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# ENVIRONMENTAL SCIENCE

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## UNIT 1: Environmental Studies: Ecosystems, Bio-diversity and its conservation

### CHALLENGES AND NEED FOR PUBLIC AWARENESS FOR ECOSYSTEM & ENVIRONMENT

1. **Growing Population:** A population of over thousands of millions is growing at 2.11 per cent every year. Over 17 million people are added each year. It puts considerable pressure on its natural resources and reduces the gains of development. Hence, the greatest challenge before us is to limit the population growth.
2. **Poverty:** India has often been described a rich land with poor people. The poverty and environmental degradation have a nexus between them. The vast majority of our people are directly dependent on the nature resources of the country for their basic needs of food, fuel shelter and fodder. About 40% of our people are still below the poverty line.
3. **Agricultural Growth:** The people must be acquainted with the methods to sustain and increase agricultural growth with damaging the environment. High yielding varieties have caused soil salinity and damage to physical structure of soil.
4. **Need to Ground water:** It is essential of rationalizing the use of groundwater. Factors like community wastes, industrial effluents and chemical fertilizers and pesticides have polluted our surface water and affected quality of the groundwater.
5. **Development and Forests:** Forests serve catchments for the rivers. With increasing demand of water, plan to harness the mighty river through large irrigation projects were made. Certainly, these would submerge forests; displace local people, damage flora and fauna. The tribal communities inhabiting forests respects the trees and birds and animal that gives them sustenance. We must recognize the role of these people in restoring and conserving forests. The strategies for the joint management of forests should be evolved in a well planned way.
6. **Degradation of Land:** At present out of the total 329 mha of land, only 266 mha possess any potential for production. Of this, 143 mha is agricultural land nearly and 85 suffers from

varying degrees of soil degradation. Of the remaining 123 mha, 40 are completely unproductive. The remaining 83 mha is classified as forest land, of which over half is denuded to various degrees.

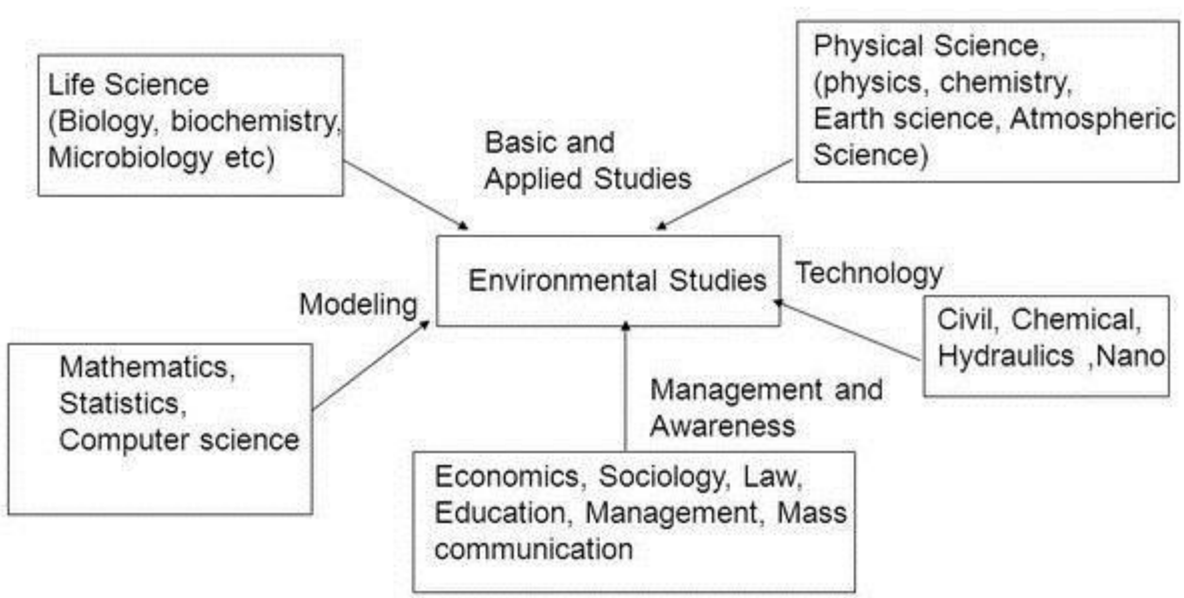
7. **Reorientation of Institutions:** The people should be roused to orient institutions, attitudes and infrastructures, to suit conditions and needs today. The change has to be brought in keeping in view India‘s traditions for resources use managements and education etc. Change should be brought in education, in attitudes, in administrative procedures and in institutions. Because it affects way people view technology resources and development.
8. **Reduction of Genetic Diversity:** Proper measures to conserve genetic diversity need to be taken. At present most wild genetic stocks have been disappearing from nature. Wilding including the Asiatic Lion are facing problem of loss of genetic diversity. The protected areas network like sanctuaries, national parks, biosphere reserves are isolating populations. Remedial steps are to be taken to check decreasing genetic diversity.
9. **Evil Consequences of Urbanisation:** Nearly 27 per cent Indians live in urban areas. Urbanisation and industrialisation has given birth to a great number of environmental problem that need urgent attention. Over 30 percent of urban Indians live in slums. Out of India‘s 3,245 towns and cities, only 21 have partial or full sewerage and treatment facilities. Hence, coping with rapid urbanization is a major challenge.
10. **Air, water and soil Pollutions:** Majority of our industrial plants are using outdated and pollution technologies and makeshift facilities devoid of any provision of treating their wastes. A great number of cities and industrial areas that have been identified as the worst in terms of air, water and soil pollution. Acts are enforced in the country, but their implement is not so easy.

## MULTIDISCIPLINARY NATURE OF ENVIRONMENTAL SCIENCES

The multidisciplinary nature of Environmental Science is imbibed in its definition that it is the study of the interaction of physical, chemical and biological components of human surroundings. To put it straight any action taken by human and its effect on the surrounding and vice versa comes under the purview of Environmental Science. Let me give an example, air pollution is a grave issue threatening the existence of life on Earth.

In recent time, considering the extent of various environmental problem like Air Pollution, Water Pollution, it is clearly observed that all these problems are somehow integrally associated. For example as the air pollution is increasing, the global temperature increases which further causes the growth of blue green algae in ponds and rivers causing eutrophication. Consideration of different variables that contribute to our immediate environment like humans, animals, insects, microbes, air, water, temperature, Sun, etc. etc. and their complex interactions are important to understand. Many theories like Gaia hypothesis, has already proven that nothing on this planet earth is isolated. We all are somehow contribute to everything else in this biosphere. There are usually rippling effects that occur when there is a disturbance to an area’s natural environment. For example, what if there is a proposal to build a housing development in an area where there is a natural forest inhabited by many indigenous organisms.

**The multidisciplinary nature of environmental science is illustrated in following diagram**




## SCOPE OF ENVIRONMENTAL STUDIES :

1) Research & Development (R & D) in environment: for cleaner technology, sustainable development, climate change mitigation strategies and environmental protection at local, regional, national and International level.
2) Green advocacy: Constitutional provisions for PIL under Article 226 (High Courts) and 32 (Supreme Court) of the Constitution for implementing various Rules, Acts and Environmental Laws (e.g. Constitutional Provisions in Article 48A and Article 51A(g), Wildlife Protection Act 1972, Forest Conservation Act 1980, Water Act 1974 which created CPCB & SPCBs, Air Act 1981, Environmental protection Act 1986, etc.) ,
3) Green marketing: for quality products with ISO mark viz. ISO 14000 certification
4) Green media: like TV, Radio, Newspapers, Magazines, research journals, hoardings etc for environmental education
5) Environmental consultancy: for environmental protection involving citizens, NGO and Government sector. In M C Mehta v. Union of India in 1988, Hon’ble Supreme Court of India made environmental studies as mandatory subject for UG students. Advocate M C Mehta (known as :green advocate”) and Mr Justice Kuldeep Singh (known as “green Judge”) done lot of legal work for important environmental justice through various Public Interest Litigations (PILs).

**IMPORTANCE OF ENVIRONMENTAL STUDIES DUE to:**

**1) International Issues: climate change, global warming, ozone depletion etc.**

**2) Problems associated with infra structure and facilities development activities**

**3) Pollution problems (air, water, soil, noise etc) and challenges for control.**

**4) Need for an alternative solution**

**5) Possibilities for species extinction**

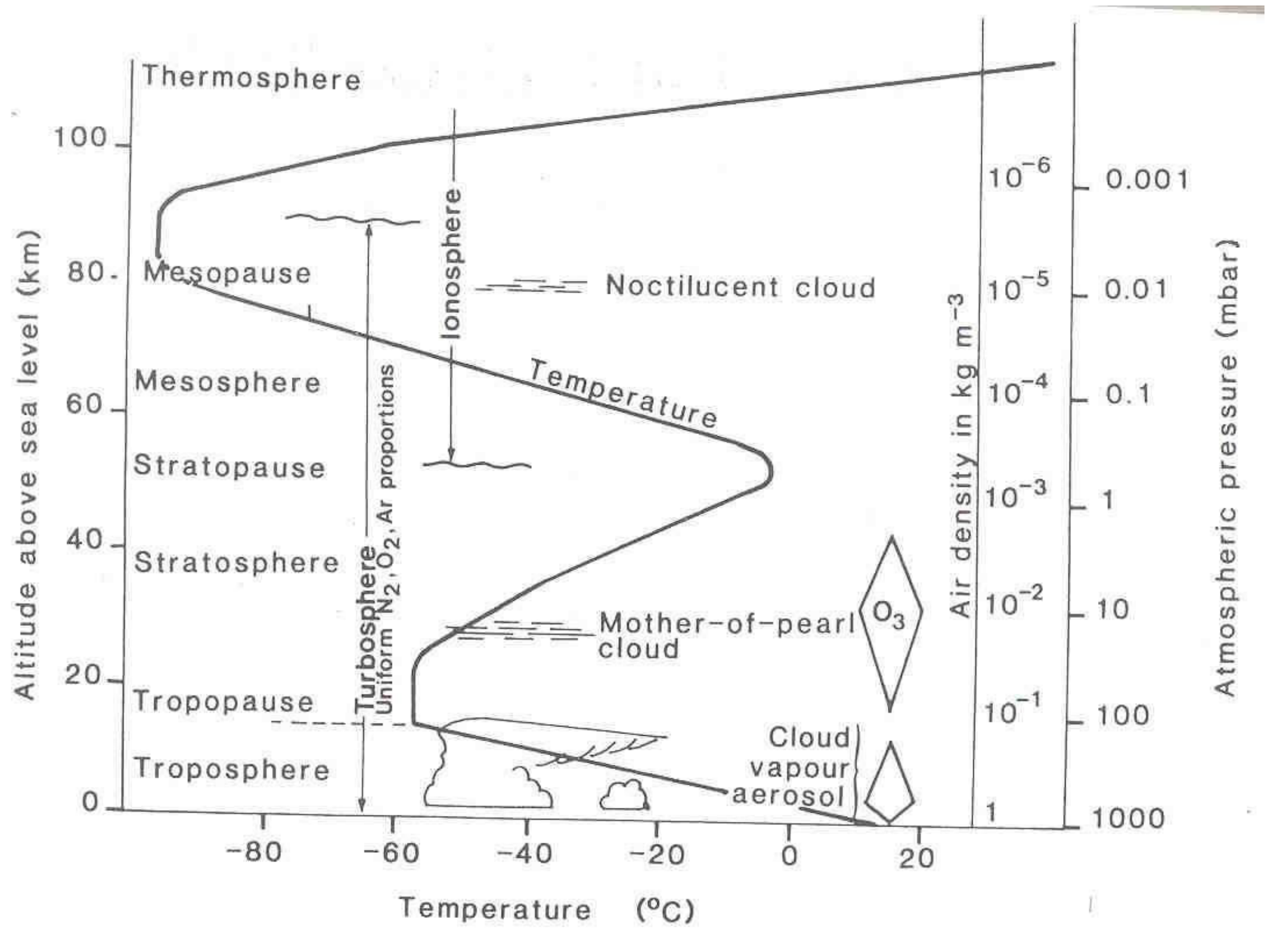
**6) Wise planning**

**7) Various scientific reports.**

## *ENVIRONMENT & its COMPONENTS*

Environment is the ***—sum total of water, air and land and inter-relationship that exist among them and with the human beings, other living organisms and materials‖***. Four components of environment are: **Atmosphere** (contains gases and weather conditions), **Lithosphere** (soil system), **Hydrosphere** (water systems) and **Biosphere** (life exists only in this component). Physical environment supports life on earth. The atmosphere that surrounds our planet Earth contains the right proportions of gases that are absolutely essential for life, one of those gases is oxygen, making up 21 percent of the air we breathe, and without it humans and animals die within minutes. The lithosphere is very important because it is a large reservoir of resources, which are so useful to man. The majority of the material objects which man requires are supplied by lithosphere. The lithosphere serves as a *source of minerals.* The minerals supply the basic materials required for making a variety of commodities, which man uses daily. The lithosphere is also the major *source of fuels* such as coal, petroleum and a natural gas. Without these fuels human life, as we know it today, would have been impossible. The lithosphere in combination with the hydrosphere and the atmosphere plays a vital role in the growth of plants and animals. It *provides nutrients to the plants.* The plants are the source of food for man and all other animals. The biological environment as the name indicates refers to the various floras (plants), fauna (animals) and microbes (micro organisms) that are found in our surroundings. For defining "Environment", it is important to understand 3 things: (i) what is surrounded (ii) by what surrounded (iii) where surrounded.

# *STRUCTURE OF ATMOSPHERE*




| **Region** | Altitude (Km) [approx.] | Temp. (°C) [approx.] | Important chemical species | Separated from next layer via |
|---|---|---|---|---|
| **Troposphere** | 0-16 | 50 to -56 | N2, O2, CO2, H2O | Tropopause |
| **Stratosphere (*ozonosphere*)** | 16-65 | -56 to -2 | O3 | Stratopause |
| **Mesosphere** | 65-90 | -2 to -92 | O2+ , NO+ | Mesopause |
| **Thermosphere (*include*** | 90-500 | -92 to 1200 | O2+ , NO+ , O+ | Thermopause |
| **Exosphere** | 500-10,000 | > 1200 | H, He | |

## FOOD CHAINS AND FOOD WEB

The many relationships between the members of a community in an ecosystem can be described by food chains and webs. Each stage in a food chain is called a trophic level, and the arrows represent the flow of energy and matter through the food chain. Food chains always start with photosynthetic producers (plants, algae, plankton and photosynthetic bacteria). Example: Autotrophs/ primary producers (grass or plants)→primary consumers(grass-hopper)→ secondary consumers(frog)→ tertiary consumers(snake)→ quaternary consumers (eagle).

**Importance of food chain & food web:**

(i) The food chains helps in understanding food relationship among the different organisms in an ecosystem (ii) The food chains are the living components of the biosphere (iii) These are the vehicles of transfer of energy from one level to another (iv) Through the food chains, transfer of materials and nutrients also takes place (v) Energy flow in ecosystem can be understood via food chain (vi) The movement of some toxic substances (like DDT) in the ecosystem, sprayed to kill the pests and insects, through the various trophic levels, their accumulation at the highest trophic level, etc. can be studied.(vii) Living marine resources are found at all levels of the food chain/web (viii) Each organism can be classified as a producer or consumer; animals may be predators as well as prey (ix) Decomposers are important consumers in food chains and webs, breaking down remains of dead organisms into simpler chemical substances for uptake by the producers (x) Food chains are useful for environmental pollution management directly or indirectly (xi) Food chains are important to understand interactions among species (competition+ -, predator/prey+ -,herbivory+ -, parasitism+ -, symbioses/mutualism+ +, commensalism+ o) (xii) Food chains maintain populations of different species at each trophic level and keep ecological balance.

In nature, ***three types of food chains*** have been distinguished: (a) **Grazing food chain:** The consumers, which start the food chain, utilizing the plant or plant part as their food, constitute the grazing food chain. This food chain begins from green plans at the base and the primary consumer is herbivore, for example: grass -> grasshopper -> birds -> hawks or falcon; (b) **Parasitic food chain:** It also begins from green plant base, and then goes to herbivores, which for example may be host of a huge number of lice, which live as ecotoparasites; (c) **Detritus food chain:** The food chain starts from dead organic matter of decaying animals and plant bodies to the microorganisms and then to detritus feeding organism derivers, and to other predators. Energy flow in an ecosystem is a one-way process.

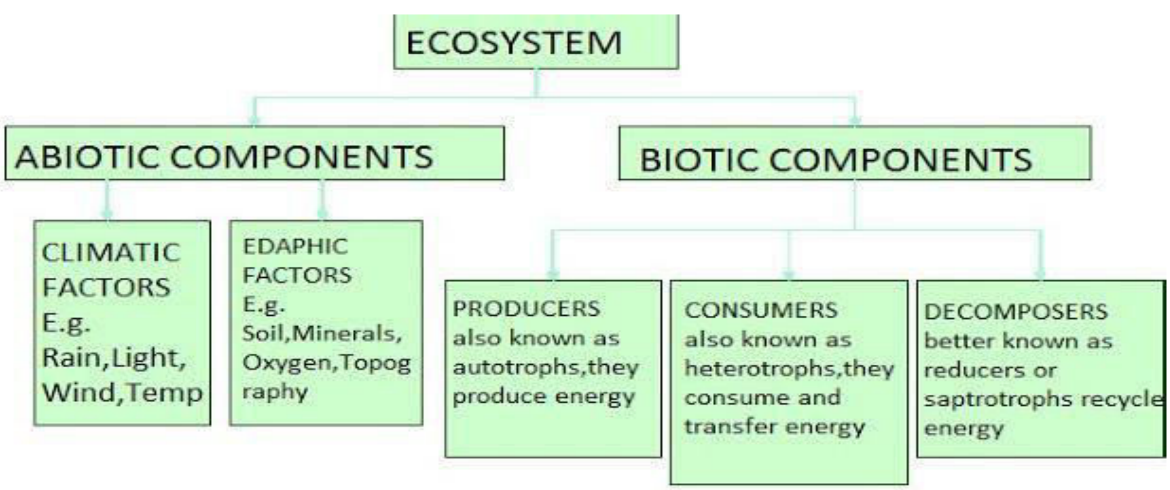
| **Organisms** | ***Source of cell carbon*** | ***Source of energy*** |
|---|---|---|
| ***Autotrophs*** | Inorganic source (CO2, HCO3) | Sun |
| ***Heterotrophs*** | Organic matter (OM) | Organic matter (OM) |
| ***Chemotrophs*** | Inorganic and/ or organic matter | Oxidation of simple inorganic compounds (FeS, H2S) |

# ***ECOSYSTEM***

Ecosystem is basic functional unit of ecology. An **ecosystem** (ecosphere) is a community of living organisms (plants, animals and microbes) in conjunction with the nonliving components of their environment (things like air, water and mineral soil), interacting as a system. These biotic and abiotic components are regarded as linked together through nutrient cycles and energy flows. As ecosystems are defined by the network of interactions among organisms, and between organisms and their environment; ecosystems are controlled both by external and internal factors. External factors such as climate, the parent material which forms the soil and topography, control the overall structure of an ecosystem and the way things work within it, but are not themselves influenced by the ecosystem. Other external factors include time and potential biota. Ecosystems are dynamic entities—invariably, they are subject to periodic disturbances and are in the process of recovering from some past disturbance. Arthur Tansley coined term "ecosystem". *Stability of an ecosystem* mainly depends on food energy that passes through the food web [$S= -\Sigma$ pi log pi, where S= Stability of ecosystem, pi= food energy that passes through the food web]. Connectance (C) determines the relationship between number of species (Ns) and trophic link (tL) i.e. $C=tL/ Ns(Ns-1)/2$; connectance is hyperbolic function of number of species.

***Biotic components*** are the living things that shape an ecosystem. A **biotic factor** is any living component that affects another organism, including animals that consume the organism in question, and the living food that the organism consumes. Biotic factors (producers/ autotrophs, heterotrophs/ consumers, decomposers/ microbes etc) include human influence. Biotic components usually include: (i) Producers,
i.e. autotrophs: e.g. plants; they convert the energy (from the sun, or other sources such as hydrothermal vents) into food; (ii) Consumers, i.e. heterotrophs: e.g. animals; they depend upon producers for food; (iii) Decomposers, i.e. detritivores: e.g. fungi and bacteria; they break down chemicals from producers and consumers into simpler form which can be reused.

***Abiotic components*** are non-living components of an organism's environment, such as temperature, light, moisture, air currents, etc.



**Abiotic and Biotic Factors in an Ecosystem**

An ecosystem consists of the biological community of living organisms (biotic) and non-living organisms (abiotic) that occurs in a specific locale, and the physical and chemical factors that make up the environment.

| Abiotic Factors | Biotic Factors |
|---|---|
| Sunlight | Photosynthetic Organisms (i.e. Primary producers) |
| Temperature | Herbivores |
| Precipitation | Carnivores |
| Water or Humidity | Omnivores |
| Soil or water chemistry (e.g., Phosphorous, CO2) | Decomposers |

**Energy transformations** and **biogeochemical cycling** are the main processes that occur in an ecosystem.

Part of what sustains an ecosystem is the constant interchange of matter between its living (biotic) and non-living or 'physical' (abiotic) components. Sustainable ecosystems are dependent upon physical factors such as precipitation, humidity or the lack of, sunlight, temperature, rocks and sedimentary deposits, soil, and overall temperature. These abiotic components play a critical role in shaping the biotic factors which are also present within ecosystems such as plants and animals each of which are adapted to the specific climate and geography of the region in question.

## TYPES/ KINDS OF ECOSYSTEMS

There are essentially two kinds of ecosystems; ***Terrestrial*** and ***Aquatic***. Any other sub-ecosystem falls under one of these two headings:

[A] **TERRESTRIAL ECOSYSTEMS:** Terrestrial ecosystems can be found anywhere apart from heavily saturated places. They are diverse types of ecosystems and location usually dependent on the latitude of the area, and amount of precipitation. They are broadly classed into:

(i) **The Forest Ecosystems:** They are the ecosystems in which an abundance of flora, or plants, is seen so they have a big number of organisms which live in relatively small space. They are further divided into:

(a) **Tropical Rain Forest:** Precipitation - 250cm/year; little temperature variation/abundant moisture; contains more species than other biomes.

(b) **Tropical evergreen forest:** These are tropical forests that receive a mean rainfall of 80 for every 400 inches annually. The forests are characterized by dense vegetation which comprises tall trees at different heights. Each level is shelter to different types of animals.

(c) **Tropical deciduous forest:** There, shrubs and dense bushes rule along with a broad selection of trees. The type of forest is found in quite a few parts of the world while a large variety of fauna and flora are found there.

(d) **Temperate evergreen forest:** Those have quite a few number of trees as mosses and ferns make up for them. Trees have developed spiked leaves in order to minimize transpiration.

(e) **Temperate deciduous forest:** The forest is located in the moist temperate places that have

sufficient rainfall. Summers and winters are clearly defined and the trees shed the leaves during the winter months.
(f) **Taiga:** Situated just before the arctic regions, the taiga is defined by evergreen conifers. As the temperature is below zero for almost half a year, the remainder of the months, it buzzes with migratory birds and insects.
(ii) **Desert Ecosystem:** Desert ecosystems are located in regions that receive an annual rainfall less than 25 cm/ year. They occupy about 17 percent of all the land on our planet. Dry, sparce vegetation; scattered grasses; eg. Parts of Africa, Asia, Australia, North America. Due to the extremely high temperature, low water availability and intense sunlight, fauna and flora are scarce and poorly developed. The vegetation is mainly shrubs, bushes, few grasses and rare trees. The stems and leaves of the plants are modified in order to conserve water as much as possible. Example: succulents such as the spiny leaved cacti. The animal organisms include insects, birds, camels, reptiles all of which are adapted to the desert (xeric) conditions.
(iii) **Grassland Ecosystem:** Grasslands are located in both the tropical and temperate regions of the world though the ecosystems vary slightly. The area mainly comprises grasses with a little number of trees and shrubs. The main vegetation includes grasses, plants and legumes that belong to the composite family. The two main kinds of grasslands ecosystems are: (1) **Savanna:** The tropical grasslands are dry seasonally and have few individual trees. They support a large number of predators and grazers. Precipitation 90-150cm/year; open, widely spaced trees, seasonal rainfall; eg. Parts of Africa, South America & Australia; (2) **Prairies:** It is temperate grassland, completely devoid of large shrubs and trees. Categories of Prairies : mixed grass, tall grass and short grass prairies.
**(iv) Mountain Ecosystem:** Mountain land provides a scattered and diverse array of habitats where a large number of animals and plants can be found. At the higher altitudes, the harsh environmental conditions normally prevail, and only the treeless alpine vegetation can survive. The animals here have thick fur coats for prevention from cold and hibernation in the winter months. Lower slopes have coniferous forests.
**[B] AQUATIC ECOSYSTEMS:** The aquatic ecosystem is the ecosystem found in a body of water. It encompasses aquatic flora, fauna and water properties, as well. The ecosystems are habitats to reptiles, amphibians and around 41% of the world's fish species. There are two main types of aquatic ecosystem - ***Marine*** and ***Freshwater***.
(a) **Marine Ecosystem:** Marine ecosystems are the biggest ecosystems, which cover around 71% of Earth's surface and contain 97% of out planet's water. Water in Marine ecosystems features in high amounts minerals and salts dissolved in them. Many kinds of organisms live in marine ecosystems: the brown algae, corals, cephalopods, echinoderms, dinoflagellates and sharks. The different divisions of the marine ecosystem are: (1) *Oceanic*: lies on the continental shelf; very large amount of earth is covered by ocean (~75%), 40% of all photosynthesis occurs in oceans; (2) *Profundal*: deep or Bottom water; (3) *Benthic:* Bottom substrates; (4) *Inter-tidal*: The place between low and high tides; (5) *Estuaries; (6) Coral reefs; (7) Salt marshes* ; (8) *Hydrothermal vents* where chemosynthetic bacteria make up the food base.
(b) **Freshwater Ecosystem: F**reshwater ecosystem covers only 0.8% of Earth's surface and contains 0.009% of the total water. Three basic kinds of freshwater ecosystems exist: (1) *Lentic*: Slow-moving or till water like pools, lakes or ponds; (2) *Lotic*: Fast-moving water such as streams and rivers; (3) *Wetlands*: Places in which the soil is inundated or saturated for some lenghty period of time.

## ECOSYSTEM FUNCTIONS

| Ecosystem Category Function | Ecosystem Function | Description |
|---|---|---|
| **Regulating Functions** | Gas Regulation | Relates to the influence of natural and managed systems in relation to biogeochemical processes including greenhouse gases, photo-chemical smog and volatile organic compounds (VOCs). |
| | Climate Regulation | Influence of land cover and biological mediated processes that regulate atmospheric processes and weather patterns which in turn create the microclimate in which different plants and animals (including humans) live and function. |
| | Disturbance Regulation | The capacity of the soil, regolith and vegetation to buffer the effects of wind, water and waves through water and energy storage capacity and surface resistance. |
| | Water Regulation | The influence of land cover, topography, soils, hydrological conditions in the spatial and temporal distribution of water through atmosphere, soils, aquifers, rivers, lakes and wetlands. |
| | Soil Retention | Minimising soil loss through having adequate vegetation cover, root biomass, retaining rocks and soil biota. |
| | Nutrient Regulation | The role of ecosystems in the transport, storage and recycling of nutrients. |
| | Waste Treatment and Assimilation | The extent to which ecosystems are able to transport, store and recycle certain excesses of organic and inorganic wastes through distribution, assimilation, transport and chemical recomposition. |
| | Pollination | Pollination is the interaction between plants and (1) biotic vectors (e.g. insects, birds and mammals) and (2) abiotoic vectors (e.g. wind and water) in the movement of male gametes for plant production. Pollination and seed dispersal are linked. |
| | Biological | The interactions within biotic communities that act as restraining forces to control populations of potential pests and disease vectors. This function consists of natural |

| | | |
|---|---|---|
| | Control | and biological control mechanisms. |
| | Barrier Effect of Vegetation | Vegetation impedes the movement of airborne substances such as dust and aerosols (including agricultural chemicals and industrial and transport emissions), enhances air mixing and mitigates noise. |
| **Supporting Functions** | Supporting Habitats | Preservation of natural and semi natural ecosystems as suitable living space for wild biotic communities and individual species. This function also includes the provision of suitable breeding, reproduction, nursery, refugia and corridors (connectivity) for species. |
| | Soil Formation | Soil formation is the facilitation of soil formation processes. Soil formation processes include the chemical weathering of rocks and the transportation and accumulation of inorganic and organic matter. |
| **Provisioning Functions** | Food | Biomass that sustains living organisms. Material that can be converted to provide energy and nutrition. Mostly initially derived from photosynthesis. |
| | Raw Materials | Biomass that is used by species for any purpose other than food. |
| | Water Supply | The role of ecosystems in providing water through sediment trapping, infiltration, dissolution, precipitation and diffusion. |
| | Genetic Resources | Self maintaining diversity of organisms developed over evolutionary time (capable of continuing to change). Measurable at species, molecular and sub molecular levels. |
| | Provision of Shade and Shelter | Relates to vegetation that ameliorates extremes in weather and climate at a local landscape scale. Shade or shelter is important for plants, animals and structures. |
| | Pharmacological Resources | Natural materials that are or can be used by organisms to maintain, restore or improve health (natural patterns can be copied by humans for synthetic products). |
| **Cultural Functions** | Landscape Opportunity | The extent and variety of natural features and landscapes. |

# ***ECOSYSTEM REGULATION for balanced ecosystem***

An ecosystem is balanced if there is continuous flow of matter and energy in food web and ecosystem so that number of species at each trophic level remains properly maintained. All Ecosystems regulate to maintain themselves under a set of environmental conditions. Also known as Biological Equilibrium. Any environmental stress tries to disturb the normal ecosystem, the ecosystem, by itself tries to resist the change and maintain itself in equilibrium, this property is known as HOMEOSTASIS. is the property of a system in which variables are regulated so that internal conditions remain stable and relatively constant. Examples of homeostasis include the regulation of temperature and the balance between acidity and alkalinity (pH). It is a process that maintains the stability of the human body's internal environment in response to changes in external conditions. Homeostasis requires a sensor to detect changes in the condition to be regulated, an effector mechanism that can vary that condition; and a negative feedback connection between the two. Feedback and regulation are self related. The negative feedback helps to maintain stability in a system in spite of external changes. It is related to homeostasis. The system can show this tolerance or resistance only within a max. or min. range. This range of tolerance is known as Homeostatic Plateau. The increase in the population of the organisms at the different levels increases the population of organisms at a lower level and is known as the positive feedback mechanism. For example:- When the population of plants increases it leads to increase in the population of herbivore animals. It increases the population of frogs and birds. Deviation counteracting mechanisms which try to bring the system back its ideal conditions, this is known as negative feed back mechanism. For example:- The increased population of insectivorous animals acts on the herbivorous insect by the process of predation. If any stress tries to disturb this equilibrium then the system has its own mechanism to counteract this disturbance which are known as counter mechanism. Ecological Succession (ecological dynamics) occurs because it is the process of life for plants, soil and other living organisms. Because organisms alter soil structure, chemistry, and microclimates, the species composition of ecological communities constantly changes over time. Succession will continue until the environment reaches it‘s final stage…the Climax Community. During Primary Succession, soil starts to form as lichens and the forces of weather and erosion help break down rocks into smaller pieces, when lichens die, they decompose, adding small amounts of organic matter to the rock to make soil Simple plants like mosses and ferns can grow in the new soil. The simple plants die, adding more organic matter. Secondary Succession begins in a place that already has soil and was once the home of living organisms Occurs faster and has different pioneer species than primary succession Example: After forest fires, the soil remains intact, thus, the area return to its natural community. Because these habitats previously supported life, secondary succession, begins on substrates that already bear soil. In ***Climax Community, a*** stable group of plants and animals that is the end result of the succession process Does not always mean big trees Grasses in prairies Cacti in deserts. Any ecosystem, no matter how inherently stable and persistent, could be subject to massive external disruptive forces (like fires and storms) that could re-set and re-trigger the successional process. As long as these random and potentially catastrophic events are possible, it is not absolutely accurate to say that succession has stopped.

# ***ENERGY FLOW IN FOOD CHAIN AND ECOSYSTEM***

**Energy flow**, also called the **calorific flow**, refers to the flow of energy through a food chain. In an ecosystem, ecologists seek to quantify the relative importance of different component species and feeding relationships. Energy is ability to do work. $E=mc^2$; where E is energy, m is mass and c is velocity of light. Only 150 millionth of sun's tremendous energy output reaches the earth's atmosphere at a constant rate of 1.4 $KJ/m^2.s$ (approx. 2 cal/cm2/min). This is called solar flux/ solar constant. Energy flow is UNIDIRECTIONAL (one way: producer →consumer →decompose). All organisms require energy for growth, maintenance, reproduction, locomotion, etc.; hence, for all organisms there must be a source of energy and a loss of usable energy. 99% of the energy used by living cells comes from the sun. Incorporation of sunlight into chemical bonds occurs through the process of photosynthesis "Invented" by cyanobacteria about 2 billion years ago.

[i] Solar energy is fixed by the photoautotrophs, called primary producers, like green plants through photosynthesis [$6CO_2+12H_2O$+2800KJ (673 Kcal) →$C_6H_{12}O_6+6O_2$]. Primary consumers absorb most of the stored energy in the plant through digestion, and transform it into the form of energy they need, such as adenosine triphosphate (ATP), through respiration. Respiration is reverse / opposite to photosynthesis [$C_6H_{12}O_6+6O_2→6CO_2+12H_2O$ +usable energy]. ***Solar energy provides practically all the energy for ecosystems. An Ecosystem can not survive without the constant input of energy from the sun.***
[ii] Secondary consumers, carnivores, then consume the primary consumers, although omnivores also consume primary producers. [iii] Tertiary consumers, consume the secondary consumers, with some energy passed on and some lost..
[iv] A final link in the food chain are decomposers which break down the organic matter of the tertiary consumers (or whichever consumer is at the top of the chain) and release nutrients into the soil. Saprotrophic bacteria and fungi are decomposers, and play a pivotal role in the nitrogen and carbon cycles. ***Organic compounds, such as proteins, carbohydrates, lipids, and other complex molecules, form a link between biotic and abiotic components of the system.***

The energy is passed on from trophic level to trophic level and each time about 90% of the energy is lost, with some being lost as heat into the environment (an effect of respiration) and some being lost as incompletely digested food (egesta). Therefore, primary consumers get about 10% of the energy produced by autotrophs, while secondary consumers get 1% and tertiary consumers get 0.1%. ***Percentage of energy transferred from one trophic level to the next is known as ecological efficiency (≈10 %).***

Trophic levels are the nourishment levels in a food chain. Biomass is the dry mass of organic material in the organism(s) [the mass of water is not usually included, since water content is variable and contains no usable energy]. Standing crop is the amount of biomass present at any point in time. Primary productivity is the rate of energy capture by producers (= the amount of new biomass of producers, per unit time and space). Gross primary production (GPP) = total amount of energy captured; Net primary production (NPP) = GPP – respiration. Net primary production is thus the amount of energy stored by the producers and potentially available to consumers and decomposers. Gross primary production (GPP) is measured by different methods viz. harvest method, $CO_2$ assimilation, $O_2$ production, radioisotopes and other methods. GPP (solar energy assimilated by photosynthesis)=NPP (chemical energy) +R (heat energy of respiration). If GPP=R, there is no change in energy content; when GPP<R, biomass decreases; when GPP>R, biomass accumulates.

**<u>There are 3 energy flow models:</u>**

[I] ***Universal energy flow model***

***[II] Single channel energy flow model***

***[III] Double channel energy flow model or Y-shaped energy flow model***

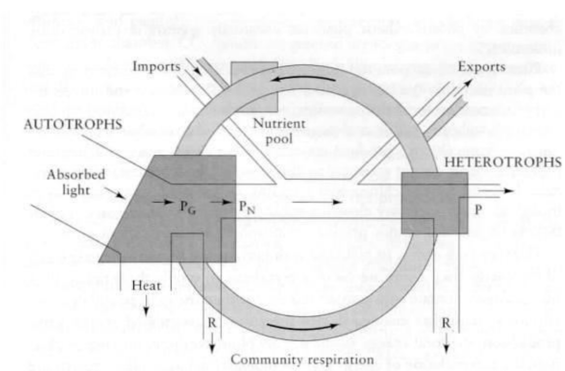
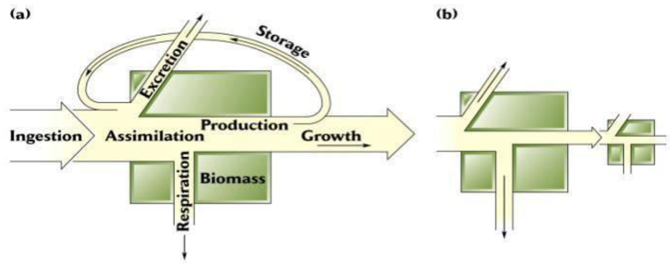
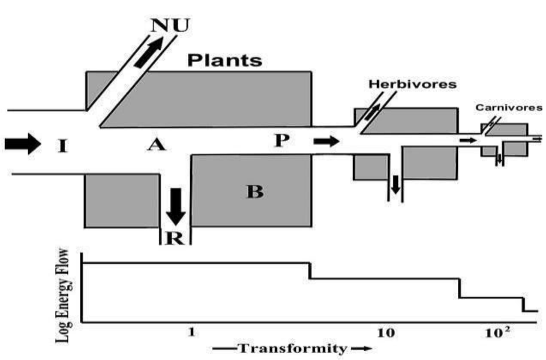
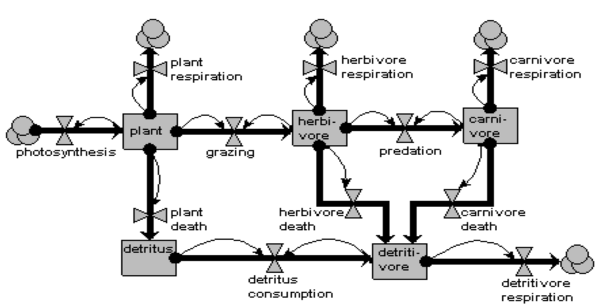



FIGURE E. P. Odum's flow diagram of an ecosystem showing the one-way flow of energy and the recycling of materials. $P_G$ = gross production, $P_N$ = net production, P = heterotrophic production, and R = respiration.




I=input energy; B=biomass; A=assimilated energy; P=production; NU=energy not used (lost in locomotion, exercise etc); R=respiration

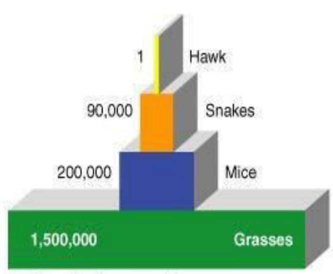
Y-shaped energy flow model shows the passage of energy through 2 chains which are separated in time and space. Double channel energy flow model or Y-shaped energy flow model are more realistic and practical working models than single channel energy flow model because (i) it confirms to basic stratified structure of ecosystem (ii) it separates the grazing and detritus food chains, in both time & space (iii) micro- consumers and macro-consumers differs greatly in size metabolism relations.

## ***ECOLOGICAL PYRAMIDS***

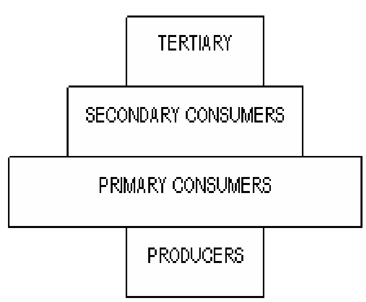
An **ecological pyramid** (also **trophic pyramid**) or *Eltonian pyramid* is a graphical representation designed to show the number of species, biomass or biomass productivity and energy content and flow at each trophic level in a given ecosystem. Charles Elton developed the concept of ecological pyramid. Ecological pyramids begin with the producers at the bottom (such as plants) and proceed through the various trophic levels (such as herbivores that eat plants, then carnivores that eat herbivores, then carnivores that eat those carnivores, and so on). *Biomass* is the amount of living or organic matter present in an organism. *Biomass pyramids* show how much biomass is present in the organisms at each trophic level, while *productivity pyramids* show the production or turnover in biomass. The highest level is the top of the food chain. An *ecological pyramid of biomass* shows the relationship between biomass and trophic level by quantifying the biomass present at each trophic level of an ecological community at a particular time. It is a graphical representation of biomass (total amount of living or organic matter in an ecosystem) present in unit area in different tropic levels. Typical units are grams per meter$^2$, or calories per meter$^2$.

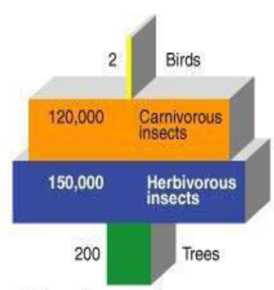
There are three types of ecological pyramids as follows: **(1) Pyramid of number (2) Pyramid of biomass (3) Pyramid of energy/ Productivity.**

**[1] Pyramid of number:** When plotted the relationships among the number of producers, primary consumers (herbivores), secondary consumers (carnivore of order 1), tertiary consumers (carnivore of order 2) and so on in any ecosystem, it forms a pyramidal structure called the pyramid of number. The shape of this pyramid varies from ecosystem to ecosystem. There are three types of pyramid of numbers (a) Upright (b) Partly upright (c) Inverted



(a) Grassland community

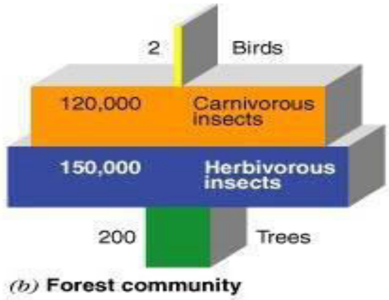


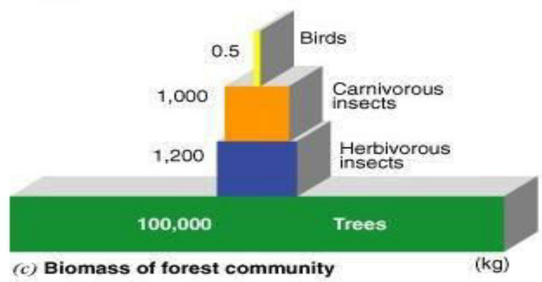



(b) Forest community

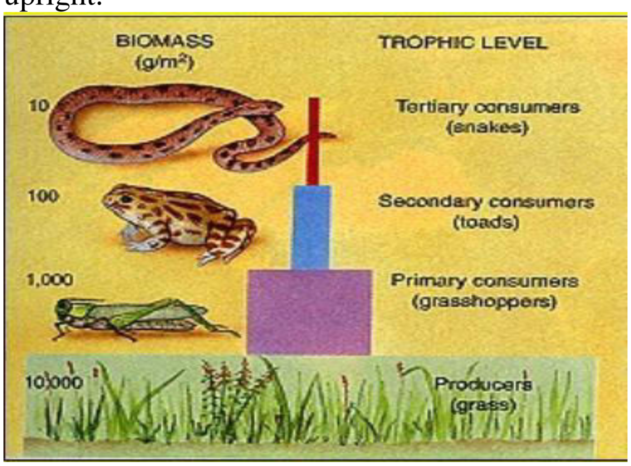
**[2] Pyramids of biomass:** When we plot the biomass (net dry weight) of producers, herbivores, carnivores and so on we have a pyramid of biomass. Two types of pyramid of biomass are found (a) Upright (b) Inverted. (a) ***Upright Pyramid of Biomass***: When larger weight of producers support a smaller weight of consumers an upright pyramid results. eg forest ecosystem.

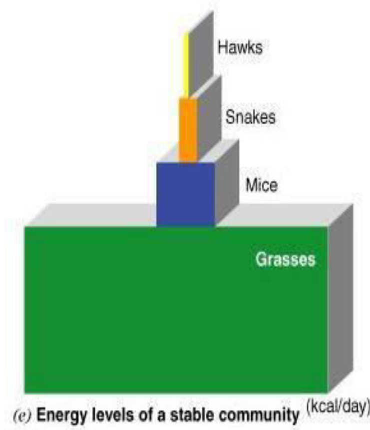
(b) ***Inverted Pyramid of Biomass***: When smaller weight of producers supports larger weight of consumers an inverted pyramid of biomass is formed eg aquatic ecosystem.




**[3] Pyramids of energy/ Productivity:** The pyramid of energy is drawn after taking into consideration the total quantity of energy utilized by the trophic levels in an ecosystem over a period of time. As the quantity of energy available for utilization in successive trophic levels is always less because there is loss of energy in each transfer, the energy pyramid will always be upright.




An *ecological pyramid of productivity* is often more useful, showing the production or turnover of biomass at each trophic level. When energy is transferred to the next trophic level, typically only 10% of it is used to build new biomass, becoming stored energy (the rest going to metabolic processes). The advantages of the *pyramid of productivity* as a representation: (i) It takes account of the rate of production over a period of time; (ii) Two species of comparable biomass may have very different life spans. Thus a direct comparison of their total biomasses is misleading, but their productivity is directly comparable; (iii) The relative energy chain within an ecosystem can be compared using pyramids of energy; also different ecosystems can be compared; (iii) There are no inverted pyramids; (iv) The input of solar energy can be added. The disadvantages of the *pyramid of productivity* as a representation: (i) The rate of biomass production of an organism is required, which involves measuring growth and reproduction through time; (ii) There is still the difficulty of assigning the organisms to a specific trophic level. As well as the organisms in the food chains there is the problem of assigning the decomposers and detritivores to a particular trophic level. Nonetheless, productivity pyramids usually provide more insight into an ecological community when the necessary information is available.

## ***Biodiversity & its importance***

Biodiversity, or biological diversity, is the variety of all species on earth. It is the different plants, animals and micro-organisms, their genes, and the terrestrial, marine and freshwater ecosystems of which they are a part. Biodiversity is the life support system of our planet- we depend on it for the air we breathe, the food we eat, and the water we drink. Biodiversity is ―variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part‖.

## Threats to Biodiversity:

Increasing population pressure and over-exploitation of the biotic resources is taking their toll on biodiversity leading to its loss. The major threats to biodiversity decline are land use changes, pollution, changes in atmospheric $CO_2$ concentrations, changes in the nitrogen cycle and acid rain, climate alterations, and the introduction of exotic species, all coincident to human population growth.

For rainforests, the primary factor is land conversion. Climate will probably change least in tropical regions, and nitrogen problems are not as important because growth in rainforests is usually limited more by low phosphorus levels than by nitrogen insufficiency.

The introduction of exotic species is also less of a problem than in temperate areas because there is so much diversity in tropical forests that newcomers have difficulty becoming established.

**Let us consider some of the major causes and issues related to threats to biodiversity:**

**1. Habitat destruction:**

As recently as 30 years ago, most of the regions in these biodiversity hotspots were inaccessible and remote. Now, due to better infrastructure, contact of these areas with humans has increased. Activities such as logging of wood, increased agriculture, increased human habitation has led to destruction of forests and pollution of rivers.

These factors are causing species ranges to reduce and habitats to become choppy. The government planned to establish habitat corridors, but these plans have not yet materialized in most areas. Activities such as mining, construction of large dams, highway construction has also caused significant destruction of habitats.

**2. Resource mismanagement:**

Increased tourism without proper regulation has led to pollution and environmental degradation. Prime examples are pilgrimage destinations like Rishikesh and hill stations like Dehradoon.

These spots, once nestled in the pristine ranges of the Himalayas, are now dirty commercial destinations. Places like Dehradoon are even experiencing a construction boom so large that illegal immigrants from Bangladesh are also flocking there.

**3. Poaching:**

Large mammals such as the tiger, rhinoceros and the elephant once faced the distinct possibility of complete extinction due to rampant hunting and poaching. However, efforts by conservationists since the 1970s have helped stabilize and grow these populations. Still, the trade in tiger hides, elephant tusks, tiger teeth, and rhinoceros horn remains profitable and rampant.

**4. Global Warming:**

There is recent evidence that climate changes are having effects on tropical forest ecology. Warming in general (as distinct from the effects of increasing concentrations of CO2 and other greenhouse gases) can increase primary productivity, yielding new plant biomass, increased organic litter, and increased food supplies for animals and soil flora (decomposers).

Temperature changes can also alter the water cycle and the availability of nitrogen and other nutrients. Basically, the temperature variations which are now occurring affect all parts of forest ecosystems, some more than others. These interactions are unimaginably complex.
While warming may at first increase net primary productivity (NPP), in the longer run, because plant biomass is increasing, more nitrogen is taken up from the soil and sequestered in the plant bodies. This leaves less nitrogen for the growth of additional plants, so the increase in NPP over time (due to a rise in temperature or $CO_2$ levels) will be limited by nitrogen availability.
The same is probably true of other-mineral nutrients. The consequences of warming-induced shifts in the distribution of nutrients will not be seen| rapidly, but perhaps only over many years. These events may affect changes] in species distribution and other ecosystem processes in complex ways.
We know little about the reactions of tropical forests, but they may differ from those of temperate forests. In tropical forests, warming may be more important because of its effects on evapotranspiration and soil moisture levels than because of nutrient redistribution.
The migratory patterns of some birds which live in both tropical and temperate regions during the year seem to be shifting, which is dangerous for these species, as they may arrive at their breeding or wintering grounds at an inappropriate time.
Or they may lose their essential interactions with plants which they pollinate or their insect or plant food supplies. Perhaps for these reasons, many migratory species are in decline, and their inability to coordinate migratory clues with climatic actualities may be partly to blame.
Also, as temperatures rise, some bird populations have shifted, with lowland and foothill species moving into higher areas. The consequences for highland bird populations are not yet clear. And many other organisms, both plant and animal, are being affected by warming.
An increase in infectious diseases is another consequence of climate change, since the causative agents are affected by humidity, temperature change, and rainfall. Many species of frogs and lizards have declined or disappeared, perhaps because of the increase in parasites occasioned by higher temperatures.
As warming continues, accelerating plant growth, pathogens may spread more quickly because of the increased availability of vegetation (a "density" effect) and because of increased humidity under heavier plant cover. As mentioned above, the fungus Phytophtora cinnamon has demolished many Eucalyptus forests in Australia.
In addition, the geographical range of pathogens can expand when the climate moderates, allowing pathogens to find new, and non-resistant hosts. On the other hand, a number of instances of amphibian decline seem to be due to infections with fungi, which flourish at cooler temperatures.

**5. Forest Fragmentation:**

The fragmentation of forests is a general consequence of the haphazard logging and agricultural land conversion which is occurring everywhere, but especially in tropical forests.

**When forests are cut into smaller and smaller pieces, there are many consequences, some of which may be unanticipated:**

(i) Fragmentation decreases habitat simply through loss of land area, reducing the probability of maintaining effective reproductive units of plant and animal populations. Most tropical trees are pollinated by animals, and therefore the maintenance of adequate pollinator population levels is essential for forest health.
When a forest becomes fragmented, trees of many species are isolated because their pollinators cannot cross the unforested areas. Under these conditions, the trees in the fragments will then become inbred and lose genetic variability and vigor.

Other species, which have more wide-ranging pollinators, may suffer less from fragmentation. Most species are not so tolerant, however. Animals, particularly large ones, cannot maintain themselves in small fragmented forests.
Many large mammals have huge ranges and require extensive areas of intact forest to obtain sufficient food, or to find suitable nesting sites. Additionally, their migrations may be interrupted by fragmentation.
These animals are also much more susceptible to hunting in forest fragments, which accounts for much of the decline in animal populations in rainforests. Species extinctions occur more rapidly in fragments, for these reasons, and also because species depend upon each other.
(ii) When forests are cut down or burned, the resulting gaps are too large to be filled in by the normal regeneration processes. This permits the ascendancy of rapid-growing, light-tolerant species and grasses. Large gaps may then be converted to scrub or grassland.
(iii) The use of herbicides and the introduction of exotic species into areas surrounding forest fragments are detrimental to forest health. Herbicides blow from cleared agricultural areas into forests, and exotic species introduced by farmers and ranchers spread, often displacing native species. These exotic organisms interrupt the forest ecosystem and, since they have few or no natural enemies in their new environment, they are difficult to eradicate.
(iv) The fragmentation of forests by logging and agricultural conversion also exaggerates the probability of major epidemics. Pathogens introduced through human activities by land use practices in areas surrounding the forest can be lethal to forest plants and animals.
(v) Rainforests are losing species, not only because of the disappearance of their habitat, but also because essential ecological processes are being interrupted by fragmentation. Fragments are much more easily accessible to human incursions than are intact forests. This leads to a variety of extractive activities within the forest interior.
Intensive hunting, by depleting animal populations, inhibits plant reproduction, since many seeds can neither be dispersed, nor flowers be pollinated without them. Where these seed dispersers have been eliminated, are at low population densities, or cannot move between forest fragments, seed dispersal will be very limited, and as a result tree species dependent upon animal dispersers may become locally extinct.

**6. Introduction of exotic species:**

Human beings, by introducing exotic species (species belonging to some other place) whether intentionally or accidentally, have created ecological crisis in many regions. Sometimes, the exotic species disrupt local ecosystems and, in some cases, even drive the native species to extinction.

**7. Overgrazing:**

The feeding of the worlds livestock is a major problem as fodder is not available in plenty throughout the year, in many areas. The poor people allow their livestock to graze the forests and grasslands, which also causes biodiversity loss.

**8. Natural Calamities:**

Catastrophic events like floods, droughts, cyclones, volcanoes, fires, etc. cause severe biodiversity loss from time-to-time.

## Endangered and Endemic Species of India:

The population has the potential to extend forward in time, but various factors may prevent the perpetuation of the species. Of the well-known species, there are several which are under threat by human activity. International Union for Conservation of Nature and Natural Resources (IUCN) categorized these species as vulnerable, rare, threatened and endangered species.

Several plant and animal species in the country are now found in only one or a few protected areas. Among the important endangered animals are charismatic species such as the tiger, the elephant, the rhino, etc. The less well-known major mammals restricted to a single area include the Indian wild ass, the Hangul or Kashmir stag, the Golden langur, the pygmy hog and a host of others.
There are also endangered bird species such as the Siberian crane, the Great Indian Bustard, the Florican and several birds of prey. During the recent past, vultures which were common a decade ago, have suddenly disappeared and are now highly threatened. Equally threatened are several species of reptiles and amphibia. Many invertebrates are also threatened, including a large number of species that inhabit our coral reefs.
Many plant species are now increasingly threatened due to changes in their habitats induced by human activity. Apart from major trees, shrubs and climbers that are extremely habitat specific and thus endangered, there are thousands of small herbs which are greatly threatened by habitat loss.
Several orchids are yet another group of plants that are under threat. Many plants are threatened due to overharvesting as ingredients in medicinal products.

***Thus main threats to our biodiversity are***: (i) loss, fragmentation and degradation of habitat (ii) the spread of invasive species (iii) unsustainable use of natural resources (iv) climate change (v) inappropriate fire regimes (vi) changes to the aquatic environment and water flows.

## ***TYPES OF BIDIVERSITY***

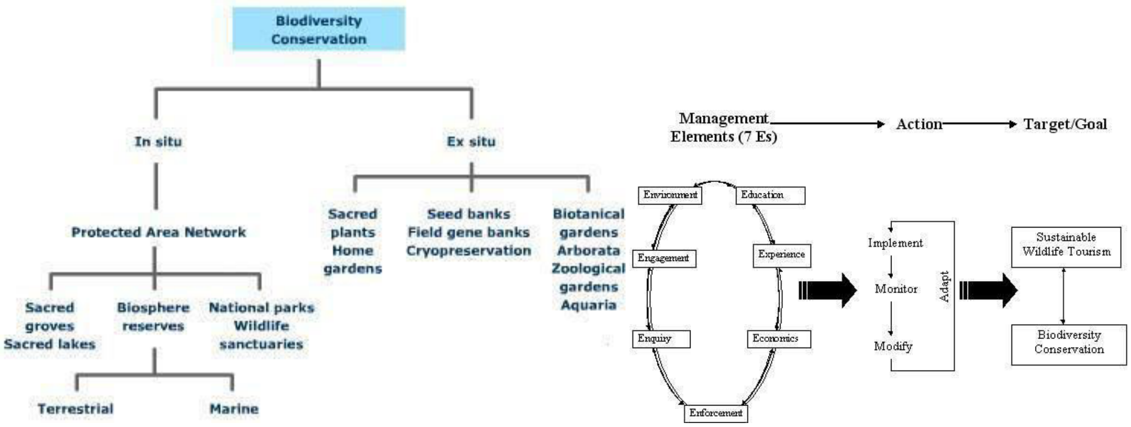
***[a] Genetic Diversity***: Genes are responsible for the traits exhibited by organisms and, as populations of species decrease in size or go extinct, unique genetic variants are lost. Species hold "genetic potential." For example, many of the crops that we grow for food are grown in monocultures of genetically homogeneous individuals. Genetic variation allows species to evolve in response to diseases, predators, parasites, pollution, and climate change.
***[b] Species Diversity***: Group of similar organisms that can interbreed and produce fertile offspring form species. Degree of variation in life form at species level constitutes species diversity.
***[c] Ecosystem Diversity***: Ecosystems include all the species, plus all the abiotic factors characteristic of a region. For example, a desert ecosystem has soil, temperature, rainfall patterns, and solar radiation that affect not only what species occur there, but the morphology, behavior, and the interactions among those species. When ecosystems are intact, biological processes are preserved. These processes include nutrient and water cycling, harvesting light through photosynthesis, energy flow through the food web, and patterns of plant succession over time.
**[d] Information Diversity**: It provides various information for healthy ecosystems.

At regional or local level, based on their spatial distribution, biodiversity can be categorized as under:

a) ***Point (●) richness***: refers to number of species that can be found at a single point in a given space.
b) ***Alpha (Ř -) richness:*** refers to the number of species found in a small homogeneous area.
c) ***Beta (β -) richness***: refers to the rate of change in species composition across different habitats.
d) ***Gamma (ô -) richness***: refers to the rate of change across large landscape gradients.

**Biodiversity conservation approach:**

The biodiversity management system for conserving biodiversity in India is shown in the chart given below:




Conservation is the protection, preservation, management, or restoration of wildlife and natural resources such as forests and water. Through the conservation of biodiversity the survival of many species and habitats which are threatened due to human activities can be ensured. Other reasons for conserving biodiversity include securing valuable Natural Resources for future generations and protecting the well being of eco- system functions. Conservation can broadly be divided into two types:

**In-situ:** Conservation of habitats, species and ecosystems where they naturally occur. This is in-situ conservation and the natural processes and interaction are conserved as well as the elements of biodiversity. In-situ conservation is not always possible as habitats may have been degraded. In-situ conservation includes a system of protected areas of different categories, e.g., National Park, Sanctuaries, Biosphere Reserves, Cultural Landscapes, and National Monument etc. According to the World Conservation Union, protected area is defined as: "An area of land and/or sea specially dedicated to the protection and maintenance of biological diversity and of natural and associated cultural resources and managed through legal or other effective mean."

**Ex-situ:** The conservation of elements of biodiversity out of the context of their natural habitats is referred to as ex-situ conservation. Zoos, botanical gardens and seed banks are all example of ex-situ conservation. Ex-situ conservation means conservation of species (sample of genetic diversity), particularly of endangered species away from their natural habitat. It is done through establishment of 'gene banks', which include genetic resource centres, botanical gardens, cultural collection and zoos etc.

## Biodiversity Hotspots: Meaning and Hotspots found in India

A biodiversity hotspot is a biogeographic region with a significant reservoir of biodiversity that is under threat from humans. A hotspot is an area which faces serious threat from human activities and supports a unique biodiversity (endemic, threatened, rare species) with representatives of evolutionary of speciation and extinction.

The concept of biodiversity was given by Norman Myers (1988).

**To qualify as a biodiversity hotspots on Myers 2000 edition of the hotspot map, a region must meet two strict criteria:**

1. It must contain at-least 0.5% or 1500 species of vascular plants of the world.
2. It has to have lost at least 70% of its primary vegetation.

Myers originally recognised 25 hotspots but recently the Conservation International has added 9 more biodiversity hotspots which make the present number to 34. These sites support nearly 60% of the world's plant, bird, mammal, reptile, and amphibian species, with a very high share of endemic species.

## Hotspots in India:

India has two major hotspots. The rate of deforestation in these areas is very high and ecosystems have reached at a fragile stage.

**1. The Western Ghats:**

**About the region:**

The Western Ghats are a chain of hills that run along the western edge of peninsular India. They are also known as Sahyadri Mountains. They receive high rainfall. It run parallel to the west coast of India and constitute more than 1600 km strip of forests in the states of Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala.

**Flora:**

These regions have moist deciduous forest and rain forest. The region shows high species diversity as well as high levels of endemism. There are over 6000 vascular plants belonging to over 2500 genera in this hotspot, of which over 3000 are endemic.

Much of the world's spices such as black pepper and cardamom have their origins in the Western Ghats. Many economically important plants such as banana, rice, ginger etc. have spread to other parts of the country from here.

**Fauna:**

Nearly 77% of the amphibians and 62% of the reptile species found here are found nowhere else. The region also harbours over 450 bird species, about 140 mammalian species, 260 reptiles and 175 amphibians. Over 60% of the reptiles and amphibians are completely endemic to the hotspot. Remarkable as this diversity is, it is severely threatened.

**2. The Eastern Himalayas:**

**About the region:**

The Eastern Himalayas is the region encompassing Bhutan, northeastern India, and southern, central, and eastern Nepal. The region is geologically young and shows high altitudinal variation. Together, the Himalayan mountain system is the world's highest, and home to the world's highest peaks, which include Mount Everest and K2.

**Flora:**

There are an estimated 10,000 species of plants in the Himalayas, of which one-third are endemic and found nowhere else in the world. Five families —Tetracentraceae,

Hamamelidaceae, Circaesteraceae, Butomaceae and Stachyuraceae — are completely endemic to this region.
Many plant species are found even in the highest reaches of the Himalayan Mountains, For example, a plant species Ermania himalayensis was found at an altitude of 6300 metres in northwestern Himalayas.

**Fauna:**

Few threatened endemic bird species such as the Himalayan Quail, Cheer pheasant. Western tragopan are found here, along with some of Asia's largest and most endangered birds such as the Himalayan vulture and White-bellied heron.
The Eastern Himalayan hotspot has nearly 163 globally threatened species including the One-horned Rhinoceros (Rhinoceros unicornis), the Wild Asian Water buffalo (Bubalus bubalis) and in all 45 mammals, 50 birds, 17 reptiles, 12 amphibians, 3 invertebrate and 36 plant species. The Relict Dragonfly (Epiophlebia laidlawi) is an endangered species found here with the only other species in the genus being found in Japan.

**Indian biodiversity & Wild Life Conservation in India**

About 6 % of the global species are found in India. India ranks $10^{th}$ among the plant rich countries of the world, $11^{th}$ in terms of number of endemic species of higher vertebrates and $6^{th}$ among the centers of diversity and origin of agricultural crops. Total number of living species identified in our country is 150,000. The shocking death of many tigers and lions due to a mysterious disease in our sanctuaries has brought wildlife conservation policies and their implementation into public focus. India has a wide variety of wildlife, many of them endangered, ranging from the snow leopard in the Himalayas to the giant Malabar squirrel in the rain forests of Kerala. Wildlife conservation has been very much in forefront of government policy and India is a signatory to the Convention on International Trade in Endangered Species (CITES). Enforcement of wildlife protection is done under the Wildlife Protection Act, 1972. The Indian Board for Wildlife (IBWL) is the apex advisory body in the field of wildlife conservation in the country and is headed by the Prime Minister. Indian wildlife is protected in 107 zoos, 49 deer parks, 16 safari parks, 6 snake parks, 24 breeding centres and 6 aquariums, besides of course 95 national parks and 500 sanctuaries. Project Tiger and Project Elephant where the habitats are maintained according to the requirements of the flagships species like tiger or elephant are also important for conservation.

## Priority areas to conserve:

***Hotspots of biodiversity***: A popular approach for selecting priority areas has been to select hotspots of diversity. Since it is not possible to conserve all biodiversity due to lack of resources and the need to use land for human activities, areas are prioritised to those which are most in need of conservation. ‗Hotspot' a term (coined by Myers in 1988) used to define regions of high conservation priority combining high richness, high endemism and high threat. Out of 25 hot spot in the world, 2 are in India (North East region and Western Ghats).
***Threatened Species***: Over the last 200 years many species have become extinct and the extinction rate is on the increase due to the influence of human activity. The status of

species has been assessed on a global scale by the World Conservation Union. Taxa that are facing a high risk of global extinction are catalogued and highlighted in the IUCN Red List of Threatened Species.

***Threatened Habitats***: Habitat destruction comes in many forms from clear felling of forests to simple changes in farming practices that change the overall surrounding habitat. If a habitat is degraded or disappears a species may also become threatened.

***Flagship and keystone species***: Conservation efforts are often focused on a single species. This is usually for two reasons: 1) Some species are key to the functioning of a habitat and their loss would lead to greater than average change in other species populations or ecosystem processes (known as keystone species). 2) Humans will find the idea of conserving one species more appealing than conserving others.

***Complementarity***: Complementarity is a method used to select areas for conservation. These methods are used to find areas that in sum total have the highest representation of diversity. For example using complementarity methods, areas could be selected that would contain the most species between them but not necessarily be the most species rich areas individually and take into account pressures of development. Distinguishing higher from lower priority areas for urgent conservation is the purpose of such area-selection methods.

## **Importance of biodiversity**:

Biodiversity is both essential for our existence and intrinsically valuable in its own right. This is because biodiversity provides the fundamental building blocks for the many goods and services a healthy environment provides. These include things that are fundamental to our health, like clean air, fresh water and food products, as well as the many other products such as timber and fibre. Other important services provided by our biodiversity include recreational, cultural and spiritual nourishment that maintain our personal and social wellbeing. Looking after our biodiversity is therefore an important task for all people. It has become clear that biodiversity is the cornerstone of our existence on Earth. It is also important to conserve biodiversity for the sake of our own curiosity and aesthetic appreciation. Medicines originating from wild species, including penicillin, aspirin, taxol, and quinine, have saved millions of lives and alleviated tremendous suffering. 40% of all prescriptions are for medicines that originated from plants and animals. No one knows how many more cures await discovery, hidden in Earth‘s poorly studied species. There are 80,000 species of edible plants known on Earth, but 90% of the world‘s food comes from a mere 20 of these species. Edible plant species, both those we know of and those we don‘t, offer a tremendous resource of possibilities that could greatly add to the security of our food. The International Union for the Conservation of Nature estimates that 22% of known mammals, 32% of amphibians, 14% of birds, and 32% of gymnosperms (all well-studied groups) are threatened with extinction (as per Hilton-Taylor *et al.* 2008 report). Species that were abundant within the last 200 years have gone extinct. Biological resources are those products that we harvest from nature. These resources fall into several categories: food, medicine, fibers, wood products, and more. For example, over 7,000 species of plants are used for food, although we rely heavily on only 12 major food crops. Most of the human population depends on plants for medicines. In the developed world, many of our medicines are chemicals produced by pharmaceutical companies, but the original formulas were often derived from plants. For example, opiate pain relievers are derived from poppies, aspirin is derived from willows, quinine for treating malaria comes from the *Chinchona* tree. The rosy periwinkle (*Vinca rosea*) and Pacific yew (*Taxa brevifolia*) both provide substances used in chemotherapy to inhibit the cell division of cancerous cells. Fibers for clothing, ropes, sacking, webbing, netting, and other materials are provided by a large number of plants, including cotton plants, flax plants (linen), hemp (cordage and sail canvas), *Agave* plants (sisal), *Corchorus* plants (jute), bamboo and palms. Trees provide the wood products used in making homes, furniture, and paper products. In addition, living organisms provide inspiration for engineers seeking better and more efficient products. The field known as biomimicry is the study of natural products that provide solutions to human needs. For example, shark skin provided the model for hydrodynamic swimming suits.