organisms living in a particular place along with non-living things

**Biome** – several ecosystems in the same climate

**Biosphere** – All Biomes together

### **Ecosystem**

The concept “**ecosystem**” was first used by A. G. Tansley (1935). Ecosystem is an ecological system which deals with community and its physical environment treated together as **a functional system**.

- According to Clarke (1954) “The organisms and the physical features of the habitat form an ecological complex or more briefly an ecosystem”
- According to E. P. Odum, *the ecosystem is the basic functional unit of organism and their environment interacting with each other with their own components.*

All the ecosystems of the earth are connected to one another, e.g. River ecosystem is connected with ecosystem of oceans, and small ecosystem of dead logs is a part of large ecosystem of a forest.

*A complete self-sufficient ecosystem is rarely found in nature but situation approaching self-sufficient may occur.*

## Ecosystems characteristics

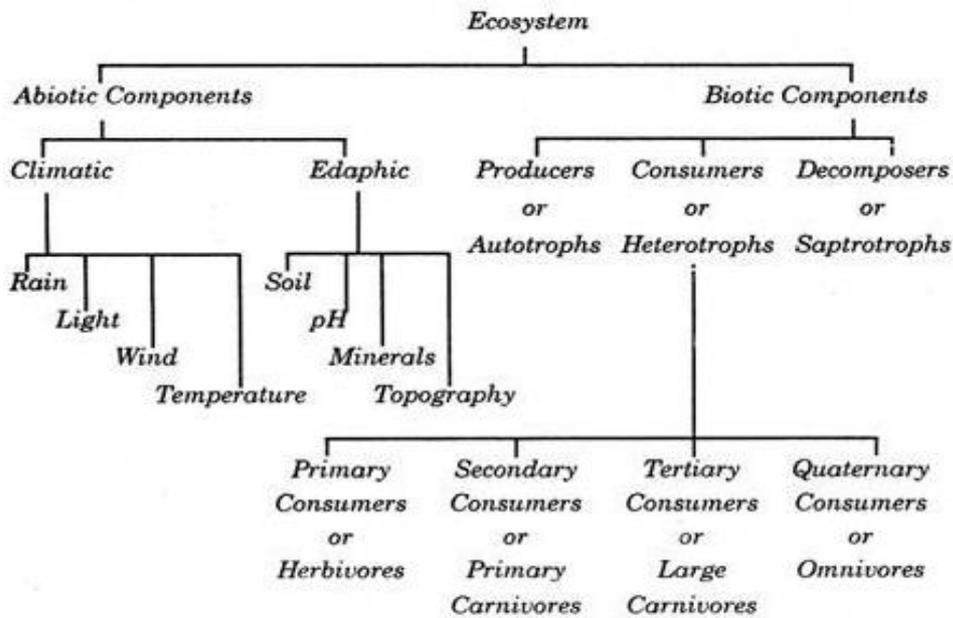
- Ecosystem is the major unit of Ecology.
- It has both structure and function
- Ecological structure is related to species diversity
- More complex structure means the greater diversity of species
- Ecological function is related to flow of energy and matter through structural component of the ecosystem

## Ecosystem structure and function

- Structural component :
  - Nonliving (abiotic)
  - Living (biotic)
- Functional Process:
  - Energy flow
  - Cycling of matter (chemicals)
- Change:
  - Dynamic (not static)
  - Succession, etc.

## Ecosystem Structure

- Nonliving (abiotic) component
- Living (biotic) component



## Nonliving (abiotic) component

Basic inorganic elements and compound such as soil, water, oxygen, calcium carbonate, phosphates, sulfur, boron and a variety of organic compounds (by product of organic activities or death) such as proteins, carbohydrates, lipids, and other complex molecules.

### **Living (biotic) component**

The biotic components of an ecosystem can be classified according to their mode of energy acquisition into 2 types

- Autotrophs
- Heterotrophs

### **AUTOTROPHS**

Organisms that can capture and transformed radiation energy of the SUN to chemical bond energy in the form of organic food from simple inorganic compounds are called **AUTOTROPHS**. It range from bacteria to plants .They are also called **PRODUCERS**. Solar energy is captured by green plants during **PHOTOSYNTHESIS**.

- On land – Green plants are the primary producers
- In water- Algae are the primary producers
- Organisms that use chemicals as a source of energy to make their own food are called **CHEMOSYNTHETIC**

### **HETEROTROPHS**

Organisms that can only obtain energy from other organisms are called **HETEROTROPHS**. Examples are animals, fungi, and many bacteria. They are different types-

1. **Herbivore** – eat plants only Ex. Cows, deer, caterpillars
2. **Carnivore** – eat animals only. Ex. Snakes, dogs, owls
3. **Omnivore** – eats plants and animals. Ex. Humans, bears, crows
4. **Detritivore** – eats decaying materials. Ex. Worms, mites, snails, crabs
5. **Decomposer** – breaks down organic matter. Ex. Bacteria and fungi

On the basic of **mode of nutrition in food chain**, biotic components of ecosystem can be described under the following three heads.

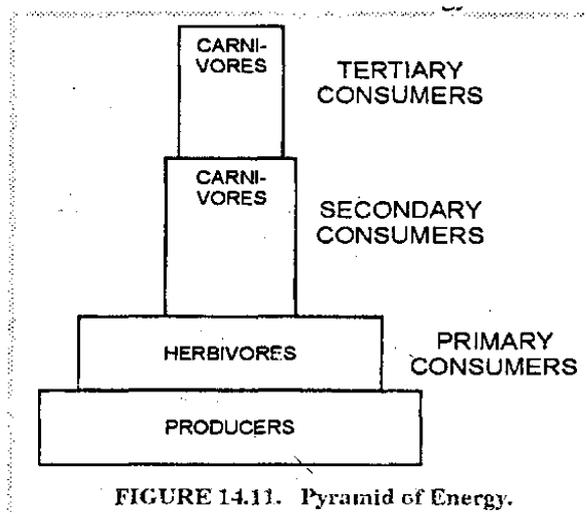
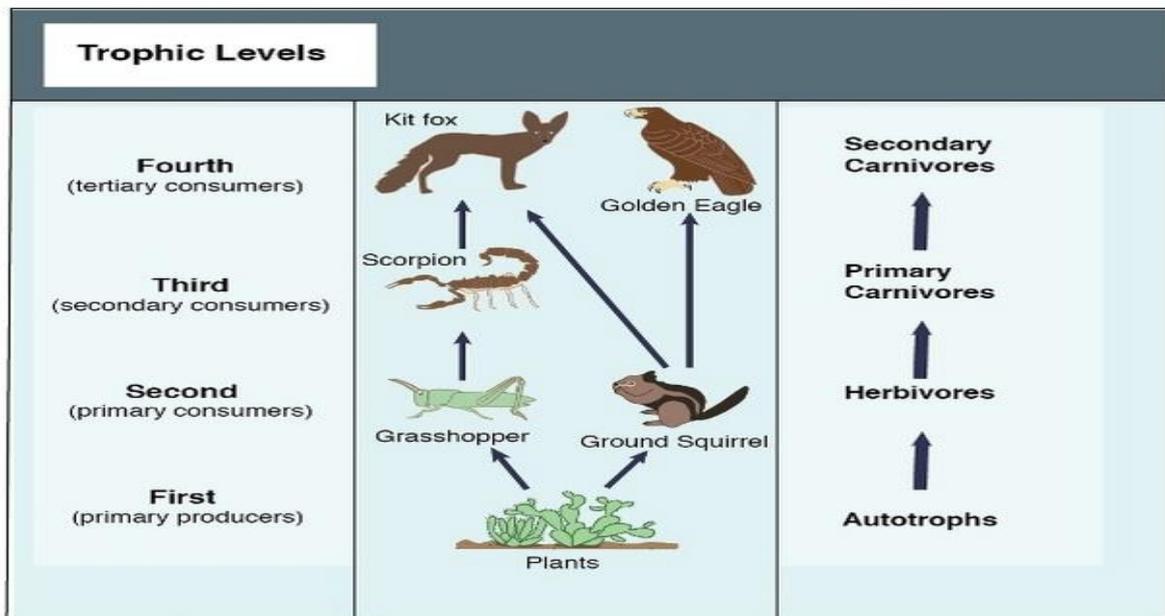
- **Producers** are the plants in the ecosystem, which can generate their own energy requirement through photosynthesis, in the presence of sunlight and chlorophyll.
- **Consumers** include herbivores, carnivores, and omnivores. The herbivores are the living organisms that feed on plants. Carnivores eat other living organisms. Omnivores are animals that can eat both plant and animal tissue.
- **Decomposers** are the fungi and bacteria, which are the saprophytes. They feed on the decaying organic matter and convert this matter into nitrogen and carbon dioxide. The saprophytes play a vital role in recycling the nutrients so that the producers i.e. plants can use them once again.

### **Trophic levels**

The different species in a food chain are called **trophic levels**. Each food chain has 3 main trophic level- producer, consumer and decomposers.

Thus Graphical representation of these trophic levels in food chain is called as **Ecological Pyramids**. It was devised by an ecologist Charles Elton, therefore this pyramid are also

called Ecological pyramid or **Eltonian pyramids**. Ecological pyramid defined as the study of flow of energy and matter from one biotic component to the next in the form of geometric structure called “**Ecological Pyramid**”.



Ecological pyramid defined as the study of flow of energy and matter from one biotic component to the next in the form of geometric structure called “**Ecological Pyramid**”. Ecological pyramids are of three types:

1. Pyramid of Number
2. Pyramid of biomass
3. Pyramid of Energy

### **Pyramid of Number**

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

In case of **grassland ecosystem** the producers are mainly grasses and are always maximum in number this number then shows a decrease towards apex as primary consumers like mice,

rabbit are lesser in number than grasses, the secondary consumers like lizard, snake, are even lesser in number than the grasses, finally the top tertiary consumers like hawks are least in number. Thus the shape of **pyramid is upright**.

But in case of **forest ecosystem** the pyramids is always inverted because the producers are mainly large trees, are lesser in numbers, the herbivores fruit eating birds are more in number than the producers, then there is gradual increase in number of secondary consumers thus making **pyramid inverted**.

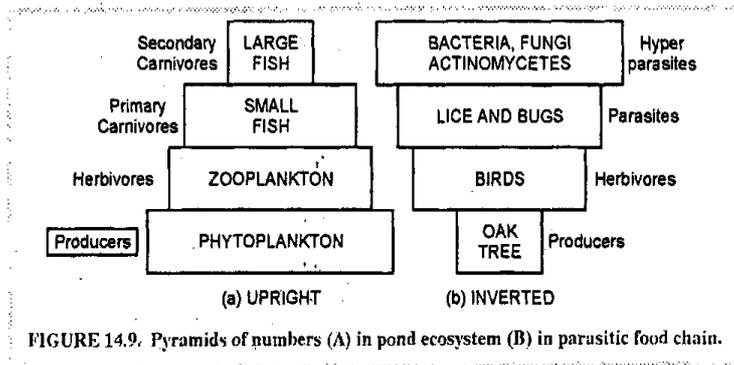


FIGURE 14.9. Pyramids of numbers (A) in pond ecosystem (B) in parasitic food chain.

### Pyramid of biomass

The pyramid of biomass represents the relationship between different trophic levels in terms of biomass. There is generally gradual decrease in biomass of organisms at successive levels from the producers to the top carnivores. Thus **pyramid of biomass is upright for grassland ecosystem**. However in case of a **pond ecosystem** as the producers are algae, are least in number and this value gradually shows an increase towards the apex of pyramid thus making the pyramid **inverted** in shape.

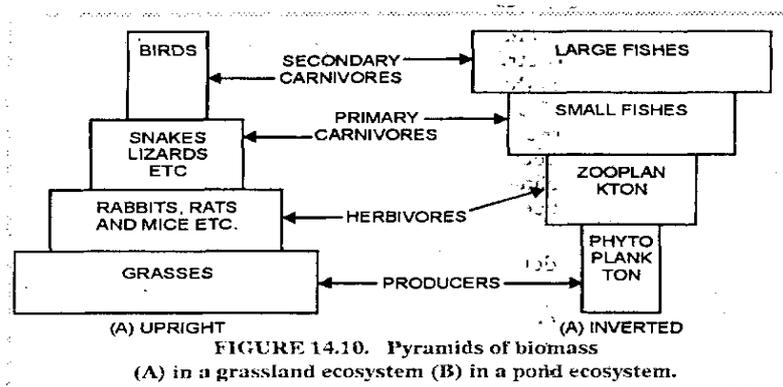


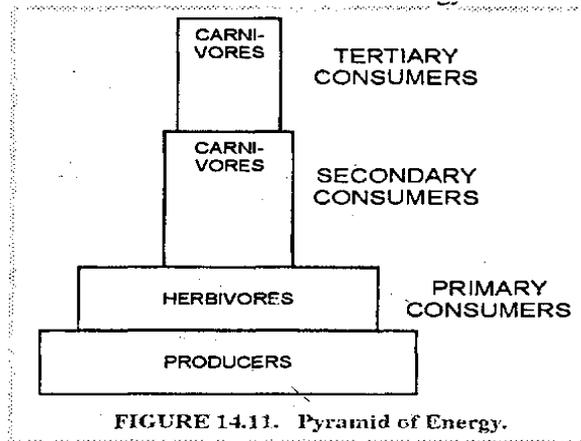
FIGURE 14.10. Pyramids of biomass (A) in a grassland ecosystem (B) in a pond ecosystem.

### Pyramid of Energy

The energy pyramid gives the best picture of overall nature of the ecosystem. In this type of pyramid the trophic level is depending upon the rate at which food is being produced. In shape it is **always upright** as in most of the cases as there is always gradual decrease in the energy content at successive trophic level from producers to various consumers.

- The greatest amount of energy is found at the base of the pyramid.
- The least amount of energy is found at top of the pyramid.

- Energy loss by respiration also progressively increasing from lower to higher trophic states.



### Food chain

Food from one trophic level reaches to the next trophic level and in this way a chain is established. This is known as **food chain**.

*A food chain may be defined as the transfer of energy and nutrients from one organism to another one through a repeated process of “eating and being eaten” in this way a chain is established which is known as food chain.*

The producers, consumers, and decomposers of each ecosystem make up a food chain.

There are many food chains in an ecosystem.

In food chain each organism eats the smaller organisms and is eaten by the larger one. All those organisms are interlinked with each other through food to constitute the food chain.

If any of the intermediate stage of the food chain is removed, the succeeding links of the food chain will be affected.

### Types of food chain

**Grazing food chain:** This type of food chain starts from the living green plants goes to grazing herbivores, and on to carnivores. Ecosystems with such type of food chain are directly dependent on an influx of solar radiation.

**Detritus food chain:** This type of food chain goes from dead organic matter into mi-croorganisms and then to organisms feeding on detritus (detrivores) and their predators. Such ecosystems are thus less dependent on direct solar energy. For example, such type of food chain operates in the decomposing accumulated litter in a temperate forest.

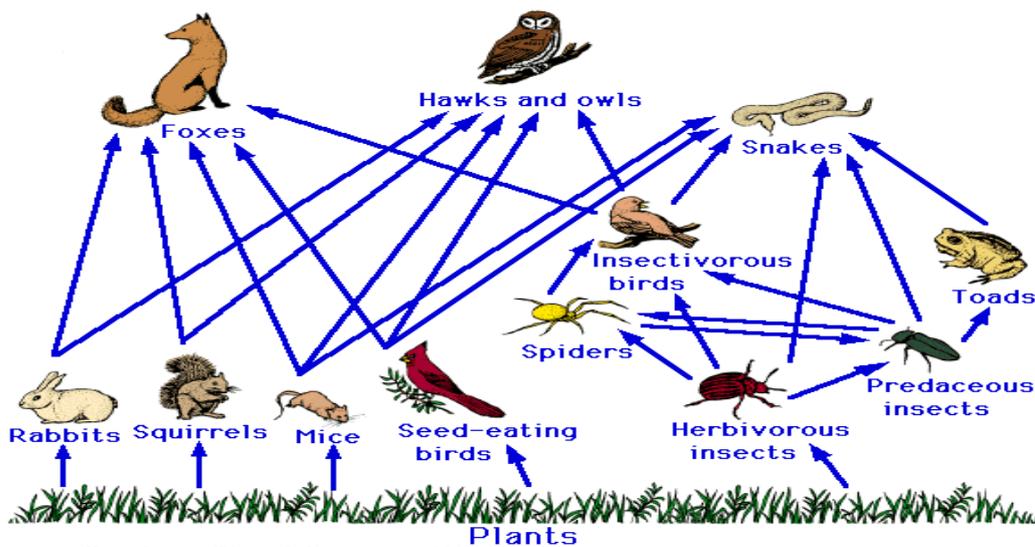
**Parasitic Food Chain:** This type of food chain starts from big hosts and ends with parasitic organisms.

### Food Web

The interconnected, interlocking pattern of food chain is known as **food web**.

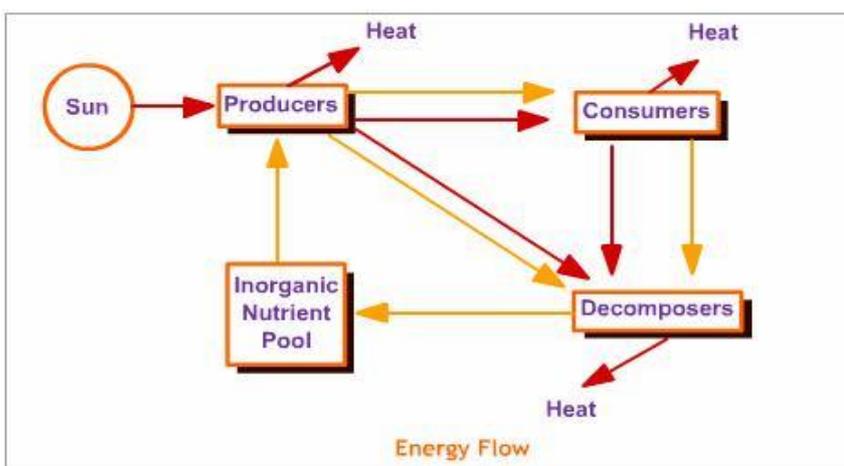
Under natural condition food chain remain interconnected with each other through different types of organisms at different levels. Such an interconnected and interlocking pattern of food chain is known as food web. Major features of Food Wed

- Many food chains are present in an ecosystem, but as a fact those food chains are not independent.
- All the food chains in an ecosystem (e.g. Forest ecosystem) are interlinked.
- Complex interrelated food chains makes up a food web.
- Food web makes the stability of the ecosystem.
- The greater the number of alternative pathways the **more stability of ecosystem**.



All the food chains in an area make up the **food web** of

### Energy flow in ecosystems



Biological activities require energy which ultimately comes from the **SUN**. Solar energy is transformed into chemical energy by a process of photosynthesis this energy is stored in plant tissue and then transformed into heat energy during metabolic activities.

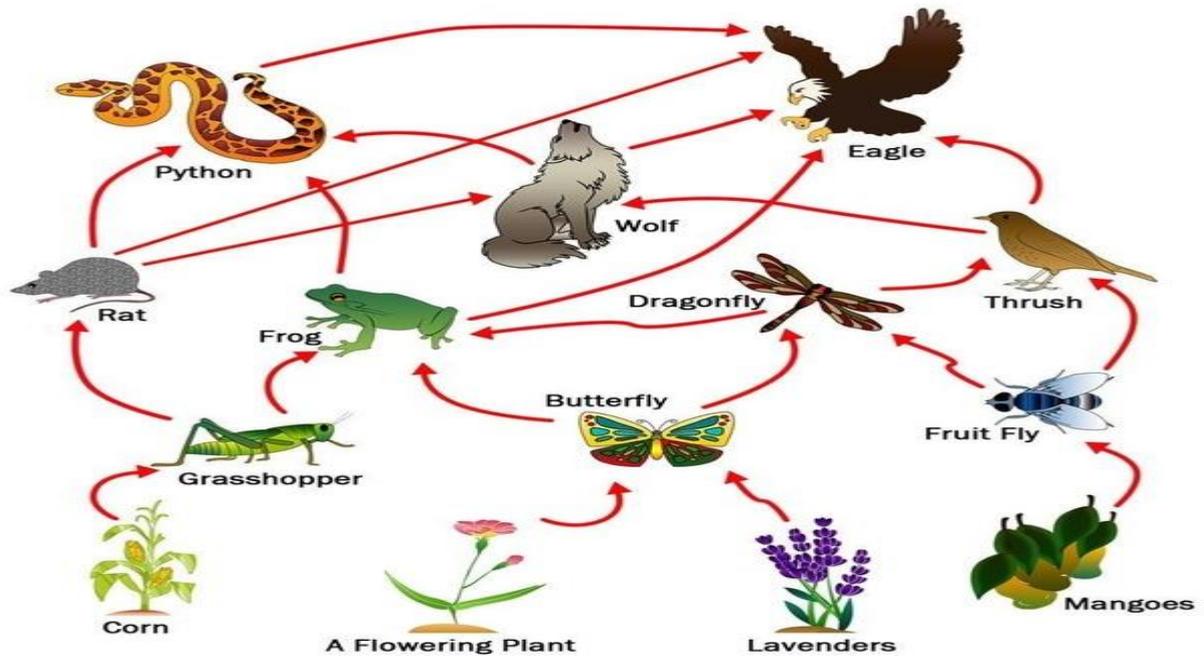
Ecosystem deals with flow of energy in the form of matter from one biotic component to next.

- Survival of any individual needs - Energy.
- Sun - is the main source of energy for almost all life
- Without a constant input of energy the living systems of earth would cease to function.
- **Less than 3%** of that energy is utilized by living organisms.
- **A secondary source of energy is chemical form.**
- In biological world the energy flows from the sun to plants and then to all heterotrophic organisms.
- The flow of energy is **unidirectional and non-cyclic**. This one way flow of energy is governed by laws of thermodynamics which states that: *Energy can neither be created nor be destroyed but may be transformed from one form to another.*
- During the energy transfer there is degradation of energy from a concentrated form (mechanical, chemical, or electrical etc.) to a dispersed form (heat).
- **No energy transformation is 100 % efficient**; it is always accompanied by some dispersion or loss of energy in the form heat. Therefore, biological systems including ecosystems must be supplied with energy on a continuous Basis.
- At each step of trophic level of Ecological Pyramid a considerable portion of potential energy is lost as heat. So, organisms in each trophic level pass on lesser energy to the next trophic level than they actually receive. This **limits the number of trophic levels** in any ecological pyramid to 4 or 5.
- Larger the numbers of trophic levels of an ecological pyramid the lesser energy is available for the top trophic level.
- Larger the numbers of trophic levels of an ecological pyramid, the lower the number of individuals and the larger their size in the top trophic level.
- The greatest amount of energy is found at the base of the pyramid.
- Energy flow in any ecological pyramid is **unidirectional**.

## Food Web

Food web is complex type of food chain where many food chains are interconnected for share of food and energy requirements thus many interconnected food chains make up a food web. It shows the interactions between different organisms in an ecosystem.

## A Food Web



### Biogeochemical cycles

Biogeochemical cycles refer to the flow of such chemical elements and compounds between organisms and the physical environment. Chemicals taken in by organisms are passed through the food chain and come back to the soil, air, and water through mechanisms such as respiration, excretion, and decomposition.

- Matter is recycled in the Biosphere.
- 95% of the living body is made up of H, C, O, N and P.
- These elements must be in a form usable by the cells.
- The biosphere is a closed system.
- Materials are moved between earth and organisms through **biogeochemical cycles**.
  - Molecule of O that you just inspired might have been inspired by someone 5,000 years ago.
  - Or the C that may be in your lunch could have come from *Amanita* sp (Poisonous mushroom).
  - A drop of water that you drunk, could have come from urine of Dinosaurs.
- All the chemical substances needed to sustain life are called nutrients.
- Remember all nutrients used by organisms come from the soil, air, and water.
- Producers convert these into usable forms for consumers.

- Every living organism needs nutrients to build tissues and carry out essential life functions. These nutrients are passed between organisms and the environment through biogeochemical cycles

Important biogeochemical cycles –

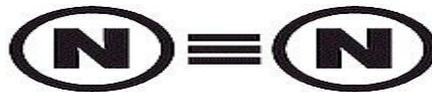
- Carbon Cycle
- Water Cycle
- Nitrogen Cycle

### Nitrogen Cycle

Nitrogen in the atmosphere it is mostly in the form of **N<sub>2</sub>** (Triple bond), which is a compound that plants and animals cannot use. The process of converting nitrogen into compounds that can be used by plants and animals is called the **\_Nitrogen Cycle**.

Nitrogen makes up about **78%** of our atmosphere.

- Although the majority of the air we breathe is N<sub>2</sub>, most of the nitrogen in the atmosphere is **unavailable** for use by organisms.
- This is because the strong **triple bond** between the N atoms in N<sub>2</sub> molecules makes it relatively inert (like a noble gas).



**Energy intensive process:**

- $N_2 + 8H^+ + 8e^- + 16 ATP = 2NH_3 + H_2 + 16ADP + 16 Pi$
- Performed only by selected bacteria and actinomycetes
- Performed in nitrogen fixing crops (ex: soybeans)

### Importance of Nitrogen

- *Nitrogen* is an essential component of Life, The building blocks of life.
- Nitrogen (N) is an essential component for the synthesis of amino acids, proteins, enzymes, chlorophylls, nucleic acid (DNA, RNA), etc.
- Most of the nitrogen in the atmosphere is in the form of gas .

### Nitrogen fixation

This process is two types

- **Physico-chemical nitrogen fixation**- Atmospheric nitrogen combine with Oxygen (as Ozone) during lighting or electrical discharge in the clouds and produce different nitrogen oxides (NO, NO<sub>2</sub>, N<sub>2</sub>O<sub>5</sub>). Further it get dissolved in

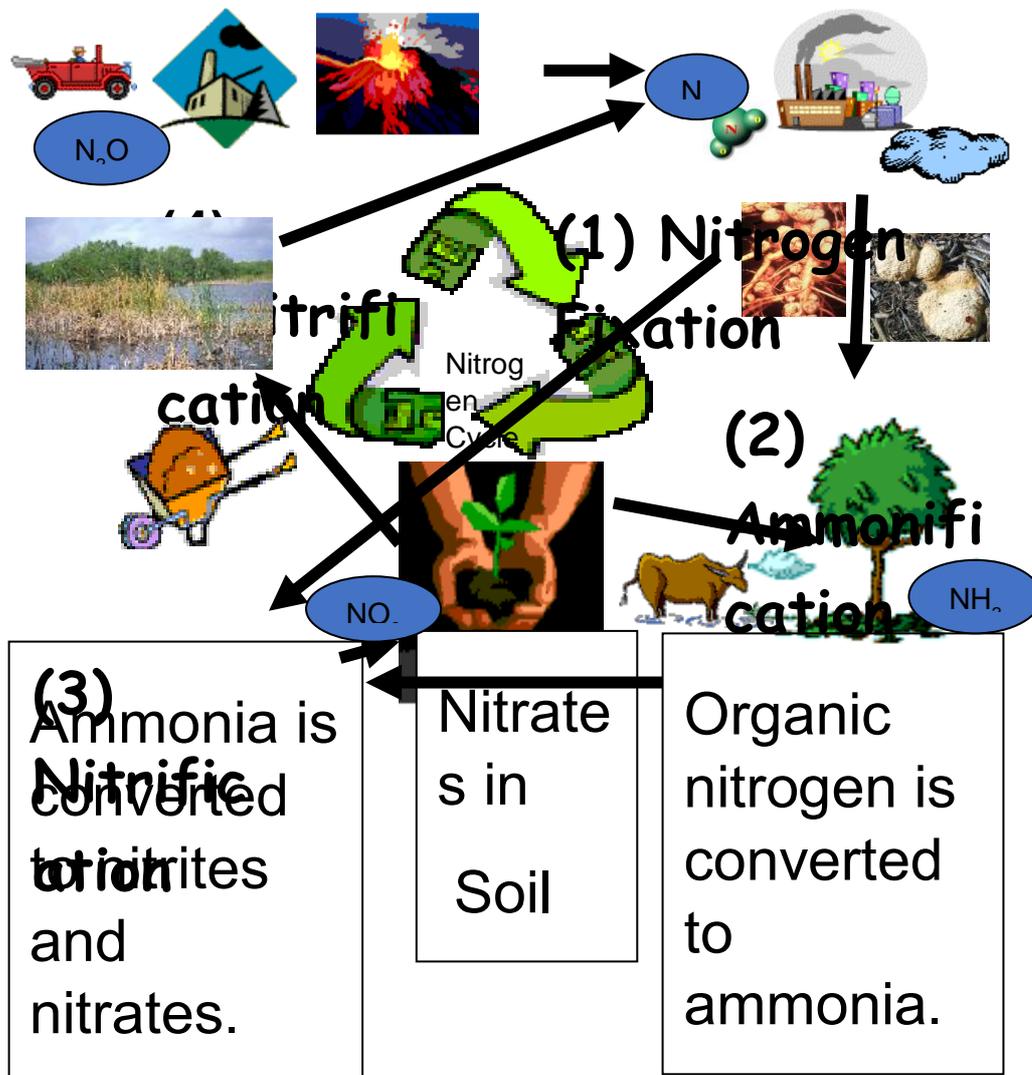
rain water and react with mineral compounds and form different nitrate salts and other nitrogenous compounds.

- **Biological nitrogen fixation**- It is carried out by some prokaryotes i.e. Blue green algae (*Nostoc*, *Anabaena* in association with the thalli of *Anthoceros*, *Salvinia* and *Azolla*) and bacteria (*Azotobacter*, *Clostridium*, *Rhodospirillum*, *Rhizobium*). Produces ammonia, nitrates and nitrites

**Steps of the nitrogen cycle**

**Nitrogen Fixation**

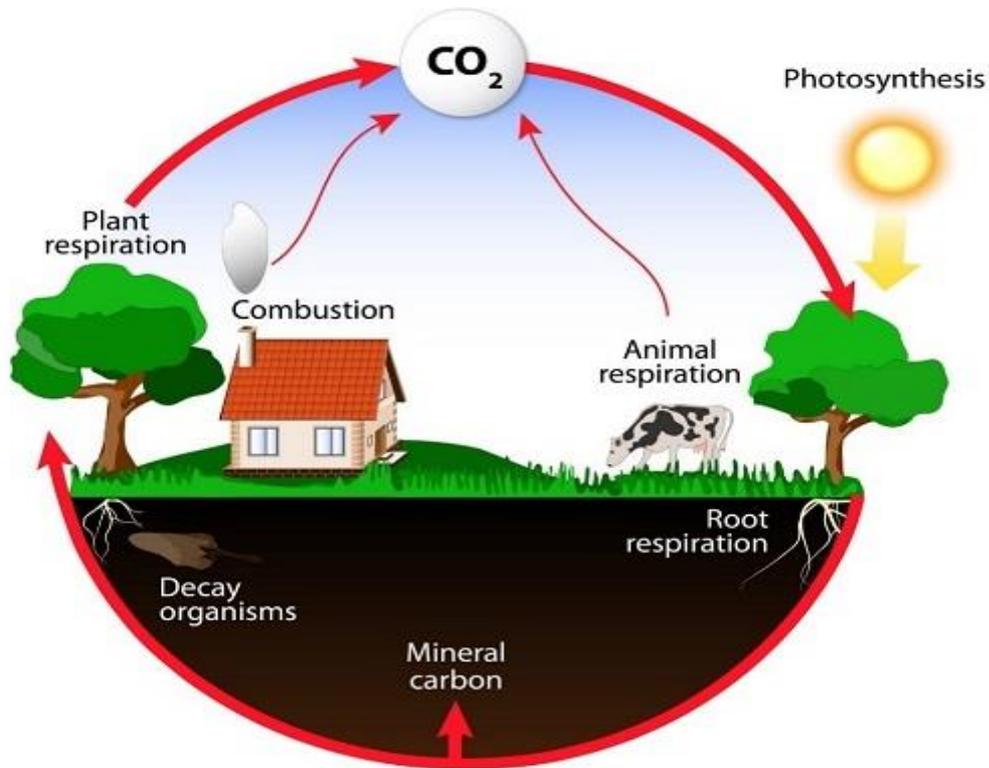
1. Nitrogen fixation – N gas is combined with O or H to form organic compounds.
2. Ammonification –N gas is converted to NH<sub>3</sub> and NH<sub>4</sub> ammonias.
3. Nitrification – ammonia to Nitrate ions used by producers to make amino acids.
4. Denitrification – sends N<sub>2</sub> gas back into the atmosphere or soil. When wastes are broken down and released.



**Carbon Cycle**

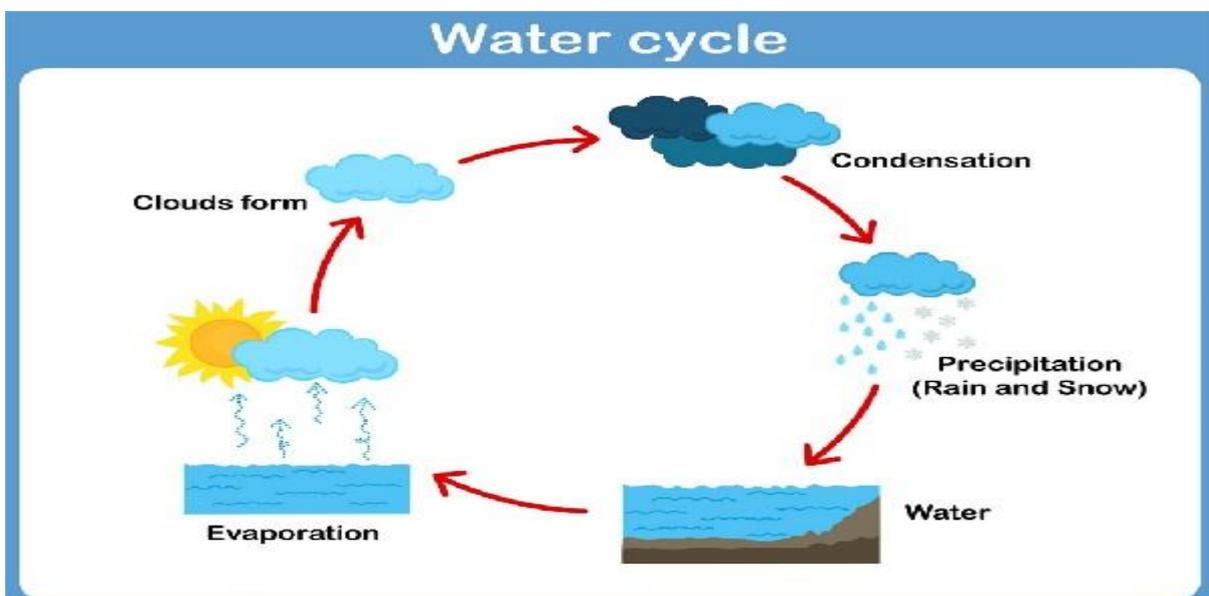
Carbon enters into the living world in the form of carbon dioxide through the process of **photosynthesis** as carbohydrates. These organic compounds (food) are then passed from

the producers to the consumers (herbivores & carnivores). This carbon is finally returned to the surrounding medium by the process of respiration or decomposition of plants and animals by the decomposers. Carbon is also recycled during the burning of fossil fuels.



## Water Cycle

The evaporation of water from ocean, rivers, lakes, and transpiring plants takes water in the form of vapour to the atmosphere. This vaporized water subsequently cools and condenses to form cloud and water. This cooled water vapour ultimately returns to the earth as rain and snow, completing the cycle.



## **Ecological succession**

The gradual replacement of one type of plant community by the other is referred as to as plant succession.

According to E. P. Odum “*plant succession is an orderly process of community change in an unit area*”. Clements gave a very simple definition of plant succession. According to him, “*succession is a natural process by which the same locality becomes successively colonized by different groups or communities*”.

Succession is a complex universal process which begins, develops, and finally stabilizes at the climax stage. The climax is the final mature, stable, self-maintaining and self-reproducing stage of vegetation development in a climatic unit. Succession is generally progressive and thus it brings about- 1) Progressive change in the soil conditions or habitats. 2) Progressive changes in the life forms

### **Causes of succession**

**A. Climatic causes:** Plant cannot adjust with the long range of variations in the climate. The fluctuating climate sometimes lead to destruction of vegetation partly or completely, as a result bare area develop, which become occupied by such plants that are better adapted to this change climatic condition.

**B. Topographic causes:** It is concerned with change of the soil. It may be of two types: -  
a) Erosion of soils by several agents, such as the wind, water current, and rains fall which lead to development of new bare area, where new plant communities begin to appear. b) Soil deposition take place by several agents, such as heavy storms, snowfalls and landslides over an area already covered with vegetation, may be suppressed or destroyed that also lead to formation of new bare area on which succession of plants communities start.

**C. Biotic causes:** Vegetation in particular habitats is affected by many biological or living agencies, such as Grazing, cutting, clearing, cultivation, harvesting, deforestation, parasitic plant and animal and which are directly responsible for vegetation changes.

## **PLANT SUCCESSION AND CLIMAX CONCEPT**

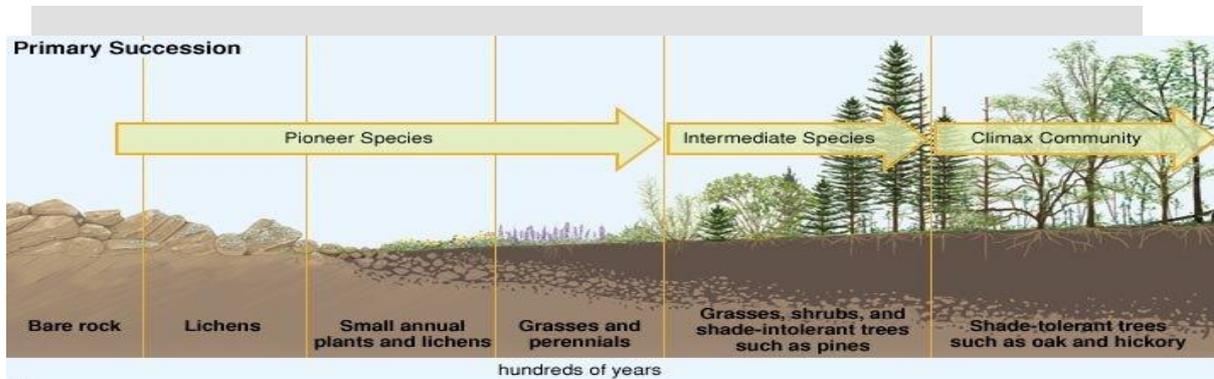
Plant succession is orderly change vegetation. It involves gradual and successive replacement of one plant population by the other. Any concrete example of plant succession taking place on a particular habitat is termed as sere, its various intermediate stages are called the seral stages and communities representing these stages are called the seral communities. The first plants which appear on the bare habitat are called pioneer plants. The plant succession is not a serial of steps or stages but is continuous and slowly changing complex. It is dynamic process. There is no jump from one dominant community to other. Dominant species of one community will persist along with some new migrants for several generations in a given area. When the habitat become extremely non-tolerable for the existing plants then the next community, that are well suited to that habitat, will come and become dominant. After several such changes, a stage may come when the habitat becomes occupied by most tolerant species that can reproduce well. Thus, the process leads to establishment of climax community; a mature, dominant, self-maintaining and slow changing plant community.

## **KINDS OF SUCCESSION**

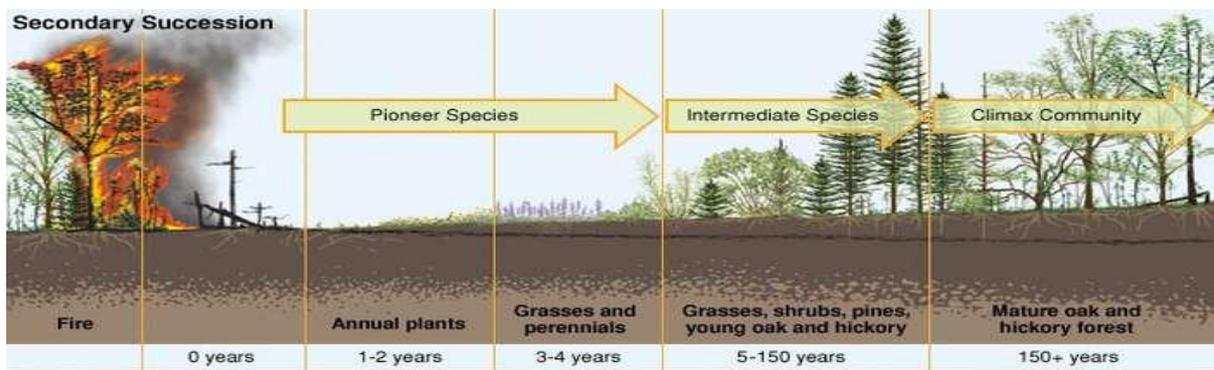
Depending upon the nature of bare area on which plant succession take place it may be of two types-

**A. Primary succession:** When the succession starts on the extreme bare area on which there was no previous existence of vegetation it is called *primary succession* or *presere*. This succession process terminates after a long series of intermediate stages.

**B. Secondary succession:** These types of succession starts on the secondary bare area which was once occupied by original vegetation but later become completely cleared of vegetation by the process called *denudation*. This denudation process is brought about by the destructive agencies, such as fire, cultivation, strong winds and rains. Such bare area is termed *denuded area or secondary bare area*. The succession progress on such an area is also termed as *subsere*. Secondary succession has fewer stages than that of the primary succession and the climax is reached very quickly in the secondary succession. These primary and secondary successions may be of the following types.



**Secondary succession** is the series of community changes which take place on a previously colonized, but disturbed or damaged habitat. For example, after felling trees in a woodland, land clearance or a fire.



**Succession is a process involving several phases**

- 1) **Nudation**: The development of a bare site is called Nudation (area without life)
- 2) **Migration**: refers to arrival of propagules.
- 3) **Invasion**: successful establishment of a species in bare area
- 4) **Ecesis**: process of successful establishment of a species in bare area
- 5) **Competition**: as vegetation becomes well established, grows, and spreads, various species begin to compete for space, light and nutrients
- 6) **Reaction**: modification of the environment through the effluence of living organism present in it.
- 7) **Stabilization**: last stage of succession and here successful community get established. The final and established community is called climax community. Example of climax community is grass land, forest and coral reef.
- 8) **Hydrosere**: The plant succession which starts in the aquatic environment is called "*hydrarch*". A series of changes taking place in the vegetation of hydrarch is called *hydrosere*.
- 9) **Halosere**: It is special type of sere which begins on a salty soil or in saline water.

- 10) **Xerosere:** It refers to the succession that occurs on the rock surface.
- 11) **Serule:** It refers to miniature succession of microorganisms, such as bacteria and different types of fungi on the fallen logs of decaying wood, trees bark etc.
- 12) **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.
- 13) **Ecotone:** **Ecotone** is a transitional area of vegetation between two different plant communities, such as forest and grassland. The mangrove forests represent an ecotone between marine and terrestrial ecosystem.
- 14) **Edge effect:** The influence of the two bordering communities on each other is known as the edge effect. The organisms which occur primarily or most abundantly in this zone are known as edge species. For example, the density of birds is greater in the ecotone between the forest and the desert.
- 15) **Ecological niche:** Niche refers to the unique functional role and position of a species in its habitat or ecosystem. In nature, many species occupy the same habitat, but they perform different functions.
- 16) **Ecological habitat:** Habitat, place where an organism or a community of organisms lives, including all living and nonliving factors or conditions of the surrounding environment.

### **Species diversity**

Species diversity is defined as the number of species and abundance of each species that live in a particular location. The number of species that live in a certain location is called species richness.

### **Biodiversity**

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.”

### **Types of Biodiversity**

Biodiversity further classifies into three major types. They are:

- **Genetic Diversity:** it is basically the variety of species expressed at the genetic level by each individual in a species. No two individuals belonging to the same species are exactly similar. For example, in the species of human beings, each human shows a lot of diversity in comparison to another human.
- **Species Diversity:** it is the biodiversity observed within a community. It stands for the number and distribution of species. The number of species in a region varies widely depending upon the varied environmental conditions.
- **Ecological Diversity:** it defines the diversity observed among the ecosystems in a particular region. Different ecosystems like mangroves, rainforests, deserts, etc., show a great variety of life forms residing in them.

### **Biodiversity conservation:**

Conservation of biodiversity is protection, upliftment and scientific management of biodiversity so as to maintain it at its threshold level and derive sustainable benefits for the present and future generation.

Methods of conservation:

There are two types of conservation methods namely in-situ and ex-situ conservations. Let us discuss the different conservation methods along with their importance.

#### **(a) In situ conservation:**

The conservation of species in their natural habitat or natural ecosystem is known as in situ conservation. In the process, the natural surrounding or ecosystem is protected and maintained so that all the constituent species (known or unknown) are conserved and benefited. The protection and management of biodiversity through in situ conservation involve certain specific areas known as protected areas which include national parks, Sanctuaries and Biosphere reserves.

#### **1. Protected areas:**

The protected areas are biogeographical areas where biological diversity along with natural and cultural resources are protected, maintained and managed through legal and administrative measures. The demarcation of biodiversity in each area is determined on the

basis of climatic and physiological conditions. In these areas, hunting, firewood collection, timber harvesting etc. are prohibited so that the wild plants and animals can grow and multiply freely without any hindrance. Some protected areas are: Cold desert (Ladakh and Spiti), Hot desert (Thar), Saline Swampy area (Sunderban and Rann of Kutch), Tropical moist deciduous forest (Western Ghats and north East) etc. Protected areas include national parks, sanctuaries and biosphere reserves.

### **National parks:**

These are the small reserves meant for the protection of wild life and their natural habitats. These are maintained by government. The boundaries are well demarcated and circumscribed. The activities like grazing forestry, cultivation and habitat manipulation are not permitted in these areas. There are about 89 national parks in India.

Some important national Parks of India are: (i) Biological Park, Nandankanan, Orissa,(ii) Corbett national Park Nainital, U.P. (First national Park)(iii) Koziranga national Park, Jorhat, Assam(iv) Tudula national Park, Maharashtra (v) Hazaribagh national Park, Hazaribagh, Bihar(vi) Bandhavgarh national park, M.P.(vii) Bandipur national park, Karnataka.(viii) Kanha National Park, M.P.(ix) Reibul Lamjao National Park, Manipur(x) Nawgaon National Park, Maharashtra

### **Sanctuaries:**

These are the areas where only wild animals (fauna) are present. The activities like harvesting of timbers, collection of forest products, cultivation of lands etc. are permitted as long as these do not interfere with the project. That is, controlled biotic interference is permitted in sanctuaries, which allows visiting of tourists for recreation.

### **Sanctuaries in Bengal**

- (i) Chapramari Wildlife Sanctuary, 1976
- (ii) Haliday Island Wildlife Sanctuary, 1976
- (iii) Lothian Island Wildlife Sanctuary, 1976
- (iv) Mahananda Wildlife Sanctuary, 1976
- (v) Sajnakhali Wildlife Sanctuary, 1976
- (vi) Senchal Wildlife Sanctuary, 1976
- (vii) Ballabhpur Wildlife Sanctuary, 1977
- (viii) Bethuadahari Wildlife Sanctuary, 1980

- (ix) Bibhutibhushan Wildlife Sanctuary, 1980
- (x) Ramnabagan Wildlife Sanctuary, 1981
- (xi) Chintamoni Kar Bird Sanctuary, 1982
- (xii) Jore Pokhri Wildlife Sanctuary, 1985
- (xiii) Raiganj Wildlife Sanctuary, 1985
- (xiv) Buxa Tiger Reserve, 1986

**Biosphere reserves:**

Biosphere reserves or natural reserves are multipurpose protected areas with boundaries circumscribed by legislation. The main aim of biosphere reserve is to preserve genetic diversity in representative ecosystems by protecting wild animals, traditional life style of inhabitant and domesticated plant/ animal genetic resources. These are scientifically managed allowing only the tourists to visit.

Biosphere Reserves in India

Biosphere Reserves in India are as under:

<i>Name of Biosphere Reserves</i>	<i>States</i>
<i>Nilgiri Biosphere Reserve (2000)</i>	Tamil Nadu, Kerala, Karnataka
<i>Sundarbans Biosphere Reserve (2001)</i>	West Bengal
<i>Gulf of Mannar Biosphere Reserve (2001)</i>	Tamil Nadu
<i>Nanda Devi Biosphere Reserve (2004)</i>	Uttarakhand
<i>Simlipal Biosphere Reserve (2009)</i>	Odisha
<i>Pachmarhi Biosphere Reserve (2009)</i>	Madhya Pradesh
<i>Nokrek Biosphere Reserve (2009)</i>	Meghalaya
<i>Achanakmar-Amarkantak Biosphere Reserve (2012)</i>	Chattisgarh, Madhya Pradesh
<i>Great Nicobar Biosphere Reserve (2013)</i>	Great Nicobar
<i>Agasthyamalai Biosphere Reserve (2016)</i>	Kerala and Tamil Nadu
<i>Khangchendzonga National Park (2018)</i>	Sikkim

**Ex-situ conservation:**

Ex-situ conservation involves maintenance and breeding of endangered plants and animals under partially or wholly control-led conditions in specific areas like zoo, gardens, nurseries etc. That is, the conservation of selected plants and animals in selected areas outside their natural habitat is known as ex-situ conservation.

Some important areas (examples) under these conservation are:(i) Seed gene bank,(ii) Field gene bank;(iii) Botanical gardens;(iv) Zoos.

### **Keystone species**

Keystone species are those which have an extremely high impact on a particular ecosystem relative to its population. Keystone species are also critical for the overall structure and function of an ecosystem, and influence which other types of plants and animals make up that ecosystem. Thus, in the absence of a keystone species, many ecosystems would fail to exist. Elephants: By eating small trees, elephants preserve the grasslands, because the grasses need plenty of sun to survive. If they were not there, the savanna would convert to a forest.

### **Sacred groves of India**

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 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 *Vikramorvasiyam*.

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.

- 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. Villagers who pass through the grove dust their clothes to make sure they do not carry anything belonging to the grove. Trees in the area cannot be cut or felled, and all deadwood found in the forest is used in the temple located in the grove. There are hundreds of such groves in Himachal Pradesh.

- 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. But the trees seem to have lost their religious importance in the minds of the people.
- 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 *law kyntangs*. The largest of them are in Mawphlang and Mausmai. These groves are a storehouse of a large number of rare plant species. The local people believe that the forest spirit will kill anyone who damages the plants and other life forms in the groves. This has contributed greatly to the preservation of these forests.
- In Bihar 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.

## MCQ

1. What term is used to describe an organism that makes its own food?
  - A. Consumers
  - B. Omnivores
  - C. Producers
  - D. Decomposers
  
2. What is used to show the many feeding relationships in an ecosystem?
  - A. Trophic level
  - B. Food Chain
  - C. Nutrient cycling diagram
  - D. Food webs

3. Which organism is likely to be in the bottom trophic level in a food chain?
  - A. Killer whale
  - B. Leopard seal
  - C. Zooplankton
  - D. Algae
  
4. What type of organisms eat both producers and consumers?
  - A. Carnivore
  - B. Decomposers
  - C. Herbivores
  - D. Omnivore
  
5. What is ultimate source of energy in an ecosystem?
  - A. Sunlight
  - B. Nutrients
  - C. Food
  - D. Water
  
6. An organism that can make its own food is called?
  - A. Consumer
  - B. Producer
  - C. Decomposer
  - D. Herbivore
  
7. A food web consists of?
  - A. Many overlapping food chains in an ecosystem.
  - B. A series of events in which one organism eats another and obtains energy.
  - C. Amount of energy that moves from one feeding level to another.
  - D. Many types of insects that are stuck.
  
8. This type of consumer obtains all of its energy by eating only producers.
  - A. Omnivore
  - B. Herbivore
  - C. Scavenger
  - D. Carnivore
  
- 9. The following are dependent on others for food**
  - A. Autotrops
  - B. Heterotrops
  - C. Both (A) and (B)
  - D. None of the above
  
10. A third-level consumer has to be which type?
  - A. Carnviore.
  - B. Decomposer.
  - C. Producer.
  - D. Herbivore.
  
11. Which is NOT an abiotic factor:
  - A. soil
  - B. air
  - C. bacteria;
  - D. water

12. Transfer of energy is represented by this in a food chain.
- A. Circles
  - B. Arrows
  - C. neon lights
  - D. pyramids
13. The natural place of an organism or community is known as
- A. Niche
  - B. Biome
  - C. Habitat
  - D. Habit
- 47. \_\_\_\_\_ are Primary consumers.**
- A. Herbivores
  - B. Carnivores
  - C. Omnivores
  - D. All of the above
15. In an ecosystem, the energy flow is always
- A. Always unidirectional
  - B. Always bidirectional
  - C. In any direction
  - D. Always down directional
16. What type of food chain is it?  
dead animals → blow fly maggot → maggots → frog → snake
- A. Detrital food chain
  - B. Decomposer food chain
  - C. Predator food chain
  - D. Grazing food chain
17. Study of interaction of living organisms with other organisms and their environment relates with
- A. Botany
  - B. Ecology
  - C. Social biology
  - D. Pharmacology
18. Organisms which convert radiant energy into chemical energy are
- A. Consumer
  - B. Hefrotrophs
  - C. Decomposers
  - D. Producers
19. Population is a group of organism of
- A. Different species
  - B. Same species
  - C. Higher species
  - D. Lower species
20. Total mass of living matter in each trophic level at any time is
- A. Biome
  - B. Pyramid
  - C. Biomass
  - D. Bioenergy

21. In a food chain, producers lies at beginning of
- Food chain
  - Food web
  - Food net
  - Food line
22. Interaction of living organisms in a series form for use of energy is
- Food web
  - Food chain
  - Food level
  - Food net
23. Ecological community is combination of two different
- Species
  - Organisms
  - Population
  - Habitat
24. What is called for the term used to express a community in its final stage of succession?
- End community
  - Final community
  - Climax community
  - Dark community
25. What is called for the term in which all the living organisms that occupy an area undergoing primary succession in the beginning stages?
- Climax community
  - Settled community
  - Dense community
  - Pioneer community
26. What is called for the process when older communities of plants and animals are replaced by newer communities?
- Evolution
  - Deforestation
  - Forestation
  - Ecological succession
27. Which process occurs after a volcanic eruption?
- Primary succession
  - Secondary succession
  - Nitrogen fixation
  - Oxidation
28. Which is the first process in ecological succession?
- Nudation
  - Migration
  - Ecesis
  - Aggregation
29. What is called for the succession occurring within a microhabitat?
- Primary succession

- B. Nudation
  - C. Serule
  - D. Climax succession
30. After landslide which of the following type of succession occurs?
- A. Primary
  - B. Secondary
  - C. Tertiary
  - D. Climax
31. Which cycle most likely includes sunlight, photosynthesis, and respiration?
- A. Water cycle
  - B. Carbon cycle
  - C. Oxygen cycle
  - D. Nitrogen cycle
32. How does carbon dioxide in the atmosphere enter into living organisms?
- A. Burning of forests
  - B. Combustion of fossil fuels
  - C. Photosynthesis
  - D. Transpiration
33. Which nutrient cycle needs a nutrient to be fixed prior to use by producers and consumers?
- A. Carbon
  - B. Nitrogen
  - C. Phosphorus
  - D. Water
34. Lightning, legumes, and bacteria are a part of the
- A. Water cycle.
  - B. Nitrogen cycle.
  - C. Carbon cycle.
  - D. Phosphorus cycle.
35. How do living things contribute to the water cycle?
- A. Evaporation
  - B. Condensation
  - C. Precipitation
  - D. Transpiration
36. Nutrients move through an ecosystem in
- A. Energy pyramids.
  - B. Ecological pyramids.
  - C. Biogeochemical cycles.
  - D. Water cycle.
37. In an ecosystem, bacteria that inhabit the roots of certain plants and soil play an essential role in cycling
- A. Carbon dioxide.
  - B. Nitrogen.
  - C. Oxygen.
  - D. Phosphorus.

38. In which cycle does carbon dioxide play a large role?
- A. Carbon
  - B. Nitrogen
  - C. Phosphorus
  - D. Water
39. **The region of earth, where life exists is known as**
- A. Atmosphere
  - B. Biosphere
  - C. Lithosphere
  - D. Hydrosphere
- 40.---**In the biosphere energy is received from**
- A. The Sun
  - B. The interior of the earth
  - C. Both (A) and (B)
  - D. Work
41. **Energy \_\_\_\_\_ in an Ecosystem.**
- A. is released
  - B. is absorbed
  - C. flows
  - D. None of the above
43. **The set of ecosystems is called a**
- A. Biome
  - B. Climate
  - C. Subsystem
  - D. Structure
44. **The following is (are) Abiotic components of the ecosystem.**
- A. Soil
  - B. Carbon
  - C. Protein
  - D. All of the above
45. **The autotrops**
- A. are self nourishing organisms
  - B. derive energy from sunlight
  - C. make organic compounds from inorganic compounds
  - D. All of the above
46. **Autotrophic components are**
- A. Producers
  - B. Consumers
  - C. Decomposers
  - D. None of the above

## DO

### Dissolved Oxygen

Oxygen, although poorly soluble in water, is fundamental to aquatic life.

- Without free dissolved oxygen, streams and lakes become uninhabitable to aerobic organisms, including fish and most invertebrates.
- Dissolved oxygen is inversely proportional to temperature, and the maximum amount of oxygen that can be dissolved in water at 0°C is 14.6 mg/L.
- The amount of oxygen dissolved in water is usually measured with the *Winkler* test.

## BOD

### Biochemical Oxygen Demand

Amount of oxygen required by bacteria and other microorganisms in **stabilizing decomposable organic matter**.

A very low oxygen demand indicates either clean water OR the presence of a toxic or nondegradable pollutant.

$$[\text{BOD}] = [\text{DO}]_{\text{Final}} - [\text{DO}]_{\text{initial}}$$

## COD

### Chemical Oxygen Demand

It measures the amount of oxygen required to chemically oxidize organic compounds in water.

A chemical oxidant is added to the sample in question, the consumption of which is then determined. A commonly **used oxidant** in COD assays is potassium dichromate ( $\text{K}_2\text{Cr}_2\text{O}_7$ ) which is **used** in combination with boiling sulfuric acid ( $\text{H}_2\text{SO}_4$ )

COD is used as a **general indicator of water quality** and is an integral part of all water quality management programs.

**What is the relationship between the COD and BOD values in Waste water?**

- COD or Chemical Oxygen Demand is the total measurement of all chemicals (organics & in-organics) in the water / waste water; BOD is a measure of, the amount of oxygen required for the bacteria to degrade the organic components present in water / waste water.
- The ratio of BOD/COD : COD is higher than BOD; maximum of up to 4 times in medium scale industries; but it varies based on the industrial process and nature of the raw materials used;

### Sedimentation

Sedimentation is the tendency for particles in suspension to settle out of the fluid in which they are entrained and come to rest against a barrier.

This is due to their motion through the fluid in response to the forces acting on them: these forces can be due to gravity, centrifugal acceleration, or electromagnetism.

Sedimentation may pertain to objects of various sizes, ranging from large rocks in flowing water to suspensions of dust and pollen particles to cellular suspensions to solutions of single molecules such as proteins and peptides. Even small molecules supply a sufficiently strong force to produce significant sedimentation.

In chemistry, sedimentation has been used to measure the size of large molecules (macromolecule), where the force of gravity is augmented with centrifugal force in an ultracentrifuge.

**Sedimentation (water treatment) is a physical water treatment process using gravity to remove suspended solids from water.<sup>[1]</sup> Solid particles entrained by the turbulence of moving water may be removed naturally by sedimentation in the still water of lakes and oceans. Settling basins are ponds constructed for the purpose of removing entrained solids by sedimentation. Clarifiers are tanks built with mechanical means for continuous removal of solids being deposited by sedimentation. This can be used in aromatherapy oils .**

### Coagulation

**It is often referred as disambiguation. Coagulation is the process by which blood forms clots. Coagulation may also refer to:**

**Coagulation (water treatment), in colloid chemistry, a process in which dispersed colloidal particles agglomerate.**

**Coagulation (milk), the coagulation of milk into curd by rennet or acid.**

**Blood Gulch, a multiplayer map called "Coagulation" in the video game Halo 2.**

**Mixing of two particles in an aerosol to form a third particle.**

**Clumping of dust particles in a protoplanetary disk, a possible early stage of planet formation.**

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### Flocculation

**Flocculation**, in the field of chemistry, is a process in which colloids come out of suspension in the form of floc or flake, either spontaneously or due to the addition of

a clarifying agent. The action differs from precipitation in that, prior to flocculation, colloids are merely suspended in a liquid and not actually dissolved in a solution. In the flocculated system, there is no formation of a cake, since all the flocs are in the suspension.

Coagulation and flocculation are important processes in water treatment with coagulation to destabilize particles through chemical reaction between coagulant and colloids, and flocculation to transport the destabilized particles that will cause collisions with floc.

### Filtration

Filtration is a physical, biological or chemical operation that separates solid matter and fluid from a mixture with a filter medium that has a complex structure through which only the fluid can pass. Solid particles that cannot pass through the filter medium are described as oversize and the fluid that passes through is called the filtrate. Filtration occurs both in nature and in engineered systems; there are biological, geological, and industrial forms.

Filtration can be carried out by several methods such as Hot filtration, Cold filtration and Vacuum filtration etc.

### pH

In chemistry, **pH** is a scale used to specify how acidic or basic a water-based solution is. Acidic solutions have a lower pH, while basic solutions have a higher pH. At room temperature (25°C or 77°F), pure water is neither acidic nor basic and has a pH of 7.

The pH scale is logarithmic and inversely indicates the concentration of hydrogen ions in the solution.

$$\text{pH} = -\log[\text{H}^+]$$

### Pesticides

A pesticide is a substance or mixture of substance intended for preventing, destroying, repelling or lessening the damage caused by pest.

A pesticide can be a insect, plant pathogen, weed, bacteria, bird etc. That compete with the human for food, destroy property, spread disease. A pesticide can be a chemical, biological agent, antimicrobial, disinfectant etc. Many chemical pesticides are poisonous to human and animals.

Classification of pesticides:

1. Herbicide: used to kill weeds. e.g. Borax.
2. Insecticide: used to kill insect. e.g. DDT
3. Rodenticide: used to kill rodents. e.g. Zinc phosphide
4. Nematicide : used to kill namatodes. e.g. DBCP
5. Fungicide: used to kill fungus. e.g. Bordeaux mixture
6. Algaecide: used to kill algae. e.g. Copper sulphate
7. Bactericide: used to kill bacteria. e.g. Oxolinic acid.
8. Piscicide: used to kill fishes. e.g. TFM

Benefits of pesticides:

1. They are used in public health programmes to control vector born diseases.
2. They are used for protecting the stored food grains.
3. They protect standing crop in the field.
4. They can be used to control household pests.

## Hazards of pesticides:

1. The pesticide industries cause soil, water and air pollutions.
2. They interfere into food chain and can cause problem of bioaccumulation.
3. They are not target specific hence also kills non-pest insects.
4. Continuous use of pesticides may develop resistance in insect pest like superpest and superbugs.

## Heavy Metals

- are natural components of the Earth's crust.
- they cannot be degraded or destroyed.
- to a small extent they enter our bodies via food, drinking water and air.
- as trace elements, some heavy metals (e.g. Cadmium, Chromium, Lead and Mercury etc.)  
are essential to maintain the metabolism of the human body.
- however, at higher concentrations they can lead to poisoning.
- heavy metal poisoning could result, for instance, from drinking-water contamination (e.g. lead pipes), high ambient air concentrations near emission sources, or intake via the food chain.

## Biological aspects of some heavy metals

### Mercury (Hg):

Mercury is the only common metal which is liquid at ordinary temperatures.

- Disruption of the nervous system.
- Damage to brain functions.
- DNA damage and chromosomal damage.
- Allergic reactions, resulting in skin rashes, tiredness and headaches.
- Negative reproductive effects, such as sperm damage, birth defects and miscarriages.
- Acidic surface waters can contain significant amounts of mercury.
- When the pH values are between five and seven, the mercury concentrations in the water will increase due to mobilisation of mercury in the ground.
- Once mercury has reached surface waters or soils microorganisms **can convert it to methyl mercury**, a substance that can be absorbed quickly by most organisms and is known to cause nerve damage.

### Cadmium (Cd):

Human uptake of cadmium takes place mainly through food. Foodstuffs that are rich in cadmium can greatly increase the cadmium concentration in human bodies (liver, mushrooms, shellfish, mussels, cocoa powder and dried seaweed).

- Diarrhoea, stomach pains and severe vomiting.
- Bone fracture.
- Reproductive failure and possibly even infertility.
- Damage to the central nervous system.
- Damage to the immune system.

- Psychological disorders.
- Possibly DNA damage or cancer development.
- Cadmium strongly adsorbs to organic matter in soils.
- When cadmium is present in soils it can be extremely dangerous, as the uptake through food will increase.
- Soils that are acidified enhance the cadmium uptake by plants.

### **Lead (Pb) :**

Foods such as fruit, vegetables, meats, grains, seafood, soft drinks and wine may contain significant amounts of lead. Cigarette smoke also contains small amounts of lead.

- Disruption of the biosynthesis of haemoglobin and anemia.
- A rise in blood pressure.
- Kidney damage.
- Miscarriages.
- Disruption of nervous systems.
- Brain damage.
- Declined fertility of men through sperm damage.
- Diminished learning abilities of children.
- Behavioural disruptions of children, such as aggression, impulsive behaviour and hyperactivity.
- Soil functions are disturbed by lead intervention, especially near highways and farmlands, where extreme concentrations may be present.
- Also soil organisms are suffered from lead poisoning.

### **Chromium (Cr):**

Chromium is a danger to human health, mainly for people who work in the steel and textile industry. People who smoke tobacco also have a higher chance of exposure to chromium.

- When it is a compound in leather products, it can cause allergic reactions, such as skin rash.
- After breathing it in, chromium(VI) can cause nose irritations and nosebleeds.
- Upset stomachs and ulcers.
- Respiratory problems.
- Weakened immune system.
- Kidney and liver damage.
- Alteration of genetic material.
- **Lung cancer.**
- Death.
- Most of the chromium in air will eventually settle and end up in waters or soils.
- Chromium in soils strongly attaches to soil particles and as a result it will not move towards groundwater.
- In water chromium will absorb on sediment and become immobile.

- Only a small part of the chromium that ends up in water will eventually dissolve.

### **Metalloids**

A metalloid is a type of chemical element which has properties in between, or that are a mixture of, those of metals and nonmetals.

#### **Arsenic (As) :**

Arsenic metalloids is believed to be more effective than in taking images and locating tumors.

- Used in preventing wood from various bacteria, fungi and insects.
- Used in various pesticides and herbicides but is rarely used nowadays.
- Used as semiconductors.
- Used in treating cancer and acute promyelocytic leukemia.
- Mixed with animal food to protect them from various diseases.

#### **Selenium (Se) :**

Too little selenium can cause health problems, but too much is also dangerous. In excess it is carcinogenic.

It can cause irritations of the mucous membranes.

In extremely high proportion it causes bronchitis and collection of fluid in the lungs.

#### **Carbon Monoxide (CO) :**

Carbon Monoxide (known by the chemical symbol CO) is a colorless and practically odorless gas.

It is poisonous to people and animals, because it displaces oxygen in the blood.

It is produced by the incomplete burning of solid, liquid, and gaseous fuels.

- Direct cellular injury
  - CNS reoxygenation injury
  - Lipid peroxygenation
  - Free radical formation
- CO toxicity in pregnancy
  - Risk of fetal injury.

#### **Ozone (O<sub>3</sub>):**

Ozone is an inorganic molecule with the chemical formula O<sub>3</sub>. It is a pale blue gas with a distinctively pungent smell. It is an allotrope of oxygen that is much less stable than the diatomic allotrope O<sub>2</sub>, breaking down in the lower atmosphere to O<sub>2</sub> (dioxygen). Ozone is formed from dioxygen by the action of ultraviolet light (UV) and electrical discharges within the Earth's atmosphere.

The main cause of ozone depletion and the ozone hole is manufactured chemicals, especially manufactured halocarbon refrigerants, solvents, propellants and foam-blowing agents (chlorofluorocarbons (CFCs), HCFCs, halons), referred to as **ozone-depleting substances (ODS)**.

Effects of ozone layer depletion:

Skin Cancer (melanoma and nonmelanoma).  
Premature aging of the skin and other skin problems.  
Cataracts and other eye damage.  
Immune system suppression.

#### **PAN:**

Peroxyacyl nitrates (also known as Acyl peroxy nitrates, APN or PANs) are powerful respiratory and eye irritants present in photochemical smog. PANs are both toxic and irritating, as they dissolve more readily in water than ozone. They are lachrymators, causing eye irritation at concentrations of only a few parts per billion. At higher concentrations they cause extensive damage to vegetation. Both PANs and their chlorinated derivatives are causing skin cancer.

#### **VOC:**

Volatile organic compounds (VOCs) are organic chemicals that have a high vapor pressure at ordinary room temperature. They include both human-made and naturally occurring chemical compounds. Most scents or odors are of VOCs. VOCs play an important role in communication between plants,<sup>[1]</sup> and messages from plants to animals. Some VOCs are dangerous to human health or cause harm to the environment. Harmful VOCs typically are not acutely toxic, but have compounding long-term health effects. Because the concentrations are usually low and the symptoms slow to develop, research into VOCs and their effects is difficult.

#### **POP:**

Persistent organic pollutants (POPs) are organic compounds that are resistant to environmental degradation through chemical, biological, and photolytic processes. Because of their persistence, POPs bioaccumulate with potential adverse impacts on human health and the environment. Many POPs are currently or were in the past used as pesticides, solvents, pharmaceuticals, and industrial chemicals.

### **Carcinogens in the air**

A carcinogen is any substance, radionuclide, or radiation that promotes carcinogenesis, the formation of cancer. Cancer is any disease in which normal cells are damaged and do not undergo programmed cell death. Carcinogens may increase the risk of cancer by altering cellular metabolism or damaging DNA directly in cells, which interferes with biological processes. Dioxins and dioxin-like compounds, benzene, kepone, EDB, and asbestos have all been classified as carcinogenic enters into human body through air. After the carcinogen enters the body, the body makes an attempt to eliminate it through a process called biotransformation. many components of outdoor air pollution including diesel engine exhaust, solvents, metals, and dust have classified as carcinogen. It also classified another major component of outdoor air pollution – called particulate matter – as a carcinogen on its own. Particulate matter is a combination of extremely small solid particles and liquid droplets that are found in the air. Particulate matter can include things like dust or smoke, as well as chemicals.

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## **An Introduction to Environmental Economics and Economic Concepts**

### **INTRODUCTION**

#### Section Overview

In this section we begin by outlining the field of economics, environmental economics, and the role of this module within environmental economics. Specifically we develop a conceptual model of the relationship between the economy and the environment that places in context many of the activities undertaken by environmental economists, in particular, environmental policy design and implementation. The model we develop draws attention to some of the key relationships between the economy and the environment and the varying importance attached to these relationships by the environmental economics profession.

## Section Learning Outcomes

By the end of this section, students should:

- understand the complexity of the interaction of economy and environment
- understand the extent to which economic activity can use the environment before resource sustainability becomes an issue

### Defining economics and the environment

Our starting point is to place this module within the field of environmental economics. To do this, we need first to have an idea of what we mean by economics and the environment.

A dictionary definition of economics would be something like:

*the science of the management of the material resources of an individual, community, or country.*

Thus, economics is about the allocation of scarce resources amongst competing uses.

What about ‘environment’? A broad definition of the environment might be the surroundings: the conditions influencing development or growth. Thus, you might include any number of things that are around you as being part of our environment. For example, the environment can be defined to include all flora and fauna, aquatic ecosystems, energy and material resources, and the atmosphere (Hanley *et al* 2007).

There are many examples of the way in which the economy and the environment interact and are interdependent (eg agriculture and the environment). Society has become very aware of the environmental impact of agriculture over the last few decades because of the increased understanding of the negative consequences of certain agricultural practices. At the same time it has become apparent that many of these practises have resulted from the policies introduced to encourage farmers to produce agricultural output. Examples of the negative consequences of agriculture include water pollution (both surface and groundwater), soil erosion and soil compaction, the loss of wetlands because of drainage, and the loss of biodiversity because of land clearance for more agriculture as well as the adoption of new technologies. These outcomes have resulted because many commodity-specific price and income support programs, such as those in the EU, North America, and Australia, did not require farmers to take account of the environmental consequences of their actions.

### Links between the economy and the environment

Let us begin by considering in general the ways in which the economy and the environment are interlinked. Then we will look at how environmental economics has developed and the scope of the subject. We employ the typical characterisation found in many textbooks and assume that the economy can be divided into two sectors: production and consumption. These sectors use the environment in three main ways.

- as a supplier of natural resource inputs
- as a supplier of environmental or amenity goods
- in its capacity as waste sink

Using the environment in one of these ways may affect the other uses, as will become clear in the following discussion.

### Supplier of resource inputs

Land, water, and stocks of raw materials are important inputs to production. These resources frequently vary between countries and so will affect the country's economy. Some countries will have large stocks of minerals, while others have good arable land.

Natural resources are either renewable (eg trees) or non-renewable (eg crude oil). This distinction is important as it influences the way the resources have to be managed in production.

These resources are used by the production sector to create goods and services for use by consumers, or as inputs for another part of the production sector, but in the process waste products will also be produced.

**?** Can you think of an example from your country where a natural resource is used in a production process, resulting in both a product for use by consumers and a waste product?

*Answer*

*An example could be coal used to generate electricity. As the coal is burned, it produces electricity, but at the same time, carbon dioxide and sulphur dioxide are also produced, and these may have detrimental effects on the environment.*

## Supplier of environmental or amenity goods

Economic benefits (ie increased utility) may be directly derived from the consumption of the flow of services that are forthcoming from a stock of environmental goods. There are many examples of where the environment provides amenity benefits for society. For example, some countries enjoy beautiful landscapes and the public benefit from these via their associated recreational services and tourism.

Environmental stocks of trees can offer global services such as climatic regulation because the trees absorb carbon dioxide, which might otherwise contribute to climate change.

Many people get enjoyment from the biodiversity that exists in the world, and this can also be considered as a form of public consumption of an environmental good.

## Waste sink capacity

This is the capacity of the environment to assimilate the waste products of production and consumption and convert them into harmless or ecologically useful products. This use of the environment is the one we are most concerned with in this module, as we look at the introduction of policies which affect how, and at what level, the environment is used as a waste sink.

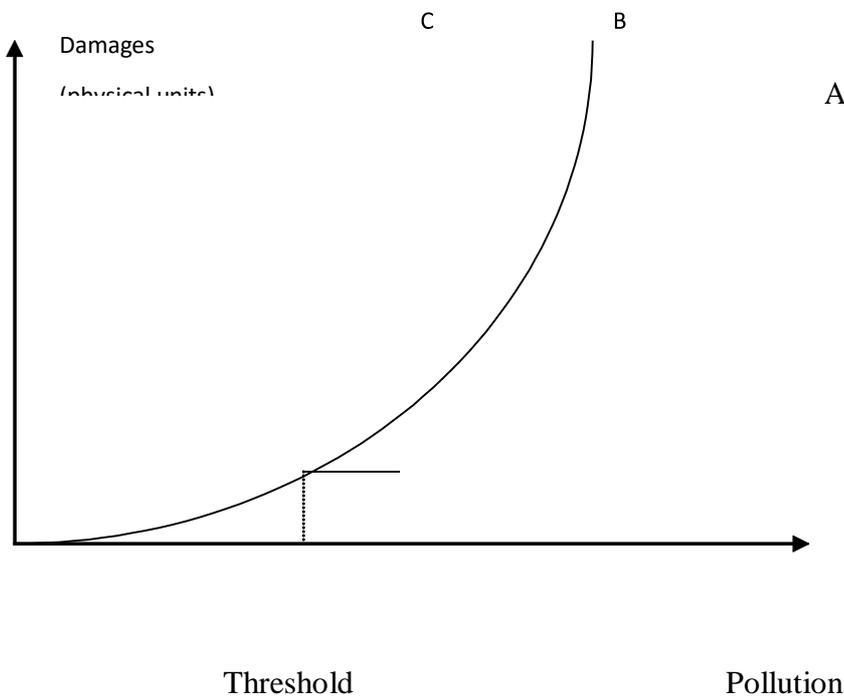
The environment is not only affected by waste products but also by intentional releases of chemicals, such as pesticides, wood preservatives, paints, and lubricants. Let us put some figures on to these wastes and intentional releases.

The impact of human activity on the composition of chemicals in the atmosphere is clear. Since 1750, pre-industrial period, carbon dioxide concentrations have changed from 280 parts per million in 1750 to 380 parts per million in 2000. There have also been significant increases in other gases such as methane and nitrous oxide. There are serious concerns being expressed about these increasing concentrations in the atmosphere and climate change (Stern 2007).

We are thinking here about the physical assimilative capacity of the environment. This is the physical capacity of the land, water and the atmosphere to absorb wastes and is determined by physical factors such as the climate, rainfall, wind patterns, and geographical location.

When thinking about waste we need to distinguish between degradable and cumulative pollutants. With cumulative pollutants we need to understand if there are any important thresholds that need to be avoided. The figure in 1.2.1, below, illustrates the importance of assimilative capacity for threshold and non-threshold cumulative pollutants.

### 1.2.1 Pollution damage functions



Source: adapted from Hanley *et al* (2007) p. 4

In 1.2.1 we have drawn three damage functions. Function A shows a simple linear damage function, Function B an exponential damage function, and Function C a damage function with a threshold. The important issue captured by Function C is that there is point beyond which a pollutant has a significantly increased impact on the environment. An example is the level of oxygen in water which, if it falls below a particular level, becomes extremely dangerous for fish.

It is common practice to describe the assimilative waste capacity of the environment mathematically.

Stock of degradable pollutant ( $S^a$ ) at time  $t$  is given by

$$S_t^a = F_t - A_t$$

Stock of cumulative pollutant ( $S^c$ ) at time  $t^*$  is given by

$$t \leq t^*$$

$$St^* = \sum_{t_i} F_t$$

- where
- $F_t$  is the positive flow in a year
  - $A_t$  is the amount assimilated in a year
  - $t_i$  is the starting date for emissions
  - $\sum$  is the sum of the item specified for the time periods given, in this case from the start,  $t_i$ , to time  $t^*$ .

Environmental management can require that we take actions to prevent further pollution because we think that an important threshold might be breached. The term used to describe this type of environmental management is the **precautionary principle**.

The **precautionary principle** states that action on preventing or restricting environmental damage should not be delayed just because there are uncertainties about how the damage is caused or the level of damage (Hanley *et al* 2007 p. 11).

The first two laws of thermodynamics

The natural laws which govern the environment and which are, therefore, of interest to us are the first two laws of thermodynamics. These relate to closed systems. Strictly speaking, the earth is not a closed system as it receives energy from the sun, but it is almost a closed system.

First law of thermodynamics

The first law states that whenever energy is converted in form, its total quantity remains unchanged. In other words, energy (or matter) can be neither created nor destroyed.

Common and Stagl (2005) use the example of coal-fired electricity generating plant. The coal is heated which produces electricity. A by-product of this process is waste heat that is transported away as cooling water or gases. In addition, various waste gases are emitted into the atmosphere, which cause pollution, such as acid rain.

Second law of thermodynamics

This law states that in a closed system, entropy does not decrease.

**Entropy** could be described as a measure of the 'disorderedness' of energy. For instance, ordered energy is useful and an example of this is the energy stored in a battery. However, disordered energy is not useful, and an example is the energy dispersed into the environment by a fire.

Entropy is a thermodynamic property of matter and is related to the amount of energy that can be transferred from one system to another in the form of work. For a given system with a fixed amount of energy, the value of the entropy ranges from zero to a maximum. If the entropy is at its maximum, then the amount of work that can be transferred is equal to zero, and if the entropy is at zero, then the amount of work that can be transferred is equal to the energy of the system.

During an irreversible process the entropy of a system always increases.

The key points to remember from the above are that, because of these natural laws:

- increased extraction of minerals by the production process leads to an increase in wastes
- there is a limit on the substitutability of inputs
- since production and consumption lead to the dissipation of matter, scarce energy is needed for recycling

The importance of these two laws relates to the use, re-use, and recycling of the environment after interactions with the economy.

Let us look more closely at the subject of recycling, as this would seem to offer a chance for the economy to retain the use of scarce resources.

## Recycling

There is a hierarchy of resource use that includes recycling. This is referred to as the 3R's – reduce, re-use, and recycle. The final and least appealing option after resource use is to dispose of any remaining waste.

There are now many materials which are routinely recycled and re-used. For example, glass bottles have been collected and re-used by a number of drinks companies for many years. In various countries this practice is encouraged by the use of deposit-refund schemes. Other examples include paper, metal, glass, plastic, textiles, and garden waste.

For instance, in the Netherlands, household waste that can be composted is collected separately from other household waste and is composted by the local authorities. To encourage citizens to participate in this scheme, householders received some free compost soon after the scheme was set up. However, there are clearly costs involved in such a scheme.

- separate waste bins were provided for the compostable waste
- information was provided to householders
- householders use time to separate their waste
- costs of separate collection and of dealing with the compost

In the Netherlands, chemical household waste is also collected separately, with similar costs involved. There are numerous examples of different economic instruments used to deal with waste at both the household level and industry.

There are clearly limits to what resources can be re-used and recycled. These limits are not only dictated by the laws of thermodynamics but also the costs associated with re-using and recycling many items.

## **ORIGINS AND SCOPE OF ENVIRONMENTAL ECONOMICS**

### Section Overview

In this section we provide an overview of the discipline of environmental

economics and current philosophical schools of thought. This in turn provides a useful means by which to understand the scope of the discipline.

### Section Learning Outcomes

By the end of this section, students should be able to:

- understand the relationship of environmental economics to economics in general
- appreciate the differing importance that environmental economists attach to the physical constraints imposed by the environment on economic activity

### Origins of environmental economics

Environmental economics developed in its present form in the 1960s as a result of the intensification of pollution and the heightened awareness among the general public in Western countries about the environment and its importance to our existence.

Economists became aware that, for economic growth to be indefinitely sustainable, the economic system needs to take into account the uses of the environment that we have already mentioned, so that natural resources are not depleted and so that the environment is not overused as a waste sink. Environmental economists view the environment as a form of natural capital which performs life support, amenity, and other functions that cannot be supplied by man-made capital. This stock of natural capital includes natural resources plus ecological systems, land, biodiversity, and other attributes.

The growth of environmental economics in the 1970s was initially within the neo-classical paradigm. In general, this approach to the environment is concerned with issues of market failure, inappropriate resource allocation, and how to manage public goods. There was little concern for the underlying relationships between the economy and the environment. Concerns about the limits of this approach to environmental economics led some environmental economists to develop what is now referred to as **ecological economics**.

Ecological economics views the relationship of the economy and the environment as central. Thus, any analysis places economic activity within the environment. This distinction is best illustrated with reference to debates concerning sustainable development and the difference between weak and strong sustainability. Ecological economics supports the notion of strong sustainability. This view of sustainability assumes that not all forms of capital (ie human and natural) are perfectly substitutable.

At times, the distinction between neo-classical environmental economists and ecological economists is of no practical relevance. However, the underlying philosophical differences do matter in certain contexts, and the main environmental economics journals illustrate this. In particular, the journal *Ecological Economics* publishes many papers that support this view of the world.

In the context of this module the material presented is generally accepted by both neo-classical environmental economists and ecological economists. The differences between the approaches are more obvious and important when we examine issues of resource management and sustainable development.

### Scope of the discipline

We have now discussed to some extent the place of environmental economics as an academic discipline and how it has developed. We are now in a position to examine the role of environmental economists in policy design and implementation.

Essentially, environmental economics revolves around three broad questions.

- What are the economic and institutional causes of environmental problems? That is, how do the economic and social systems shape incentives in ways that lead to environmental degradation as well as to improvements?
- How can we assess the economic importance (ie monetary value) of environmental degradation/improvements?
- How can we design economic incentives to slow or halt environmental degradation and bring about improvements in the quality of the natural environment?

The first question leads to an analysis of market failure and government failure.

For example, one of the principal reasons for market failure is that there are incomplete markets for environmental assets. By incomplete we mean there are many cases where no market exists for the efficient allocation of an environmental resource. There are plenty of examples of where markets are incomplete including:

- clean air
- beautiful views
- unpolluted beaches
- tropical rainforests, with their biodiversity and their carbon-fixing properties
- a quiet environment

To ensure that we employ scarce resources efficiently the environment needs to be included in economic calculations, and environmental economics aims to do this.

The second question requires that we are able to place economic values on environmental degradation/improvements. As we have already noted, many environmental resources and goods are not priced in markets. Thus, to do this, environmental economics has developed a set of methods to place values on these types of goods.

To address the third question we will use economic tools to critically evaluate environmental policies and whether they are likely to achieve the aims of decreasing or halting environmental degradation.

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## Section 2 Self Assessment Question

*Question 4*

*Q*

True or false?

- (a) Environmental economics is a development of the neo-classical paradigm.
- (b) Ecological economics proposes that the stock of natural capital available may impose limits to economic growth.
- (c) A key objective of environmental economics is to ensure that the design and implementation of environmental policy reduces degradation to efficient levels.

## BASIC ECONOMIC PRINCIPLES

### Section Overview

In this section we introduce and develop the most important economic concepts in relation to environmental economics. Given the focus of the subject area we concentrate on microeconomic principles. In this section we provide a brief introduction to some of the economic terminology that you will come across as you work your way through this module. Pay particular attention to the words and phrases that are highlighted. Don't worry if their meaning is not entirely clear at this stage. We will be returning to look in detail at many of the underlying concepts later in the module.

### Section Learning Outcomes

By the end of this section, students should:

- understand the link between economic principles and environmental issues
- understand the ways in which the key concepts employed by economists are use in applied policy analysis

### Positive and normative economics

Economists frequently distinguish between 'positive' and 'normative' economics. Positive economics is concerned with the development and testing of positive statements about the world that are objective and verifiable. Normative statements derive from an opinion or a point of view. Thus the words 'should', 'ought to' or 'it is better to' frequently occur. The validity of normative statements can never be tested. Positive statements, on the other hand, can be tested, at least in theory, if not always in practice.

For anyone working in a management position it is helpful to distinguish between positive and normative statements. Managers and the people they work with, or are advised by, are likely to make liberal use of both, although normative statements may sometimes be disguised as positive statements. Whilst both types of statement may deserve attention, better management decisions are likely to result when the distinction between them is recognised.

It is often possible to rephrase normative statements in such a way that they become positive ones. For example, the normative statement 'the subsidies of the European Union's Common Agricultural Policy (CAP) should be removed' could be rephrased as the positive statement 'removing CAP subsidies will raise farm prices in developing countries'. The validity of the latter statement could, in theory, be tested.

Whether or not raising farm prices in developing countries is a good thing is another question. To say that 'raising farm prices in developing countries is a good thing' is a normative statement. On the other hand, the assertion that 'raising farm prices in developing countries will improve rural incomes in those countries' is a positive statement. Why? Because, again, it could, in theory, be tested. It does not say that rural incomes in developing countries ought to be raised, just that higher farm prices will have that effect.

To say that rural incomes should be raised is a normative statement, which you may well agree with, especially if you live and work in the rural areas of a developing country, or believe that increasing rural incomes is the best way to reduce poverty. On the other hand, if you live in the city of a developing country and believe that the removal of CAP subsidies will raise food prices, or if you are an EU food producer dependent upon CAP subsidies, you may feel differently about this – you may be less keen on raising rural incomes in developing countries, unless other ways can be found of achieving it.

You will notice that positive statements can often be broken down into a cause and an effect. Whether the effect is desirable or not is a normative question that will depend upon the subjective opinion of those affected. Economists practising positive economics can help analyse the effects in greater detail by breaking them down into positive and testable statements in the way we have done above. They can advise policy-makers in government, business, and other organisations both on the effects of specific policies and on the specific policies that need to be implemented in order to achieve desired effects. However, it is ultimately politicians and managers, and the people that empower them, that decide – on the basis of normative judgements – what is ‘desirable’ and what is not.

It is important to realise that economists practising positive economics do, however, make value judgements. Any analysis involves an element of subjectivity. In the first place, even what to analyse and how to analyse it often depends upon the subjective views of the analyst regarding what is, and what is not, important. Economic decisions have many different effects and it is rarely possible to examine them all in detail.

Indeed, whether to examine a problem from an economic perspective at all, or whether to focus instead on alternative perspectives, such as those provided by the disciplines of sociology, biology, or political science, depends in large part on normative/subjective views of the world.

### Applying scientific methods and reasoning

Scientific reasoning involves constructing theories to explain how the world works. In general, the simplest explanation is preferred. As new information about the world becomes available which throws doubt on a theory, then the theory is modified. Consider the following example of how the process can be applied to an economic problem.

- We have the following information about the world – supermarkets are selling more organic apples than before – and we want to know why this is the case.

- Now we construct a theory – the volume of organic apple sales depends upon the price at which they are sold – this is a positive statement.
- Next we state a hypothesis – the volume of organic apples that a supermarket will sell rises if it reduces the price of organic apples – another positive statement.
- Then we test it by looking for evidence to support the price-sales link in different countries and for different time periods.

- If the evidence supports the hypothesis
  - we accept it, and
  - move on to more refined hypotheses, such as those relating to how big the response by consumers is to price changes.
- If the evidence does not support the hypothesis, we either
  - modify the hypothesis, or
  - reject it.

This process of trial and error gradually leads to a theory that fits well with experience. It enables the economist to

- explain what has happened
- say what might happen in the future when prices change

Can the theory be tested?

In the organic apple sales example, yes.

But what happens if the hypothesis is not testable?

You have to try to frame ideas of how the world works in such a way that evidence can be found to support or reject the idea. Incidentally, this limits what we can theorise about. In practice it is sometimes possible to find a way round the unmeasurable by using a proxy variable. This is a variable that reflects the characteristics of the other, unmeasurable, one. So in the case of placing a monetary measure on the value of the environment we can

- look at the price paid for related goods
- ask individuals using survey methods what value they place on the environment

This is not perfect, but proxy variables can be a way round such problems.

Why do economists make assumptions?

In everyday life assumptions are made because nothing would ever be achieved without them. Whenever we open an economics textbook we do so with the underlying assumption that, for whatever reason, economics is a subject worth studying. We don't examine this assumption in detail every time we open an economics book (unless we are extremely disillusioned) because otherwise we would make very little progress with our reading. We also learn from experience which assumptions have lasting validity.

This illustrates an important reason why economists make assumptions. Assumptions save time and concentrate the mind on the problem to hand, and

when well-proven become part of the body of established knowledge.

The use of assumptions in economics also relates to the need for an analytical method that provides clarity, scientific rigour, and flexibility.

Consider the theory represented by the positive statement that we made earlier: ‘the volume of organic apples that a supermarket will sell rises if it reduces the price of organic apples’. The theory is stated with the assumptions that: (a) the quality of

apples remains constant; (b) consumers are made aware of the price fall; and (c) consumers prefer more apples to fewer apples.

The use of these assumptions helps clarify the relationship between organic apple sales and organic apple prices. It does so in a scientific manner by explicitly recognising that organic apple sales can also be affected by other variables such as quality, price information, and consumer preferences. In a controlled laboratory experiment these variables would be kept constant. In economics it is not possible to conduct laboratory experiments. Instead, economics depends greatly on the techniques of statistics for testing its theories and hypotheses. These techniques can be used to identify the relationship between different variables, such as sales and price.

Setting out underlying assumptions when developing and testing a theory or hypothesis also provides the analyst with the flexibility to vary the assumptions at a later date. Modifying assumptions and examining the effects of these modifications on the original theory provides a methodical way of examining economic problems and the variables that link cause and effect. For example, once we have established the nature of the link between apple prices and apple sales we can move on to look at the link between sales and quality.

What is an economic paradigm?

It has been observed that research tends to cluster around ‘big ideas’ called research paradigms. Once a particular paradigm is accepted as dominant, people often research issues adopting these central tenets. In the 1950s and 1960s the dominant economic paradigm regarded markets as being prone to failure, and the duty of government was to intervene and correct these failures in an impartial manner. People became disenchanted with this approach as a result of the 1967–1977 decade of inflation and unemployment, leading to the ascendancy of a new paradigm – one which regarded government intervention as being more likely to worsen than improve market failures. In this paradigm, the job of government is limited to the role of ensuring free competition and making companies respond to shareholders. In recent years, this paradigm has begun to be displaced by one that re-emphasises the role of government in correcting market failures. This is especially the case in environmental economics, although the ‘credit-crunch’ of 2008 drew attention to problems in financial markets that were possibly under regulated.

Terminology and basic concepts

Like any academic discipline, economics abounds with terminology and jargon. Sometimes it may seem as if the terminology of economics is designed to confuse.

However, its purpose, when used properly, is to convey in a concise and precise manner the meaning associated with certain basic concepts and to facilitate the discussion of economic problems. Of course it can, like so many useful innovations, be abused. It can be used to mystify rather than clarify, and to take shortcuts that create ambiguity at the expense of precision. You should always be on your guard against such abuses.

## Economic agents

Business and development managers need to know about the economic agents they will be working with, competing against, representing, or producing for. Economic agents are individuals, consumers, managers, business owners, shareholders, or workers. In fact, an economic agent is anyone who acts in an economic way, **allocating resources to satisfy wants**.

The **firm** may also be treated as a unitary economic agent with the sole objective of maximising its **profits** (defined as the **surplus of revenue over costs**). This is, of course, a simplification of how real firms work, since, in practice, they usually consist of a number of different agents, such as managers, workers, and shareholders, each with their own set of objectives. Nevertheless, it is a useful assumption to make when examining the choices that confront the managers of a business enterprise.

## Markets

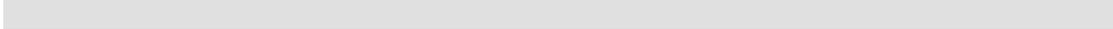
The definitions of a market are varied and often depend upon the context in which the word is used. A market or market place is often identified with a specific location where goods are sold or exchanged. Today, the exchange of goods and services does not always take place at a specific location. A more appropriate definition of a market might be 'a mechanism by which buyers and sellers of goods and commodities are brought together for the purposes of exchange'. The market might involve buyers and sellers haggling over the price of goods displayed in stalls on the village square, or it might be on the internet whereby computer users from all round the world can view, order, and pay for products online.

A market may also involve a combination of different exchange mechanisms. Economists talk in terms of the market for a particular good or service, such as the market for apples, for books, or financial services. Various mechanisms may be used for selling in each of these specific markets.

## Efficiency

Efficiency is a word that is often thrown about without much thought being given to its precise definition. Doing something efficiently is often the economists' or managers' way of saying that it is done well, as opposed to badly or inefficiently. As such it is usually something to be strived for. In fact there are various different forms of efficiency, each with their own specific definition. For now we can assume that efficiency is associated with activities that tend in some way or other to maximise benefits and minimise costs.

Many economic concepts and their associated terminology are linked in one way or another to the goal of achieving economically efficient outcomes. They include



those listed below.

- **Opportunity cost:** economically efficient outcomes are only possible when one takes into account the opportunity cost of an action or resource. In taking a particular course of action or utilising a resource in a particular way, one is forgoing the opportunity to undertake an alternative course of action or utilise
  - the resource in a different way. Opportunity cost, therefore, equates to the benefits forgone in the next best alternative use or action. For example, the economic cost of chopping down a forest is not just the cost of employing labour and machinery to do the job, but also includes the cost of lost opportunities to use the forest for alternative purposes, such as for recreation, or to provide environmental benefits.
- **Productivity:** productivity is usually used in relation to labour, but can be measured in terms of the output per unit of any **factor of production**, such as land, labour, capital, water, and so on. A plantation may, for example, substitute agricultural machinery for labour. The few labourers that are left each produce far more than they did before the machinery was introduced. However, the machinery may break down frequently, disrupting production and reducing per hectare yields. Whilst labour productivity has increased, land productivity may have fallen.
- **Marginal analysis:** in studying economics you will soon become familiar with the concept of marginal analysis. Economists are interested in the cost or benefit associated with the consumption or production of the next additional unit. For example, if we extract another litre of oil from the ground will the cost of extraction be more or less than the benefit obtained. If the benefit is greater than the cost we would proceed.

### Section 3 Self Assessment Questions

#### *Question 5*

*Q*

The opportunity cost of an input in a production process is **best** defined as:

- (a) the cost of the input in units of money
- (b) the price set by the government
- (c) the price usually paid in actual markets
- (d) the value of commodities that could have been produced in the best alternative use of the input
- (e) none of the above

#### *Question 6*

*Q*

Explain the difference between positive and normative economics.

#### *Question 7*

*Q*

Write three short examples each of positive and normative economic statements.

## THE NEO-CLASSICAL ECONOMIC MODEL

### Section Overview

In this section, we introduce the neo-classical model and its underlying assumptions. Most of the basic theories developed in neo-classical economics begin with the model of **perfect competition**. The assumptions upon which this model is based are usually taken as a starting point. Economists know that we do not pretend to live in a world of perfect competition. However, the assumption of perfect competition allows us to identify important aspects of economic behaviour as well as the economic outcome of such behaviour. It helps reveal key economic relationships that might otherwise remain obscure. Once we understand what occurs under perfect competition we can begin to relax some of the model's assumptions and observe the effects.

### Section Learning Outcomes

By the end of this section, students should understand:

- the key assumptions that underpin basic economic models and analysis
- key assumptions that are required for the basic model to work
- the relationship between supply and demand
- the importance of measures of elasticity in conducting economic analysis of market behaviour

### Perfect competition

The main focus of the neo-classical model is on the question of how resources can be allocated most efficiently. It promotes the development of freely competitive markets in which individuals are given as much economic freedom as possible; the individual is left to decide what to buy, what to produce, and what to sell.

Ideally, the market should resemble as closely as possible the model of perfect competition. Theory can show that a perfectly competitive market can result in the most efficient allocation of resources. From the narrow viewpoint of economic theory this can be termed the optimal result for society, or the socially optimal outcome. This theoretical result applies both to a single market and to all the markets in an economy if all could be perfectly competitive. Thus, if markets work badly, according to this theoretical model the government has a duty to individuals and to society to correct this, ie governments should intervene to correct market failure.

So what is perfect competition?

The model of perfect competition rests on a number of key assumptions.

- *Rationality*

The first assumption made is that people are economically rational, preferring more of those goods and services they value to less.

Does this sound reasonable? The answer is surely, yes.

It is a short step from wanting more rather than less of the good things to wanting to maximise the amount of good things (literally ‘goods’) you can get. Rational economic man or woman has objectives, and attempts to maximise them. In neo-classical economics, this is stated as follows:

- consumers allocate their incomes in order to **maximise their satisfaction** from the goods and services they consume
- producers allocate resources in order to **maximise their profits**

Does this still sound reasonable? It is at this stage that doubt may creep in, especially with regard to profit maximisation. After all, business decisions are taken by managers, who are frequently not the owners of the business.

Nevertheless, the profit maximisation assumption is still plausible, if not inevitable. If managers create more value at lower cost than competitors, their business will prosper, its profits will rise and managers may be rewarded accordingly. And even if the profit maximisation motive isn’t always valid it is still useful to consider the outcomes that would arise if it were.

- *Perfect knowledge*

More contentious is the second assumption of the neo-classical model: that economic agents make decisions in the light of perfect knowledge. Buyers and sellers know all the prices of all the goods in the market, know everything they need to know about the quality of goods, the character of the other economic agents, what the government is going to do next, and so on. There is no doubt, no uncertainty. Like a computer with perfect knowledge, rational economic man can compare prices with what they have or want, and set out to maximise their objective, be it consumer satisfaction or business profits.

In reality this is frequently an unrealistic assumption. So in practice economists will start by examining the world as if perfect knowledge existed and then they relax this assumption so as to make their analysis more realistic. In this way, we use the neo-classical model as the basis for a comparison with the real world. The same applies to the remainder of the assumptions presented here.

- *Many participants*

A perfectly competitive market consists of a large number of participants who are ‘**price-takers**’. That means that an individual participant has no influence on market prices – they must accept the market price for whatever they buy or sell. If the market were dominated by a few participants, individual participants would not be price-takers and the market would not be perfectly competitive. At the opposite end of the spectrum to perfect competition is monopoly where the monopolist determines what the market price will be.

- *No barriers to market entry or exit*

If a market is to be truly competitive, there must be scope for new buyers and sellers to enter a market, and for old participants to leave and find other markets. This of course applies to markets for resources like labour as well as markets for goods and services. If the wages of plumbers are high compared to the wages of carpenters, the latter will leave their jobs and look for jobs as plumbers. We speak of 'resource mobility' in this respect.

- *Homogeneous commodities*

This assumption requires that the good or service associated with a particular market is identical in all respects. For example, in the apple market all apples are assumed to be of equal size, shape, colour, taste, origin etc. In other words there is nothing to distinguish one apple in the market from another. As with rationality in much applied analysis this assumption is relaxed. Indeed, product differentiation is an important business strategy, as can be seen on the shelves in shops or supermarkets throughout the world – in reality an apple is not just an apple, but can be small, large, have a flavour that is sharp or sweet, the colour may be yellow, green, red, and so on.

#### Methods of economic analysis

Economics uses three ways of describing theories. Two are mathematical: algebra, and graphs or diagrams; the third is simply in words, through progressive logical explanations.

We use **words** every day, so many people find that introductory economics is most accessible when presented in narrative form. The trouble is that words can be ambiguous, vague, and long-winded!

**Diagrams** are useful because they allow you to picture a relationship. From a diagram it is possible to capture at a single glance something that may take several paragraphs of text to describe in words. The most commonly used diagram in economics is the one that depicts supply and demand, an upward sloping line/curve (supply) intersecting with a downward sloping line/curve (demand) in the shape of an x. We shall be examining this diagram in the next unit.

**Algebra** is the most concise way of describing economic theories, and much of economics can be expressed in a few pages using calculus. The models developed in this way can capture static or dynamic relationships as well as being partial or general equilibrium analysis.

- Often we compare one equilibrium position in a market with another equilibrium position in the same market, a procedure called **comparative static analysis**. (An equilibrium position occurs where supply is equal to demand and the price is stable.) The alternative to static analysis is **dynamic analysis**. This concentrates on the behaviour of models out of equilibrium, typically moving from one equilibrium to another.
- A **general equilibrium analysis** tries to consider all the markets and all the forces that affect the subject under examination. **Partial equilibrium analysis** assumes that other things remain the same beyond the boundaries of the market or area that is our concern. This works quite well for small

changes, but becomes an inaccurate method when large important changes are considered.

## Demand

We now examine the basic features of how markets work. We look at the role played by consumers in the market, and the business opportunities that markets create. Markets work via interactions between supply and demand (which are represented graphically by the supply curve and the demand curve). Understanding the nature of these interactions is essential for the tasks faced by managers in both business and development.

Some key aspects of the theory of consumer demand are as follows:

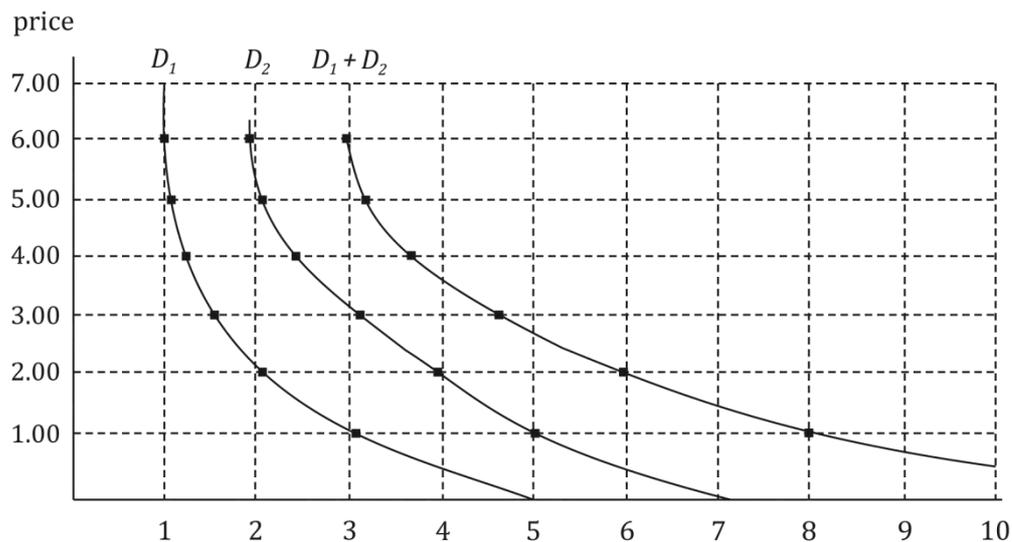
- The *ceteris paribus* assumption. It is an important and commonly used assumption in economics. When examining the relationship between price and demand we have to assume all other influences on demand remain constant or unchanged. Of course, if other factors are not held constant then a fall in price may not be enough to increase demand, such as in the case where consumer incomes are dropping at the same time as prices are dropping. Nevertheless, even in such a case, the expected inverse relationship between price and demand implies that the depressed demand caused by a decline in incomes will, in part at least, be offset by the rise in demand resulting from the price fall.
- The distinction between movements **along** the demand curve and **shifts** in the demand curve. Movements along the demand curve result from a change in the price of the good being demanded (*ceteris paribus*). A shift in the demand curve is caused by other factors, such as changes in consumer incomes or tastes, or in the price of other goods.
- A demand curve may in fact be a straight line. The shape of the demand curve is determined by consumer tastes and preferences.
- A demand curve can be used to represent the demand of an individual consumer, a group of consumers, a nation of consumers or, indeed, a whole world of consumers. In the table in 4.3.1 and figure in 4.3.2, below, you can see that a market demand curve is derived by summing the demand of individual consumers at each price. In this case there are only two consumers, with demand curves  $D_1$  and  $D_2$ . The market demand curve is thus  $D_1 + D_2$ .
- Demand is synonymous with **consumption** or **purchase**, not **want**. If the annual demand for apples is five tonnes at a given price, then that is what is actually purchased at that price. The amount of apples people aspire to consume is sometimes referred to as **real demand** and the amount they do consume as **effective demand**. When we talk about demand we are referring to effective demand unless we state otherwise.

*The demand schedule for apples*

Price (£)	$D_1$ demand (kg)	$D_2$ demand (kg)	Market demand (kg) $D_1 + D_2$
1.00	3.0	5.0	8.0
2.00	2.0	4.0	6.0
3.00	1.4	3.3	4.7
4.00	1.1	2.6	3.7
5.00	1.1	2.0	3.1
6.00	1.0	2.0	3.0

Source: unit author

*Summing demand curves*



Source: unit author

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## **Substitutes and complements**

The question of whether goods are **substitutes** or **complements** is an important one that can be very helpful in analysing the demand for various goods and services. For example, if we want to understand fluctuations in the demand for sugar we may

gain insights by looking at the demand for coffee because the two products are complements. For example, if there is a sudden fall in the demand for sugar, people in the industry will want to know why. In this hypothetical case the answer is found by looking at the demand curve for coffee. The price of coffee has risen suddenly, causing a contraction in demand (an upward movement along the coffee demand curve). Since many people use sugar in their coffee, changes in the coffee market have a significant effect on the sugar market also. The two goods are complements, so a rise in the price of coffee results in a fall in the demand for both sugar (the demand curve for sugar shifts to the left) and coffee (movement along the demand curve).

Let's now look at an example of substitutes. From an environmental perspective it is beneficial for consumers to switch consumption from environmentally damaging products to close substitutes that are less harmful to the environment. Government taxation policy, as in the case of the unleaded fuel example, is considered by many economists to be an appropriate way of encouraging such a change. However, such a policy will often only work effectively if there are reasonably close substitutes for the goods that are being discouraged. For example, attempts to reduce the use of private cars by raising the cost of driving (through road taxes, tolls, price of fuel etc) will only have a limited effect if consumers do not consider alternative forms of transport (typically public transport) to be a close enough substitute for private cars.

## Elasticity

Elasticity, as the name suggests, is a measure of responsiveness. When we talk about **demand elasticity** (which in economics we often do) we are referring to the responsiveness of demand to particular factors that have an influence on demand. The resulting elasticities of interest include the following:

- **(Own) price elasticity** of demand. If the price elasticity of demand for a particular good is high then a change in the price of that good will have a very significant effect on the demand for that good. If, on the other hand, the elasticity is low, even fairly large price changes will fail to have a significant impact on demand. Another way of saying 'high elasticity' is 'very elastic', or 'inelastic' in the case of low elasticity.
- **Income elasticity** of demand. As we have seen, income can have a significant influence on the demand for a particular good or service. A good whose demand is highly elastic with respect to income will be consumed in much greater quantities if incomes rise or much smaller quantities if incomes fall.
- **Cross-price elasticity** of demand. We talk about the cross-price elasticity of

demand of good A with respect to good B. This is a measure of the influence of good B's price on the demand for good A.

Given these definitions of elasticities the following points can be observed:

- An **elasticity of zero** implies that the factor under consideration has no influence on demand.
- An **elasticity between zero and 1** represents a positive influence on demand, but one that is said to be **inelastic**. The percentage change in demand is less than the percentage change in the influential factor.

- An **elasticity greater than 1** signifies an **elastic** relationship. The percentage change in demand is greater than the percentage change in the influential factor.
- Own-price elasticities of demand are usually negative, reflecting the inverse relationship between price and demand; however, the negative sign is typically ignored.

A perfectly inelastic demand curve is depicted by a straight vertical demand curve. The amount consumers demand is fixed and unaffected by price. Few commodities are perfectly inelastic, but quite a number may approach it, for example, water, food, and fuel.

A summary of formulae to estimate demand elasticities is presented in 4.3.3.

*Summary of formulae to estimate demand elasticities*

- (1) **(Own) price elasticity** is a measure of the influence on demand of variations in the good's own price. It is given by the following equation

$$\text{price elasticity of demand} = \frac{\text{percentage change in demand}}{\text{percentage change in price}}$$

- (2) **Income elasticity** is a measure of the influence on demand of variations in consumer income

$$\text{income elasticity of demand} = \frac{\text{percentage change in demand}}{\text{percentage change in income}}$$

- (3) **Cross-price elasticity** is a measure of the influence on demand for good A of variations in the price of another good, B

$$\text{cross-price elasticity} = \frac{\text{percentage change in demand for A}}{\text{percentage change in price of B}}$$

Source: unit author

It is important to bear in mind that the responsiveness of demand to price changes will depend on the current level of consumption/demand. Consider the following example from the water sector. When the price of water is so low as to be almost insignificant, and large volumes of it are being consumed (ie at the bottom of the demand curve), a doubling of the price of water (assuming it is metered) may have little or no effect on consumption. Under these circumstances, demand for water with respect to price is perfectly inelastic, or almost so. However, as one moves back up the demand curve, demand will probably respond more to price changes. As the price of water gets higher, consumers will pay more attention to the cost of

using water. In other words, elasticity will increase, at least initially. The elasticity at any particular price level will depend upon the shape and position of the demand curve.

Elasticity is a useful concept for helping us to understand the way markets work, particularly markets in the food, agriculture, and natural resources sectors.

Normal goods and inferior goods

A **normal good** is one for which demand increases as income increases.

Goods that are not normal are called **inferior goods**. In other words, as income

risers demand for these goods falls.

## Supply

Now that we have introduced the demand schedule and taken a look at the factors that influence demand, we turn our attention briefly to supply.

It is sufficient to understand that, providing one accepts the profit maximising assumption, firms/suppliers will, *ceteris paribus*

- raise output if prices rise or costs fall
- reduce output if prices fall or costs increase

Movements along the supply curve result from a change in the price of the good being supplied (*ceteris paribus*).

A shift in the supply curve is caused by factors that affect the cost of production, or any other factor affecting the volume of production other than the price of the good itself. Examples are the impact on harvests of the weather or outbreaks of pests and diseases. Changes in technology may also shift the supply curve by changing the cost of production per unit of output.

## Elasticity of supply

The elasticity of supply is a measure of the responsiveness of supply to some influence. Here, we are only concerned with the elasticity of supply with respect to price, that is, the responsiveness of supply to variations in the price of the good being supplied. The own price elasticity of supply is defined by the following formula:

$$\text{price elasticity of supply} = \frac{\text{percentage change in supply}}{\text{percentage change in price}}$$

The same general principles apply as in the case of demand elasticities. Perfectly inelastic supply curves are straight vertical lines with an elasticity of zero. Elasticities between 0 and 1 represent inelastic supply response, whilst those greater than 1 signify an elastic supply response. It is also important to note that there can be differences in the position of supply curves in short and long run. Long-term supply curves tend to be much more elastic than short-term supply curves. This is because, in many contexts, supply cannot be adjusted in the short run because of physical as well as financial constraints on the firm. Given a long enough period, almost any adjustments to the production process can be made.

## Supply and demand – finding the market equilibrium

We now examine how an industry supply curve and market demand curve interact

to produce a market equilibrium. We have already discussed the factors that affect the shape and position of each of these curves: price, income, and consumer preferences in the case of the demand curve; price, costs, and other factors in the case of the supply curve.

- It is important to bear in mind that the supply curve and the demand curve are both independent of each other. The shape and position of the demand curve is

not affected by the shape and position of the supply curve, and vice versa.

What the supply and the demand curves have in common is their representation of responses to price.

In a perfectly competitive market an equilibrium is achieved when supply equates to demand.

$$Q_S = Q_D$$

Thus, price varies until  $Q_S = Q_D$ . Two key mechanisms are involved in ensuring that if price is not at this clearing level, it will adjust until it reaches that level. These are as follows.

- **If the price lies above the clearing price**, producers will be left with excess stocks that consumers are not willing to buy at the prevailing price. In this situation the market is characterised by what is called **excess supply**. In order to clear these stocks, producers will have to accept a lower price for their goods. Price will fall until the market is in equilibrium and supply equates to demand. Remember the assumption of perfect information and consider how this will facilitate this mechanism.
- **If the price lies below the clearing price**, there will be what is termed **excess demand**. Many consumers will be unable to purchase the goods they are seeking because suppliers have run out of stock. At the prevailing price, suppliers are unable to meet demand. Market forces will eventually rectify this situation as consumers bid up the price until the equilibrium price is reached.

Remember that, in a perfectly competitive market, producers are price-takers. Individually, none of them can effect a price change. All buyers and sellers have perfect information about the quantities available for sale and the prevailing price. If these conditions did not exist then an equilibrium would not necessarily be established at  $Q_S = Q_D$ , although it might well be established at another point. For example, if supply was controlled by a monopoly, the latter could set the price wherever it liked. However, a monopoly is still bound by how much the market demands at any given price.

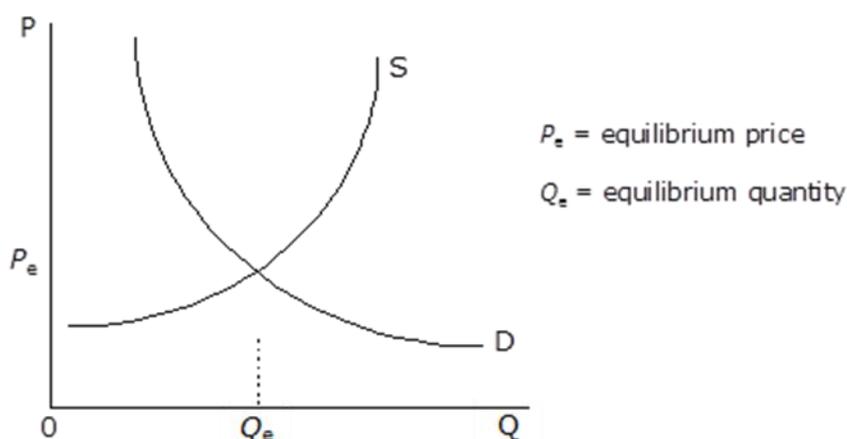
Now consider a situation where the suppliers are price-takers, but information about market conditions is not widely available. In this case excess supply or demand might persist, slowing down, or preventing altogether, the process of reaching an equilibrium at  $Q_S = Q_D$ .

However, in a competitive environment we have price independently determining where suppliers and consumers position themselves along their respective supply and demand curves. We also have the equilibrium price being determined by the interaction of supply and demand. At the point of equilibrium there is no reason

for the market to move away from this position unless either the supply or the demand curve moves. You should recall from the previous two sections the factors that are likely to bring about a shift in either of these two curves.

The supply and demand model can be represented as a figure as shown in 4.5.1, below.

### Basic supply and demand



Source: unit author

The supply function shows **planned** responses to differing levels of price.

If either the supply or demand curve shifts, a new equilibrium price will be created. A shift in the demand curve to the right will raise the equilibrium price. A movement of supply to the right will reduce the equilibrium price.

Importantly the analysis presented assumes that movements/shifts of the supply and demand curves are independent of each other. Making this assumption helps us to illustrate clearly what is meant by a market equilibrium, and the way in which a market clearing price is established.

### Endogenous and exogenous variables

- **Exogenous variables** are considered to emanate from outside the market in question. They include all those influences such as consumers' preferences, incomes, technological change, the cost of inputs, climate etc.
- **Endogenous variables** are those which lie within the market system. There are three of them: the price of a good, the quantity of the good supplied, and the quantity demanded.

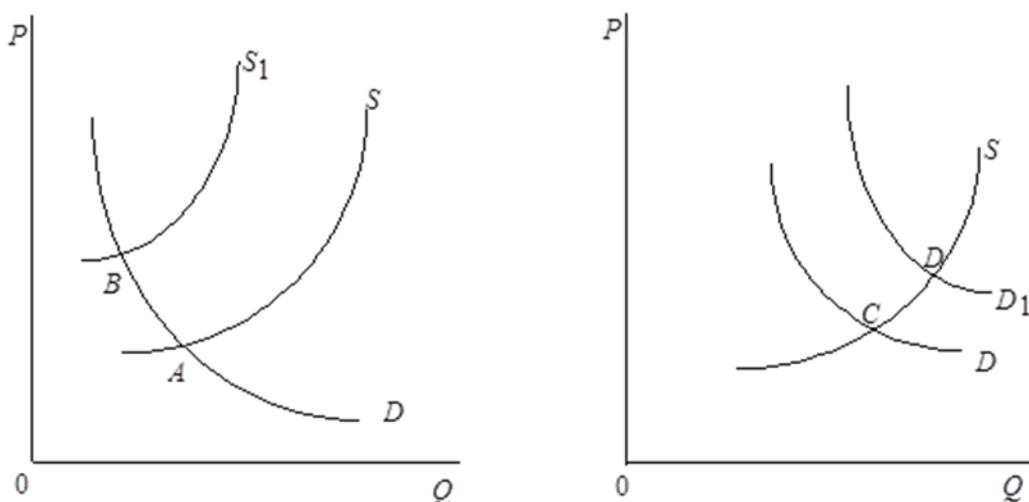
### Comparative static analysis

**Comparative static analysis** means comparing two market equilibria before and after a change. Consider the figure in 4.5.2, below, which illustrates a supply shift and a demand shift. In each case, comparative statics is concerned with comparing

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the two static equilibria ( $A$ ,  $B$  and  $C$ ,  $D$ ) rather than how the market moves from  $A$  to  $B$  or  $C$  to  $D$ .

### Comparative statics



Source: unit author

In each case, the worst mistake would be to say that a change in the good's own price caused the shift in equilibrium. In moving from *A* to *B*, increasing price reduces quantity demanded along the demand curve. However, the new equilibrium was caused by the **shift** in the supply curve. Note that:

- a shift in the supply curve leads to a movement along the demand curve to a new static equilibrium position (eg at *B*). This could be caused, for example, by an increase in the costs of production, or for one season by bad weather for an agricultural crop.
- a shift in the demand curve leads to a movement along the supply curve to a new static equilibrium position (at *D*). This could result from by an increase in consumer incomes, a change in preferences in favour of the good, a decrease in the price of a complementary good, or an increase in the price of a substitute.

### Pareto Optimality

We now turn to the concept of Pareto Optimality, named after the economist Vilfredo Pareto. It is a concept that you will find recurring frequently in the economics literature. The main proposition of Pareto Optimality can be summed up as follows.

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*An economy is in a Pareto Optimal state when no further changes in the economy can make one person better off without at the same time making another worse off.*

You may immediately recognise that this is the socially optimal outcome achieved by a perfectly competitive market referred to above. It can be shown that an economy will be Pareto Optimal when the economy is perfectly competitive and in a state of static general equilibrium. The intuitive case for this is based on the fact that prices

reflect economic values in a competitive market. If a unit of goods or services could produce more or bring greater satisfaction in some activity other than its present use, someone would have been willing to bid up its price, and it would have been attracted to the new use.

When this price system is in equilibrium, the marginal revenue product, the opportunity cost, and the price of a resource or asset will all be equal. Each unit of every good and service is in its most productive use or best consumption use. No transfer of resources could result in greater output or satisfaction.

This can be examined more formally in terms of three criteria that have to be met for a market equilibrium to result in Pareto Optimality. These are that there should be: exchange efficiency, production efficiency and output efficiency.

### **Exchange efficiency**

Exchange efficiency occurs when, for any given bundle of goods, it is not possible to redistribute them such that the utility (welfare) of one consumer is raised without reducing the utility (welfare) of another consumer.

A simple example of this is where there are two individuals, one with a loaf of bread, the other with a block of cheese. Both can be made better off by exchanging bread for cheese. An efficient exchange system will allow exchange of bread and cheese to take place until neither party can be made better off without one of them becoming worse off.

In a multi-product, multi-consumer economy, exchange is far more complex and involves the use of money to facilitate exchange. However, the principle is the same. So long as products can be reallocated to make one person better off without making another worse off, the economy is operating sub-optimally from the point of view of exchange efficiency. In a perfectly competitive market, exchange will occur until this criterion is met.

Exchange efficiency alone does not necessarily result in Pareto Optimality. This is because it relates only to a specific bundle of goods. It may be possible to make one or more individuals even better off – without making any one else worse off – by altering the bundle of goods produced in the economy. This could involve raising the total volume of goods produced, as well as altering the combination of goods produced.

### **Production efficiency**

Production efficiency occurs when the available factors of production are allocated between products in such a way that it is not possible to reallocate the production factors so as to raise the output of one product without reducing the output of

another product.

This is analogous to technical or production efficiency at the level of the firm. What is being said here is that there are many situations in which it is possible to raise the total output in an economy by simply reallocating factors of production at no additional cost. This is because factors of production are more productive in some uses than they are in others. In a competitive economy, producers bid for factors of production until they are reallocated to their most productive use.

For example, if there is a lot of unproductive, low-wage labour employed in the agricultural sector and labour shortages in the industrial sector where labour productivity is potentially high, factory owners will bid up the price of labour and draw labour from the agricultural sector into the industrial sector. This could significantly raise output in the industrial sector without having a negative impact on output in the agricultural sector. So long as factors of production can be redistributed in a way that increases the output of one product without reducing the output of others, the economy is operating sub-optimally in terms of production efficiency.

### Output efficiency

Output efficiency occurs where the combination of products actually produced is such that there is no alternative combination of products that would raise the welfare of one consumer without reducing the welfare of another.

Both the exchange efficiency and the production efficiency criteria must hold in order for this criterion to be met. The combination of outputs produced according to this criterion is distributed between consumers according to the exchange efficiency criterion, and the economy is operating with production efficiency.

Pareto Optimality is the result of rational economic behaviour on the part of producers, consumers and owners of factors of production in a perfectly competitive economy. Although we don't have the scope to examine the underlying theory here it can be shown that Pareto Optimality will be achieved if all markets are perfectly competitive and in equilibrium.

It is important to realise that, whilst Pareto Optimality is the outcome in an economy that meets each of the three efficiency criteria listed earlier, this does not mean that there is only one 'optimal' allocation of resources. A Pareto efficient economy results in the maximisation of aggregate economic welfare for a given distribution of income and a specific set of consumer preferences. A shift in income distribution changes the incomes of individual consumers. As their incomes change, so too will their preferences, as their demand curves for various products shift to the left or right. This will result in a different equilibrium point in the various markets that make up the economy. Every alternative distribution of income or set of preferences is characterised by a different Pareto Optimum. Thus, since there is an infinite number of different ways in which income can be distributed, there is also an infinite number of different Pareto Optimal equilibriums.

Obviously, in practice, no economy can be expected to attain the Pareto Optimum position. Moreover, the Pareto principle is of little practical use as a policy tool since it is rarely possible to devise a policy that makes someone better off without

making someone else worse off. Nevertheless, it is an important concept in the neo-classical tradition of economics and integrates much of the theory. It is also a standard against which economists can explore the real world, where making one person better off almost invariably means making someone else worse off.

## Section 4 Self Assessment Questions

### Question 8

Q

Which of the following are core assumptions of perfect competition?

- (1) Many buyers and sellers, none of whom can individually influence market prices.
- (2) Homogeneous commodities.
- (3) No barriers to market entry or exit.
- (4) Perfect knowledge.
- (5) Rationality, with firms maximising profits and consumers maximising satisfaction or utility.

- (a) All of the above
- (b) None of the above
- (c) Only (1), (3), and (4)
- (d) Only (2), (3), and (4)
- (e) Only (1), (2), and (4)
- (5)

Now read the following paragraph and then answer Questions 9 and 10.

*‘Over the past couple of years, grape prices soared because the champagne grape was in short supply; the harvest shrank by about a quarter over this period. Global demand remained unchanged until 12 months ago but if another world recession can be held at bay it is reckoned that champagne sales will grow by about a fifth to a new peak.’*

### Question 9

Q

An increase in the price of champagne grape caused by a cut in the supply of grape would be represented in a diagram of demand and supply curves for grape by which of the following?

- (a) a shift to the left of the demand curve
- (b) a shift to the left of the supply curve
- (c) a shift to the right of the supply curve

- (d) a movement along the supply curve towards the origin
- (e) a movement along the supply curve away from the origin

*Question 10*

*Q*

An increase in the price of champagne itself, caused by economic growth, and an increase in global demand would be best represented in a diagram of demand and supply curves for champagne by which of the following?

- (a) a shift to the left of the demand curve
- (b) a shift to the right of the demand curve
- (c) a shift to the right of the supply curve
- (d) a movement along the demand curve
- (e) no change in the diagram

## AN INTRODUCTION TO MARKET FAILURE AND GOVERNMENT FAILURE

### Section Overview

This section provides a brief explanation of why market failure occurs. We also examine reasons why government policy can affect the environment in a negative way.

### Section Learning Outcomes

By the end of this section, students should be able to:

- define what is meant by market failure
- differentiate between the different forms of market failure

### Market failure

Neo-classical economics is concerned with markets for goods allocating scarce resources to alternative uses, and prices being established which reflect the scarcity and levels of demand for goods.

Think for a moment about our daily life and what affects it. We live in a particular environment, breathing the air. However, we do not pay a price for the air, since there is no market in air. As a result, we cannot reflect our preference for breathing clean rather than dirty air through the market. This is an example of **market failure**.

Market failure occurs when the conditions for perfect competition are not met. If the market fails, then government intervention designed to correct the market failure may bring benefits to society. However, government intervention may fail to secure these benefits, it can make matters worse and it can be the reason why there is market failure. This is known as **government failure**.

We know that the market mechanism will lead to the socially optimal outcome only under very specific conditions. However, it is highly unlikely that these conditions will be fully satisfied. The existence of perfect competition in reality as it is defined in textbooks is highly unlikely. For example, we require that prices will result from the realisation of all possible markets working and existing. This is only likely to occur when a complete and effective system of property rights exists, including property rights to environmental goods such as clean air.

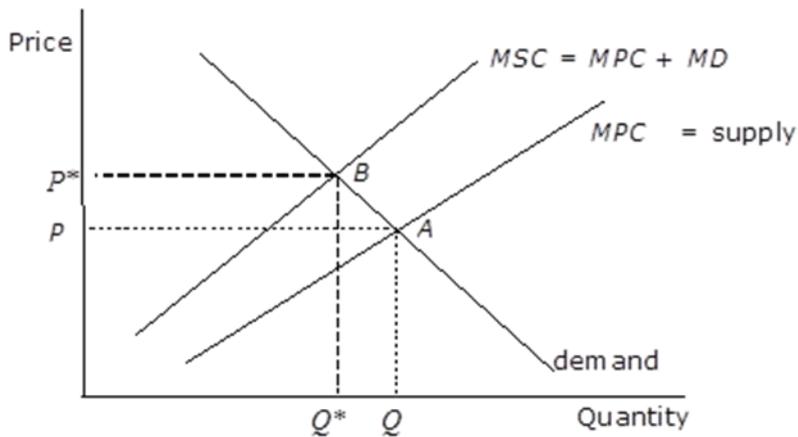
When either condition is not satisfied, markets fail and this can, deliberately or unintentionally, bring about undesirable consequences.

Let us work through the argument for a negative externality. In this case, the marginal private cost (*MPC*) is less than the marginal social cost (*MSC*). The marginal private cost represents the short-run market supply curve. Hence, with a

negative externality, the short-run market supply curve is lower than society's short-run supply curve would be. The difference between  $MSC$  and  $MPC$  are the marginal damages ( $MD$ ).  $MDs$  are the amount of the negative externality which as the quantity of output increases, increase as well. These are damages being inflicted on society as a result of the private producer not taking account of the costs that result from production, such as air or water pollution. This situation is illustrated in 5.1.1.

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### 5.1.1 Effect of a negative externality



A shows the equilibrium position with a negative externality. Price is  $P$  and quantity supplied is  $Q$ .

B shows the socially optimal outcome, where price is  $P^*$  and quantity supplied is  $Q^*$ .

Hence, with a negative externality, too much of the externality-producing good is supplied at too low a price (relative to the optimum).

This is an example of market failure. It results from the absence of property rights and a market for the marginal damages produced by this activity.

Source: unit author

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### Government failure

Having taken note of the possibility that markets might fail, what can governments do to improve the situation? Do you think that government intervention is always successful, or can you think of examples where the government intervention has actually made the position worse?

There are plenty of reasons why government failure can occur. For example, the government may come under pressure from certain groups in society and act in the interests of these groups rather than in the interests of society as a whole; there may be a lack of information resulting in the best policy decisions not being taken; and politicians and bureaucrats may not have the goal of maximising society's welfare.

A classic example of government failure that has resulted in environmental harm

is the Common Agricultural Policy (CAP) of the European Union. Historically, the CAP has supported farmers' incomes through the use of high product prices. This has led to overproduction and intensive farming. Some of the results of this have been a reduction in hedgerows, leading to a loss of habitat; surface and ground water pollution; overgrazing and pollution from ammonia emissions from livestock farming. More recently, in an effort to correct these government failures, policy has been introduced that offers farmers financial incentives to provide the level of environmental quality desired by society.

There are plenty of other examples of how government policy has resulted in environmental degradation. For example, energy policies have often increased environmental problems. This is because energy use has frequently been subsidised, leading to a wasteful use of energy. This has increased air pollution and problems of waste disposal.

## Section 5 Self Assessment Questions

### *Question 11*

*Q*

What is meant by 'market failure'?

### *Question 12*

*Q*

What happens to the level of output produced when there is a discrepancy between private and social costs?

## UNIT SUMMARY

In this unit, we looked at the linkages between the environment and the economy.

We defined the environment as including the atmosphere, all flora and fauna, and energy and material resources, and stated its main uses for the economy as

- a supplier of resource inputs
- a supplier of public consumption environmental or amenity goods
- a waste sink

We looked at the difference between degradable and cumulative pollution and noted that, in mathematical terms, stock of degradable pollutant at time  $t$  is given by

$$S_t^a = F_t - A_t$$

Stock of cumulative pollutant at time  $t^*$  is given by

$$S_{t^*}^c = \sum_{t_i} F_t$$

where

$F_t$  is the positive flow in a year

$A_t$  is the amount assimilated in a year

$t_i$  is the starting date for emissions

The natural laws (that is, the first two laws of thermodynamics) which the environment obeys, mean that increased extraction of minerals leads to an increase in wastes; there is a limit on the substitutability of inputs; and, since production and consumption lead to the dissipation of matter, scarce energy is needed for recycling.

Recycling was examined in more depth, leading to the following conclusions

- not everything can be recycled
- recycling uses scarce resources, so may not be either economically or environmentally desirable

The unit then considered the scope of environmental economics.

Many of the key economics concepts and principles that will be encountered in this module were then introduced. In particular, the basic economic model and key concepts were introduced. Specifically, we explained both supply and demand and

how their interaction leads to a market equilibrium. We then introduced various types of elasticity which can be used to examine how changes to market prices/quantities will be reflected in changes in behaviour.

Finally, the ideas of market failure and government failure were introduced. The importance of market failure is at the heart of many of the reasons why we need to have environmental policy. The impact of market failure on the efficient allocation of resources was introduced, as was the impact of government failure on resource allocation.

## UNIT SELF ASSESSMENT QUESTIONS

*Question 1*

*Q*

Using the Key Readings, draw a diagram that captures the three functions that the environment provides when interacting with the economy.

*Question 2*

*Q*

Write a short paragraph giving examples of the ways in which a production activity such as agriculture might impact upon the environment.

*Question 3*

*Q*

Write a short paragraph about the relationship between neo-classical environmental economics and ecological economics.

*Question 4*

*Q*

Draw a diagram to show the effect on prices and quantities, relative to the socially optimal outcome, of a positive externality.

*Question 5*

*Q*

Give an example of the way in which the three main uses of the environment overlap and can conflict.

Question 6

Q

<b>Demand for carrots (kg per week)</b>	<b>Price of carrots (£ per kg)</b>
110	1.10
120	0.80
130	0.60
140	0.50
150	0.40
160	0.35
170	0.30
180	0.27

Using the table above calculate the price elasticity of demand for carrots for a price change from 0.60 to 0.80

- (a) with reference to the initial price and quantity
- (b) with reference to the final price and quantity
- (c) using an average of the initial and final prices and

quantities Explain the usefulness of the third answer you calculated.

## KEY TERMS AND CONCEPTS

**ecological economics** a branch of economics that places significant emphasis on the physical linkages between the economy and the environment

**entropy** a measure of disorderness of energy

**environmental economics** the branch of economics dealing with the environment

**externality** an unintended consequence, good or bad, of the actions of another economic agent

**government failure** when government policy brings about undesirable outcomes

**market failure** when a market does not functioning properly or does not exist

**neo-classical economics** an economic paradigm that places markets at the heart of efficient resource allocation

**political economy** the study of the interaction between the economy and politics

**precautionary principle** actions to prevent/stop environmental loss should not be delayed because of scientific uncertainty

**public goods** a good which is non-rival and non-excludable

## **Environmental Laws, Assessment and Management**

**(4**

### **Lectures)**

- EIA, EIS, EMP, Environmental Audit, ISO 14000 series, Eco-labeling schemes.
- Risk Assessment
- Environmental Laws and Protocols
- IPCC, Rain water harvesting and ground water recharge, Conservation of wetlands, Ramsar sites, Soil erosion, reclamation of degraded land, desertification and its control.
- Chipko movement, Appiko movement, Silent Valley movement and Gandhamardan movement. People Biodiversity register, Project tiger, Project Elephant, Crocodile Conservation, GOI-UNDP Sea Turtle project, Indo-Rhino vision.
- Carbon sequestration and carbon credits, Swachh Bharat Abhiyan. Sustainable Habitat: Green Building, GRIHA Rating Norms

## **Contemporary Environmental Issues**

**(4**

### **Lectures)**

- Biodiversity loss, Climate change, Ozone layer depletion, Sea level rise
- Plastic pollution, Drinking water scarcity, Forest Fire (Amazon, Kongo)
- Water resource projects – Narmada dam, Tehri dam, Almatti dam
- Environmental Disasters: Minamata Disaster, Love Canal Disaster, Bhopal Gas Disaster, 1984, Chernobyl Disaster, 1986, Fukushima Daiichi nuclear disaster, 2011.

## ENVIRONMENTAL LAWS, ASSESSMENT AND MANAGEMENT

### *Definition:*

**EIA:** Environmental Impact Assessment (EIA) is an assessment process Environmental Impact Assessment is defined as an activity designed to identify the impact on the biogeophysical environment, on man and well-being of legislative proposals, projects, policies, operational procedures and to interpret and communicate information.

The **objective of EIA** is (i) to identify, predict and evaluate the economic, environmental and social impact of development activities (ii) to provide information on the environmental consequences for decision making and (iii) to promote environmentally sound and sustainable development through the identification of appropriate alternatives and mitigation measures.

The first comprehensive environmental legislation (Section 102) in United States came into force on 1st January 1970 in the form of National Environmental Policy Act (NEPA). In India, the Central Ministry of Environment and Forests issued a Notification on 27th January, 1994 making EIA statutory for 29 specified activities falling under sectors such as industries, mining, irrigation, power and transport etc.

The entire process of EIA is governed by eight **guiding principles** viz. *Participation; Transparency; Certainty; Accountability; Credibility; Cost effectiveness; Flexibility; Practicality*

**Participants in EIA Process:** *Proponent; Decision maker; Assessor; Reviewer; Expert advisers, Media and Public, Environmental organisations etc.* EIA Process in Sequence of Application:

1. Involvement of Stakeholders

2. Project Screening and Scoping which involves-

- (i) Determine necessity for EIA requirement.
- (ii) Describe various screening criteria.
- (iii) Scoping determines coverage or scope of EIA.

3. Project Design and Construction involving-

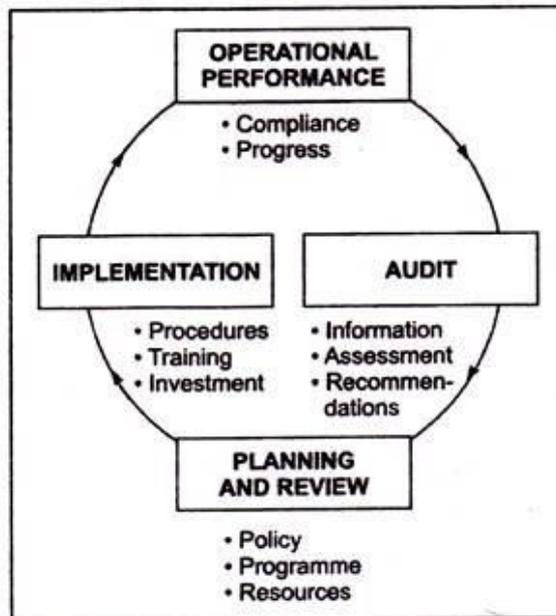
- (i) Type of project under consideration.
- (ii) Physical dimensions of the area being considered.
- (iii) Whether the resources will be used optimally?
- (iv) Whether there is an irretrievable commitment of land?
- (v) Whether the project is a critical phase of a larger development?
- (vi) Whether there will be serious environmental disruptions during construction?
- (vii) What are the long-term plans of the proponent?

4. Project Operation:

- (i) What provisions have been made to check the safety equipment regularly?
  - (ii) How will the hazardous waste products be handled?
  - (iii) What are the contingency plans developed to cope up with the possible accidents?
  - (iv) What provisions have been made for training the employees for environmental protection?
  - (v) What plans have been made for environmental monitoring?
- **EIS:** Environmental Impact Statement is a full-disclosure document which details the developmental or building project creation process; includes the range of alternatives to the development plan; analyzes the potential impacts on the environment resulting from the project and its alternatives; and shows how the project will be compliant with all other applicable environmental laws.

There are several sections of an EIS; each serves a unique purpose. The sections include: Purpose and Need, Alternatives, Affected Environment, Environmental Consequences, Comments and Coordination and List of Preparers.

- **EMP:** An Environmental Management Plan (EMP) can be defined as “an environmental management tool used to ensure that undue or reasonably avoidable adverse impacts of the construction, operation and decommissioning of a project are prevented; and that the positive benefits of the projects are enhanced.” The objectives of an EMP should include (Hill, 2000):
  - ✓ Ensuring compliance with regulatory authority stipulations and guidelines which may be local, provincial, national and/or international;
  - ✓ Ensuring that there is sufficient allocation of resources on the project budget so that the scale of EMP-related activities is consistent with the significance of project impacts;
  - ✓ Verifying environmental performance through information on impacts as they occur;
  - ✓ Responding to changes in project implementation not considered in the EIA;
  - ✓ Responding to unforeseen events; and
  - ✓ Providing feedback for continual improvement in environmental performance.
  
- **Environmental Audit:** Environmental auditing is a management tool designed to provide information on environmental performance to the right people at the right time. This audit encompasses all kinds of activities related to environmental measures of an organisation.



**Fig. 38.1: Environmental management cycle**

An environmental audit is a systematic means of providing environmental management information:

- (a) To all levels of management;
- (b) For a variety of purposes.

A full environmental audit will cover:

- (i) Compliance with environmental regulations,
  - (ii) Implementation of company's environmental policies and procedures,
  - (iii) Good environmental management practice, and
  - (iv) Past activities.
- **ISO 14000 Series:** ISO technical committee ISO/TC 207, Environmental management, is responsible for developing and maintaining the ISO 14000 family of standards. ISO/TC 207 was established in 1993, as a result of ISO's commitment to respond to the complex challenge of "sustainable development" articulated at the 1992 United Nations Conference on Environment and Development in Rio de Janeiro. ISO has a multi-faceted approach to meeting the needs of all stakeholders from business, industry, governmental authorities and nongovernmental organizations, as well as consumers, in the field of the environment.

- ISO has developed standards that help organizations to take a proactive approach to managing environmental issues: the ISO 14000 family of environmental management standards which can be implemented in any type of organization in either public or private sectors – from companies to administrations to public utilities.
- ISO is helping to meet the challenge of climate change with standards for greenhouse gas accounting, verification and emissions trading, and for measuring the carbon footprint of products.
- ISO develops normative documents to facilitate the fusion of business and environmental goals by encouraging the inclusion of environmental aspects in product design.
- ISO offers a wide-ranging portfolio of standards for sampling and test methods to deal with specific environmental challenges. It has developed some 570 International Standards for the monitoring of such aspects as the quality of air, water and the soil, as well as noise, radiation, and for controlling the transport of dangerous goods. They also serve in a number of countries as the technical basis for environmental regulations.

ISO International Standards and related normative documents provide consumers, regulators and organizations in both public and private sectors with environmental tools with the following characteristics:

- ✓ Technically credible as ISO standards represent the sum of knowledge of a broad pool of international expertise and stakeholders
- ✓ Fulfil stakeholder needs as the ISO standards development process is based on international input and consensus
- ✓ Facilitate the development of uniform requirements as the ISO standards development process is built on participation by its national member institutes from all regions of the world
- ✓ Promote efficiencies when the same standards are implemented across markets, sectors, and/or jurisdictions
- ✓ Support regulatory compliance when the standards are used to meet market and regulatory needs
- ✓ Enhance investor confidence because the standards can be used for conformity assessment such as by audit, inspection or certification. This enhances confidence

in products, services and systems that can be demonstrated to conform to ISO standards and provides practical support for regulation.

The ISO 14000 family is designed to be implemented according to the same Plan-Do-Check-Act (PDCA) cycle underlying all ISO management systems standards. The following table classifies the standards making up the ISO 14000 family according to their optimal place in the PDCA cycle. The whole ISO 14000 family of standards provides management tools for organizations to manage their environmental aspects and assess their environmental performance. Together, these tools can provide significant tangible economic benefits, including the following:

- ✓ Reduced raw material/resource use
- ✓ Reduced energy consumption
- ✓ Improved process efficiency
- ✓ Reduced waste generation and disposal costs
- ✓ Utilization of recoverable resources.

**Eco-label Schemes:** Eco-labels are voluntary certification practiced around the world. It is developed by governments, manufacturers, and third-party organisations independently. Producers and service providers demonstrate through eco-label that they comply with high standards of environmental protection during the life-cycle of the product and the provided services. Eco-labels are important for promotion of international sustainable consumption and production policy which aims at reducing the negative impact of consumption and production on the environment, health, climate and natural resources and encouraging corporate social responsibility and sustainable lifestyles.

Eco-label has gained significance in international trade because the General Agreement of Trade and Tariff (GATT), executed by 22 nations (including India) in 1948, has insisted upon transparency of the governments involved in the trade agreements and international trade facilitated by World Trade Organisation (WTO). Government of India in 1991 launched its first eco-label scheme, known as 'Eco-mark' through the Central Pollution Control Board (CPCB), GoI that follows a cradle-to-grave approach (from raw material extraction, to manufacturing, and to disposal). It advocates pro-active and promotional roles of the consumers, the industry, and the government at one platform to address environmental protection issues and to implement environmental protection strategy.

Ecolabel is awarded by most countries on the basis of environmental considerations, but in India it is also linked with the safety and quality of products. The products should meet both environmental and quality criteria set by the Bureau of Indian Standards (BIS). The BIS is responsible for setting quality and safety norms and closely involved with the implementation of the Ecomark scheme. The programme is run by the Ministry of Environment of Forests and Climate Change (MoEF&CC), with the technical advice of the Central Pollution Control Board (CPCB).

The Central Pollution Control Board has set up the guidelines for the environmentally friendly products. The products can obtain environmental labelling from the Government of India if they meet the criterion set by the acts in Indian laws- the Water (Prevention and Control of Pollution) Act, 1974, the Air (Prevention and Control of Pollution) Act, 1981, the Water (Prevention & Control of Pollution) Cess Act, 1977 and the Environment (Protection) Act, 1986.

Product Categories identified in the Ecomark Scheme: The CPCB has identified following product categories:

1. *Aerosol Propellants*, 2. *Batteries*; 3. *Dry Batteries*; 4. *Cosmetics*; 5. *Electrical/Electronic Goods*; 6. *Fire-extinguisher*; 7. *Food Additives*; 8. *Food Items: Edible Oils, Tea and Coffee*; 9. *Leather*; 10. *Lubricating Oils*, 11. *Packaging Materials*, 12. *Paints and Powder Coatings*, 13. *Paper*, 14. *Plastic Products*, 15. *Soaps & Detergents*, 16. *Textiles*, 17. *Wood Substitutes*

Out of 16 categories following 13 categories incorporated Ecomark requirements in their BIS standards. It is under process for rest three categories.

1. *Batteries*; 2. *Cosmetics*; 3. *Electrical/Electronic Goods*, 4. *Fire-extinguisher*, 5. *Food Additives*, 6. *Food Items: Edible Oils, Tea and Coffee*, 7. *Leather*, 8. *Packaging Materials*, 9. *Paints and Powder Coatings*, 10. *Paper*, 11. *Soaps & Detergents*, 12. *Textiles*, 13. *Wood Substitutes*

#### **List of Eco Labeling Schemes of Different Countries:**

<i>Sl. No.</i>	<i>Country</i>	<i>Year of Starting</i>	<i>Name of the Program</i>
<b>1.</b>	Germany	1977	Blue Angel
<b>2.</b>	Canada	1988	Environmental Choice Programme
<b>3.</b>	Japan	1989	EcoMark

4.	United States	1989	Green Seal
5.	India	1991	Ecomark
6.	European Union	1992	European Union Ecolabel Award Scheme
7.	France	1992	NF-Environment
8.	China	1993	China Environmental Labeling Scheme

**RISK ASSESSMENT:** Risk is broadly defined as the likelihood that a harmful consequence will occur as the result of an action or condition. It involves the combined evaluation of hazards and exposure. Environmental risk assessment (ERA) deals with the interactions of agents or hazards, humans, and ecological resources. It describes human populations, ecological resources, and agents; analyzes agents and exposure potential; characterizes the potential for adverse effects; defines uncertainties; generates options to deal with the risks; and communicates information about the risks to humans and ecosystems. ERA has two components; human health risk assessment and ecological risk assessment. The stages of doing an ERA include: hazard identification and problem formulation, analysis, and risk characterization. The main outputs are the risk management and communication plans. Risk-management legislation has become both more specific with clearly defined codes of practice and regulations about operation, monitoring and enforcement, and more comprehensive in the sense that it now covers:

- ✓ occupational risk environments both inside and outside the work place;
- ✓ national and international rules and regulations regarding the discharge and distribution of toxic substances;
- ✓ the acceptance of planning and other behavioural controls to reduce the impact of environmental damage and natural hazard; and
- ✓ the formation of extensive scrutinizing devices to appraise, review and quantify risks in relation to associated benefits both to existing, and to future generations.

Ecotoxicological models are widely applied first of all for Environmental Risk Assessment (ERA). It has given occasion to development of different types of toxic substance models. We distinguish between fate models and effect models and FTE models that are a combination of fate and effect models. The fate models may be divided into three classes focusing on a region or country, focusing on a specific case and models that are a hybrid of the two classes. The effect models are classified according to the hierarchical level of concern: an organism, a population, an ecosystem, a landscape (region), or the entire ecosphere. Most ecotoxicological

models are biogeochemical models because they are based on mass conservation principles, but ecotoxicological models concerned with populations are of course population dynamic models.

## ENVIRONMENTAL LAWS AND PROTOCOLS:

### International<sup>1</sup>:

Sl. No.	Sub- Topics for International Environmental Law	Instruments
1.	Hazardous Waste	Basel Convention (1989) Basel Convention Amendment (1995) Protocol on Liability and Compensation for Damage Resulting from Transboundary Movements of Hazardous Wastes, (1999)
2.	Nuclear Waste	Convention on Nuclear Safety (1994) Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (2001) Convention on Third Party Liability in the Field of Nuclear Energy [“Paris Convention”] (1960) Protocol to Amend the Paris Convention (2004)
3.	Ocean and Marine Sources	Agreement for the Establishment of the Indo-Pacific Fisheries Council (1948) and Amendments (1961) Agreement Instituting the Latin American Organization for Fisheries Development (OLDEPESCA) (1982) Convention for the Conservation of Salmon in the North Atlantic (1982) Convention for the Conservation of Southern Bluefin Tuna (1993) Convention for the Prevention of Marine Pollution from Land-Based Sources (1974) & “OSPAR” Convention (1992) UNECE Water Convention (1992) and Amendment (2003) UN Convention on the Law of the Non-navigational Uses of International Watercourses (1997)

<sup>1</sup> Available at [https://www.nyulawglobal.org/globalex/International\\_Environmental\\_Legal\\_Research1.html](https://www.nyulawglobal.org/globalex/International_Environmental_Legal_Research1.html), accessed on 7<sup>th</sup> February, 2020 at 2 PM.

4.	Ozone and Protection of the Atmosphere	<p>Convention for the Protection of the Ozone Layer [“Vienna Convention”] (1985)</p> <p>Geneva Convention on Long-Range Transboundary Air Pollution (1979)</p> <p>Kyoto Protocol to the United Nations Framework Convention (1997)</p> <p>Montreal Protocol (1987), *London Amendment (1990), Copenhagen Amendment (1992), *Montreal Amendment (1997), and *Beijing Amendment (1999)</p> <p>United Nations Framework Convention on Climate Change (1992)</p>
5.	Pollution	<p>Stockholm Convention on Persistent Organic Pollutants (2001)</p> <p>International Convention for the Prevention of Pollution from Ships (1973) &amp; 1978 Protocol (“MARPOL”)</p> <p>International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (1969) and Protocol (1973)</p> <p>International Convention on Civil Liability for Bunker Oil Pollution Damage (2001)</p> <p>International Convention on Civil Liability for Oil Pollution Damage (1969) &amp; Protocols of 1976, 1984, 1992, and 2000 Amendments</p> <p>Minamata Convention on Mercury (2013)</p>
6.	Protection of Species and Wildlife	<p>Agenda 21: Programme of Action for Sustainable Development (1992), Rio Declaration on Environment and Development (1992), and the Statement of Principles for the Sustainable Management of Forests (1992)</p> <p>Cartagena Protocol on Biosafety (2000)</p> <p>Convention on Biological Diversity (1992)</p> <p>North American Agreement on Environmental Cooperation (1993)</p> <p>United Nations Convention to Combat Desertification in Countries Experiencing Serious Drought (1994)</p>
7.	Sustainable Development	<p>Agenda 21: Programme of Action for Sustainable Development (1992), Rio Declaration on Environment and Development (1992), and the Statement of Principles for the Sustainable Management of Forests (1992)</p>

		<p>Convention on the Conservation of Antarctic Marine Living Resources (1980)</p> <p>Convention on Wetlands of International Importance especially as Waterfowl Habitat (“Ramsar”) (1971), Paris Protocol (1982), and Regina Amendments (1987)</p> <p>Rio Declaration on Environment and Development (1992)</p> <p>Antarctic Treaty (1959) &amp; Protocol on Environmental Protection (1991)</p>
8.	Trade & The Environment	<p>Convention on Int’l Trade in Endangered Species of Wild Fauna and Flora [“CITES”] (1973)</p> <p>North American Agreement on Environmental Cooperation [“NAAEC”] (1993)</p> <p>Aarhus Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters (1998)</p>

**INDIA:** The Constitution of India imposes a duty on every citizen ‘to protect and improve the natural environment including forests, lakes, rivers, and wildlife’. Reference to the environment has also been made in the Directive Principles of State Policy as well as the Fundamental Rights. The Department of Environment was established in India in 1980 to ensure a healthy environment for the country. This later became the Ministry of Environment and Forests in 1985. The constitutional provisions are backed by a number of laws – acts, rules, and notifications. Following is a list of the environmental legislations that have come into effect<sup>2</sup>—

#### GENERAL

- 1986 - The Environment (Protection) Act authorizes the central government to protect and improve environmental quality, control and reduce pollution from all sources, and prohibit or restrict the setting and /or operation of any industrial facility on environmental grounds.
- 1986 - The Environment (Protection) Rules lay down procedures for setting standards of emission or discharge of environmental pollutants.

<sup>2</sup> Available at <http://edugreen.teri.res.in/explore/laws.htm>, accessed on 7<sup>th</sup> February, 2020 at 2.13 PM.

- 1989 - The objective of Hazardous Waste (Management and Handling) Rules is to control the generation, collection, treatment, import, storage, and handling of hazardous waste.
- 1989 - The Manufacture, Storage, and Import of Hazardous Rules define the terms used in this context, and sets up an authority to inspect, once a year, the industrial activity connected with hazardous chemicals and isolated storage facilities.
- 1989 - The Manufacture, Use, Import, Export, and Storage of hazardous Micro-organisms/ Genetically Engineered Organisms or Cells Rules were introduced with a view to protect the environment, nature, and health, in connection with the application of gene technology and microorganisms.
- 1991 - The Public Liability Insurance Act and Rules and Amendment, 1992 was drawn up to provide for public liability insurance for the purpose of providing immediate relief to the persons affected by accident while handling any hazardous substance.
- 1995 - The National Environmental Tribunal Act has been created to award compensation for damages to persons, property, and the environment arising from any activity involving hazardous substances.
- 1997 - The National Environment Appellate Authority Act has been created to hear appeals with respect to restrictions of areas in which classes of industries etc. are carried out or prescribed subject to certain safeguards under the EPA.
- 1998 - The Biomedical waste (Management and Handling) Rules is a legal binding on the health care institutions to streamline the process of proper handling of hospital waste such as segregation, disposal, collection, and treatment.
- 1999 - The Environment (Siting for Industrial Projects) Rules, 1999 lay down detailed provisions relating to areas to be avoided for siting of industries, precautionary measures to be taken for site selecting as also the aspects of environmental protection which should have been incorporated during the implementation of the industrial development projects.
- 2000 - The Municipal Solid Wastes (Management and Handling) Rules, 2000 apply to every municipal authority responsible for the collection, segregation, storage, transportation, processing, and disposal of municipal solid wastes.
- 2000 - The Ozone Depleting Substances (Regulation and Control) Rules have been laid down for the regulation of production and consumption of ozone depleting substances.

- 2001 - The Batteries (Management and Handling) Rules, 2001 rules shall apply to every manufacturer, importer, re-conditioner, assembler, dealer, auctioneer, consumer, and bulk consumer involved in the manufacture, processing, sale, purchase, and use of batteries or components so as to regulate and ensure the environmentally safe disposal of used batteries.
- 2002 - The Noise Pollution (Regulation and Control) (Amendment) Rules lay down such terms and conditions as are necessary to reduce noise pollution, permit use of loud speakers or public address systems during night hours (between 10:00 p.m. to 12:00 midnight) on or during any cultural or religious festive occasion.
- 2002 - The Biological Diversity Act is an act to provide for the conservation of biological diversity, sustainable use of its components, and fair and equitable sharing of the benefits arising out of the use of biological resources and knowledge associated with it

#### FOREST AND WILDLIFE

- 1927 - The Indian Forest Act and Amendment, 1984, is one of the many surviving colonial statutes. It was enacted to ‘consolidate the law related to forest, the transit of forest produce, and the duty leviable on timber and other forest produce’.
- 1972 - The Wildlife Protection Act, Rules 1973 and Amendment 1991 provides for the protection of birds and animals and for all matters that are connected to it whether it be their habitat or the waterhole or the forests that sustain them.
- 1980 - The Forest (Conservation) Act and Rules, 1981, provides for the protection of and the conservation of the forests.

#### WATER

- 1882 - The Easement Act allows private rights to use a resource that is, groundwater, by viewing it as an attachment to the land. It also states that all surface water belongs to the state and is a state property.
- 1897 - The Indian Fisheries Act establishes two sets of penal offences whereby the government can sue any person who uses dynamite or other explosive substance in any way (whether coastal or inland) with intent to catch or destroy any fish or poisonous fish in order to kill.
- 1956 - The River Boards Act enables the states to enroll the central government in setting up an Advisory River Board to resolve issues in inter-state cooperation.

- 1970 - The Merchant Shipping Act aims to deal with waste arising from ships along the coastal areas within a specified radius.
- 1974 - The Water (Prevention and Control of Pollution) Act establishes an institutional structure for preventing and abating water pollution. It establishes standards for water quality and effluent. Polluting industries must seek permission to discharge waste into effluent bodies. The CPCB (Central Pollution Control Board) was constituted under this act.
- 1977 - The Water (Prevention and Control of Pollution) Cess Act provides for the levy and collection of cess or fees on water consuming industries and local authorities.
- 1978 - The Water (Prevention and Control of Pollution) Cess Rules contains the standard definitions and indicate the kind of and location of meters that every consumer of water is required to affix.
- 1991 - The Coastal Regulation Zone Notification puts regulations on various activities, including construction, are regulated. It gives some protection to the backwaters and estuaries.

## AIR

- 1948 – The Factories Act and Amendment in 1987 was the first to express concern for the working environment of the workers. The amendment of 1987 has sharpened its environmental focus and expanded its application to hazardous processes.
- 1981 - The Air (Prevention and Control of Pollution) Act provides for the control and abatement of air pollution. It entrusts the power of enforcing this act to the CPCB .
- 1982 - The Air (Prevention and Control of Pollution) Rules defines the procedures of the meetings of the Boards and the powers entrusted to them.
- 1982 - The Atomic Energy Act deals with the radioactive waste.
- 1987 - The Air (Prevention and Control of Pollution) Amendment Act empowers the central and state pollution control boards to meet with grave emergencies of air pollution.
- 1988 - The Motor Vehicles Act states that all hazardous waste is to be properly packaged, labelled, and transported.

**INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC):** The Intergovernmental Panel on Climate Change (IPCC) is a United Nations body, founded in 1988, which evaluates climate change science.

The IPCC assesses research on climate change and synthesises it into major 'assessment' reports every 5–7 years. The most fourth assessment report – often referred to as AR4 – was published in 2007 and totals more than 2,800 pages. The fifth (AR5) is scheduled to be published during 2013 and 2014.

IPCC assessments are produced in three volumes, each of which is prepared by a working group. Working Group One (WG1) examines scientific evidence for climate change and the extent to which human activity is the cause. Working Group Two (WG2) focuses on the impacts of climate change, and how plants, animals and humans can adapt. Working Group Three (WG3) focuses on climate mitigation. The research, writing and reviewing involved in each IPCC assessment report takes several years.

The IPCC process involves hundreds of scientists and draws on the work of thousands more. Most contribute as volunteers. The IPCC secretariat employs ten staff and each working group has a small administrative staff. These are based at the University of Bern (WG1), Stanford's Carnegie Institute for Science (WG2) and the Potsdam Institute for Climate Impact Research (WG3).

The IPCC itself is comprised of representatives from 194 governments who review the contents of reports before publication and have to agree the final text. Professor Paul Edwards, historian and professor of information at Michigan University, writes in his book *A Vast Machine* that "IPCC draft reports undergo more scrutiny than any other documents in the history of science". Governments and NGOs recommend academics to be considered for inclusion in the working groups which author the IPCC Reports, and the IPCC Bureau, the organisation's coordinating body, selects the final list of experts. Details of the 831 AR5 authors and editors are available on the IPCC website. This article was written by Carbon Brief in conjunction with the Guardian and partners.<sup>3</sup>

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<sup>3</sup> Available at <https://www.theguardian.com/environment/2011/dec/06/what-is-ipcc>, accessed on 7<sup>th</sup> February, 2020 at 2.10 PM.

**RAIN WATER HARVESTING AND GROUND WATER RECHARGE<sup>4</sup>:** Ground water, which is the source for more than 85 percent of India's rural domestic water requirements, 50 percent of its urban water requirements and more than 50 percent of its irrigation requirements is depleting fast in many areas due to its largescale withdrawal for various sectors.

### **Methods and techniques for ground water recharge<sup>5</sup>**

Urban Areas (Roof Top Rain Water / run off harvesting through)

- Recharge Pit
- Recharge Trench
- Tubewell
- Recharge Well

Rural Areas (Rain Water Harvesting through)

- Gully Plug
- Contour Bund
- Gabion Structure
- Percolation tank
- Check Dam/ Cement Plug/ Nala Bund
- Recharge shaft
- Dugwell Recharge
- Ground Water Dams/Subsurface Dyke

**Ground water recharge in Rural areas:** In rural areas, rain water harvesting is taken up considering watershed as a unit. Surface spreading techniques are common since space for such systems is available in plenty and quantity of recharged water is also large. Following techniques may be adopted to save water going waste through slopes, rivers, rivulets and nalas.

- ***Gully plug:*** Gully plugs are built using local stones, clay and bushes across small gullies and streams running down the hill slopes carrying drainage to tiny catchments during rainy season. Gully Plugs help in conservation of soil and moisture. The sites for gully

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<sup>4</sup> Available at <http://cgwb.gov.in/documents/Manual%20on%20Artificial%20Recharge%20of%20Ground%20Water.pdf>, accessed on 7<sup>th</sup> Feb, 2020 at 2.30 PM

<sup>5</sup> Available at <http://vikaspedia.in/energy/environment/rainwater-harvesting-1/rain-water-harvesting-techniques-to-augment-ground-water>, accessed on 7<sup>th</sup> Feb, 2020 at 2.45 PM.

plugs may be chosen whenever there is a local break in slope to permit accumulation of adequate water behind the bunds.

- **Contour bund:** Contour bunds are effective methods to conserve soil moisture in watershed for long duration. These are suitable in low rain fall areas where monsoon run off can be impounded by constructing bunds on the sloping ground all along the contour of equal elevation. Flowing water is intercepted before it attains the erosive velocity by keeping suitable spacing between bunds. Spacing between two contour bunds depends on the slope, the area and the permeability of the soil. Lesser the permeability of soil, the close should be spacing of bunds. Contour bunding is suitable on lands with moderate slopes without involving terracing.
- **Gabion structure:** This is a kind of check dam commonly constructed across small streams to conserve stream flows with practically no submergence beyond stream course. A small bund across the stream is made by putting locally available boulders in a mesh of steel wires and anchored to the stream banks. The height of such structures is around 0.5 m and is normally used in the streams with width of less than 10 m. The excess water over flows this structure storing some water to serve as source of recharge. The silt content of stream water in due course is deposited in the interstices of the boulders. With the growth of vegetation, the bund becomes quite impermeable and helps in retaining surface water run off for sufficient time after rains to recharge the ground water body.
- **Percolation tank:** Percolation tank is an artificially created surface water body, submerging in its reservoir a highly permeable land, so that surface runoff is made to percolate and recharge the ground water storage. Percolation tank should be constructed preferably on second to third order streams, located on highly fractured and weathered rocks, which have lateral continuity downstream. The recharge area downstream should have sufficient number of wells and cultivable land to benefit from the augmented ground water. The size of percolation tank should be governed by percolation capacity of strata in the tank bed. Normally percolation tanks are designed for storage capacity of 0.1 to 0.5 MCM. It is necessary to design the tank to provide a ponded water column generally between 3 & 4.5 m. The percolation tanks are mostly earthen dams with masonry structure only for spillway. The purpose of the percolation tanks is to recharge the ground water storage and hence seepage below the seat of the bed is permissible.

For dams upto 4.5 m height, cut off trenches are not necessary and keying and benching between the dam seat and the natural ground is sufficient.

- **Check dams / cement plugs / nala bunds:** Check dams are constructed across small streams having gentle slope. The site selected should have sufficient thickness of permeable bed or weathered formation to facilitate recharge of stored water within short span of time. The water stored in these structures is mostly confined to stream course and the height is normally less than 2 m and excess water is allowed to flow over the wall. In order to avoid scouring from excess run off, water cushions are provided at downstream side. To harness the maximum run off in the stream, series of such check dams can be constructed to have recharge on regional scale. Clay filled cement bags arranged as a wall are also being successfully used as a barrier across small nalas. At places, shallow trench is excavated across the nala and asbestos sheets are put on two sides. The space between the rows of asbestos sheets across the nala is backfilled with clay. Thus a low cost check dam is created. On the upstream side clay filled cement bags can be stacked in a slope to provide stability to the structure.
- **Recharge shaft:** This is the most efficient and cost-effective technique to recharge unconfined aquifer overlain by poorly permeable strata. Recharge shaft may be dug manually if the strata is of non-caving nature. The diameter of shaft is normally more than 2 m. The shaft should end in more permeable strata below the top impermeable strata. It may not touch water table. The unlined shaft should be backfilled, initially with boulders/ cobbles followed by gravel and coarse sand. In case of lined shaft the recharge water may be fed through a smaller conductor pipe reaching up to the filter pack. These recharge structures are very useful for village ponds where shallow clay layer impedes the infiltration of water to the aquifer. It is seen that in rainy season village tanks are fully filled up but water from these tanks does not percolate down due to siltation and tubewell and dugwells located nearby remains dried up. The water from village tanks get evaporated and is not available for the beneficial use. By constructing recharge shaft in tanks, surplus water can be recharged to ground water. Recharge shafts of 0.5 to 3 m. diameter and 10 to 15 m. deep are constructed depending upon availability of quantum of water. The top of shaft is kept above the tank bed level preferably at half of full supply level. These are back filled with boulders, gravels and coarse sand. In upper portion of 1 or 2 m depth, the brick masonry work is carried out for the stability of the structure. Through this technique all the accumulated water in village tank above

50% full supply level would be recharged to ground water. Sufficient water will continue to remain in tank for domestic use after recharge.

- **Dugwell recharge:** Existing and abandoned dug wells may be utilized as recharge structure after cleaning and desilting the same. The recharge water is guided through a pipe from desilting chamber to the bottom of well or below the water level to avoid scouring of bottom and entrapment of air bubbles in the aquifer. Recharge water should be silt free and for removing the silt contents, the runoff water should pass either through a desilting chamber or filter chamber. Periodic chlorination should be done for controlling the bacteriological contaminations.
- **Ground water dams or sub-surface dykes:** Sub surface dyke or under-ground dam is a subsurface barrier across stream which retards the base flow and stores water upstream below ground surface. By doing so, the water levels in upstream part of ground water dam rises saturating otherwise dry part of aquifer. The site where sub-surface dyke is proposed should have shallow impervious layer with wide valley and narrow out let. After selection of suitable site, a trench of 1-2 m wide is dug across the breadth of stream down to impermeable bed. The trench may be filled with clay or brick/ concrete wall upto 0.5m. below the ground level. For ensuring total imperviousness, PVC sheets of 3000 PSI tearing strength at 400 to 600 gauge or low-density polythene film of 200 gauges can also be used to cover the cut out dyke faces. Since the water is stored within the aquifer, submergence of land can be avoided and land above the reservoir can be utilized even after the construction of the dam. No evaporation loss from the reservoir and no siltation in the reservoir takes place. The potential disaster like collapse of the dams can also be avoided.
- **Ground water recharge in urban areas:** In rural areas, rain water harvesting is taken up considering watershed as a unit. Surface spreading techniques are common since space for such systems is available in plenty and quantity of recharged water is also large. Following techniques may be adopted to save water going waste through slopes, rivers, rivulets and nalas. In urban areas, rain water available from roof tops of buildings, paved and unpaved areas goes waste. This water can be recharged to aquifer and can be utilized gainfully at the time of need. The rain water harvesting system needs to be designed in a way that it does not occupy large space for collection and recharge system. A few techniques of roof top rain water harvesting in urban areas are described below.

- **Recharge pit:** In alluvial areas where permeable rocks are exposed on the land surface or are located at very shallow depth, rain water harvesting can be done through recharge pits. The technique is suitable for buildings having a roof area of 100 sq.m. These are constructed for recharging the shallow aquifers. Recharge Pits may be of any shape and size. They are generally constructed 1 to 2 m. wide and 2 to 3 m deep. The pits are filled with boulders (5-20 cm), gravels (5-10mm) and coarse sand (1.5- 2mm) in graded form. Boulders at the bottom, gravels in between and coarse sand at the top so that the silt content that will come with runoff water will be deposited on the top of the coarse sand layer and can easily be removed. For smaller roof area, pit may be filled with broken bricks/ cobbles. A mesh should be provided at the roof so that leaves or any other solid waste / debris is prevented from entering the pit. A desilting /collection chamber may also be provided at the ground to arrest the flow of finer particles to the recharge pit. The top layer of sand should be cleaned periodically to maintain the recharge rate. By-pass arrangement is to be provided before the collection chamber to reject the first showers.
- **Recharge trench:** Recharge trenches are suitable for buildings having roof area of 200-300 sq. m. and where permeable strata is available at shallow depths. Trench may be 0.5 to 1 m wide, 1 to 1.5m. deep and 10 to 20 m. long depending upon availability of water to be recharge. These are back filled with boulders (5-20cm), gravel (5-10 mm) and coarse sand (1.5-2 mm) in graded form – boulders at the bottom, gravel in between and coarse sand at the top so that the silt content that will come with runoff will be coarse sand at the top of the sand layer and can easily be removed. A mesh should be provided at the roof so that leaves or any other solid waste/debris is prevented from entering the trenches and a desilting/collection chamber may also be provided on ground to arrest the flow of finer particles to the trench. By-pass arrangement is to be provided before the collection chamber to reject the first showers. The top layer of sand should be cleaned periodically to maintain the recharge rate.
- **Tube wells:** In areas where the shallow aquifers have dried up and existing tubewells are tapping deeper aquifer, rain water harvesting through existing tubewell can be adopted to recharge the deeper aquifers. PVC pipes of 10 cm dia are connected to roof drains to collect rainwater. The first roof runoff is let off through the bottom of drainpipe. After closing the bottom pipe, the rainwater of subsequent rain showers is taken through a T to an online PVC filter. The filter may be provided before water

enters the tubewells. The filter is 1 –1.2 m. in length and is made up of PVC pipe. It's diameter should vary depending on the area of roof, 15 cm if roof area is less than 150 sq m and 20 cm if the roof area is more. The filter is provided with a reducer of 6.25 cm on both the sides. Filter is divided into three chambers by PVC screens so that filter material is not mixed up. The first chamber is filled up with gravel (6-10mm), middle chamber with pebbles (12-20 mm) and last chamber with bigger pebbles (20-40 mm). If the roof area is more, a filter pit may be provided. Rainwater from roofs is taken to collection/desilting chambers located on ground. These collection chambers are interconnected as well as connected to the filter pit through pipes having a slope of 1:15. The filter pit may vary in shape and size depending upon available runoff and are back-filled with graded material, boulder at the bottom, gravel in the middle and sand at the top with varying thickness (0.30-0.50m) and may be separated by screen. The pit is divided into two chambers, filter material in one chamber and other chamber is kept empty to accommodate excess filtered water and to monitor the quality of filtered water. A connecting pipe with recharge well is provided at the bottom of the pit for recharging of filtered water through well.

- **Trench with recharge well:** In areas where the surface soil is impervious and large quantities of roof water or surface runoff is available within a very short period of heavy rainfall, the use of trench/ pits is made to store the water in a filter media and subsequently recharge to ground water through specially constructed recharge wells. This technique is ideally suited for area where permeable horizon is within 3m below ground level. Recharge well of 100-300 diameter is constructed to a depth of at least 3 to 5 m below the water level. Based on the lithology of the area, well assembly is designed with slotted pipe against the shallow and deeper aquifer. A lateral trench of 1.5 to 3m width and 10 to 30 m length, depending upon the availability of water is constructed with the recharge well in the centre. The number of recharge wells in the trench can be decided on the basis of water availability and local vertical permeability of the rocks. The trench is backfilled with boulders, gravels and coarse sand to act as a filter media for the recharge wells. If the aquifer is available at greater depth say more than 20 m, a shallow shaft of 2 to 5 m diameter and 3-5 metres deep may be constructed depending upon availability of runoff. Inside the shaft a recharge well of 100-300 mm dia is constructed for recharging the available water to the deeper aquifers. At the bottom of the shaft a filter media is provided to avoid choking of recharge well.

**CONSERVATION OF WETLANDS:** Water is the most critical substance for the existence of life on the Earth. The highly uneven surface of the Earth has many areas where the land is saturated with or is submerged under the water that flows or remains standing for different duration - from days to centuries before it returns to the oceans and the atmosphere. These watery areas were inhabited by a large diversity of plants and animals. The foundations of human civilisation were laid on these lands.

### **Definitions of WETLAND: <sup>6</sup>**

**U.S. Fish and Wildlife Service** (Cowardin et al. 1979): Wetlands are “lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water” and “must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year”.

**Ramsar Convention, 1971** (Ramsar Convention Secretariat 2013): “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”. And “may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands”.

**Pittock et al. (2015):** “Places where water is the primary factor controlling plant and animal life and the wider environment, where the water table is at or near the land surface, or where water covers the land”.

### **Kinds of Wetlands<sup>7</sup>**

- **Glacial Lakes:** A lake formed at the base of a glacier

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<sup>6</sup> Available at <https://www.apn-gcr.org/resources/files/original/0ea8b42961e6a5efbede3b81e11793dd.pdf>, accessed on 7<sup>th</sup> February, 2020 at 301 PM.

<sup>7</sup> Available at <https://www.apn-gcr.org/resources/files/original/0ea8b42961e6a5efbede3b81e11793dd.pdf>, accessed on 7<sup>th</sup> February, 2020 at 301 PM.

- **Peat bogs:** a thick mass of partly decomposed or undecomposed remains of plants (mostly Sphagnum mosses in northern latitudes)
- **Shallow lakes:** Natural lakes with an average depth of about 3 meters which allows the abundant growth of macrophytes in its entire area
- **Deep Lakes:** Lakes with water depths that prevent the growth of submerged macrophytes; may have a narrow peripheral littoral zone with macrophytic vegetation
- **Flood-plains:** areas lying lateral to river channels and periodically flooded when the river flow exceeds the channels' carrying capacity
- **Marshes:** habitats with waterlogged or water saturated substrate with herbaceous vegetation; may also have areas with shallow water; natural or incidental to human activity that causes water logging
- **Swamps:** habitats with predominantly woody vegetation adapted to submerged or waterlogged substrates.
- **Ox-bows:** shallow water bodies created by the separation of meander loops of a river either by sediment deposition; may become periodically connected with the river at high flood time.
- **Lagoons:** a coastal water body that is connected to the sea by one or more small openings through which it exchanges water with the sea especially during the tide. The lagoons often receive freshwater runoff from their landward catchments.
- **Reservoirs:** Any large water body created by constructing a dam over a stream or river
- **Tanks:** Water bodies created generally by impounding the surface runoff from seasonal streams; Also, those created by dredging Temple Tanks: Natural or human made water bodies near the temples and used for cultural/ religious activities only
- **Fish ponds:** Natural or human made water bodies used mainly for fish culture (aquaculture)
- **Paddy fields:** Agricultural fields for growing paddy
- **Village ponds:** small shallow water bodies in the villages used for multiple purposes.

**Protection of wetlands:**<sup>8</sup> Wetlands are not delineated under any specific administrative jurisdiction. The primary responsibility for the management of these ecosystems is in the hands of the Ministry of Environment and Forests. Although some wetlands are protected after the formulation of the Wildlife Protection Act, the others are in grave danger of extinction.

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<sup>8</sup> Available at [https://www.researchgate.net/publication/238087971\\_Conservation\\_of\\_wetlands\\_of\\_India\\_-\\_A\\_review/link/00b7d522ef1ef644d8000000/download](https://www.researchgate.net/publication/238087971_Conservation_of_wetlands_of_India_-_A_review/link/00b7d522ef1ef644d8000000/download), accessed on 7<sup>th</sup> February, 2020 at 4 PM.

Effective coordination between the different ministries, energy, industry, fisheries revenue, agriculture, transport and water resources, is essential for the protection of these ecosystems. Protection laws and government initiatives Wetlands conservation in India is indirectly influenced by an array of policy and legislative measures (Parikh & Parikh 1999). Some of the key legislations are given below:

- The Indian Fisheries Act - 1857
- The Indian Forest Act – 1927
- Wildlife (Protection) Act – 1972
- Water (Prevention and Control of Pollution) Act – 1974
- Territorial Water, Continental Shelf, Exclusive Economic Zone and other Marine Zones Act – 1976
- Water (Prevention and Control of Pollution) Act – 1977
- Maritime Zone of India (Regulation and fishing by foreign vessels) Act – 1980
- Forest (Conservation act) – 1980
- Environmental (Protection) Act – 1986
- Coastal Zone Regulation Notification – 1991
- Wildlife (Protection) Amendment Act – 1991
- National Conservation Strategy and Policy
- Statement on Environment and Development – 1992
- National Policy and Macro level Action Strategy on Biodiversity-1999

India is an also signatory to the Ramsar Convention on Wetlands and the Convention of Biological Diversity. Apart from government regulation, development of better monitoring methods is needed to increase the knowledge of the physical and biological characteristics of each wetland resources, and to gain, from this knowledge, a better understanding of wetland dynamics and their controlling processes.

**SOIL EROSION, RECLAMATION OF DEGRADED LAND, DESERTIFICATION AND ITS CONTROL:**<sup>9</sup> Land is a vital resource for producing food, preserving forests and biodiversity, facilitating the natural management of water systems and acting as a carbon store.

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<sup>9</sup> Available at [https://www.teriin.org/sites/default/files/2018-04/Vol%20I%20-%20Macroeconomic%20assessment%20of%20the%20costs%20of%20land%20degradation%20in%20India\\_0.pdf](https://www.teriin.org/sites/default/files/2018-04/Vol%20I%20-%20Macroeconomic%20assessment%20of%20the%20costs%20of%20land%20degradation%20in%20India_0.pdf), accessed on 7<sup>th</sup> February, 2020 at 4.05 PM.

Appropriate land management can protect and maximize these services for society. Conversely, desertification, along with climate change and the loss of biodiversity were identified as the greatest challenges to sustainable development during the 1992 Rio Earth Summit. The United Nations Convention to Combat Desertification (UNCCD) is one of 3 Rio Conventions which focuses upon Desertification, Land Degradation and Drought (DLDD).

**Sustainable Land Management – Some success around the world:** In Zimbabwe, water harvesting combined with conservation agriculture increased farmers gross margins 4 to 7 fold and increased returns on labour 2-to-3 fold compared to standard practices. These practices have had the greatest success in zones with lower rainfall (Winterbottom, et.al, 2013).

From 1991 to 2004, Brazil's grain production more than doubled from 58 million tons to 125 million tons as a result of widespread adoption of conservation agriculture and introduction of improved crop varieties (Winterbottom, et.al, 2013)

In China, the adoption of no-till systems of wheat production and raised yields and reduced production costs, results in an average increase of 30% net economic returns over 4 years (Rosegrant, 2014).

In western Kenya, 60,000 smallholder farmers in western Kenya are benefiting from carbon credits generated by applying sustainable land management farming techniques. So far they have achieved a reduction of 24,788 mt CO<sub>2</sub>, which is equivalent to emissions from 5,164 vehicles in a year. By using SLM practices, yields of some crops increased by 15-20% (World Bank, 2014). Over 5 million hectares of degraded land in the Sahel have been restored through a practice known as 'farmer-managed natural regeneration.' This has resulted in an additional half a million tons of grain production each year and enough fodder to support more livestock. To date, it has improved food security of about 2.5 million people (CGIAR, 2013).

Research in Malawi indicates that agroforestry practices generally increase yields from 1 tonne/hectare to 2-3 tonnes/hectare even if farmers cannot afford inorganic fertilizers (Winterbottom, et.al, 2013).

An initiative by the International Fund for Agricultural Development (IFAD) that mobilized local community participation has helped restore around one-third of the Syrian steppe that had become badly degraded due to severe drought and intensive grazing (IFAD in UNCCD, 2011).

Sustainable land management, including closing yield-potential gaps and reaching 95% of potential maximum crop yields could result in an additional 2.3 billion tons of crop production per year, equivalent to a potential gain of US 1.4 trillion (Economics of Land Degradation Initiative, 2013)

Food and Agricultural Organization (FAO) implemented the “Acacia Operation Project-Support to food security, poverty alleviation and soil degradation control in the gums and resins producer countries” in 6 countries in sub-Saharan Africa (Burkina Faso, Chad, Niger, Kenya, Senegal and Sudan). The project resulted in the restoration of 13240 ha. (FAO in UNCCD, 2011).

A national afforestation program in which degraded and public lands are eligible for financing has been established in Romania. In 2005 and 2006 over 5000 ha of degraded lands were afforested at € 5000/ha.

According to UNCCD (1996), land is defined as, “The terrestrial bio-productive system that comprises soil, vegetation, other biota, and the ecological and hydrological processes that operate within the system (UNCCD, 1996, Part1, Article 1e).” Relating to this definition of land, land degradation has been defined by UNCCD as the, “Reduction or loss of biological or economic productivity and complexity of rain-fed cropland, irrigated cropland or range, pasture, forests, & woodlands resulting from land use or from a process or combination of processes arising from human activities & habitation patterns such as-

- Soil erosion caused by water and/or wind
- Deterioration of physical, chemical, biological or economic properties of soil
- Long-term loss of natural vegetation

Land degradation (LD) can be broadly divided into physical, chemical & biological degradation (Nkonya et al, 2013)

- ✓ Physical degradation is erosion, soil organic carbon loss, change in soil’s physical structure-e.g. compaction, waterlogging. Globally soil erosion is the most important LD process resulting in removal of topsoil. Soil productivity is depleted through reduced rooting depth, loss of plant nutrients and physical loss of topsoil

- ✓ Chemical degradation refers to leaching, salinisation, fertility depletion, acidification, nutrient imbalances
- ✓ Biological degradation implies the loss of vegetation, rangeland degradation and loss in biodiversity including soil organic matter

Thus, the definition of land and by its extension land degradation refers not only to soil but the negative impacts on the entire bio-productive system.

Causes of Land Degradation:<sup>10</sup>

- ✓ **Natural degradation:** The major natural hazards in the region, environmental conditions which act as predisposing factors for land degradation, are:
  - **For water erosion:** monsoonal rains of high intensity; steep slopes of the mountain and hill lands; soils with low resistance to water erosion (e.g. silty soils, vertisols).
  - **For wind erosion:** semi-arid to arid climates; high rainfall variability, with liability to drought spells; soils with low resistance to wind erosion (e.g. sandy soils). an open cover of natural vegetation.
  - **For soil fertility decline:** strong leaching in humid climates; soils which are strongly acid, and/or with low natural fertility.
  - **For waterlogging:** alluvial plains or interior basins which restrict outward drainage of groundwater.
  - **For salinization:** semi-arid to arid climates with low leaching intensity; plains and interior basins which restrict outward drainage of groundwater; soils which are naturally slightly saline.
  - **For lowering of the water table:** semi-arid to arid climates with low rates of groundwater recharge.

In some cases, these natural hazards are of sufficient intensity to give rise to unproductive land without human interference. Examples are the naturally saline soils which occur in some interior basins of dry regions, or areas of natural gullying ('badlands').

- ✓ **Direct causes of degradation:**
  - Deforestation of unsuitable land: Deforestation is both a type of degradation as such, and also a cause of other types, principally water erosion. Deforestation

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<sup>10</sup> Available at <http://www.fao.org/3/v4360e/V4360E08.htm>, accessed on 7<sup>th</sup> February, 2020 at 4.06 PM.

in itself is not necessarily degrading without it, most productive agricultural lands (in the temperate zone as well as the tropics) would not be available. Deforestation becomes a cause of degradation first, when the land that is cleared is steeply sloping, or has shallow or easily erodible soils; and secondly, where the clearance is not followed by good management. It is the leading cause of water erosion in steeply sloping humid environments. It is also a contributory cause of wind erosion, soil fertility decline and salinization.

- ***Overcutting of vegetation:*** Rural people cut natural forests, woodlands and shrublands to obtain timber, fuelwood and other forest products. Such cutting becomes unsustainable where it exceeds the rate of natural regrowth. This has happened widely in semi-arid environments, where fuelwood shortages are often severe. Impoverishment of the natural woody cover of trees and shrubs is a major factor in causing both water erosion and wind erosion. In the GLASOD assessment it is cited as a cause for 98% of the area affected by wind erosion. This assessment also cites it as a contributory cause to salinization.
- ***Shifting cultivation without adequate fallow periods:*** In the past, shifting cultivation was a sustainable form of land use, at a time when low population densities allowed forest fallow periods of sufficient length to restore soil properties. Population increase and enforced shortening of fallow periods has led to it becoming non-sustainable. Shifting cultivation is found in the hill areas of northeast India, where it is a cause of water erosion and soil fertility decline.
- ***Overgrazing:*** Overgrazing is the grazing of natural pastures at stocking intensifies above the livestock carrying capacity. It leads directly to decreases in the quantity and quality of the vegetation cover. This is a leading cause not only of wind erosion, but also of water erosion in dry lands. Both degradation of the vegetation cover and erosion lead to a decline in soil organic matter and physical properties, and hence in resistance to erosion.
- ***Intense grazing:*** Intense grazing at the end of the annual dry season, and during periods of drought, does not necessarily lead to degradation; the vegetation may recover during the succeeding rains. Degradation occurs when the recovery of vegetation and soil properties during periods of normal rainfall does not reach its previous status.
- ***Non-adoption of soil-conservation management practices:*** Under arable use, management practices are needed to check water erosion on all sloping lands.

In dry lands, measures to check wind erosion are necessary also on level land.

Soil conserving management practices may be grouped into:

- **Biological methods:** maintenance of a "round surface cover, of living plants or plant litter; vegetative barriers, including both contour hedgerows and grass strips; and windbreaks and shelterbelts.
  - **Earth structures:** terraces, and the various forms of bank-and ditch structures (bunds, storm drains, etc.).
  - **Maintaining soil resistance to erosion:** primarily, maintenance of soil organic matter and thereby aggregation and structure.
- ***Extension of cultivation onto lands of longer potential and/or high natural hazards:*** These are also called 'fragile' or marginal lands. Historically the more fertile, or high-potential, agricultural lands were the first to be occupied. Population increase has led to the widespread use of lands of longer potential, those which are less fertile or have greater degradation hazards. Such marginal lands include:
    - steeply sloping land;
    - areas of shallow or sandy soils, or with laterite crusts;
    - cultivation of semi-arid lands, and grazing of the drier semi-arid areas, marginal to deserts.
  - ***Improper crop rotations:*** As a result of population growth, land shortage and economic pressures, farmers in some areas have adopted cereal-based, intensive crop rotations, based particularly on rice and wheat, in place of the more balanced cereal-legume rotations that were formerly found. This is a contributory cause of soil fertility decline.
  - ***Unbalanced fertilizer use:*** Where soil fertility has declined, as a result of prolonged cultivation or erosion, farmers attempt to maintain crop yields. The primary method available for doing so is application of fertilizer. In the short term, a yield response is most readily and cheaply obtained from nitrogenous fertilizer. There has been a steady increase in the ratios of nitrogen to phosphorus, and nitrogen to all other nutrients, in the region. Where phosphate deficiencies have been recognized and counteracted by phosphatic fertilizer, deficiencies of other nutrients, including sulphur and zinc, have been reported. The short-term measure of combatting fertility decline by application only of

macronutrients, and particularly nitrogenous fertilizer, is leading to a greater problem of nutrient imbalance in the medium term. Among the consequences is likely to be longer yield responses to fertilizers.

- ***Problems arising from planning and management of canal irrigation:*** The development of salinization and waterlogging on the large-scale canal irrigation schemes of the Indo-Gangetic plains has been frequently described. Application of water in excess of natural rainfall led to a progressive rise in the water table from the 1930s onward. Where the water table has reached close to the surface, waterlogging occurs leading, through evaporation of water containing salts, to salinization. Sodification follows where sodium replaces other bases in the soil exchange complex. The problem could have been avoided, or reduced, if deep drains had been included in the initial implementation of irrigation schemes. More detailed accounts of the complex processes involved will be found in development planning studies of Pakistan and Indian irrigated areas.
- ***Overpumping of groundwater:*** In areas of non-saline ('sweet') groundwater, the technology of tubewells has led to abstraction of water in excess of natural recharge by rainfall and river seepage. This has progressively lowered the water table, as in Iran, India and Pakistan.
- ✓ ***Underlying causes of degradation:*** There are more basic reasons underlying the reasons for land degradation outlined above.
  - ***Land shortage:*** It has always been recognized that land is a finite resource, but only recently has the full impact of this fact occurred. In earlier times, food shortage or poverty could be combatted by taking new, unused, land into cultivation. Over most of South Asia, this solution is no longer available. The percentage change in agricultural land over the ten years 1980-1990 is under 2.5% for India, Pakistan, Sri Lanka and Afghanistan, whilst for Bangladesh there has been a small absolute decrease. When combined with increases in rural population, land shortage has led to decreases in the already small areas of agricultural land per person in six of the eight countries, including all in the humid zone. The relative decrease in land per person over 1980-90 was 14% for India and 22% for Pakistan. In Iran, with a smaller rural population increase, the land/people ratio has remained virtually constant.
  - ***Land tenure:*** tenancy and open access resources Farmers will be reluctant to invest in measures to conserve land resources if their future rights to use these

resources are not secure. Two kinds of property rights lead to this situation, tenancy and open access resources.

Despite efforts by legislation and land reform programmes over many years, tenant occupation of farmland is still very widespread. The landowner is now frequently from the cities, and the land is farmed by tenants paying some form of rental. Relations between landlord and tenant are often good, and the tenant in fact remains on the same farm for many years. However, such tenants lack the incentive to maintain the land in good condition, being interested mainly in the immediate harvest.

There is a distinction between common property and open access resources. In common property resources, use is restricted to members of a community, village or clan, and is subject to constraints, socially applied. For example, pastoralists often have customs for when certain areas must be rested from grazing, villages restrict the cutting of communal woodland. On open access land there are no such constraints. With no legal basis to their use, incentive to farm the land other than for immediate needs is completely lacking. This is a serious cause of deforestation followed by water erosion.

- ***Economic pressures and attitudes:*** Small land holdings lead to severe economic pressures on farmers, to obtain sufficient food and income to meet immediate needs. Because of such pressure in the short term, labour, land and capital resources cannot be spared to care for the land, for example green manuring or soil conservation structures. This is also the underlying reason for two other direct causes noted above, improper crop rotations and unbalanced fertilizer use. Poverty leads to land degradation. It could almost certainly be shown that richer farmers maintain their soils in better state than poorer. Research based on sample studies to confirm this is desirable.
- ***Population increase:*** Together with land shortage, the second basic cause of degradation is the continuing increase in rural, agricultural, population. Growth rates for total population 1980-1990 for six countries range from 2.1-3.6% per year (for Afghanistan the figure is affected by migration and war). Only in Sri Lanka have attempts to reduce the rate of population increase made substantial progress, with a growth rate of 1.4%. Urban populations are increasing faster than rural. The trend towards urbanization, however, is not sufficient to reverse the key that absolute levels of rural population have increased and are

increasing. In Bangladesh, Bhutan, India, Nepal and Pakistan, rural populations were 17-32% higher in 1990 than in 1980. In absolute terms, the scale is greatest in India, where already densely populated rural areas contained 79 million more people in 1990 than 10 years earlier.

#### SOLUTIONS AND REMEDIES:<sup>11</sup> Management of deforestation

- **Afforestation:** Planting of tree is the best options to make forest in a non-forest land are the one of the best options to reduce the consequences of deforestation. It can reduce the soil erosion. Use of timber alternate: Use of mud brick for the construction instead of timbers for land reclamation.
- **Eco- forest:** System which cut only the specific tree required, create minimal damage to that particular forest area.
- **Green business:** This includes paper recycling and using wood alternatives.
- **Management on overgrazing:** Management practices like water development, placement of salt and supplements, fertilizer application, fencing, burning can control the overgrazing. By control the gap between the grazing and giving time to for re-vegetation also helps to reduce overgrazing. Keeping the livestock not more than 4 days in pad-dock, can reduce over grazing. The density of the livestock in a particular grazing area also needs to be controlled (25).
- **Managing irrigation:** Irrigation system can be controlled like drip irrigation to reduce soil erosion. Using high and low salt water was most effective in maintaining the productive capacity of the clay soil. Often high irrigation leads to leach of nutrient and top fertile soil along with that water. Management of irrigation is an essential fact or to keep the quality of soil (40).
- **Managing urban sprawl:** The urban planning is the most important factor, to control the urban sprawl. Appropriate government policies can also control the urban sprawling. Policies appropriate to control the urban sprawling are necessary. Fertile field near by the urbane area need to be protected by the local government rules, because of the tendency of converting such land for commercial purpose will bring more income than agriculture (41). So, effective policy is required to control such usage of fertile land. There should be a proper waste management system dumping of these

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<sup>11</sup> Available at [https://www.researchgate.net/publication/236892461\\_Land\\_Degradation\\_Its\\_Control\\_Management\\_and\\_Environmental\\_Benefits\\_of\\_Management\\_in\\_Reference\\_to\\_Agriculture\\_and\\_Aquaculture](https://www.researchgate.net/publication/236892461_Land_Degradation_Its_Control_Management_and_Environmental_Benefits_of_Management_in_Reference_to_Agriculture_and_Aquaculture), accessed on 7<sup>th</sup> Feb, 2020 at 5.18 PM.

waste generated as part of urban sprawling will degrade the land, can cause soil salinity, acidity and loss of its vegetative properties. By using the digital technologies like Geographic Information Systems (GIS), mapping and monitoring will be useful for monitoring purposes for the local authorities and governments (42—46). Another possibility is to use System Dynamics (SD) framework, which captures the stock and flow. Development of models using Cellular Automata (CA) helps to visualize the impact of urban sprawl (29).

- **Managing mining and quarrying:** The impact can be reduced by proper management of the mining process, using advanced technologies rather than conventional methods. After mining by proper back filling, spreading the soil back over the top, the land can be reclaimed (47). The refilled land after mining can be used for planting trees. The top soil can be stacked if not used and can be used later for plantation. It can be adequately protected from leaching out during raining. The use of geo-textiles, the permeable fabrics which separate, filter, reinforce, protect or drain the soil, will help the re-vegetation process (48). Policies for controlling mining activities depend on the geographical location and threat to the land can be implemented to control mining and quarrying processes. Managing agricultural intensification Agricultural intensification needs to be managed properly to reduce the environmental effect. This can be done through education of the farmers. The intensification is necessary for especially in developing countries for the food security. It can be adopted with ecologically friendly appropriate technology. Implementation of integrated pest and nutrient management, policies for environmental taxes for nitrogen fertilizers, high yielding varieties, terracing, legume inter-cropping, contour hedgerows, cover crops, minimum tillage, selection of appropriate crops, organic and inorganic fertilizer use etc. can be done for sustainable agricultural intensification (34).
- **Land reclamation:** Recovery of land's productivity, which might have been lost during the past or during the creation of new land from sea or river, is called as land reclamation. The requirements are land may be damaged due to natural hazards like fire, earthquake, tsunami etc. or human activity like poor farming methods. The land with high water content, waterlogged land, which is not suitable for agricultural activities. The increasing population in urban cities, where the land scarcity is huge, it is difficult to find new land. By Land reclamation it can increase available arable land or it expands the carrying capacity, control of overcrowding in areas, economy through new industries

(49, 50). The world's largest land reclamation is done Dubai, The Palm Jumeirah, 31-square-kilometer island group costing US\$ 14 billion.

**ENVIRONMENTAL MOVEMENTS:** Environmental movements in India, centering on dams, displacement and resettlement effectively articulated their agenda on the human consequences of tampering with the courses of natural resources, have initiated protest action against the forces and agencies responsible for environmental degradation. Further, the issues raised by the actors of the ecology and environment movement by the "Friends of the Earth" and by the natural and Social Science scholars in defense of the nature and the planet earth, suggests that the ecology movement is not a mere exercise in romanticism nor a movement relating to food, fodder and fuel alone. In India it is also seen that the ethnic practices of worshipping planets, trees, forest, and rivers reflects the natural and social domains and the wisdom of seeing unity in the living and the non-living world in the Indian tradition. The ecological movements in India encapsulate all categories of caste, class, race, religion, nations and also categories of species divisions and the divisions of the organic and inorganic world.

Environmental movements in India have contributed in defining the models of development, shifting from a resource intensive and ecologically unstable state to an ecologically symbiotic state of functioning. A couple of environmental movements experienced in India so far include Chipko Andolan (Barthelemy, 1982), Save the Bhagirathi and stop Tehri project (Manu, 1984), Save the Narmada movement (Narmada Bachhao Andolan) in Madhya Pradesh and Gujrat; Youth organisation and Tribal people in the Gandhamardan Mines against Balco, the opposition of Baliapal Test Range, Bauxite mining in Kashipur and Niyamgiri; the Appiko movement in the Western Ghats; the campaign against the Silent Valley Project; reclaiming wastelands in Bankura district, and the opposition to the Gumti Dam in Tripura, etc., are some examples.

Many local movements centering deforestation, water logging, salinization and desertification in the command areas of major rivers of Kosi, Gandak, and Tungabhadra and in canal irrigated areas of western India, like Punjab and Haryana, have established the efficient use of water as a source of natural commodity. All these movements have reflected the ill-conceived natural resource consumption by the so called development projects, which have resulted in devastations in the natural resource base of the nation. In the following section we describe

couple of major environmental movements that have occurred in different parts of India across time.

- **CHIPKO MOVEMENT:** Chipko Movement started in April, 24 1973 at Mandal of Chamoli district of Gharwal division of Utter Pradesh. The Organiser of the movement had a belief on the ideology of non-violence as propagated by Mahatma Gandhi and Vinoba Bhave. The movement was raised out of ecological destabilization in the hills. The fall in the productivity in forest produces forced the hill dwellers to depend on the market which became a central concern for the inhabitants. The continuous natural distress like flood, and land slide due to Alakananda (1970) river and other catashophes like Tawaghat tragedy (1977) and Bhagirathi blockade (1978) Branch Rivers of river Ganga caused massive flood in the Gangetic plains. These floods brought a marked change in the ecological history of the region. A look into the forest policies and forest resources exploitation data show that due to over mining of forest resources in different time periods such natural calamities have occurred.

In 1973 the State Forest Department gave a lease of forest trees to Simon Company, a manufacturer of sporting goods from far off Allahabad (Mishra and Tripathy, 1975) The relationship between the erosion and floods on the one hand, and mass scale falling of trees on the other was recognized. On March 27 decision was taken to ‘Chipko’ that is ‘to hug’ the trees that were threatened by axe and thus the chipko andolan (movement) was born.

The Chipko movement experimented and established certain original approaches, like marginality, action research and social investigation. Few social workers integrated the Chipko movement for preservation of forest in the sub-Himalayan region of Gharwal. The movement made people conscious of the value of forest, its preservation and the need for maintaining ecological balance. The movement has established the importance of need oriented programmes, indigenous strategies, self-reliance, ecological balance and structural changes that resulted in high degree of peoples participation with the help of appropriate small scale technologies. It was experienced that the Western model of development reflected in the form of large scale infrastructure which have marginalised the women to the level of labour delivering products, the Chipko movement proved that women who produce all subsistence goods can maintain the status quo by retaining the traditional eco-system. They saw that conservation of forest seems to be their only source of living and survival. Chipko movement offered women a platform to realise

command over Public power and authority. New ecological concepts were built through this movement that made women to realise these issues which were earlier controlled by their male counterparts. This has resulted in various changes in the gender relations in rural Gharwal region in performing the household and social responsibility. The top down approach long adopted by the State in development of women could not bring much change in the power structure of the rural people. The new concept of ecological challenges became more concerned for the women (Jain, 1984).

- **SILENT VALLEY MOVEMENT:** The silent valley is located in Palghat district of Kerala. It is surrounded by different hills of the State stretched over a total area of 8950 hectares. The flora and fauna of the valley is natural and very rich in biodiversity. The valley has contributed varieties of genes for pest and disease control of rice. The idea of a dam on river Kunthipuja in this hill system was conceived by the British in 1929, while the technical feasibility survey was carried out in 1958 and the project was sanctioned by the Planning Commission of Government of India in 1973 with a cost estimation of Rs. 25.00 crores, which enhanced to 80 crores in 1980. The project had dual purpose of generating 240 MW of power, to irrigate 10,000 hectares of additional crop land and to create jobs for 2000 to 3000 people during the construction period.

Like other social movements in India, Silent Valley movement was also spontaneous, natural, initially went through unorganised processes but later on became more organized. In initial phase the local level groups protesting against the project neither could nor tried to contact the larger platforms because of their apprehensions and lack of clarity on the issue. In initial period the movement at local level had the experiment with the outside forces before co-opting them into their fold. The movement also established the fact that civil society reflects or offers the true concept of development. From the experiences one can say that if the philosophy of the movement gets supports by the higher-level platform then it became easy to establish the facts of the concept of people's development as a part of the development process. This movement contributed certain path ways to the other movements in India. It also established the fact that development should not bring destitution to the people and destruction to the natural resources base.

- **GANDHAMARDAN MOVEMENT:** Gandhamardan, one of the bauxite rich hill ranges, is situated in Sambalpur and Bolangir region of western Odisha. This region is

regarded by tribals and peasants as their mother who provides them with food, firewood, fodder and also water for cultivation and drinking purposes. Gandhamardan hill carries 22 streams and 150 perennial springs. The stream water and plants are the integral part of the local ecological pattern. In the ethnic composition of the region tribal communities like Gonds, Binjhals, Kandhas are the majority one, while Kulta a caste group are the numerical preponderant. The socio-cultural life processes of the local people are inter-twined with the Gandhamardan hill and Nrusingha Nath and Hari Shankar temples. Gandhamardan hill is a cultural territory for the locals of the region (Panigrahi, 1985).

BALCO had a plan for mining the Gandhamardan hills with an original investment of Rs. 31.20 crores and creation of an estimated employment of 500 persons on regular basis and 3000 persons as contract labourers. In addition, BALCO had also promised 25 kms railway line, hospital, schools for the local people, plantation under social forestry and a royalty of one crore to the State. The first blasting of BALCO in July 1985 damaged the much revered Nrusingha Nath, the 800 years old temple, which developed physical cracks in the temple and its Garuda Stambha. In the initial days BALCO butchered around 60,000 trees for the construction of road and ropeway. The tribal people of the region had preserved the forest plants as divine symbols and preserved them as totem of their clans. The destruction of trees by BALCO, therefore, is considered as a threat to their culture and society.

The adverse effects of BALCO on the local agriculture have contributed towards the environmental consciousness of the people. The Durgei stream irrigating 200 acres of land in Manabhanga village was affected due to the construction of a minor irrigation project on the stream to supply drinking water to BALCO Township. In addition, the irrigation project submerged a big Mango orchard and private irrigated plots. The blasting of hills brought cracks in Khandei Jharan canal and silted the agriculture land that made the land very hard to plough. Gradually the villagers became conscious about the environment and feared that their agro-forestry based livelihood will be jeopardised with the BALCO project. As a result of which, local leadership started with the tribals and peasants and it went from the religion base to a secular base. The costs to maintain the agitation by the locals was collected in the form of rice, and mobilised people to different places of agitation and spread the anti-BALCO message in the region. Gandhamardan Surakhya Parishads (GSYP) were formed in villages, Gram Panchayat and region level which facilitated the grass root movement by involving all sections,

both at micro level and macro level. The villagers realised that BALCO management has not merely betrayed the local inhabitants' faith in the modernization process, but also planned to take away the natural resources of their Gandhamardan hills.

- **APPIKO MOVEMENT:**<sup>12</sup> The famous Chipko Andolan (Hug the Trees Movement) of Uttarakhand in the Himalayas inspired the villagers of the Uttara Kannada district of Karnataka Province in southern India to launch a similar movement to save their forests. In September 1983, men, women and children of Salkani "hugged the trees" in Kalase forest. (The local term for "hugging" in Kannada is appiko.) Appiko Andolan gave birth to a new awareness all over southern India. In 1950, Uttara Kannada district forest covered more than 81 percent of its geographical area. The government, declaring this forest district a "backward" area, then initiated the process of "development". There major industries - a pulp and paper mill, a plywood factory and a chain of hydroelectric dams constructed to harness the rivers - sprouted in the are. These industries have overexploited the forest resource, and the dams have submerged huge-forest and agricultural areas. The forest had shrunk to nearly 25 percent of the district's area by 1980. The local population, especially the poorest groups, were displaced by the dams. The conversion of the natural mixed forests into teak and eucalyptus plantations dried up the water sources, directly affecting forest dwellers. In a nutshell, the three major p's - paper, plywood and power - which were intended for the development of the people, have resulted in a fourth p: poverty.

Deforestation in the Western Chats: The Sahyadri Range, or the Western Ghats, in southern India is the home of a tropical forest ecosystem. Although this tropical forest constitutes a potentially renewable resource, it is also a very fragile ecosystem and therefore merits special attention. The past 30 years have seen the onslaught of "development" activities and an increase in population, both of which have exhausted this fragile resource system. In the case of Kerala, which comprises 42 percent of the entire Western Ghat area, the forest cover fell from 44 percent in 1905 to a meager 9 percent in 1984. Such deforestation in the Western Ghats has caused severe problems for all southern India. The recurring drought in the provinces of Karnataka,

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<sup>12</sup> Hegde Pandurang, THE APPIKO MOVEMENT: FOREST CONSERVATION IN SOUTHERN INDIA, Available at <https://www.culturalsurvival.org/publications/cultural-survival-quarterly/appiko-movement-forest-conservation-southern-india>, accessed on 7<sup>th</sup> Feb, 2020 at 5.44 PM.

Maharashtra, Kerala and Tamil Nadu clearly indicates watershed degradation. The power generation, water supply and ultimately the whole economy of southern India is adversely affected. The drought in Karnataka Province indicates the extent of the damage caused by change in Sahyadri's fragile ecosystem. The ongoing "development" policy of exploiting the "resources - mainly forest and mineral resources - in the Western Ghats for the benefit of the elite has deprived the poor of their self-supporting systems.

The Appiko Movement is trying to save the Western Ghats by spreading its roots all over southern India. The movement's objectives can be classified into three major areas. First, the Appiko Movement is struggling to save the remaining tropical forests in the Western Ghats. Second, it is making a modest attempt to restore the greenery to denuded areas. Third, it is striving to propagate the idea of rational utilization in order to reduce the pressure on forest resources. To save, to grow and to use rationally - popularly known in Kannada as Ubsu ("save"), Belesu ("grow") and Balasu ("rational use") - is movement's popular slogan.

As said earlier, the deforestation in the Western Ghats has already affected hydroelectric dams, reservoirs and agriculture. The central government's Planning Commission has recognized the "high depletion" of natural resources in the Western Ghats in its Seventh Plan document. The first area of priority for the Appiko Movement is the remaining tropical forests of Western Ghats. The area is so sensitive that to remove the forest cover will lead to a laterization process, converting the land into rocky mountains. Thus a renewable resource becomes a nonrenewable one. Once laterization sets in, it will take centuries for trees to grow on that land. Before we reach such an extreme point the Appiko Movement aims to save the remaining forests in the Western Ghats through organizing decentralized groups at the grassroots level to take direct action.

**The Movement Methods:** The Appiko Movement uses various techniques to raise awareness: foot marches in the interior forests, slide shows, folk dances, street plays and so on. The movement has achieved a fair amount of success: the state government has banned felling of green trees in some forest areas; only dead, dying and dry trees are felled to meet local requirements. The movement has spread to the four hill districts of Karnataka Province, and has the potential to spread to the Eastern Ghats in Tamil Nadu Province and to Goa Province.

The second area of the Appiko Movement's work is to promote afforestation on denuded lands. In the villagers to grow saplings. Individual families as well as village youth clubs have taken an active interest in growing decentralized nurseries. An all-time record of 1.2 million saplings were grown by people in the Sirsi area in 1984-1985. No doubt this was possible due to the cooperation of the forest department, which supplied the plastic bags for growing saplings. In the process of developing the decentralized nursery, the activists realized that forest department makes extra money in raising a nursery. The cost paid for one sapling grown by a villager was 20 paise (US 2c), whereas the cost of a single sapling raised by the forest department amounted to a minimum of Rs 2 (US 15c). In addition, the forest department used fertilizers and gave tablets to saplings. The Appiko Movement's experience has brought an overuse of chemical fertilizers into the forest nursery, making it a capital-intensive, money-making program. The nursery program propagated by the forest department is really a means for utilizing village labor at cheap rates. Appiko activists have learnt lessons from this experience, and they are now growing saplings only to meet their own needs, not to give to the forest department.

The villagers have initiated a process of regeneration in barren common land. The Youth Club has taken the responsibility for the project and the whole village has united to protect this land from grazing, lopping and fire. The experience shows that in those areas where soil is present, natural regeneration is the most efficient and least expensive method of bringing barren area under free cover. In the areas in which topsoil is washed off, tree planting - especially of indigenous, fast-growing species - is done. The irony is that the forest department is resorting to the mechanized planting of exotic species, and also uses huge amounts of fertilizers on these exotic, monoculture plantations. This work will definitely harm the soil, and eventually the tree cover, in the area. Two obvious techniques of greening are being performed: one the forest department's method, is capital intensive, and the other, the people's technique of growing through regeneration, is a natural process for sustainable development of the soil.

The third major area of activity in the Appiko Movement is related to rational use of the ecosphere through introducing alternative energy sources to reduce the pressure on the forest. The activists have constructed 2,000 fuel-efficient chulhas ("hearths") in the area, which save fuelwood consumption by almost 40 percent. The activists do not wait for government subsidies or assistance, since there is spontaneous demand from the

people. Even in Sizsi town and in other urban areas, these chulhas are installed in hotels, reducing firewood consumption.

The other way to reduce pressure on the forest is through building gohar (gas plants). An increasing number of people are building bio-gas plants. However, the Appiko activists are more interested in those people who are from poorer sections - who cannot afford gas plants - so they emphasize chulhas.

Some people deter the regeneration process in the forest area through incorrect lopping practices. The Appiko Movement is trying to change people's attitudes so that they realize their mistake and stop this practice.

The thrust of the Appiko Movement in carrying out its work reveals the constructive phase of the people's movement. Through this constructive phase, depleted natural resources can be rebuilt. This process promotes sharing of resources in an egalitarian way, helping the forest dwellers. The movement's aim is to establish a harmonious relationship between people and nature, to redefine the term development so that ecological movements today form a basis for a sustainable, permanent economy in the future.

**PEOPLE'S BIODIVERSITY REGISTER:** People's Biodiversity Registers (PBR) document folk knowledge of status, uses, history, ongoing changes and forces driving changes in biodiversity resources, gainers and losers in these processes and people's perceptions of how these resources should be managed. A number of PBRs have been prepared in different parts of India beginning 1995 through initiatives of NGOs and educational institutions working with local communities and village councils. These attempts have been motivated by a desire to promote decentralised systems of management of natural resources and to create the basis for equitable sharing of benefits of commercial utilisation of folk knowledge of uses of biodiversity. The documents bring together important locality specific information on biodiversity resources and ecological processes affecting them. They lead to recognition of conservation oriented local practices such as protection of sacred groves. They help mobilise local communities to prudently manage local biodiversity resources in ways that would promote social justice. It is however important to recognise that not all folk knowledge may be valid, nor all folk practices wise, and to create systems of careful assessment of the material. There are many encouraging signs globally, as well as within India, such as the coming in force of the Convention on Biological Diversity, forces promoting decentralised democratic systems

of governance and institutions of co-management of natural resources which suggest that programmes like PBR will have an important role to play in promoting conservation, sustainable use and equitable sharing of benefits of biodiversity resources in the coming decades.

**PROJECT TIGER<sup>13</sup>:** In 1973, Project Tiger was launched in the Palamau Tiger Reserve, and various tiger reserves were created in the country based on a ‘core-buffer’ strategy. The Project Tiger was launched in Jim Corbett National Park of Uttarakhand in 1973. Tiger reserves are governed by the Project Tiger (1973). It is a Centrally Sponsored Scheme of the Ministry of Environment and Forest and is administered by the National Tiger Conservation Authority. India has more than 80 national parks and 441 Sanctuaries of which some have been declared as Tiger reserves.

The main aim of the Project is to protect tigers from extinction by ensuring a viable population in their natural habitats. Under this, the Government has set up a Tiger Protection Force under PT to combat poachers. The Tiger Reserves are constituted on a ‘core-buffer strategy’.

- **Core Zone:** The core area is kept free of biotic disturbances and forestry operations, where collection of minor forest produce, grazing, human disturbances are not allowed within. These areas are required to be kept for the purposes of tiger conservation, without affecting the rights of the Scheduled Tribes or such other forest dwellers. These areas are notified by the State Government in consultation with an Expert Committee (constituted for that purpose).
- **Buffer Zone:** The Act defines buffer zone as the area peripheral to the critical tiger habitat or core area providing supplementary habitat for dispersing tigers, besides offering scope for co-existence of human activity (tribals). The limits of such areas are determined with the concerned Gram Sabha and an Expert Committee constituted for the purpose.

### **Tiger Task Force**

The implementation of Project Tiger over the years has highlighted the need for a statutory authority with legal backing to ensure tiger conservation. On the basis of the recommendations

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<sup>13</sup> Available at <https://www.pmfias.com/project-tiger-elephant-indian-rhino-snow-leopard/>, accessed on 10<sup>th</sup> Feb, 2020 at 11.46 PM.

of National Board for Wild Life, a Task Force was set up to look into the problems of tiger conservation in the country. The recommendations of the Task Force include strengthening of Project Tiger by giving it statutory and administrative powers.

National Board for Wild Life ==> Tiger Task Force ==> National Tiger Conservation Authority

### **National Tiger Conservation Authority (NTCA)**

- The National Tiger Conservation Authority was established in December 2005 following a recommendation of the Tiger Task Force.
- The National Tiger Conservation Authority administers Project Tiger.
- Administration of the tiger reserves will be in accordance with guidelines of NTCA.
- Tiger reserves in India are administered by field directors as mandated by NTCA.
- No alteration in the boundaries of a tiger reserve shall be made except on a recommendation of the NTCA and the approval of the National Board for Wild Life.
- No State Government shall de-notify a tiger reserve, except in public interest with the approval of the NTCA and the approval of the National Board for Wild Life.
- The Wild Life (Protection) Amendment Act, 2006
- The Act provides for creating National Tiger Conservation Authority and Tiger and Other Endangered Species Crime Control Bureau (Wildlife Crime Control Bureau).

**NTCA members:** The Wildlife Protection Amendment Act, 2006 provides for the constitution of the National Tiger Conservation Authority. The NTCA was set up under the Chairmanship of the Minister for Environment and Forests. The Authority will have

- eight experts having qualifications in wildlife conservation and welfare tribals,
- 3 MPs,
- The Inspector General of Forests, in charge of project Tiger, will be ex-officio Member Secretary
- Others

### **Functions of NTCA**

- The Authority lays down standards, guidelines for tiger conservation in the Tiger Reserves, National Parks and Sanctuaries.

- The Tiger Conservation Authority would be required to prepare an Annual Report, which would be laid in the Parliament along with the Audit Report.
- State level Steering Committees will be set up in the Tiger States under the Chairmanship of respective Chief Ministers.
- This has been done with a view for ensuring coordination, monitoring and protection of tigers in the States.
- A provision has been made for the State Governments to prepare a Tiger Conservation Plan.
- Provision will be made for the States to establish a Tiger Conservation Foundation, based on the good practices emanating from some tiger reserves.
- Steps Taken by the Government for Tiger Conservation

### **Legal Steps**

- Amendment of the Wild Life (Protection) Act, 1972 to Wild Life (Protection) Act, 2006 for providing enabling provisions towards constituting the National Tiger Conservation Authority and the Tiger and Other Endangered Species Crime Control Bureau.
- Enhancement of punishment in cases of offence relating to a tiger reserve or its core area.

### **Administrative Steps**

- Strengthening of anti poaching activities, including special strategy for monsoon patrolling.
- State level Steering Committees under the Chairmanship of Chief Ministers and establishment of Tiger Conservation Foundation.
- Creation of Special Tiger Protection Force (STPF) [Budget 2008]

### **Financial Steps**

Financial and technical help is provided to the States under various Centrally Sponsored Schemes, viz. Project Tiger and Integrated Development of Wildlife Habitats.

### **International Cooperation**

- India has a bilateral understanding with Nepal on controlling trans-boundary illegal trade in wildlife
- India has signed a protocol on tiger conservation with China.

- India has signed a with Bangladesh for conservation of the Royal Bengal Tiger.
- A sub-group on tiger/leopard conservation has been constituted for cooperation with the Russian Federation.
- A Global Tiger Forum of Tiger Range Countries has been created for addressing international issues related to tiger conservation.
- India is a party to CITES. CITES's landmark decision states that 'tigers should not be bred for trade in their parts and derivatives'.

**PROJECT ELEPHANT<sup>14</sup>:** Project Elephant is a Central Government sponsored scheme launched in February 1992. Through the Project Elephant scheme, the government helps in the protection and management of elephants to the states having wild elephants in a free-ranging population. It ensures the protection of elephant corridors and elephant habitat for the survival of the elephant population in the wild. The union government provides technical and financial help to these states to carry out and achieve the goals of project elephant. Not just that, assistance for the purpose of the census, training of field officials is also provided to ensure the mitigation and prevention of man-elephant conflict. This elephant conservation strategy is mainly implemented in 16 of 28 states or union territories in the country which includes Arunachal Pradesh, Assam, Andhra Pradesh, Chhattisgarh Jharkhand, Kerala, Karnataka, Meghalaya, Maharashtra, Nagaland, Orissa, Tamil Nadu, Uttaranchal, Uttar Pradesh, and West Bengal. The government of India in the year 2010 declared Elephant as the national heritage animal of the country on the recommendations of the standing committee of the national board for wildlife. This was done to make sure that sufficient protection to elephants was provided before their numbers fall to panic levels like in the case of tigers. A proposed National elephant conservation authority (NECA) on the lines with NTCA has been proposed to be constituted by amending the Wildlife Protection Act 1972.

**Project Elephant Objectives:**

- To ensure the Welfare of domesticated elephants
- Protection of elephants, their habitats and elephant corridors.
- Mitigation and prevention of human-elephant conflict.

**Aims of Project Elephant:**

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<sup>14</sup> Available at <https://byjus.com/govt-exams/project-elephant-reserves-in-india-list/>

- Develop and promote scientific and planned management strategies for Elephant conservation.
- Prevent illegal trade of ivory and ensure elephant protection from hunters and poachers.
- Develop strategies to prevent unnatural causes of elephants' death in India.
- Ensure ecological restoration of the natural elephant habitats and their migratory routes.
- To mitigate and prevent the increasing conflict in elephant habitats between humans and elephants.
- Reduce and remove domestic livestock grazing, the pressure of humans and their activities in important elephant habitats.
- Promote scientific research on issues related to elephant conservation and educating the public on these issues.
- To facilitate veterinary care for proper breeding and health care of domesticated elephants and to facilitate Eco-development for the elephants.

### **Campaign Haathi Mere Saathi**

The Ministry of Environment and forests in partnership with Wildlife Trust of India has launched a campaign Hathi Mere Sathi. The aim of the campaign was to increase public awareness and develop friendships between elephants and the local population. The campaign Haathi Mere Saathi was for the welfare of the elephants, to conserve and protect the elephants in India. The campaign was launched in Delhi on 24th May 2011 at Elephant- 8 ministerial meetings. The countries that are a part of the Elephant-8 ministerial meeting are Kenya, Srilanka, Botswana, Republic of Congo, Tanzania, Indonesia, Thailand, and India.

### **Elephant Task Force**

The increased tension due to rampant retaliatory killing of elephants and human-elephant conflict prompted the government to set up the Elephant Task Force along the lines of the Tiger Task Force. The focus of the Elephant Task Force was to bring pragmatic solutions for the conservation of elephants in the long-term.

**CROCODILE CONSERVATION:**<sup>15</sup> In response to declining crocodylian populations, in co-operation with the Government of India and State Governments, a crocodile conservation

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<sup>15</sup> Available at <https://www.sciencedirect.com/science/article/abs/pii/S0006320784900764>, accessed on 10<sup>th</sup> February, 2020 at 12.34 PM

programme, the UNDP/FAO Crocodile Breeding and Management Project, was launched in 1975. The Primary project aims were:

- to boost reproductive output by collection of wild-laid eggs with subsequent incubation and rearing of young until of a size (less vulnerable to predation) suitable for release in the wild;
- to locate, establish and manage a series of crocodile rehabilitation centres and sanctuaries in suitable habitats.

Sixteen crocodile rehabilitation centres and eleven crocodile sanctuaries have been established. A total of 879 gharials, 190 estuarine crocodiles and 493 mugger have been released. A viable breeding population of gharials now exists in the National Ghambal Sanctuary. A Crocodile Breeding and Management Training Institute was established by the Government of India in 1980 and has trained 48 managers of crocodile stations. Improvements are required in the management of crocodile sanctuaries and the evaluation of crocodile habitat. Releases of crocodiles in the wild require monitoring of survival and movements. There is a need for educating the public about crocodile conservation.

#### **GOI-UNDP Sea Turtle project:**

Started in: MoEF initiated the Sea Turtle Conservation Project in collaboration of UNDP in 1999 with Wildlife Institute of India, Dehradun as the Implementing Agency.

**Objective:** The objective of conservation of olive ridley turtles and other endangered marine turtles.

#### **Key Facts:**

- The project is being implemented in 10 coastal States of the country with special emphasis in State of Orissa.
- The project has helped in preparation of inventory map of breeding sites of Sea Turtles, identification of nesting and breeding habitats along the shore line, and migratory routes taken by Sea Turtles, development of guidelines to safeguard and minimize turtle mortality.
- One of the important achievements have been demonstration of use of Satellite Telemetry to locate the migratory route of Olive Ridley Turtles in the sea and sensitizing the fishermen and State Government for the use of Turtle Exclusion Device (TED) in fishing trawlers to check turtle mortality in fishing net.

**INDIAN RHINO VISION 2020:**<sup>16</sup> Started in: Phase 1 of IRV 2020 was conducted from 2005 to 2008.

**Objective:** Its goal is to have a wild population of at least 3,000 Greater one-horned rhinos in the Indian state of Assam – spread over seven protected areas – by the year 2020.

**Key Functions:**

- Improving the protection and security of rhinos in all rhino areas in Assam.
- Expanding the distribution of rhinos over seven protected areas to reduce the risks associated with having a whole population in one area.
- Translocating rhinos from two source populations (Kaziranga and Pabitora) into five target protected areas (Manas, Laokhowa, Buracharpori-Kochmora, Dibrusaikhowa and Orang)
- The project also aims to reduce the rhino population pressures in any single habitat by ensuring a better distribution of the rhino population over suitable ranges.
- In addition, the project concentrates on integrating the local communities into the conservation effort. It aims to provide jobs for people living around the national parks (in conservation or tourism), to help to protect crops from being raided and to implement further educational methods.

**CARBON SEQUESTRATION AND CARBON CREDITS:**<sup>17</sup> Global Warming Gas, CO<sub>2</sub> has increased by approximately 43% since industrial revolution and is expected to further increase to 60% in 2100 if the current trend continues (Kumar et al., 2016c). Mitigation strategy of CO<sub>2</sub> can be attained mainly by three possible ways: primarily by improving energy efficiency of existing engine technology and proper fossil fuel utilization, secondly by CO<sub>2</sub> sequestration and the lastly by facilitating the uses of unconventional fuels such as bio-hydrocarbon, biodiesel, etc. (Bhartiet al., 2014a). Mitigation strategies include carbon capture and storage of CO<sub>2</sub> by biological means may reduce the CO<sub>2</sub> emissions on

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<sup>16</sup> Available at <https://www.civildaily.com/government-schemesprojects-related-to-environment-conservation-in-india/>, accessed on 10<sup>th</sup> February, 2020 at 12.40 PM.

<sup>17</sup> Abhay Kumar, Swati Shabnam, Sunita Kumari, P.R. Oraon and Bijay Kumar Singh, SCIENCE CARBON SEQUESTRATION AND CARBON CREDIT, VOL. VIII, SPECIAL ISSUE (A) AUGUST-2018 MULTIOLOGIC IN, Available at <https://www.researchgate.net/publication/326977229> CARBON SEQUESTRATION AND CARBON CREDIT, accessed on 10<sup>th</sup> February, 2020 at 1.20 PM.

environment. The Fifth Assessment of the Intergovernmental Panel on Climate Change (IPCC) underscores the high likelihood of significant future global climate warming if greenhouse gas (GHG) emissions continuously increase (IPCC, 2013). Several carbon (C) capture and storage schemes have been developed (Von der Assenet al., 2013; Boot-Handford et al., 2014). Pan et al. (2011) suggested that a third of annual CO<sub>2</sub> emissions is captured and stored by terrestrial ecosystems. CO<sub>2</sub> and nitrogen deposition may interact with other climate factors like warming and precipitation to affect tree physiology, carbon allocation, and ecosystem carbon sequestrations (Allen et al. 2010; Tian et al. 2012; Norby and Luo 2004). Sequestration methods include enhancing the storage of carbon in soil (soil sequestration), storage of carbon in forests and other vegetation (plant sequestration), storing carbon in underground geological formations (geo-sequestration) storing carbon in the ocean (ocean sequestration) and subjecting carbon to chemical reactions to form inorganic carbonates (mineral carbonation). Soil sequestration It is estimated that soils contain between 700 gigatons (Gt) and 3000 Gt of carbon or more than three times the amount of carbon stored in the atmosphere as carbon dioxide. However, most agricultural soils have lost 50–70 per cent of the original soil organic carbon pool that was present in the natural ecosystem prior to clearing and cultivation. When forests are converted to agricultural land, the soil carbon content decreases. Plant sequestration Plants use the energy of sunlight to convert CO<sub>2</sub> from the atmosphere to carbohydrates for their growth and maintenance, via the process of photosynthesis. Natural terrestrial biological sinks for CO<sub>2</sub> already sequester about one third of CO<sub>2</sub> emissions from fossil fuel combustion. These natural sinks are a transient response to higher atmospheric CO<sub>2</sub> concentration, which enhances the rate of photosynthesis. Geo-sequestration Geo-sequestration is the injection and storage of greenhouse gases underground, out of contact with the atmosphere. The most suitable sites are deep geological formations, such as depleted oil and natural gas fields or deep natural reservoirs filled with saline water (saline aquifers). Geo-sequestration is part of the three-component scheme of carbon capture and storage which involves capture of CO<sub>2</sub> either before or after combustion of the fuel transport of the captured CO<sub>2</sub> to the site of storage, and injection and storage of the CO<sub>2</sub>. Ocean sequestration The ocean represents the largest carbon store on earth. Before the industrial revolution it contained 60 times as much carbon as the atmosphere and 20 times as much carbon as the land vegetation and soil. The ocean has been a significant sink for anthropogenic CO<sub>2</sub> emissions of similar magnitude to the land sink but, as with the land sink, the ocean sink will decrease in strength. Increasing CO<sub>2</sub> concentration in the upper layer of the oceans is also causing ocean acidification with potentially severe consequences

for marine organisms and ecosystems. Mineral sequestration Mineral sequestration also known as mineral carbonation involves reaction of CO<sub>2</sub> with metal oxides that are present in common, naturally occurring silicate rocks. The process mimics natural weathering phenomena, and results in natural carbonate products that are stable on a geological time scale. There are sufficient reserves of magnesium and calcium silicate deposits to fix the CO<sub>2</sub> that could be produced from all fossil fuel resources.

**Carbon credit:** A carbon credit is a tradable certificate or permit representing the right to emit one ton of carbon or carbon dioxide equivalent (t CO<sub>2</sub>e). One carbon credit is one ton of carbon dioxide, or in some markets, carbon dioxide equivalent gases. In such cases, a company has two ways to reduce emissions. i. It can reduce the GHG (greenhouse gases) by adopting new technology or improving upon the existing technology to attain the new norms for emission of gases. ii. It can tie up with developing nations and help them set up new technology that is carbon credits of the company in developing country can be transferred to the company in developed country. Developing countries like India and China are likely to emerge as the biggest sellers and Europe is going to be the biggest buyers of carbon credit. Presently almost global carbon credit trading was estimated at \$5 billion with India's contribution at around \$1 billion. China is currently the largest seller of carbon credit controlling about 70% of the market share. MCX has become first exchange in Asia to trade carbon credits. ➤ Carbon Credit: A permit that allows the holder to emit one ton of carbon dioxide. ➤ This is a type of financial derivative product that derives its value from reduction in emission of GHGs ➤ The value of one CER in Indian Rupees is about Rs. -325-1300.

**Carbon Trading:** Carbon trading is a mechanism through which countries that have to achieve their emission targets are achieved. Carbon trading means trading of units of carbon dioxide reduced in the environment. Countries which reduce carbon emissions earn Carbon Emission Certificates(CERs) which are traded and is called carbon trading. One carbon credit is equal to 1 ton of carbon dioxide reduced in the environment. There are various exchanged in which carbon emission are traded like Chicago Climate Exchange, NASDAQ OMX, POWER NEXT, European Energy Exchange etc. in India MCX and NCDEX are two exchanges which deal with trading of carbon emission in form of Carbon Emission Reduction Certificates which countries earn through completion of CDM projects or in form of ERU. Emission Reduction Units which are earned on successful completion of J.I. projects.

**SWACHH BHARAT ABHIYAN:**<sup>18</sup> The Swachh Bharat Abhiyan is the most significant cleanliness campaign by the Government of India. Shri Narendra Modi led a cleanliness pledge at India Gate, which about thirty lakh government employees across the country joined. This involves the following programmes-

- Swachh Bharat Mission
- Swachh Bharat Mission for Urban Areas
- Swachh Bharat Mission (Gramin)
- Swachh Vidyalaya Abhiyan

**Swachh Bharat Mission:** Swachh Bharat Mission is a massive mass movement that seeks to create a Clean India by 2019. The father of our nation Mr. Mahatma Gandhi always puts the emphasis on swachhta as swachhta leads to healthy and prosperous life. Keeping this in mind, the Indian government has decided to launch the swachh bharat mission on October 2, 2014. The mission will cover all rural and urban areas. The urban component of the mission will be implemented by the Ministry of Urban Development, and the rural component by the Ministry of Drinking Water and Sanitation.

**Swachh Bharat Mission for Urban Areas:** The programme includes elimination of open defecation, conversion of unsanitary toilets to pour flush toilets, eradication of manual scavenging, municipal solid waste management and bringing about a behavioural change in people regarding healthy sanitation practices. The mission aims to cover 1.04 crore households, provide 2.5 lakh community toilets, 2.6 lakh public toilets, and a solid waste management facility in each town. Under the programme, community toilets will be built in residential areas where it is difficult to construct individual household toilets. Public toilets will also be constructed in designated locations such as tourist places, markets, bus stations, railway stations, etc. The programme will be implemented over a five-year period in 4,401 towns.

The total assistance available for construction of an individual toilet is Rs 4000/- from the Central Government and an amount of Rs 1333/- at least from the State Government. However in the case of the North East States, the states are required to contribute only Rs 400/- per individual toilet. However, there is no bar on releasing any extra funds at any stage by the ULB/State Government through additional resources.

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<sup>18</sup> Available at <http://vikaspedia.in/health/sanitation-and-hygiene/swachh-bharat-mission>

The expected assistance for construction of community toilets - Central Government will contribute upto 40% of the cost of construction of community toilet as a VGF/ outright grant. As per SBM guidelines, the States/UTs shall provide an additional 13.33% for the said component. The NE and special category states shall be required to contribute 4% only. The balance shall have to be arranged through innovative mechanisms by the urban local body. The approximate cost per seat for a community toilet is Rs 65,000/-. Rs 62,009 crore is likely to be spent on the programme. Of this, the Centre will pitch in Rs 14,623 crore. Of the Centre's share of Rs 14,623 crore, Rs 7,366 crore will be spent on solid waste management, Rs 4,165 crore on individual household toilets, Rs 1,828 crore on public awareness and Rs 655 crore on community toilets.

**Swachh Bharat Mission (Gramin):** The Nirmal Bharat Abhiyan has been restructured into the Swachh Bharat Mission (Gramin). The mission aims to make India an open defecation free country in Five Years. It seeks to improve the levels of cleanliness in rural areas through Solid and Liquid Waste Management activities and making Gram Panchayats Open Defecation Free (ODF), clean and sanitised. Under the mission, One lakh thirty four thousand crore rupees will be spent for construction of about 11 crore 11 lakh toilets in the country. Technology will be used on a large scale to convert waste into wealth in rural India in the forms of bio-fertilizer and different forms of energy. The mission is to be executed on war footing with the involvement of every gram panchayat, panchayat samiti and Zila Parishad in the country, besides roping in large sections of rural population and school teachers and students in this endeavor. Incentive as provided under the Mission for the construction of Individual Household Latrines (IHHL) shall be available for all Below Poverty Line (BPL) Households and Above Poverty Line (APL) households restricted to SCs/STs, small and marginal farmers, landless labourers with homestead, physically handicapped and women headed households. The Incentive amount provided under SBM(G) to Below Poverty Line (BPL) /identified APLs households shall be up to Rs.12,000 for construction of one unit of IHHL and provide for water availability, including for storing for hand-washing and cleaning of the toilet. Central Share of this Incentive for IHHLs shall be Rs.9,000/- (75%) from Swachh Bharat Mission (Gramin). The State share will be Rs.3,000/-(25%). For North Eastern State, and Special category States, the Central share will be Rs. 10,800/- and the State share Rs.1,200/- (90% : 10%). The beneficiary is to be encouraged to additionally contribute in the construction of his/her IHHL to promote ownership.

**Swachh Vidyalaya Abhiyan:** The Ministry of Human Resource Development has launched Swachh Vidyalaya Programme under Swachh Bharat Mission with an objective to provide separate toilets for boys and girls in all government schools within one year. The programme aims at ensuring that every school in the country must have a set of essential interventions that relate to both technical and human development aspects of a good Water, Sanitation and Hygiene Programme. The Ministry financially supports States/Union Territories inter alia to provide toilets for girls and boys in schools under Sarva Shiksha Abhiyan (SSA) and Rashtriya Madhyamik Shiksha Abhiyan (RMSA).

**Rashtriya Swachhata Kosh:** The Swachh Bharat Kosh (SBK) has been set up to facilitate and channelize individual philanthropic contributions and Corporate Social Responsibility (CSR) funds to achieve the objective of Clean India (Swachh Bharat) by the year 2019. The Kosh will be used to achieve the objective of improving cleanliness levels in rural and urban areas, including in schools. The allocation from the Kosh will be used to supplement and complement departmental resources for such activities. To incentivise contributions from individuals and corporate, modalities are being considered to provide tax rebates where it is possible.

**Sustainable Habitat: Green Building:**<sup>19</sup> Green Building, also known as green construction or sustainable 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 complements the classical building design concerns of economy, utility, durability, and comfort. Although new technologies are constantly being developed to complement current practices in creating greener structures, the common objective is that 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

The concept of sustainable development can be traced to the energy (especially fossil oil) crisis and the environment pollution concern in the 1970s. The green building movement in the U.S. originated from the need and desire for more energy efficient and environmentally friendly

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<sup>19</sup> Available at <http://environment-ecology.com/environment-and-architecture/80-green-building.html>, accessed on 10<sup>th</sup> Feb, 2020 at 1.44 PM.

construction practices. There are a number of motives to building green, including environmental, economic, and social benefits. However, modern sustainability initiatives call for an integrated and synergistic design to both new construction and in the retrofitting of an existing structure. Also known as sustainable design, this approach integrates the building life-cycle with each green practice employed with a design-purpose to create a synergy amongst the practices used.

Green building brings together a vast array of practices and techniques to reduce and ultimately eliminate the impacts of buildings on the environment and human health. It often emphasizes taking advantage of renewable resources, e.g., using sunlight through passive solar, active solar, and photovoltaic techniques and using plants and trees through green roofs, rain gardens, and for reduction of rainwater run-off. Many other techniques, such as using packed gravel or permeable concrete instead of conventional concrete or asphalt to enhance replenishment of ground water, are used as well.

While the practices, or technologies, employed in green building are constantly evolving and may differ from region to region, there are fundamental principles that persist from which the method is derived: Siting and Structure Design Efficiency, Energy Efficiency, Water Efficiency, Materials Efficiency, Indoor Environmental Quality Enhancement, Operations and Maintenance Optimization, and Waste and Toxics Reduction. The essence of green building is an optimization of one or more of these principles. Also, with the proper synergistic design, individual green building technologies may work together to produce a greater cumulative effect. On the aesthetic side of green architecture or sustainable design is the philosophy of designing a building that is in harmony with the natural features and resources surrounding the site. There are several key steps in designing sustainable buildings: specify 'green' building materials from local sources, reduce loads, optimize systems, and generate on-site renewable energy.

The national mission on sustainable habitat approved by Prime minister. It is one of the eight missions under national climate change action plan and aims to make cities sustainable through improvements in energy efficiency in buildings, management of solid waste & shift to public transport. The National Mission for Sustainable Habitat which is a component of the National Action Plan for Climate Change will broadly cover the following aspects: Extension of the energy conservation building code - which addresses the design of new and large commercial buildings to optimize their energy demand; Better urban planning and modal shift to public transport - make long term transport plans to facilitate the growth of medium and small cities

in such a way that ensures efficient and convenient public transport; Recycling of material and urban waste management - a special areas of focus will be development of technology for producing power from waste. The National Mission will include a major R&D programme, focusing on bio-chemical conversion, waste water use, sewage utilization and recycling options wherever possible.

**GRIHA Rating Norms:** 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. Throughout their life cycles, from construction to operation and then demolition, they consume resources in the form of energy, water, materials, etc. and emit wastes either directly in the form of municipal wastes or indirectly as emissions from electricity generation. 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 assess the performance of their building against certain nationally acceptable benchmarks. The system has been developed to help 'design and evaluate' new buildings (buildings that are still at the inception stages). A building is assessed based on its predicted performance over its entire life cycle – inception through operation.<sup>20</sup> The stages of the life cycle that have been identified for evaluation are:

- Pre-construction stage: (intra- and inter-site issues like proximity to public transport, type of soil, kind of land, where the property is located, the flora and fauna on the land before construction activity starts, the natural landscape and land features).
- Building planning and construction stages: (issues of resource conservation and reduction in resource demand, resource utilization efficiency, resource recovery and reuse, and provisions for occupant health and well-being). The prime resources that are considered in this section are land, water, energy, air, and green cover.
- Building operation and maintenance stage: (issues of operation and maintenance of building systems and processes, monitoring and recording of energy consumption, and occupant health and well-being, and also issues that affect the global and local environment).

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<sup>20</sup> Available at [www.pmcindia.gov.in/green\\_building](http://www.pmcindia.gov.in/green_building), accessed on 10th February, 2020 at 1.42 PM.

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'.<sup>21</sup> The benefits of a green design to a building owner, user, and the society as a whole includes as follows:<sup>22</sup>

- Reduced energy consumption without sacrificing the comfort levels
- Reduced destruction of natural areas, habitats, and biodiversity, and reduced soil loss from erosion etc.
- Reduced air and water pollution (with direct health benefits)
- Reduced water consumption
- Limited waste generation due to recycling and reuse
- Reduced pollution loads
- Increased user productivity
- Enhanced image and marketability

**GRIHA (Green Rating for Integrated Habitat Assessment)**  
India's own green building rating

**2000**

- TERI conducted over 100 building audits.
- TERI Reform, constructed in Green building.

**2007**

- MINDRE adopts GRIHA as National Rating system for green buildings.
- EDCO code released in India.

**2009**

- Committee of secretaries, 7 star GRIHA mandatory for all Govt. Buildings.
- CPWD adopts GRIHA.
- Acknowledged as an innovative tool by UN.

**2011**

- GRIHA adopted by PCMC (Premium discounts to developers and property tax rebate for buyers announced in PCMC for GRIHA rated projects).
- EC linked to GRIHA pre-certification.
- Committee of secretaries recommends up scaling of GRIHA.
- ARIJSM and CREDAI sign MoU.

**2013**

- Launch of GRIHA LD rating for large development.
- GRIHA app launched for android.
- GRIHA new user friendly mobile design website launched.
- GRIHA adopted in Noida (FAR incentive for GRIHA rated projects in Noida).
- GRIHA adopted in Greater Noida (FAR incentive for GRIHA rated projects in Greater Noida).
- GRIHA adopted in Pune (FAR incentives for GRIHA rated projects in Pune).
- GRIHA, adopted in Kerala.

**2015**

- 5 star GRIHA adopted by PCMC (Premium discounts to developers and property tax rebate for buyers announced in PCMC for 5 star GRIHA rated projects).
- FAR for GRIHA projects in Pune.
- FAR for ALDA (Amended) urban development authority.

**2005**

- TERI GRIHA released indigenous green building rating of INDA.

**2008**

- National mission on sustainable habitat launched.

**2010**

- Evaluators' and Trainers' programme launched.

**2012**

- Launch of GVA GRIHA rating for Buildings less than 2,000 sq. m.
- GRIHA product catalogue launched.
- Guidelines for large development launched.
- Concessional rate of interest for GRIHA rated projects by SIDBI.

**2014**

- Launch of GRIHA (Peak) rating for existing day schools.
- GRIHA app for iOS launched.
- MoU, Delhi Division, Govt FAR incentive for GRIHA rated projects.
- MoU signed between USGBC and TERI.
- Sakin adopts GRIHA.

**2015**

- Launch of GRIHA & GRIHA LD v.2015.
- Government of West Bengal, Department of Municipal Affairs adopts GRIHA.
- FAR for GRIHA projects in Paschim Medinipur.
- FAR for GRIHA projects in Pune.
- FAR for ALDA (Amended) urban development authority.

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**GRIHA recognized as India's own green building rating system in INDIA'S INDC submitted to UNFCCC.**

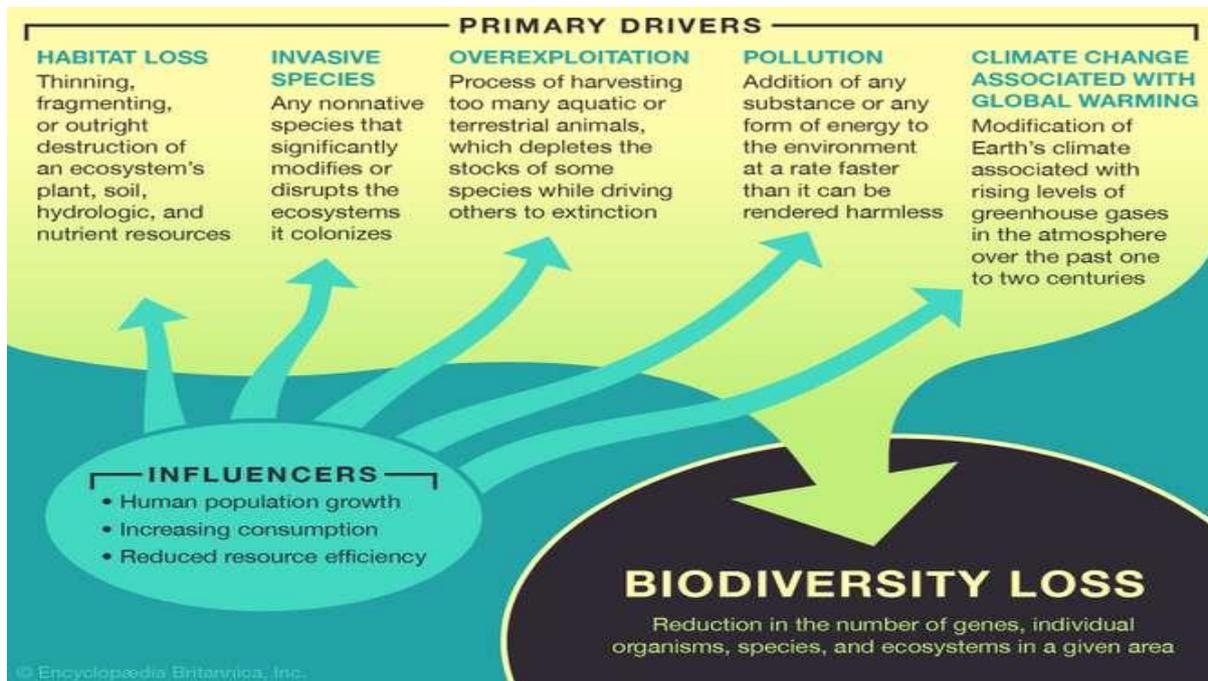
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<sup>21</sup> Available at [www.pcmcindia.gov.in/green\\_building](http://www.pcmcindia.gov.in/green_building), accessed on 10<sup>th</sup> February, 2020 at 1.42 PM.

<sup>22</sup> Available at <https://www.grihaindia.org/about-griha>, accessed on 10<sup>th</sup> February, 2020 at 1.34 PM.

## CONTEMPORARY ENVIRONMENTAL ISSUES

**BIODIVERSITY LOSS**<sup>23</sup>: Biodiversity loss, also called loss of biodiversity, a decrease in biodiversity within a species, an ecosystem, a given geographic area, or Earth as a whole. Biodiversity, or biological diversity, is a term that refers to the number of genes, species, individual organisms within a given species, and biological communities within a defined geographic area, ranging from the smallest ecosystem to the global biosphere. (A biological community is an interacting group of various species in a common location.) Likewise, biodiversity loss describes the decline in the number, genetic variability, and variety of species, and the biological communities in a given area. This loss in the variety of life can lead to a breakdown in the functioning of the ecosystem where decline has happened.



The loss of biodiversity as identified by the Researchers have five important drivers which are as under:

- **Habitat loss and degradation**—which is any thinning, fragmentation, or destruction of an existing natural habitat—reduces or eliminates the food resources and living space for most species. Species that cannot migrate are often wiped out.
- **Invasive species**—which are non-native species that significantly modify or disrupt the ecosystems they colonize—may outcompete native species for food and habitat, which

<sup>23</sup> Available at <https://www.britannica.com/science/biodiversity-loss>

triggers population declines in native species. Invasive species may arrive in new areas through natural migration or through human introduction.

- **Overexploitation**—which is the harvesting of game animals, fish, or other organisms beyond the capacity for surviving populations to replace their losses—results in some species being depleted to very low numbers and others being driven to extinction.
- **Pollution**—which is the addition of any substance or any form of energy to the environment at a rate faster than it can be dispersed, diluted, decomposed, recycled, or stored in some harmless form—contributes to biodiversity loss by creating health problems in exposed organisms. In some cases, exposure may occur in doses high enough to kill outright or create reproductive problems that threaten the species's survival.
- **Climate change associated with global warming**—which is the modification of Earth's climate caused by the burning of fossil fuels—is caused by industry and other human activities. Fossil fuel combustion produces greenhouse gases that enhance the atmospheric absorption of infrared radiation (heat energy) and trap the heat, influencing temperature and precipitation patterns.

Ecologists emphasize that habitat loss (typically from the conversion of forests, wetlands, grasslands, and other natural areas to urban and agricultural uses) and invasive species are the primary drivers of biodiversity loss, but they acknowledge that climate change could become a primary driver as the 21st century progresses. In an ecosystem, species tolerance limits and nutrient cycling processes are adapted to existing temperature and precipitation patterns. Some species may not be able to cope with environmental changes from global warming. These changes may also provide new opportunities for invasive species, which could further add to the stresses on species struggling to adapt to changing environmental conditions. All five drivers are strongly influenced by the continued growth of the human population and its consumption of natural resources.

**CLIMATE CHANGE:** The Earth's climate has changed throughout history. Just in the last 650,000 years there have been seven cycles of glacial advance and retreat, with the abrupt end of the last ice age about 11,700 years ago marking the beginning of the modern climate era — and of human civilization. Most of these climate changes are attributed to very small variations in Earth's orbit that change the amount of solar energy our planet receives.

## **The evidence for rapid climate change:<sup>24</sup>**

- Global Temperature Rise
- Warming of Oceans
- Shrinking Ice Sheets
- Glacial Retreat
- Decreased Snow Cover
- Sea Level Rise
- Declining Arctic Sea Ice
- Extreme Events
- Ocean Acidification

**The UN Intergovernmental Panel on Climate Change (IPCC):<sup>25</sup>** The Intergovernmental Panel on Climate Change (IPCC) was set up by the World Meteorological Organization (WMO) and United Nations Environment to provide an objective source of scientific information. In 2013 the IPCC provided more clarity about the role of human activities in climate change when it released its Fifth Assessment Report. It is categorical in its conclusion: climate change is real and human activities are the main cause.

### **Fifth Assessment Report**

The report provides a comprehensive assessment of sea level rise, and its causes, over the past few decades. It also estimates cumulative CO<sub>2</sub> emissions since pre-industrial times and provides a CO<sub>2</sub> budget for future emissions to limit warming to less than 2°C. About half of this maximum amount was already emitted by 2011. The report found that:

- From 1880 to 2012, the average global temperature increased by 0.85°C.
- Oceans have warmed, the amounts of snow and ice have diminished and the sea level has risen. From 1901 to 2010, the global average sea level rose by 19 cm as oceans expanded due to warming and ice melted. The sea ice extent in the Arctic has shrunk in every successive decade since 1979, with  $1.07 \times 10^6$  km<sup>2</sup> of ice loss per decade.
- Given current concentrations and ongoing emissions of greenhouse gases, it is likely that by the end of this century global mean temperature will continue to rise above the pre-industrial level. The world's oceans will warm and ice melt will continue. Average

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<sup>24</sup> Available at <https://climate.nasa.gov/evidence/>, accessed on 10<sup>th</sup> February, 2020 at 2.10 PM

<sup>25</sup> Available at <https://www.un.org/en/sections/issues-depth/climate-change/>, accessed on 10<sup>th</sup> February, 2020 at 2.15 PM.

sea level rise is predicted to be 24–30 cm by 2065 and 40–63 cm by 2100 relative to the reference period of 1986–2005. Most aspects of climate change will persist for many centuries, even if emissions are stopped.

- There is alarming evidence that important tipping points, leading to irreversible changes in major ecosystems and the planetary climate system, may already have been reached or passed. Ecosystems as diverse as the Amazon rainforest and the Arctic tundra, may be approaching thresholds of dramatic change through warming and drying. Mountain glaciers are in alarming retreat and the downstream effects of reduced water supply in the driest months will have repercussions that transcend generations.

### **Global Warming of 1.5°C**

In October 2018 the IPCC issued a special report on the impacts of global warming of 1.5°C, finding that limiting global warming to 1.5°C would require rapid, far-reaching and unprecedented changes in all aspects of society. With clear benefits to people and natural ecosystems, the report found that limiting global warming to 1.5°C compared to 2°C could go hand in hand with ensuring a more sustainable and equitable society. While previous estimates focused on estimating the damage if average temperatures were to rise by 2°C, this report shows that many of the adverse impacts of climate change will come at the 1.5°C mark.

**OZONE DEPLETION:**<sup>26</sup> Ozone depletion, gradual thinning of Earth's ozone layer in the upper atmosphere caused by the release of chemical compounds containing gaseous chlorine or bromine from industry and other human activities. The thinning is most pronounced in the polar regions, especially over Antarctica. Ozone depletion is a major environmental problem because it increases the amount of ultraviolet (UV) radiation that reaches Earth's surface, which increases the rate of skin cancer, eye cataracts, and genetic and immune system damage. The Montreal Protocol, ratified in 1987, was the first of several comprehensive international agreements enacted to halt the production and use of ozone-depleting chemicals. As a result of continued international cooperation on this issue, the ozone layer is expected to recover over time.

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<sup>26</sup> Available at <https://www.britannica.com/science/ozone-depletion>, accessed on 10<sup>th</sup> February, 2020 at 2.24 PM.

## **SEA LEVEL RISE:<sup>27</sup>**

Rising seas is one of those climate change effects. Average sea levels have swelled over 8 inches (about 23 cm) since 1880, with about three of those inches gained in the last 25 years. Every year, the sea rises another .13 inches (3.2 mm). The change in sea levels is linked to three primary factors, all induced by ongoing global climate change:

- **Thermal expansion:** When water heats up, it expands. About half of the sea-level rise over the past 25 years is attributable to warmer oceans simply occupying more space.
- **Melting glaciers:** Large ice formations such as mountain glaciers naturally melt a bit each summer. In the winter, snows, primarily from evaporated seawater, are generally sufficient to balance out the melting. Recently, though, persistently higher temperatures caused by global warming have led to greater-than-average summer melting as well as diminished snowfall due to later winters and earlier springs. That creates an imbalance between runoff and ocean evaporation, causing sea levels to rise.
- **Loss of Greenland and Antarctica's ice sheets:** As with mountain glaciers, increased heat is causing the massive ice sheets that cover Greenland and Antarctica to melt more quickly. Scientists also believe that meltwater from above and seawater from below is seeping beneath Greenland's ice sheets, effectively lubricating ice streams and causing them to move more quickly into the sea. While melting in West Antarctica has drawn considerable focus from scientists, especially with the 2017 break in the Larsen C ice shelf, glaciers in East Antarctica are also showing signs of destabilizing.

Most predictions say the warming of the planet will continue and is likely to accelerate, causing the oceans to keep rising. This means hundreds of coastal cities face flooding. But forecasting how much and how soon seas will rise remains an area of ongoing research. The most recent special report from the Intergovernmental Panel on Climate Change says we can expect the oceans to rise between 10 and 30 inches (26 to 77 centimeters) by 2100 with temperatures warming 1.5 °C. That's enough to seriously affect many of the cities along the U.S. East Coast. Another analysis based on NASA and European data skewed toward the higher end of that range, predicting a rise of 26 inches (65 centimeters) by the end of this century if the current trajectory continues.

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<sup>27</sup> Available at <https://www.nationalgeographic.com/environment/global-warming/sea-level-rise/>, accessed on 10<sup>th</sup> February, 2020 at 2.32 PM.

**PLASTIC POLLUTION:** Plastic pollution, accumulation in the environment of synthetic plastic products to the point where they create problems for wildlife and their habitats as well as for human populations. In 1907 the invention of Bakelite brought about a revolution in materials by introducing truly synthetic plastic resins into world commerce. By the end of the 20th century, however, plastics were found to be persistent pollutants of many environmental niches, from Mount Everest to the bottom of the sea. Whether being mistaken for food by animals, flooding low-lying areas by clogging drainage systems, or simply causing significant aesthetic blight, plastics have attracted increasing attention as a large-scale pollutant.<sup>28</sup>

Millions of animals are killed by plastics every year, from birds to fish to other marine organisms. Nearly 700 species, including endangered ones, are known to have been affected by plastics. Nearly every species of seabird eats plastics. Most of the deaths to animals are caused by entanglement or starvation. Seals, whales, turtles, and other animals are strangled by abandoned fishing gear or discarded six-pack rings. Microplastics have been found in more than 100 aquatic species, including fish, shrimp, and mussels destined for our dinner plates. In many cases, these tiny bits pass through the digestive system and are expelled without consequence. But plastics have also been found to have blocked digestive tracts or pierced organs, causing death. Stomachs so packed with plastics reduce the urge to eat, causing starvation.

Plastics have been consumed by land-based animals, including elephants, hyenas, zebras, tigers, camels, cattle, and other large mammals, in some cases causing death.

Tests have also confirmed liver and cell damage and disruptions to reproductive systems, prompting some species, such as oysters, to produce fewer eggs. New research shows that larval fish are eating nanofibers in the first days of life, raising new questions about the effects of plastics on fish populations.<sup>29</sup>

**DRINKING WATER SCARCITY:** Water scarcity is the lack of sufficient available water resources to meet the demands of water usage within a region. It already affects every continent and around 2.8 billion people around the world at least one month out of every year. More than

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<sup>28</sup> Available at <https://www.britannica.com/science/plastic-pollution>, accessed on 10<sup>th</sup> February, 2020 at 2.37 PM

<sup>29</sup> Available at <https://www.nationalgeographic.com/environment/habitats/plastic-pollution/>, accessed on 10<sup>th</sup> February, 2020 at 2.24 PM

1.2 billion people lack access to clean drinking water.<sup>30</sup> Water covers 70% of our planet, and it is easy to think that it will always be plentiful. However, freshwater—the stuff we drink, bathe in, irrigate our farm fields with—is incredibly rare. Only 3% of the world’s water is fresh water, and two-thirds of that is tucked away in frozen glaciers or otherwise unavailable for our use.

As a result, some 1.1 billion people worldwide lack access to water, and a total of 2.7 billion find water scarce for at least one month of the year. Inadequate sanitation is also a problem for 2.4 billion people—they are exposed to diseases, such as cholera and typhoid fever, and other water-borne illnesses. Two million people, mostly children, die each year from diarrheal diseases alone.<sup>31</sup>

Many of the water systems that keep ecosystems thriving and feed a growing human population have become stressed. Rivers, lakes and aquifers are drying up or becoming too polluted to use. More than half the world’s wetlands have disappeared. Agriculture consumes more water than any other source and wastes much of that through inefficiencies. Climate change is altering patterns of weather and water around the world, causing shortages and droughts in some areas and floods in others.

**FOREST FIRE (AMAZON, KONGO):** Every year it seems like there’s another disastrous wildfire in the American West. In 2018, nearly 9 million acres were burned in the US alone. Uncontrolled fires often started accidentally by people, rampage and decimate forests. For most people, forest fire is synonymous with disaster. But there are some kinds of forest fires that actually benefit the environment. A controlled burn is a wildfire that people set intentionally for a specific purpose. Well-thought out and well-managed controlled burns can be incredibly beneficial for forest management—in part because they can help stop an out-of-control wildfire. The technique is called backburning, and it involves setting a controlled fire in the path of the approaching wildfire. All the flammable material is burnt up and extinguished. When the wildfire approaches, there’s no more fuel left for it to keep going, and it dies out.

- **AMAZON<sup>32</sup>:** The Amazon Biome spans approximately 6.7 million square kilometers, which is twice the size of India. The basin is shared by eight countries

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<sup>30</sup> Available at [www.sciencedaily.com › terms › water-scarcity](http://www.sciencedaily.com/terms/water-scarcity), accessed on 10<sup>th</sup> February, 2020 at 2.42 PM

<sup>31</sup> Available at <https://www.worldwildlife.org/threats/water-scarcity>, accessed on 10<sup>th</sup> February, 2020 at 2.43 PM.

<sup>32</sup> Available at <https://towardsdatascience.com/an-analysis-of-amazonian-forest-fires-8facca63ba69>, accessed on 10<sup>th</sup> February, 2020 at 3.44 PM.

(Brazil, Bolivia, Peru, Ecuador, Colombia, Venezuela, Guyana and Suriname), as well as the overseas territory of French Guiana. Approximately 60% of the Amazon Basin is located within Brazil, and thus the political situation in Brazil has a large impact on the region. Whilst the Amazon rainforest is far removed from most people, it contains the highest biodiversity of anywhere in the world, and is home to around 30% of the world's known species, as well as to 390 billion trees (more than 50 times the number of humans on Earth) belonging to over 16,000 different species. By the 2010 IBGE census, 817,000 Brazilians classified themselves as indigenous. Due to the plethora of species, the preponderance of trees, and the large numbers of indigenous people living predominantly within remote regions of the Amazon, these groups have the most to lose from land-use changes related to deforestation, urbanization, and forest fires. The rivers of the Amazon basin accounts for 15–16% of the world's total river discharge into the oceans. The Amazon River flows for more than 6,600 km, and with its hundreds of tributaries and streams contains the largest number of freshwater fish species in the world.

Whilst most fires in the Amazon are started by humans, this is not always the case. The three main causes of forest fires are:

- Dry environment
- Lightning strikes
- Volcanic eruptions

The only one of those that we see a lot of in the tropical Amazon is lightning strikes, and a relatively dry environment during El Nino years, which are often correlated with droughts in South America. Typically, a high moisture content prevents ignition of fires and slows their propagation, because higher temperatures are needed to evaporate any water present in the material and heat the material to its fire point.

- **CONGO:**<sup>33</sup> Across Central Africa, there's a huge smear of red that's much bigger and denser than even its Amazonian counterpart. While Brazil experienced the highest number of fire alerts over this time period, the Central African countries of Mozambique, Angola, Zambia and the Democratic Republic of Congo (DRC) all followed close behind – and each sat well ahead of the numbers in Indonesia.

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<sup>33</sup> Available at <https://news.globallandscapesforum.org/38534/how-much-should-we-worry-about-the-congo-basin-fires/>, accessed on 10<sup>th</sup> December, 2019 at 2.47 PM.

The highest number of fires in the region sit in and around the Congo Basin, which is often termed the ‘second green lung’ of the planet, after the Amazon. The Basin comprises a mosaic of rivers, forests, savannas and swamps, including the recently-discovered Cuvette Centrale peatlands, which are the biggest stretch of tropical peatlands in the world and estimated to store around 30 gigatons of carbon – equivalent to three years of global fossil fuel emissions.

## **WATER RESOURCE PROJECTS**

- **NARMADA DAM:** The Narmada Dam or Sardar Sarovar Dam, as known locally, is a gravity dam built across the Narmada river near Navagam in Gujarat. The dam is a part of the Narmada Valley Project, a large hydraulic engineering project involving the construction of a series of large irrigation and hydroelectric multi-purpose dams over the Narmada River. The project took form in 1979 as part of a development scheme to increase irrigation and produce hydroelectricity.<sup>34</sup> Gujarat remains the greatest intended beneficiary of the Narmada project after Madhya Pradesh in terms of increased irrigation; and after Madhya Pradesh and Maharashtra in hydroelectricity. However, the bulk of the displaced along the Narmada river are in Madhya Pradesh, with the project’s ambit of 30 dams. The Sardar Sarovar dam (commonly referred to as the Narmada dam) in Gujarat near its border with Maharashtra is the biggest.
- **TEHRI DAM:** Tehri Dam is the highest dam in India and fourth highest dam in the world. It is around 260.5 metre high and 592 metre long. It is part of the Tehri Dam & Hydro Power Project (the multi-purpose river valley project) taken up for construction on River Bhagirathi to tap its vast potential for irrigation and hydro-electric purposes. It is located in the Tehri district of Uttarakhand.

Tehri dam is an earth and rock fill dam. Its spillway system consists of chute spillway (consisting of three spillway radial gates) and four shaft spillways. It is designed for Probable Maximum Flood (PMF) of 15540 cumec and a drop of 220 m. The reservoir has gross storage capacity of 3540 MCM and effective storage capacity of 2615 MCM. if the dam is constructed and the flow of the sacred river impeded (the Bhagirathi becomes the holy river Ganges when it meets downstream with the Alakananda at Devaprayag), the entire Gangetic valley will suffer as a consequence.

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<sup>34</sup> Available at <https://timesofindia.indiatimes.com/topic/narmada-dam>, accessed on 10<sup>th</sup> February, 2020 at 3.47 PM.

Silt, brought down from the upper reaches of the catchment and containing valuable mineral deposits, will be caught behind the dam strangling the holy river. This has enormous consequences for all who live on the Gangetic plain; to halt the flow of this natural fertilizer could cause severe agricultural problems in the foreseeable future, possibly even famine. The Dam Authority and the Government of India's Planning Commission have not sufficiently dealt with this problem. Sunderlal Bahugana points out that the dam's social and humanitarian impacts have been totally ignored. Statistics show that over two-thirds of those to be relocated live in small villages in the valley that fall below or in the vicinity of the submergence line. In their forced relocation, no attention has been given to the breakup of village and family units. Although the government reports state that communities are to be relocated as a whole and adequate land and monetary compensation is to be given, researchers have found that this is not the case. Entire families have been split apart and deprived of their only means of economic support. The cultural survival of these "backward classes," who have lived and survived without modern technology or electricity for centuries, has been ignored.<sup>35</sup>

- **ALMATTI DAM:** Almatti Dam is a part of the Upper Krishna Project which is present in the state of Karnataka. Karnataka planned the upper Krishna project to use 4897 Mm<sup>3</sup> ( 173 TMC ) of water in two stages. In the first stage it uses 3,369 Mm<sup>3</sup> (119 TMC) and it uses 1528 Mm<sup>3</sup> (54 TMC). Narayanpur reservoir has been completed but the construction of the Almatti dam was under dispute. The Bacchawat tribunal (KWDT – I) stated that Karnataka had proposed to complete the Almatti dam in the second stage without specifying the exact full height. The Central Water Commission had given the clearance to build the Almatti dam to a height of 519 m in the first stage.<sup>36</sup>

#### **ENVIRONMENTAL DISASTERS:**

- **MINAMATA DISASTER:**<sup>37</sup> Minamata disease was first discovered in Minamata City in Kumamoto prefecture, Japan in 1956. It was caused by the release of methylmercury in the industrial wastewater (point source pollution) from the Chisso Corporation's chemical factory, which continued from 1932 to 1968. This highly toxic chemical bioaccumulated in shellfish and fish in Minamata Bay and the

<sup>35</sup> Available at <http://vikaspedia.in/energy/environment/dams-of-india/tehri-dam-1>, accessed on 10<sup>th</sup> February, 2020 at 3.48 PM.

<sup>36</sup> Available at <https://interstatedisputes.wordpress.com/2013/10/05/inter-state-water-disputes-in-india/>, accessed on 10<sup>th</sup> February, 2020 at 4 PM.

<sup>37</sup> Available at <https://www.bu.edu/sustainability/minamata-disease/>, accessed on 10<sup>th</sup> February, 2020 at 2.45 PM.

Shiranui Sea, which when eaten by the local populace resulted in mercury poisoning. While cat, dog, pig and human deaths continued over more than 30 years, the government and company did little to prevent the pollution.

As of March 2001, 2,265 victims had been officially recognized (1,784 of whom had died) and over 10,000 had received financial compensation from Chisso. By 2004, Chisso Corporation had paid \$86 million in compensation, and in the same year was ordered to clean up its contamination. Lawsuits and claims for compensation continue to this day.

A second outbreak of Minamata disease occurred in Niigata Prefecture in 1965. Both the original Minamata disease and Niigata Minamata disease are considered two of the Four Big Pollution Diseases of Japan.

- **LOVE CANAL DISASTER:** In 1978, Love Canal, located near Niagara Falls in upstate New York, was a nice little working-class enclave with hundreds of houses and a school. It just happened to sit atop 21,000 tons of toxic industrial waste that had been buried underground in the 1940s and '50s by a local company.<sup>38</sup> Public awareness of the disaster unfolded in the late 1970s when investigative newspaper coverage and grassroots door-to-door health surveys began to reveal a series of inexplicable illnesses—epilepsy, asthma, migraines, and nephrosis—and abnormally high rates of birth defects and miscarriages in the Love Canal neighborhood. As it turns out, consecutive wet winters in the late 1970s raised the water table and caused the chemicals to leach (via underground swales and a sewer system that drained into nearby creeks) into the basements and yards of neighborhood residents, as well as into the playground of the elementary school built directly over the canal. After a series of frustrating encounters with apathetic NYS officials, who were slow to act but quick to dismiss the activists (most of whom were working-class women who lived in the neighborhood) as a collection of hysterical housewives, President Jimmy Carter declared a state of emergency in 1978 and had the federal government relocate 239 families. This left 700 families who federal officials viewed as being at insufficient risk to warrant relocation, even though tests conducted by the NYS Department of Health revealed that toxic substances were leaching into their homes. After another hard battle, activists forced Carter to declare a second state of emergency in 1981,

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<sup>38</sup> Available at [http://content.time.com/time/specials/packages/article/0,28804,1986457\\_1986501\\_1986441,00.html](http://content.time.com/time/specials/packages/article/0,28804,1986457_1986501_1986441,00.html), accessed on 10<sup>th</sup> February, 202 at 2.30 PM

during which the remaining families were relocated. The total cost for relocation of all the families was \$17 million.<sup>39</sup>

- **BHOPAL GAS DISASTER, 1984:**<sup>40</sup> Bhopal is known for its historical records, artificial lakes and greenery but most of all, the city is remembered across the globe for the worst industrial mishap of the world. Post-midnight on December 3, 1984, poisonous gas that leaked from the factory of Union Carbide in Madhya Pradesh capital Bhopal killed thousands of people directly. The incident is now known as the Bhopal disaster or Bhopal gas tragedy. As per official records, the Bhopal gas tragedy killed 3,787 people. The figures were updated by the Madhya Pradesh government later as the immediate official estimate had put the death toll due to gas leak from Union Carbide factory at 2,259.

However, activists fighting for justice for Bhopal gas tragedy victims put the figures of death between 8,000 and 10,000. In an affidavit, submitted in 2006, the government said that the Bhopal gas leak caused 5,58,125 injuries that included approximately 3,900 severely and permanently disabling injuries.

The gas leak in the Union Carbide (now known as Dow Chemicals) was reported after midnight on the intervening night of December 2 and 3. The incident had taken place at the Plant Number C of the Union Carbide factory in Bhopal. As the cool morning breeze picked up pace, it carried the poisonous gas leaking from the Union Carbide factory to rest of the city and killing people - both awake and asleep. As per government's affidavit, about 3,000 people died of poisonous gas within a few hours of the incident.

- **CHERNOBYL DISASTER, 1986:** The Chernobyl Power Complex, lying about 130 km north of Kiev, Ukraine, and about 20 km south of the border with Belarus, consisted of four nuclear reactors of the RBMK-1000 design (see information page on RBMK Reactors). Units 1 and 2 were constructed between 1970 and 1977, while units 3 and 4 of the same design were completed in 1983. The accident destroyed the Chernobyl 4 reactor, killing 30 operators and firemen within three months and several further deaths later. One person was killed immediately and a second died in hospital soon after as a result of injuries received. Another person is reported to have died at the time from a coronary thrombosis. Acute radiation syndrome (ARS) was originally diagnosed in

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<sup>39</sup> Available at [https://www.geneseo.edu/history/love\\_canal\\_history](https://www.geneseo.edu/history/love_canal_history), accessed on 10<sup>th</sup> February, 2020 at 2.43 PM

<sup>40</sup> Available at <https://www.indiatoday.in/india/story/bhopal-gas-tragedy-what-had-happened-this-day-33-years-ago-that-killed-thousands-1099247-2017-12-03>, accessed on 10<sup>th</sup> February, 2020 at 3.00 PM

237 people onsite and involved with the clean-up and it was later confirmed in 134 cases. Of these, 28 people died as a result of ARS within a few weeks of the accident. Nineteen more workers subsequently died between 1987 and 2004, but their deaths cannot necessarily be attributed to radiation exposure. Nobody offsite suffered from acute radiation effects although a significant, but uncertain, fraction of the thyroid cancers diagnosed since the accident in patients who were children at the time are likely to be due to intake of radioactive iodine fallout. Furthermore, large areas of Belarus, Ukraine, Russia, and beyond were contaminated in varying degrees.<sup>41</sup>

- ✓ The Chernobyl accident in 1986 was the result of a flawed reactor design that was operated with inadequately trained personnel.
  - ✓ The resulting steam explosion and fires released at least 5% of the radioactive reactor core into the atmosphere and downwind – some 5200 PBq (I-131 eq).
  - ✓ Two Chernobyl plant workers died on the night of the accident, and a further 28 people died within a few weeks as a result of acute radiation poisoning.
  - ✓ UNSCEAR says that apart from increased thyroid cancers, "there is no evidence of a major public health impact attributable to radiation exposure 20 years after the accident."
  - ✓ Resettlement of areas from which people were relocated is ongoing. In 2011 Chernobyl was officially declared a tourist attraction.
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- **FUKUSHIMA DAIICHI NUCLEAR DISASTER, 2011:**<sup>42</sup> The Great East Japan Earthquake of magnitude 9.0 at 2.46 pm on Friday 11 March 2011 did considerable damage in the region, and the large tsunami it created caused very much more. Eleven reactors at four nuclear power plants in the region were operating at the time and all shut down automatically when the quake hit. Subsequent inspection showed no significant damage to any from the earthquake. The operating units which shut down were Tokyo Electric Power Company's (Tepco) Fukushima Daiichi 1, 2, 3, and Fukushima Daini 1, 2, 3, 4, Tohoku's Onagawa 1, 2, 3, and Japco's Tokai, total 9377 MWe net. Fukushima Daiichi units 4, 5&6 were not operating at the time, but were affected. The main problem initially centred on Fukushima Daiichi units 1-3. Unit 4 Following a major earthquake, a 15-metre tsunami disabled the power supply

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<sup>41</sup> Available at <https://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/chernobyl-accident.aspx>, accessed on 10<sup>th</sup> February, 2020 at 3.07 PM.

<sup>42</sup> Available at <https://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/fukushima-accident.aspx>, accessed on 10<sup>th</sup> February, 2020 at 3.10 PM.

and cooling of three Fukushima Daiichi reactors, causing a nuclear accident on 11 March 2011. All three cores largely melted in the first three days.

- ✓ The accident was rated 7 on the INES scale, due to high radioactive releases over days 4 to 6, eventually a total of some 940 PBq (I-131 eq).
- ✓ Four reactors were written off due to damage in the accident – 2719 MWe net.
- ✓ After two weeks, the three reactors (units 1-3) were stable with water addition and by July they were being cooled with recycled water from the new treatment plant. Official 'cold shutdown condition' was announced in mid-December.
- ✓ Apart from cooling, the basic ongoing task was to prevent release of radioactive materials, particularly in contaminated water leaked from the three units. This task became newsworthy in August 2013.
- ✓ There have been no deaths or cases of radiation sickness from the nuclear accident, but over 100,000 people were evacuated from their homes to ensure this. Government nervousness delays the return of many.
- ✓ Official figures show that there have been well over 1000 deaths from maintaining the evacuation, in contrast to little risk from radiation if early return had been allowed became a problem on day five.

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