Environment and ecology (BOP-355)- UNIT II

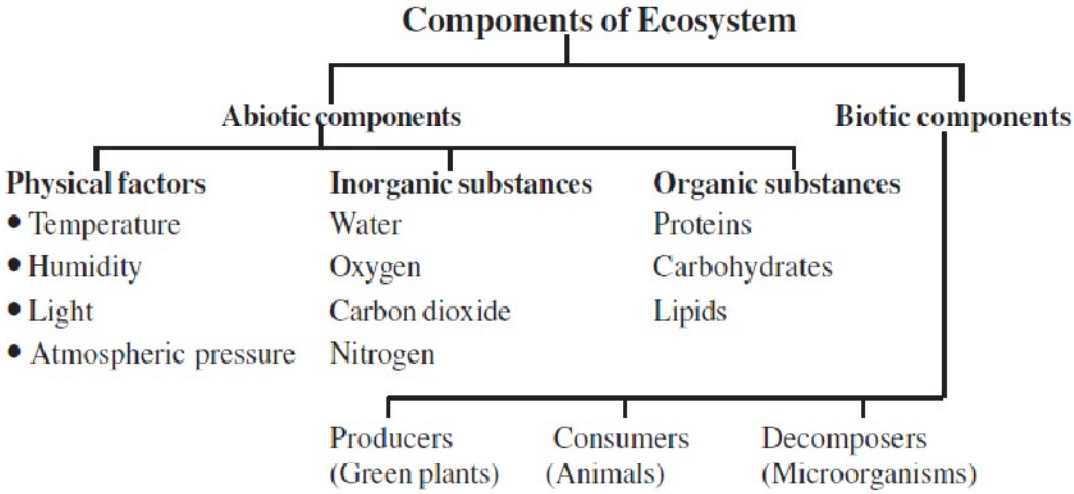
ECOSYSTEM

The portion of the earth which sustains life is called biosphere. Biosphere is very huge and cannot be studied as a single entity. It is divided into many distinct functional units called ecosystem.

Components of an ecosystem

Components of ecosystem: They are broadly grouped into:-

(a) Abiotic and (b) Biotic components



(a) Abiotic components (Nonliving): The abiotic component can be grouped into following three categories:-

(i) Physical factors: Sun light, temperature, rainfall, humidity and pressure. They sustain and limit the growth of organisms in an ecosystem.

(ii) Inorganic substances: Carbon dioxide, nitrogen, oxygen, phosphorus, sulphur, water, rock, soil and other minerals.

(iii) Organic compounds: Carbohydrates, proteins, lipids and humic substances. They are the building blocks of living systems and therefore, make a link between the biotic and abiotic components.

(b) Biotic components (Living)

(i) Producers: The green plants manufacture food for the entire ecosystem through the process of photosynthesis. Green plants are called autotrophs, as they absorb water and nutrients from the soil, carbon dioxide from the air, and capture solar energy for this process.

(ii) Consumers: They are called heterotrophs and they consume food synthesized by the autotrophs. Based on food preferences they can be grouped into three broad categories. Herbivores (e.g. cow, deer and rabbit etc.) feed directly on plants, carnivores are animals which eat other animals (eg. lion, cat, dog etc.) and omnivores organisms feeding upon both plants and animals e.g. human, pigs and sparrow.

(iii) Decomposers: Also called saprotrophs. These are mostly bacteria and fungi that feed on dead decomposed and the dead organic matter of plants and animals by secreting enzymes outside their body on the decaying matter. They play a very important role in recycling of nutrients. They are also called detrivores or detritus feeders.

Functions of ecosystem

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

(i) Energy flow through food chain

(ii) Nutrient cycling (biogeochemical cycles)

(iii) Ecological succession or ecosystem development

(iv) Homeostasis (or cybernetic) or feedback control mechanisms

Ponds, lakes, meadows, marshlands, grasslands, deserts and forests are examples of natural ecosystem. Many of you have seen an aquarium; a garden or a lawn etc. in your neighbourhood. These are man made ecosystem.

Types of ecosystems

Ecosystems are classified as follows:

(i) Natural ecosystems (ii) Man made ecosystems

(i) Natural ecosystems

(a) Totally dependent on solar radiation e.g. forests, grasslands, oceans, lakes, rivers and deserts. They provide food, fuel, fodder and medicines.

(b) Ecosystems dependent on solar radiation and energy subsidies (alternative sources) such as wind, rain and tides. e.g tropical rain forests, tidal estuaries and coral reefs.

(ii) Man made ecosystems

(a) Dependent on solar energy-e.g. Agricultural fields and aquaculture ponds.

(b) Dependent on fossil fuel e.g. urban and industrial ecosystems.

. ECOSYSTEM FUNCTION–ENERGY FLOW THROUGH ECOSYSTEM

Food chains and energy flow are the functional properties of ecosystems which make them dynamic. The biotic and abiotic components of an ecosystem are linked through them.

Food Chain

Transfer of food energy from green plants (producers) through a series of organisms with repeated eating and being eaten is called a food chain. Each step in the food chain is called trophic level. During this process of transfer of energy some energy is lost into the system as heat energy and is not available to the next trophic level. Therefore, the number of steps are limited in a chain to 4 or 5. Following trophic levels can be identified in a food chain.

(1) Autotrophs: They are the producers of food for all other organisms of the ecosystem.

They are largely green plants and convert inorganic material in the presence of solar energy by the process of photosynthesis into the chemical energy (food). The total rate at which the radiant energy is stored by the process of photosynthesis in the green plants is called Gross Primary Production (GPP). This is also known as total photosynthesis or total assimilation. From the gross primary productivity a part is utilized by the plants for its own metabolism. The remaining amount is stored by the plant as Net Primary Production (NPP) which is available to consumers.

(2) Herbivores: The animals which eat the plants directly are called primary consumers or herbivores e.g. insects, birds, rodents and ruminants.

(3) Carnivores: They are secondary consumers if they feed on herbivores and tertiary consumers if they use carnivores as their food. e.g. frog, dog, cat and tiger.

(4) Omnivores: Animals that eat both plant and animals e.g. pig, bear and man

(5) Decomposers: They take care of the dead remains of organisms at each trophic level and help in recycling of the nutrients e.g. bacteria and fungi.

There are two types of food chains:

(i) Grazing food chains: which starts from the green plants that make food for herbivores and herbivores in turn for the carnivores.

(ii) Detritus food chains: start from the dead organic matter to the detrivore organisms which in turn make food for protozoan to carnivores etc.

In an ecosystem the two chains are interconnected and make y-shaped food chain. These

two types of food chains are:-

(i) Producers Herbivores Carnivores

(ii) Producers Detritus Feeders Carnivores

Food web

Trophic levels in an ecosystem are not linear rather they are interconnected and make a food web. Thus food web is a network interconnected food chains existing in an ecosystem. One animal may be a member of several different food chains. Food webs are more realistic models of energy flow through an ecosystem. The flow of energy in an ecosystem is always linear or one way. The quantity of energy flowing through the successive trophic levels decreases. At every step in a food chain or web the energy received by the organism is used to sustain itself and the left over is passed on to the next trophic level.

Ecological pyramid

Ecological pyramids are the graphic representations of trophic levels in an ecosystem. They are pyramidal in shape and they are of three types: The producers make the base of the pyramid and the subsequent tiers of the pyramid represent herbivore, carnivore and top carnivore levels.

(1) Pyramid of number: This represents the number of organisms at each trophic level. For example in a grassland the number of grasses is more than the number of herbivores that feed on them and the number of herbivores is more than the number of carnivores. In some instances the pyramid of number may be inverted, i.e herbivores are more than primary producers as you may observe that many caterpillars and insects feed on a single tree.

(2) Pyramid of biomass: This represents the total standing crop biomass at each trophic level. Standing crop biomass is the amount of the living matter at any given time. It is expressed as gm/unit area or kilo cal/unit area. In most of the terrestrial ecosystems the pyramid of biomass is upright. However, in case of aquatic ecosystems the pyramid of biomass may be inverted e.g. in a pond phytoplankton are the main producers, they have very short life cycles and a rapid turn over rate (i.e. they are rapidly replaced by new plants). Therefore, their total biomass at any given time is less than the biomass of herbivores supported by them.

(3) Pyramid of energy: This pyramid represents the total amount of energy at each trophic level. Energy is expressed in terms of rate such as kcal/unit area /unit time or cal/unit area/unit time.eg. in a lake autotroph energy is 20810 kcal/m/year. Energy pyramids are never inverted.

Water Cycle

Water is essential for life. No organism can survive without water. Precipitation (rain, snow, slush dew etc.) is the only source of water on the earth. Water received from the atmosphere on the earth returns back to the atmosphere as water vapour resulting from direct evaporation and through evapotranspiration the continuous movement of water in the biosphere is called water cycle (hydrological cycle). You have already studied that earth is a watery planet of the solar system, about 2/3rd of earth surface is covered with water. However a very small fraction of this is available to animals and plants. Water is not evenly distributed throughout the surface of the earth. Almost 95 % of the total water on the earth is chemically bound to rocks and does not cycle. Out of theremaining 5%, nearly 97.3% is in the oceans and 2.1% exists as polar ice caps. Thus only0.6% is present as fresh water in the form of atmospheric water vapours, ground and soil water. The driving forces for water cycle are 1) solar radiation 2) gravity .Evaporation and precipitation are two main processes involved in water cycle. These two processes alternate with each other Water from oceans, lakes, ponds, rivers and streams evaporates by sun's heat energy.Plants also transpire huge amounts of water. Water remains in the vapour state in air andforms clouds which drift with wind. Clouds meet with the cold air in the mountainous regions above the forests and condense to form rain precipitate which comes down due to gravity.

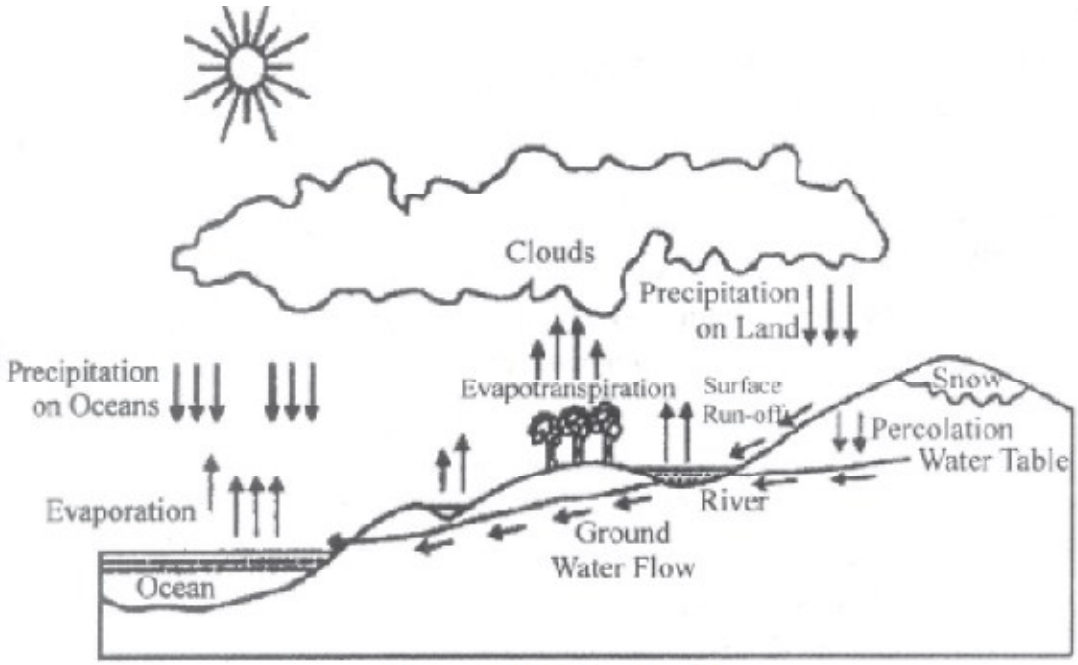


Fig. 5.8: Water Cycle

On an average 84% of the water is lost from the surface of the through oceans by evaporation. While 77% is gained by it from precipitation. Water run off from lands through rivers to oceans makes up 7% which balances the evaporation deficit of the ocean. On land, evaporation is 16% and precipitation is 23%.

BIOLOGICAL DIVERSITY

Sum total of all the variety of living organisms on earth constitute biodiversity. Biological diversity is usually considered at three different levels – a) genetic diversity i.e. at geneticlevel , b) species diversity i.e. at the level of species, and c) ecosystem diversity i.e. at the level of ecosystem.

Genetic diversity

Each species, varying from bacteria to higher plants and animals, stores an immense amount of genetic information. For example, the number of genes is about 450-700 in mycoplasma, 4000 in bacteria (eg. Escherichia coli) , 13,000 in Fruit-fly (Drosophila melanogaster); 32,000 – 50,000 in rice (Oryza sativa); and 35,000 to 45,000 in human beings (Homosapiens sapiens). This variation of genes, not only of numbers but of structure also, is of great value as it enables a population to adapt to its environment and to respond to the process of natural selection. If a species has more genetic variation, it can adapt better to the changed environmental conditions. Lower diversity in a species leads to genetic uniformity of genetically similar crop plants. This homogeneity is desirable in producing uniform quality of grain. But genetic uniformity restricts adaptability of a species to environmental stress as all the plants have same level of resistance. With the above background, genetic diversity refers to the variety of genes contained within species of plants, animals and micro-organisms. New genetic variation in individuals occurs by gene and chromosomal mutation, and in organisms with sexual reproduction may be spread across the population by recombination. For instance, two brothers differ in their structure, although their parents are the same. The differences could be in alleles (different variants of the same gene), in entire gene (the traits determining particular characteristics) or in chromosomal structure. The amount of genetic variation (gene pool) present in an inter-breeding population is shaped or decided by the process of natural selection. Selection leads to certain genetic attributes being preferred and results in changes in the frequency of genes within this pool. This forms the basis of adaptation among the living organisms. India has high genetic diversity and is regarded as a Vavilov's centre of high crop genetic diversity – so named after the Russian agro-botanist N I Vavilov, who identified eight such centres of origin of cultivated plants around the world in the 1950s.

Species diversity

Species diversity refers to the variety of species within a geographical area. Species diversity can be measured in terms of: Species richness – refers to the number of various species in a defined area.

IMPORTANCE OF BIODIVERSITY

Ethical and moral values

(a) Every form of life on earth is unique and warrants respect regardless of its worth to human beings;
(b) This is the ecosystems right of an organism. Note that every organism has an inherent right to exist regardless of whether it's valuable to human beings or not.
(c) Humankind is part of nature and the natural world has a value for human heritage. The well being of all future generations is a social responsibility of the present generations, hence the existence of an organism warrants conservation of the organism.

Aesthetic value

(d) Human beings derive great enjoyment from natural environment. The shapes, structure and colour stimulate our senses and enrich our culture. This is illustrated majorly in the popularity of biodiversity
(e) conservation measures and the myriad of the many organizations which fight for the protection of different organisms. A lot of money is paid to conserve wildlife for their value in nature through so many organizations.
(f) Wild species enhance our appreciation and enjoyment of the environment through:
Leisure activities e.g. bird watching and nature trailing;
Spotting activities e.g. spot hunting, spot fishing, diving and mushroom picking;
Hearing, touching or just seeing wildlife;
(g) Enjoyment as seen in art and culture e.g. dolls and teddy bears.

Utilitarian values

These contribute to our material well-being, besides our feelings and emotions, they are things that will give us satisfaction and include conservative and productive materials from biodiversity e.g. agricultural materials or food sources, medicine, industrial raw materials, educational values and scientific research.

Ecological values

Biodiversity maintains the integrity of the environment through:
• Maintaining CO2/O2 balance. It is through biodiversity that sequential balance of CO2 and O2 is maintained. The greenhouse effect is as a result of CO2 accumulation in the atmosphere, ozone layer depletion also occurs overtime making the earth warmer and more prone to natural calamities.
• Regulation of biochemical cycles e.g. O2, hydrological cycles etc. Biological resources are important media in biochemical cycles, without which the cycles are not complete.
• Absorption and breakdown of pollutants and waste materials through decomposition, e.g. in food webs and food chains where the flow of energy goes through production consumption decomposition without which breakdown and absorption of materials will not be complete.
In an ecosystem there is no waste as decomposition will take place to purify our environment by transforming the waste to other forms of biodiversity.
• Determination and regulation of the natural world climate whether local, regional or micro through influencing temperature, precipitation and air turbulence.
• Acting as indicators of environmental changes e.g. the green house effect as a result of global

warming causes changes in weather seasonality and also affects crops among others.
• Protective services, e.g. protection of human beings from harmful weather conditions by acting as wind breaks, flood barriers among others.

CONSERVATION OF BIODIVERSITY

Conservation is the planned management of natural resources, to retain the balance in nature and retain the diversity. It also includes wise use of natural resources in such a way that the needs of present generation are met and at the same time leaving enough for the future generations. Conservation of biodiversity is important to:-

1. prevent the loss of genetic diversity of a species,
2. save a species from becoming extinct, and
3. protect ecosystems damage and degradation.

CONSERVATION STRATEGIES

Conservation efforts can be grouped into the following two categories:
1. In-situ (on-site) conservation includes the protection of plants and animals within their natural habitats or in protected areas. Protected areas are land or sea dedicated to protect and maintain biodiversity.
2. Ex-situ (off-site) conservation of plants and animals outside their natural habitats. These include botanical gardens, zoo, gene banks, seek bank, tissue culture and cryopreservation.

In-situ methods

i) Protection of habitat: The main strategy for conservation of species is the protection of habitats in representative ecosystems. Currently, India has ninety six National Parks, five hundred Wildlife Sanctuaries, thirteen Biosphere Reserves, twenty seven Tiger Reserves and eleven Elephant Reserves covering an area of 15.67 million hectares or 4.7 % of the geographical area of the country. Twenty one wetlands, thirty mangrove areas and four coral reef areas have been identified for intensive conservation and management purposes by the Ministry of Environment and Forests, Govt. of India.

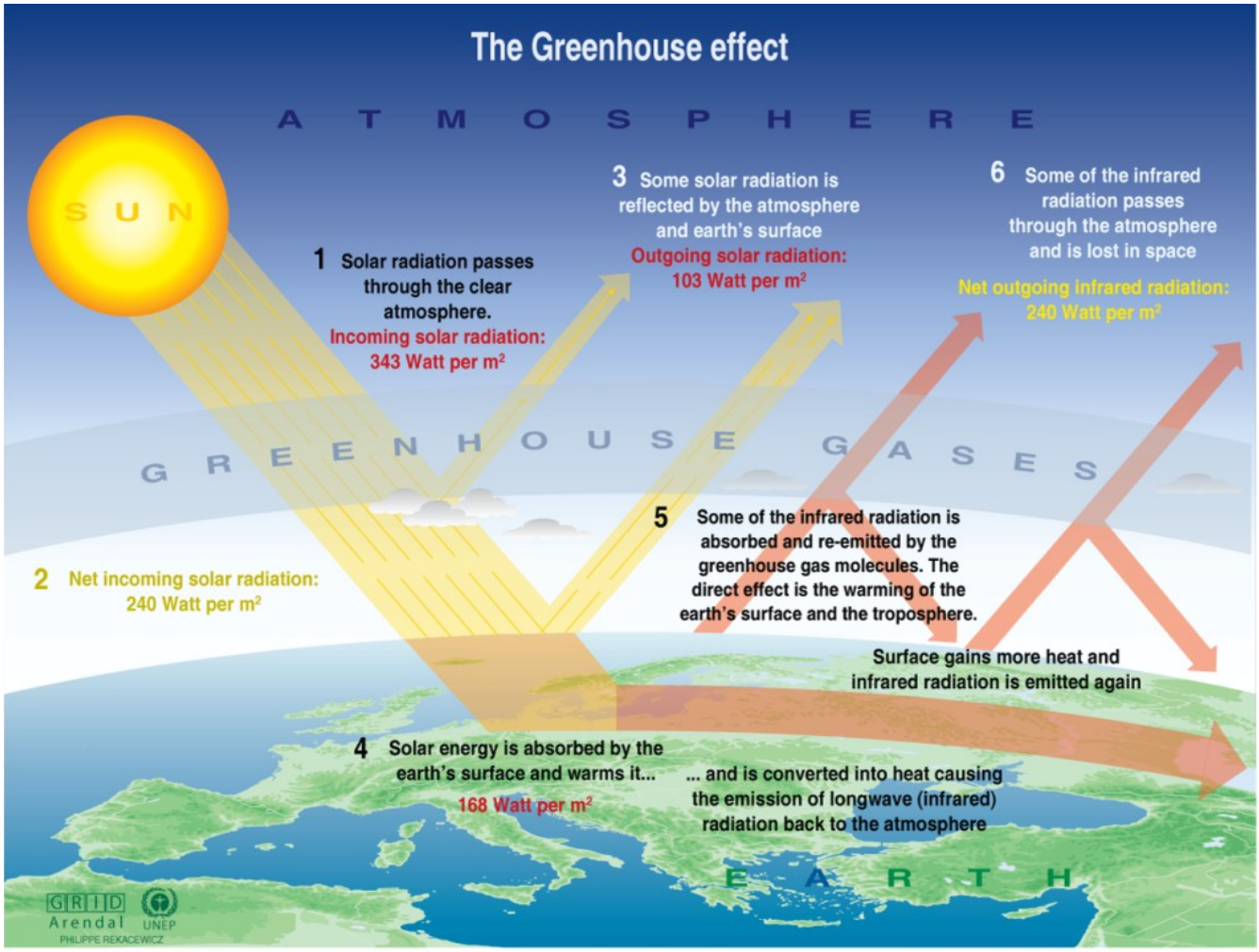
National parks and sanctuaries

India is unique in the richness and diversity of its vegetation and wildlife. India's national parks and wildlife sanctuaries (including bird sanctuaries) are situated Ladakh in Himalayas to Southern tip of Tamil Nadu with its rich bio-diversity and heritage. Wildlife sanctuaries in India attract people from all over the world as the rarest of rare species are found here.
With 96 national parks and over 500 wildlife sanctuaries, the range and diversity of India's wildlife heritage is unique. Some of the main sanctuaries in India are: The Jim Corbett Tiger Reserve- Uttaranchal, Kanha National Park, Madhya Pradesh, Bandhavgarh National Park-Madhya Pradesh, Ranthambhor National Park-Sawai Madhopur, Gir National Park-Sasangir (Gujarat) etc. Wildlife lovers eager to see magnificent Bird Sancturaty at Bharatpur, Rajasthan as it is the second habitat in the world that is visited by the Siberian Cranes in winter and it provides a vast breeding area for the native water birds, Great Indian bustard is found in the Indian deserts. In wesern Himalayas, one can see birds like Himalayan monal pheasant, western tragopanm koklass, white crested khalij pheasant, griffon vultures, lammergiers, choughs, ravens. In the Andaman and Nicobar region, about 250 species and subspecies of birds are found, such as rare Narcondum horn bill, Nicobar pigeon and megapode. While the national parks and sanctuaries in South India, too. For e.g. Madumalai in Tamil Nadu and

Bandipur Tiger Reserve and Nagahole National Park in Karnataka. Many National Parks and Sancturies have been established to preserve wildlife in their natural environment. Some of them are given below along with important species found there.
Kaziranga sanctuary (Assam) – One-horned rhinoceros
Manas sanctuary (Assam) – Wild buffaloes
Gir forest (Gujarat) – Lions, chital, sambar, wild bears
Kelameru bird sanctuary (Andhra Pradesh) – Pelicans and marine birds
Dachigam sanctuary (Jammu and Kashmir) – Kashmir stags, Himalayan tahr, wild goats, sheep, antelopes.
Bandipur sanctuary (Karnataka) – Indian bison, elephants, langurs
Periyar sanctuary (Kerala) – Elephants, barking deer, sambhar
Kanha National Park (Madhya Pradesh) – Tiger, leopards, wild dogs□ □Simipal National Park (Orissa) – Mangroves, marine turtles lay eggs
Bharatpur bird sanctuary (Rajasthan) – Ducks, herons
Corbett National Park (Uttaranchal) –Tigers, barking deer, sambar, wild bear, rhesus monkey.
Jaladpara sanctuary (West Bengal) – Rhinoceros
Wildlife Conservation Society (WCS) India in association with other NGO partners and tribal people, is making every possible effort to develop new models of wildlife conservation to preserve India's most treasured fauna and to protect the environment.

Ex-situ Conservation
(i) Botanical gardens, zoos, etc. To complement in-situ conservation efforts, ex-situ conservation is being undertaken through setting up botanic gardens, zoos, medicinal plant parks, etc by various agencies. The Indian Botanical Garden in Howrah (West Bengal) is over 200 years old. Other important botanical gardens are in Ooty, Bangalore and Lucknow. The most recent one is The Botanical Garden of Indian Republic established at NOIDA, near Delhi in April, 2002. The main objectives of this garden are –
• ex-situ conservation and propagation of important threatened plant species,
• serve as a Centre of Excellence for conservation., research and training,
• build public awareness through education on plant diversity and need for conservation.
A number of zoos have been developed in the country. These zoological parks have been looked upon essentially as centres of education about animal species and recreation. They have also played an important role in the conservation of endangered animal species such as the Manipur Thamin Deer (*Cerus eldi eldi)* and the White winged Wood Duck (*Cairina scutulata).* Notable successful examples of captive breeding are those of Gangetic gharial (*Gavialis gangeticus),* turtles and the white tiger.
(ii) **Gene Banks :** *Ex-situ* collection and preservation of genetic resources is done through gene banks and seed banks. The National Bureau of Plant Genetic Resources (NBPGR), New Delhi preserves seeds of wild relatives of crop plants as well as cultivated varieties; the National Bureau of Animal Genetic Resources at Karnal, Haryana maintains the genetic material for domesticated animals, and the National Bureau of Fish Genetic Resources, Lucknow for fishes.
(iii) **Cryopreservation:** ("freeze preservation") is particularly useful for conserving vegetative propagated crops. Cryopreservation is the storage of material at ultra low temperature of liquid nitrogen (-1960C) and essentially involves suspension of all metabolic processes and activities.

Cryopreservation has been successfully applied to meristems, zygotic and somatic embryos, pollen, protoplasts cells and suspension cultures of a number of plant species.



Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.

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