

General Knowledge Today



Environment -1: Ecology & Biomes

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Model Questions

Prelims MCQ Topics

Autecology and Synecology, Smallest and Largest Ecological Units, Ecosystem and Ecosystem Services, Biomes Features, Difference between Biosphere and Ecosphere, Similarities / Differences between Biomes and Ecozones, Ecological Niche, Difference between Niche and Habitat, Ecological Equivalents, Narrow Niche and Broad Niche, Food Chain and Food Webs, Various Trophic Levels, Ecological Pyramids, Biomass Productivity, Primary versus Secondary Productivity, Key Features of Various Biomes.



Key Ecology Concepts

The study of the interactions between living things and their environments is known as ecology. In ecology, *everything is connected to everything else* and there is a constant interaction between organisms and their environment.

Autecology and Synecology

Autecology & Synecology are two main branches of ecology. Autecology is the study of individual organism or individual species. It is also known as population ecology. Synecology is the study of group of organisms of different species which are associated together as a unit in form of a community. Also known as community ecology.

Autecology helps us to understand the relationships between individual plants and environment. Synecology helps us to understand the relationships between communities and environment.

Various Ecological Units

There are several types of inter-related ecological units such as species, population, community, ecosystem, biome, ecosphere, biosphere etc. Many of these concepts suffer from inconsistencies and confusions over terminology.

Organisms and Populations

Theoretically, an organism should be smallest ecological unit. However, since all organisms have finite life spans, reproducing population is considered to be the *smallest ecological unit*, because it is persistent in time. Population refers to a group of individuals that belong to the same species and that are interbreeding.

Why population and not species is smallest ecological unit?

Species refers to a group of organisms in which two individuals are capable to interbreed and ordinarily don't breed with other groups. If a species interbreeds freely with other species, it would no longer be a distinctive organism. But biology is a science of exceptions. There are numerous examples where organisms of a species interbreed with individuals of another species. Such interbreeding between species is more common in plants in comparison to animals. Due to these exceptions, what exactly is a species – is very difficult to define.

Since ecology and environment has more to do with interaction among organisms and with their environment; population and not species is considered the smallest ecological unit. Species is in fact the smallest unit of taxonomic classification rather.

Community

A community refers to all the populations in a specific area at certain time There are two essential things which make a group of populations eligible to be called community. These are interaction and *inter-dependence* for nutrition, food or other resources. Such interactions may involve life-death



struggle among various organisms, as well as nutrient cycles manifested through various kinds of food webs and food chains.

How diversity of populations affects stability in community?

A complex community (i.e. that has a high diversity of populations) is more stable in comparison to community having low diversity. This is because food webs of communities of high diversity are more interconnected, and the greater inter-connectivity makes it more resilient to disturbance. If one species is removed, the other species which depend on it for food have other options to switch.

Producers, consumers and Decomposers

In terms of nutrition, that all organisms within a community are either producers, or consumers or decomposers. The producers or *autotrophs* are the plants which make their own food from inorganic raw material. This work is accomplished via photosynthesis or chemosynthesis. Consumers or *heterotrophs* get their nutrition / energy from the things they consume. They cannot produce their own food and have to look outside world for those things to consume. All organisms finally yield to *decomposers*, which break down organic matter into simple products. Fungi and bacteria are the common decomposers. They serve as the “garbage collectors” or “recyclers” in our environment.

Ecosystem

An ecosystem is community plus its physical environment. Thus, ecosystem is a complex community of living plants, animals, and microorganisms (called biotic components of ecosystem) linked by energy and nutrient flows that interact together and their physical environment (called abiotic component of ecosystem) such as soil, air, water, sunlight etc. Kindly note that an ecosystem is the smallest functional ecological unit.

An ecosystem may be natural or manmade (such as aquarium), terrestrial or aquatic, and lentic (stagnant water such as pond) and lotic (running water such as river) in case of aquatic systems.

Ecosystem Services

Services derived from ecosystems are referred to as *Ecosystem Services*. There are four categories of Ecosystem Services as follows:

Supporting services

- Nutrient dispersal and cycling
- Seed dispersal
- Primary production

Provisioning services

- Food (including seafood and game), crops, wild foods, and spices
- Water
- Minerals (including diatomite)
- Pharmaceuticals, biochemical, and industrial products



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- Energy (hydropower, biomass fuels)

Regulating services

- Carbon sequestration and climate regulation
- Waste decomposition and detoxification
- Purification of water and air
- Crop pollination
- Pest and disease control

Cultural services

- Cultural, intellectual and spiritual inspiration
- Recreational experiences (including ecotourism)
- Scientific discovery

Ecosystem services may include facilitating the enjoyment of nature, which may generate many forms of income and employment in the tourism sector, often referred to as eco-tourisms, Water retention, thus facilitating a more evenly distributed release of water, Soil protection, open-air laboratory for scientific research, etc.

Biomes

Biomes are *groups of ecosystems* that *share similar climatic conditions* and *same kind of abiotic and biotic factors* spread over a *large area*. The biomes are either terrestrial or aquatic. There are several systems of classification of biomes. The main types of biomes include Deserts (Hot, Cold, Semi Arid and Coastal), Aquatic Biomes (marine or freshwater), Forest (Tropical, Temperate, Taiga , Montane etc.), Grassland (Savannah etc.) and Tundra (Arctic Tundra, Alpine Tundra).

Importance of Biomes

Biomes play a crucial role in sustaining life on earth. For example, the Aquatic biome is home to millions of fish species and the source of the water cycle. It also plays a very important role in climate formation. The terrestrial biomes provide foods, enrich the air with oxygen and absorb carbon dioxide and other bad gases from the air. They also help regulate climate and so on.

Biosphere and Ecosphere

All the biomes together make up the biosphere. Biosphere is the entire part of the earth where living things exist. This includes soil, water, light, and air. The word Biosphere includes sum total of life and life-support systems viz. atmosphere, hydrosphere, lithosphere, and pedosphere.

What is difference between Biosphere and Ecosphere?

Ecosphere is the global ecosystem i.e. the sum total of life on earth together with the global environment and the earth's total resources containing five essential elements: energy, air, water, sand, and living things. The term ecosphere was coined to denote sum total of life or living things along with organic and inorganic environment supporting it. In summary, there is no material



difference between Biosphere and Ecosphere.

Which is suitable term for largest ecological unit – Biosphere or Ecosphere?

The largest ecological unit depends on how we define it. As per the WWF classification, the largest ecological unit is Biosphere. In other classifications, the term Ecosphere is used as largest ecological unit.

Ecozones

Ecozones are the Biogeographic division of the Earth's land surface, based on distributional patterns of terrestrial organisms. Since they include only terrestrial part of biosphere, they are called Terrestrial Ecozones also.

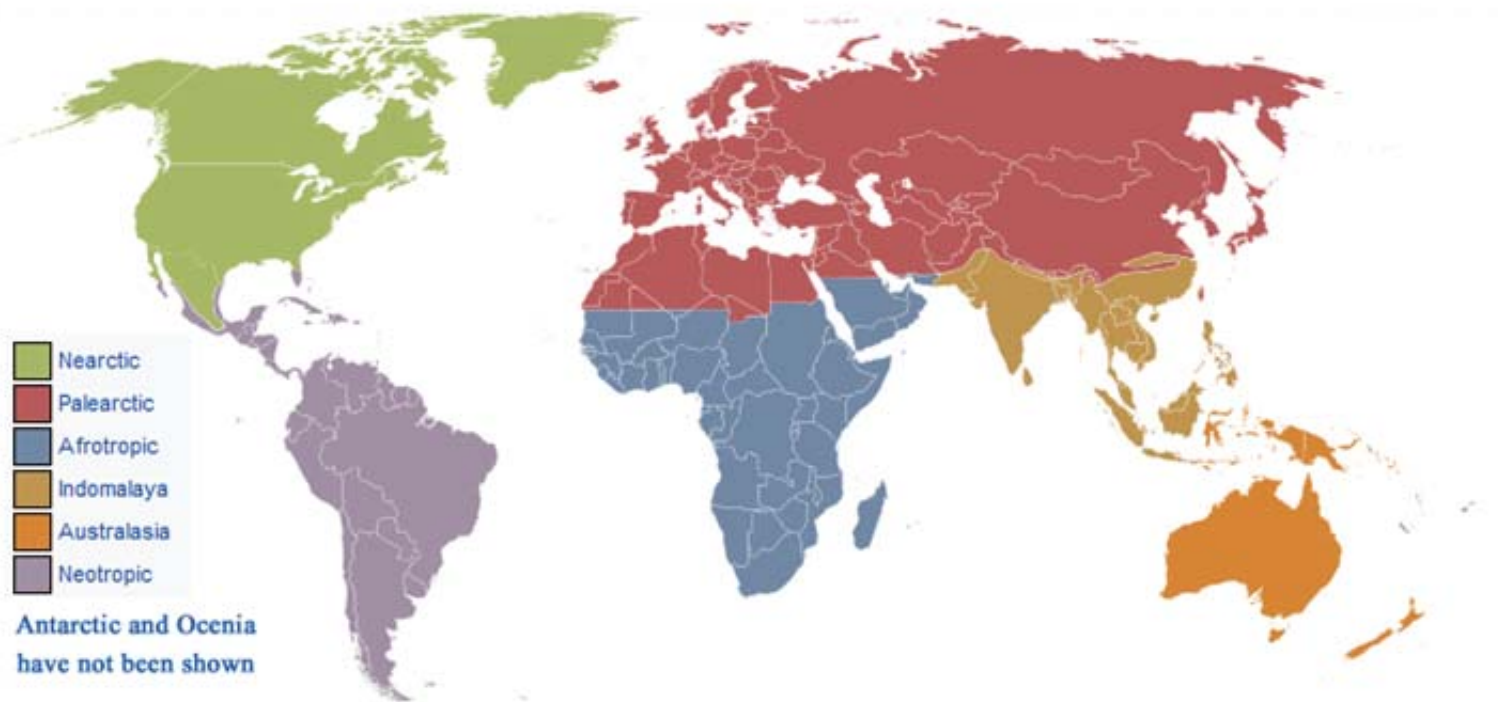
Similarities / Differences between Biomes and Ecozones

Both biomes and Ecozones are groups of ecosystems however, an Ecozone comprises only land parts of Earth surface, while the biomes comprise both aquatic and land parts.

Major Ecozones

There are 8 Ecozones on earth as shown in the following table:

Ecozone	Area Km ²	Included regions
Paleartic	54.1	Includes the bulk of Eurasia and North Africa, This is largest
Nearctic	22.9	Includes most of North America
Afrotropic	22.1	Includes Sub-Saharan Africa
Neotropic	19.0	Includes South America and the Caribbean
Australasia	7.6	Includes Australia, New Guinea, and neighbouring islands. The northern boundary of this zone is known as the Wallace line.
Indo-Malaya	7.5	Includes the Indian subcontinent and Southeast Asia
Oceania	1.0	Includes Polynesia, Melanesia, Micronesia, New Zealand and some parts of Australia
Antarctic	0.3	Includes Antarctica.



Ecological Niche

Ecological niche of an organism is the physical space occupied by it, its functional role in the community i.e. trophic position, its position in environment and the conditions of existence.

Difference between Niche and Habitat

A niche describes how an organism *makes its living* and *responds to the distribution of resources* and competitors. The ecological niche involves both the place where an organism lives as well as the roles that an organism does in its habitat. For example, various *habitats* of *house sparrow* include woodlands, grasslands, and deserts; houses, factories, warehouses, zoos etc. However, when we talk about its *niche*, it would include – eating insects, grains, seeds etc.; making nests in houses, trees and shrubs etc. Thus, niche is a broader concept than habitat and its focus is on functional role played by the species rather than only the place it needs to live. For any organism, the niche includes both the physical habitat and how it has adapted to life in that habitat.

In summary, *Habitat is “address” while Niche is “profession”*.

Ecological Equivalents

Organisms that occupy the same or similar ecological niches in different geographical regions are known as Ecological Equivalents. For examples, owls and cats, both feed on mice; but owls are found in deserts or forests while cats are around human habitations. In this context, owls and cats are ecological equivalents in terms of their feeding role. Similarly, Kangaroos of Australia perform the same functions (herbivores) as antelopes or Bison of North America. Both live in similar habitats of different regions but have similar profession of herbivores.



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Can two species share the same niche?

Each species has one Niche; no two species can share the same niche for long because then the competition for resources will drive the inferior species out This is called character displacement or niche shift or niche displacement. Further, please note that competition for food, light and space is most severe between two closely related species occupying same niche.

Narrow Niche and Broad Niche

When an organism is adapted various kinds of environmental conditions for its survival, it has a generalized or broad niche. Such organisms are called generalists. On the other hand, if the organism needs specific set of conditions for its survival, it has a specialized niche or narrow niche. Such organisms are called specialists.

There are many species of plants and animals which can survive only a narrow range of climatic or environmental conditions. For example, Giant Panda has a very specialized niche because 99% of its food is bamboo plants. The destruction of bamboo in China has led the Giant Panda to reach stage of near extinction. Thus, narrow niche is one of the reasons behind the extinction of species.

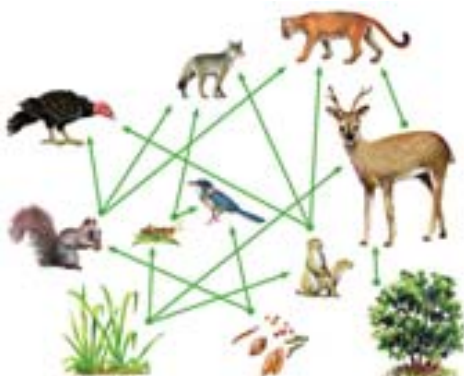
- Examples of Narrow Niche: Giraffes, Lemurs, Ganges River Dolphin etc.
- Example of Broad Niche: Humans, Rodents, House Sparrows etc.

Food Chain and Food Webs

Food chain refers to a linked feeding series in an ecosystem. A food chain illustrates the order in which a chain of organisms feed upon each other and the sequence of organisms through which energy and materials are transferred, in the form of food, from one trophic level to another. The following graphics shows a simple food chain.



The food chains are not isolated and are inter-linked to each other. For example, a Hawk can eat snakes as well as other smaller birds. A mouse can eat grass, bread or even grasshoppers. A Lizard can eat insects of different types. Thus, various food chains are intertwined in each other making a food web. A Foodweb is thus a system of interlocking and interdependent food chains. A typical Foodweb is shown in the below graphics.





Trophic Levels

There are basically four levels to the food chain viz. producers, primary consumers, secondary consumers, and tertiary consumers.

First Trophic Level (Plants)

Producers or Autotrophs produce all of the available food. They make up the first trophic (feeding) level. They possess the highest biomass (the total weight of all the organisms in an area) and the greatest numbers. This is evident from the fact that the plants make around 99 percent of the earth's total biomass.

Second Trophic Level (Herbivores or Primary Consumers)

Primary consumers (Herbivores) are organisms that directly feed on producers. A good example is a cow. They make up the second trophic level.

Third Trophic Level (Carnivores or Secondary Consumers)

The next level consists of organisms that feed on primary consumers. They are the secondary consumers, and they make up the third trophic level. They are called carnivores and omnivores

Fourth Trophic Level (Apex Predators or Tertiary Consumers)

Apex predator species occupy the highest trophic level(s) and have a crucial role in maintaining the health of their ecosystems. Apex predators affect prey species' population dynamics. Where two competing species are in an ecologically unstable relationship, apex predators tend to create stability if they prey upon both. Inter-predator relationships are also affected by apex status.

Ecological Pyramids

An ecological pyramid shows the relationship of biomass, productivity or energy at different trophic levels. The primary producers are generally shown at the bottom and apex predators at the top. The pyramids are different for different ecosystems. There are three types of Ecological Pyramids as follows:

- Pyramid of numbers: This shows the number of individual organisms at successive trophic levels. It can be upright or inverted.
- Pyramid of Biomass: This shows the biomass at successive trophic levels. It can be upright or inverted.
- Pyramid of energy: It shows the rate of energy flow and/or productivity at successive trophic levels. It is always upright.

Pyramid of Numbers

This Pyramid shows the numbers of the producers, herbivores and the carnivores at their successive trophic levels. This pyramid can be either upright, or inverted or partially upright.

Pyramid of numbers in grassland Ecosystem



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In a grassland ecosystem, the number of producers (mainly grasses) is always maximum, followed by decreasing numbers at second trophic level (herbivores), third trophic level (carnivores) and least number of apex predators. Thus, a pyramid of numbers in grassland is upright.

Pyramid of Numbers in Pond Ecosystem

In a pond ecosystem, the producers are phyto-planktons such as algae, bacteria etc. They are maximum in number. The small herbivorous fishes, rotifers etc. are smaller in number than producers, while the small carnivorous fishes are even less in number. Finally, the apex consumers or biggest carnivorous fishes are least in number. Thus, the Pyramid of numbers in a Pond Ecosystem is also upright.

Pyramid of Numbers in Forest Ecosystem

In a forest ecosystem, the producers are large size trees which make the base of Pyramid. The herbivores such as fruit eating birds, deer, elephants etc. make the primary consumers and are less than primary producers. After that, the number goes down at each successive level. Thus, a Pyramid of numbers in a Forest Ecosystem is partially upright or spindle shaped.



Pyramid of Biomass : Terrestrial system

Pyramid of Numbers in Parasitic Food Chain

A single plant or animal in a parasitic food chain may support numerous parasites, which might be further supporting a larger number of hyperparasites. Thus, the pyramid of numbers in a parasitic food chain is inverted.

Pyramid of Biomass

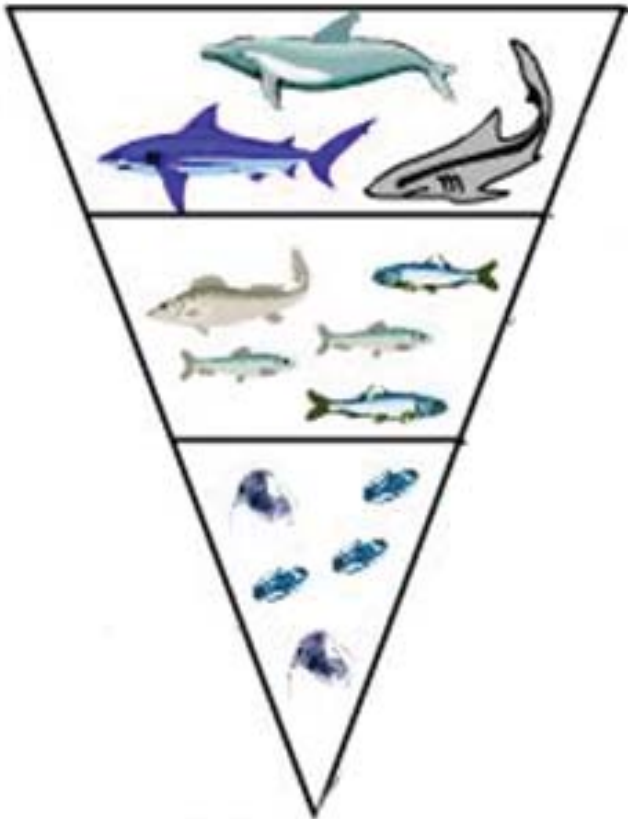
Pyramid of Biomass in Forests and Grasslands

Pyramid of biomass for terrestrial ecosystems (grasslands, forests) the biomass generally decreases at



each higher trophic level from plants via herbivores to carnivores. This is evident from the fact that the terrestrial producers' viz. grasses, trees and shrubs have a much higher biomass than the animals that consume them, such as deer, zebras and insects. The level with the least biomass is the highest predators in the food chain, such as foxes and eagles. Thus, in terrestrial ecosystems, the Pyramid of Biomass is upright.

Pyramid of Biomass in Aquatic Ecosystems

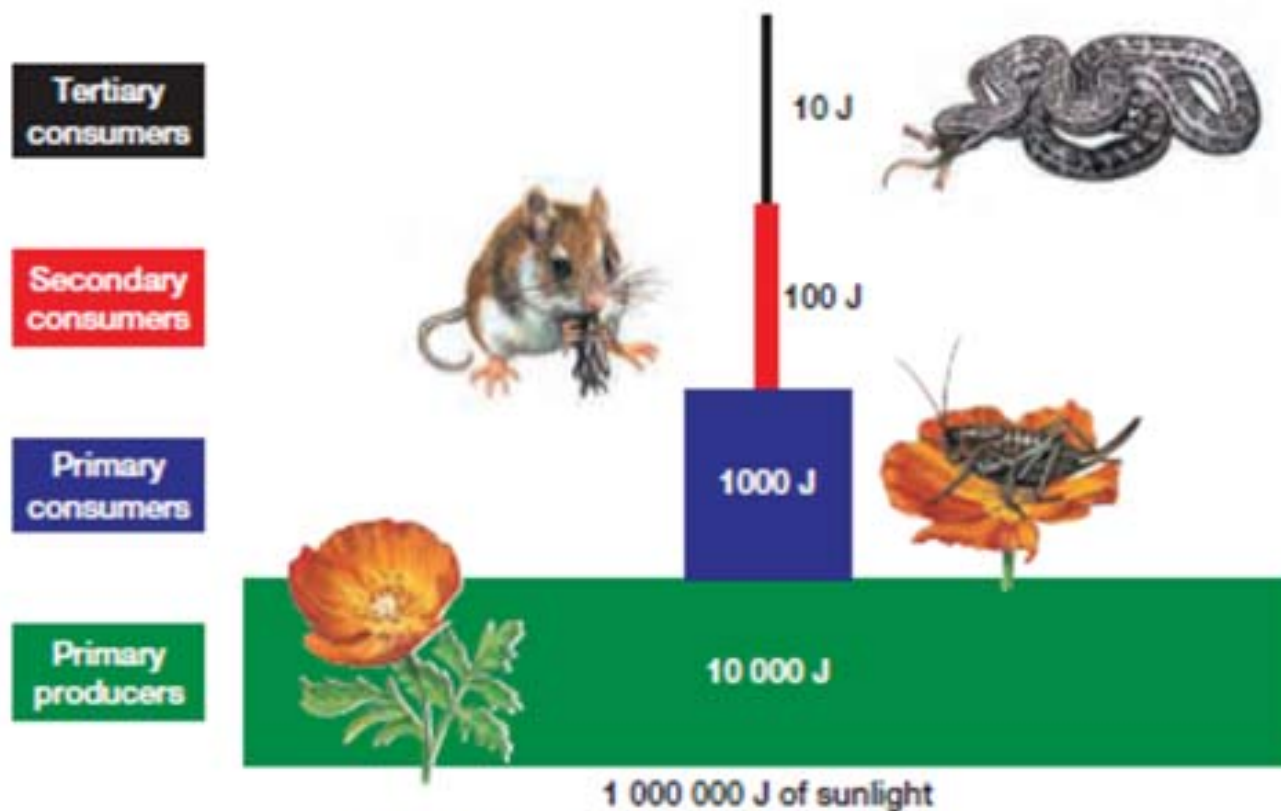


Pyramid of Biomass : Ocean Ecosystem

In the aquatic system, the biomass can increase at higher trophic levels. For example, in Oceans, the food chain typically starts with phytoplankton and ends at predatory fish, which has largest biomass. Thus, the pyramid of biomass is inverted in the aquatic systems including marine, ponds etc.

Pyramid of Energy

Energy cannot be recycled and during the flow of energy from one trophic level to other, there is a considerable loss in the form of heat, respiration, mechanical energy etc. Thus, highest energy is available to primary producers and lowest to tertiary consumers. Thus, the pyramid of energy is always upright and vertical. In this pyramid, the energy is minimum as the highest trophic level and is maximum at the lowest trophic level.



Pyramid of Energy

Since there is a successive reduction in energy flow at successive trophic levels, shorter the food chain, greater would be the available food energy. The reason is with an increase in the length of food chain, there is a corresponding more loss of energy.

Biomass Productivity

The *rate of generation of biomass in an ecosystem is called Productivity* which is expressed in units of energy (example: joules per meter² per day) or in units of dry organic matter (example: kg per meter² per year).

Primary Productivity

Primary production is the synthesis of new organic material from inorganic molecules such as water and CO₂ via photosynthesis or chemosynthesis. The rate at which radiant energy is stored by photosynthetic and chemosynthetic activity of producers is called primary productivity.

Further, the total energy fixed by plants via photosynthesis is called Gross Primary Productivity. A small fraction of this energy fixed is used in the respiration of plants, which gives them necessary energy for various physiological and morphological functions. When this respiratory utilization is reduced from Gross Primary Productivity, what we get is Net Primary Productivity. Net Primary Productivity is the actual rate of biomass productivity, which refers to the balance between gross photosynthesis and respiration and other plant losses. The primary productivity is also known as energy storage at producer level.



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Highest Net Primary Productivity of Various Ecosystems

Kindly note that highest primary productivity is found in Tropical Forests, Estuaries and Swamps/ Marshes.

Each of them produces around 9000 Kcal per meter² per year.

- Tropical Rainforests have high primary productivity because of availability of plenty of solar light and water.
- A typical estuary has high primary productivity because it is shallow (gets plenty of sunlight) and has turbulent water (which brings the nutrient rich material from sea bed).
- Swamps and Marshes have high primary productivity because they have lots of nutrients and sunlight.

After Tropical Rainforests, Estuaries and Swamps / Marshes, the highest primary productivity is found in coral reefs, algal beds and temperate forests. Least primary productivity is found in cold and hot deserts including tundra.

Secondary Productivity

Productivity of heterotrophs such as animals is called secondary productivity. It is also known as energy storage at consumer level. Secondary productivity is done by consumers via assimilation of the food they take. Since not all the primary biomass is consumed; and since not all the consumed is digested; secondary production is only a fraction of primary production.

Key Features of Biomes

Tundra Biome

The word Tundra is derived of a Finnish word "tunturi" which means *treeless mountain tract*. In Tundra Biome, the tree growth is hindered by low temperatures and short growing seasons. The vegetation in Tundra is composed of Dwarf Shrubs, mosses, lichens etc. Some scattered trees are also found. The ecological boundary (ecotone) between the tundra and taiga forests is called tree line or timberline.

Distribution of Tundra Biome

There are three types of Tundra Regions in the world viz. *Arctic Tundra, Alpine Tundra and Antarctic Tundra*. In Northern hemisphere, the Tundra occurs north of the Taiga belt.



Salient Features of Tundra Biome

The most important characteristic of Tundra is the Permafrost. Permafrost is the permanently frozen soil. Permafrost is consisting mostly of gravel and finer material. The soil is frozen from 25-90 cms down and very few plants can grow in it, so the permafrost is plain without many trees. Some parts of the permafrost are bare and support growth of some lichens.

- There are *ONLY two seasons in Polar Tundra regions viz. summer and winter*. During winter, it is very cold and dark, while during summer, the temperature rises a bit and the permafrost melts at some points, making the ground soggy.
- The Arctic Tundra is known for its cold, desert-like conditions. In winter the temperature of Arctic Tundra regions may drop as down as -50°C . The average winter temperature is -34°C (-30°F), but the average summer temperature is $3-12^{\circ}\text{C}$ ($37-54^{\circ}\text{F}$) which enables this biome to sustain life. Rainfall may vary in different regions of the arctic. Annual precipitation, including melting snow, is 15 to 25 cm.
- In summer, the upper layer of Permafrost gets melted and when water saturates the upper surface, bogs and ponds may form, providing moisture for plants. There are no deep root systems in the vegetation of the arctic tundra; however, there are still a wide variety of plants that are able to resist the cold climate. There are about 1,700 kinds of plants in the arctic and subarctic, and these include low shrubs, sedges, reindeer mosses, liverworts, and grasses, more than 400 varieties of flowers and crustose and foliose lichen.



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- The plants of the Arctic Tundra region are adapted to sweeping winds and disturbances of the soil. Plants are short and group together to resist the cold temperatures and are protected by the snow during the winter. They can carry out photosynthesis at low temperatures and low light intensities. The growing seasons are short and most plants reproduce by budding and division rather than sexually by flowering.
- The fauna in the arctic is also diverse. They include herbivorous mammals such as lemmings, voles, caribou, arctic hares and squirrels, Carnivorous mammals such as arctic foxes, wolves, and polar bears, Migratory birds such as ravens, snow buntings, falcons, loons, sandpipers, terns, snow birds, and various species of gulls, Insects such as mosquitoes, flies, moths, grasshoppers, black flies and arctic bumble bees and Fishes such as cod, flatfish, salmon, and trout.
- The animals of the Arctic Tundra are adapted to handle long, cold winters and to breed and raise young quickly in the summer. Animals such as mammals and birds also have additional insulation from fat. Many animals hibernate during the winter because food is not abundant. Another alternative is to migrate south in the winter, like birds do. Reptiles and amphibians are few or absent because of the extremely cold temperatures. Because of constant immigration and emigration, the population continually oscillates.

Fragile Ecosystem of the Arctic Tundra

From the above description, it is quite clear that the ecosystem of Arctic Tundra is extremely fragile because of the lack of abundant plant life so if the primary consumers can't find enough food, the predators can't eat.

In the Arctic Ecosystem, the primary producers, or the plants are on the bottom of the pyramid. These are very limited resources, which are thrown off by the slightest lack of sunlight and water available to them. The permafrost in the ground also throws off the drainage of the water leaving the plants there hard to digest. In the middle are the primary consumers such as lemmings, musk oxen and insects who feed on the limited plant life available. On top are the small predators such as the snowy owl and arctic fox and polar bears. Due the scarcity of the primary producers, the fragile ecosystem and food chain causes the population continually oscillate. This means that extinction of just one species has the capability to destroy the entire ecosystem in Tundra regions.

Global Warming & Tundra Climate

Due to global warming, the future of the tundra becomes more uncertain. The global warming has caused spread of more woody plants by the increasing temperatures, and it has been feared that it may endanger moss and lichen species in two fifths of the biome in the years to come.

Oil Drilling in Tundra

Oil Drilling is popular in the tundra because it is rich in mineral resources. The pollution caused by



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Oil drilling would kill the habitats of fish, and animals. The major problem of oil drilling is the risk of oil spills. When a large spill occurs, it can kill many tiny organisms when it comes in contact with it. As a result, plants will die and will not be able to produce oxygen that we need to live. Also, the herbivores in the ecosystem will die because they will have no food to eat. This can cause major damage to the food chain.

Alpine Tundra

While the Arctic Tundra is located in Polar regions, the Alpine tundra is located on mountains *throughout the world at high altitude where trees cannot grow*. Alps and Pyrenees of Europe, the Rift Mountains of Africa (such as Mount Kilimanjaro), and a large portion of the Tibetan Plateau are best examples of Alpine Tundra. The growing season is approximately 180 days. The night-time temperature is usually below freezing.

Difference between Arctic Tundra and Alpine Tundra

The major difference between the arctic Tundra and Alpine Tundra is that unlike the arctic tundra, the soil in the alpine is well drained. The Alpine Tundra does not have permafrost. The plants of Alpine Tundra are very similar to those of the arctic ones, however there is a major difference in the fauna of Arctic Tundra and Alpine Tundra. Kea parrot, marmot, mountain goats, chinchilla, woodland caribou, and pika are some of the best known species of Alpine Tundra.

Antarctic Tundra

Antarctic Tundra occurs on Antarctica and on several Antarctic and sub-antarctic islands. Most of it is too cold and dry to support vegetation. In some portions of Antarctica, there are areas of rocky soil that support plant life. The flora presently consists of around 300–400 lichens, 100 mosses, 25 liverworts, and around 700 terrestrial and aquatic algae species, which live on the areas of exposed rock and soil around the shore of the continent. Antarctica's two flowering plant species, the Antarctic hair grass (*Deschampsia antarctica*) and Antarctic pearlwort (*Colobanthus quitensis*) are found on the northern and western parts of the Antarctic Peninsula. The major difference between Arctic Tundra and Antarctic Tundra is that Antarctic Tundra lacks a large mammal fauna, while in Arctic Tundra we find an array of mammals as mentioned above. The reason is that Antarctica is physically isolated from other continents. However, the shores are inhabited by Sea mammals and sea birds, including seals and penguins. Further, some small mammals, like rabbits and cats, have been introduced by humans to some of the subantarctic islands.

Taiga Biome

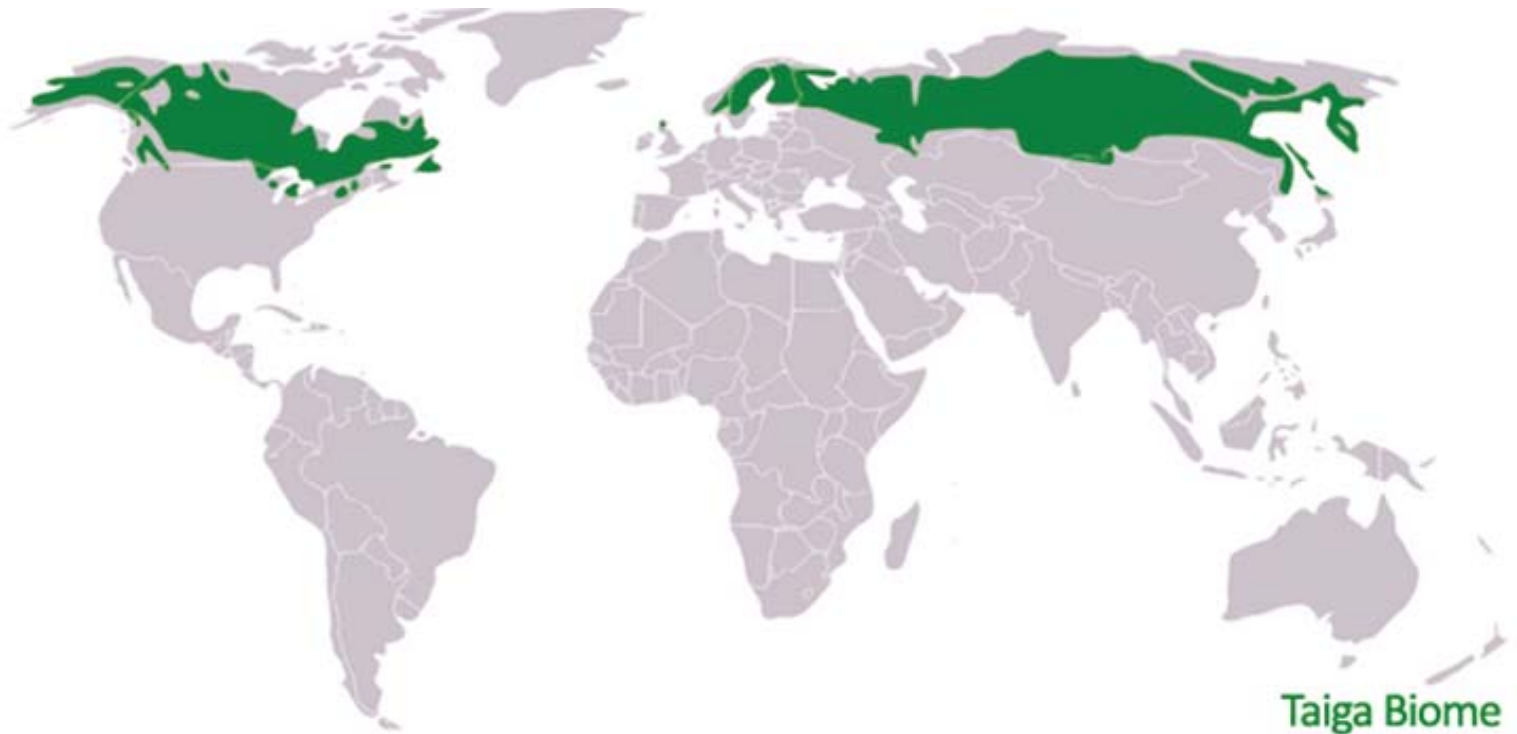
Taiga is also known as Boreal Forest. Taiga is earth's largest terrestrial biome, covering 29% of World's Forest cover and is characterized by coniferous forests.

Extent of Taiga Biome



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Taiga Biome covers in North America most of inland Canada and Alaska as well as parts of the extreme northern continental United States; and in most of Sweden, Finland, inland and northern Norway, much of Russia (Siberia), northern Kazakhstan, northern Mongolia, and northern Japan (Hokkaidō Island).



Taiga Biome

Largest areas under Taiga are located in Russia and Canada. Please note that there is no Taiga on Southern hemisphere.

Key Features of Taiga Biome

Taiga accounts for lowest annual average temperatures after the tundra and permanent ice caps Here we note that the *extreme minimums temperatures of Taiga are typically lower than those of the tundra* In Tundra it is around -50°C , in Taiga it has been recorded -68°C at Verkhoyansk in Siberia.

In winter, there are long periods of frozen Ice on Polar Tundra, yet the nearby Arctic Ocean contains enough heat to tweak the temperature a little bit This is the reason that lowest reliably recorded temperatures in the Northern Hemisphere were recorded in the taiga of north-eastern Russia. The soil in Taiga is young with little development and profile. This is mainly because of the fact that cold hinders the development of soil. The taiga **soil is also poor in nutrients**.

Soil Features in Taiga Biome

The Taiga soil is poor in nutrients in comparison to the temperate deciduous forests. This is because the fallen leaves and moss can remain on the forest floor, without decomposing for a long time in the cool, moist climate. This would result in poor organic contribution to the soil. Further, the Taiga soil is acidic due to the falling pine needles. Since the soil is acidic, the acidity aids in the decomposition of the mineral components and the minerals are washed away in the lower horizons. This leaching of



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the minerals makes them inaccessible to the tree roots. This causes infertility of the soil.

The leaching of the nutrients, along with the permeability of the soil gives Taiga a *light colored eluvial soil horizon leached of most base forming cations such as Calcium*. Since the soil is acidic due to the falling pine needles, the forest floor has only lichens and some moss growing on it.

However, diversity of soil organisms in the boreal forest (southern Taiga) is high, comparable to the tropical rainforest. The Taiga soils are dominated by the microscopic fungi. These microscopic fungi play an important role in the decomposition of the dead phytomass. So, the above mentioned infertility is compensated by the activity of the microorganisms in the upper soil horizons. In summary the soil of the Taiga Biome and Boreal forests is

- Young with little development
- Poor in Nutrients
- Rich with Soil organisms in comparison to Tropical Forests
- Acidic due to fallen leaves

Flora of Taiga Biome

Taiga is spread over both Asia and North America. Both of them were connected by the 1600 kilometres wide *Bering land bridge* at various times during the Pleistocene ice ages in the Geological history. (It connected Alaska to Siberia). So, due to this reason, a number of animal and plant species were able to colonize both continents and are distributed throughout the taiga biome that spreads in both of them like Tundra.

The forests of the taiga are *largely coniferous*, dominated by larch, spruce, fir, and pine. There are also some small-leaved deciduous trees like birch, alder, willow, and poplar; mostly in areas escaping the most extreme winter cold. Southernmost parts of the taiga has trees such as oak, maple, elm, and tilia scattered among the conifers, and there is usually a gradual transition into a temperate mixed forest. The Southern Taiga is a closed canopy forest consisting closely spaced trees with mossy ground cover. It also has shrubs and wildflowers such as the fireweed. Wherever the trees are located at a father space, land is covered by lichens and mosses. These lichens and mosses are more common in the northernmost taiga. In northernmost taiga the forest cover is not only more sparse, but often stunted in growth.

The trees are coniferous which an adaptation to cold harsh climate is. Most of the species of Taiga such as spruce, fir, and pine are Evergreen. This is because the sun is low in the horizon for most of the year; it is difficult for plants to generate energy from photosynthesis. The trees do not lose their leaves seasonally and are able to photosynthesize with their older leaves in late winter and spring when light is good but temperatures are still too low for new growth to commence. The leaves are *needle shaped* to curb loss of water and with *dark green color* to increase absorption of sunlight.



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However, Larch, which seems to be most cold-tolerant, is deciduous. The roots of Taiga Trees are shallow, which is basically to take advantage of the young thin soils. The conical shape and downward-drooping limbs help them shed snow. Further, there are also some broadleaf plants found in Taiga. Examples are birch, aspen, willow, and rowan.

Taiga Environment Challenges

The Taiga is being destroyed everyday by both humans and nature. Nature causes forest fires with lightning, diseased by parasites or herbicides, and spruce trees that grow on top thick moss are frequently blown over by strong winds. Large-scale clear cutting, plantation forestry, introduction of exotic tree species, soil scarification, ditching, and use of pesticides or herbicides have led to habitat loss. Large-scale industrial forestry, or logging, is the greatest important threat effecting the boreal forest. Other threats to the Taiga are oil and gas exploration, road building, mining, human triggered forest fire, and climate change. Animals of the Taiga are being hunted and trapped for their fur which decreases their population greatly. Hydroelectric power has ruined the water system. Many fish have mercury poisoning. The Taiga is being destroyed equal to that of the rainforest.

Wildfires in Taiga Biome

One of the most important environmental factors that affect the Taiga Forests is *Wildfires*. *Wildfires have been an integral part of the Taiga environment for several thousand years*. The main natural reason of the wildfires in Taiga is lightning strikes. However, the spread of the fire is dependent on weather, soil conditions, topography and the amount of dry organic matter (fuel) on the soil surface. The combination of these factors forms the fire regime, which is characterized by the intensity, pattern of distribution and type of fire (i.e. ground or crown fire).

By knowing a specific site's *forest type, habitat and local climate*, it is possible to determine the natural frequency of fire, which can vary from just a few years to hundreds of years. For example, wildfires develop more often in forests under a more continental climate (e.g. in Eastern Siberia) and in drier habitats with sandy soils (e.g. on the fluvial-glacial plains of Western Siberia).

Plant Adaptations to Wildfires

Where fires occur more frequently, plant communities often have special ecological mechanisms to make them more resistant or even adapted to fire. For example the *older trees of the Taiga Zones have thicker bark*. There are some plants in which the seed cones open just after a wildfire (e.g. Jack Pine, an excellent adoption to pioneer the development of new trees).

Advantage Wildfires

Due to heavy and thick bark, and due to the canopy made by the trees, usually, the wildfire would burn away the upper canopy of the trees and let sunlight reach the ground. New plants will grow and provide food for animals that once could not live there because there were only evergreen trees. This is how even wildfires add in development of new forests in Taiga environment. Many smaller



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herbaceous plants that grow closer to the ground may survive in the Crown wildfires that eliminate only the canopies. The periodic wildfires clear out the tree canopies, allowing sunlight to invigorate new growth on the forest floor. That is why the wildfires have become a necessary part of the life cycle in the taiga.

Montane grasslands and shrublands

This biome is defined in the WWF Classification. It includes all the high altitude (montane, subalpine, and alpine) grasslands and shrublands around the world. They are located in plenty of subtropical and tropical regions. In India, the elevations of Western Ghats are included in Montane grasslands and shrublands. Plants of these habitats display adaptations such as rosette structures, waxy surfaces, and hairy leaves.

Tropical Rainforest

The tropical rainforest is *earth's most complex biome* in terms of both structure and species diversity. It occurs under optimal growing conditions: abundant precipitation and year round warmth. The World Wildlife Fund's biome classification puts the tropical rainforests under *Tropical Moist Broadleaf Forest*.

Distribution of Tropical Rainforests

The Tropical rain forests is roughly located within 28° north or south of the equator, spread in Asia, Australia, Africa, South America, Central America, Mexico and on many of the Pacific Islands. They roughly cover 6-7% of earth's area and are home to half of its biodiversity. The largest rainforests are in Brazil (South America), Democratic Republic of Congo (Africa), and Indonesia. Other tropical rainforests lie in Southeast Asia, Hawaii, and the Caribbean Islands.



Tropical Rain Forests

The Amazon rainforest in South America is the world's largest, covering an area about two-thirds



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the size of the continental United States.

Etymology: Rainforests

Rainforests are called so because they are wet due to round the year rains. *There are apparently no seasons in Tropical rain forests near the equator, yet the tropical rainforests which are away from equator have only wet and dry seasons.* Tropical rainforests receive 175 to 300 inches precipitation annually.

Tropical rain forests are found in regions where temperatures and precipitation are high year-round. Mean monthly temperatures exceed 18 °C during all months of the year, due to location near to equator. Please note that there is no annual rhythm to the forest; rather each species has evolved its own flowering and fruiting seasons. Sunlight is a major limiting factor.

Layers of Trees in Rainforests

A tropical rainforest consists of four layers: the *emergent trees*, *canopy*, the *understory*, and the *forest floor*.

- The emergent and canopy layers make up the very top of the rainforest, where a few trees, called emergent, poke out above the green growth to reach the sun. Most of the plant growth in rainforests is here, close to the sun.
- Most rainforest animals, including monkeys, birds, and tree frogs, live in the canopy.
- Below the canopy are the young trees and shrubs that make up the understory. The plants in this layer cannot grow to large sizes because the canopy blocks most of the sunlight.
- The forest floor is almost bare because very little sunlight can get through the canopy and understory to reach the ground. This is where fallen leaves and branches rot quickly to release nutrients for other plants to grow.
- Large mammals such as South American tapirs and Asian elephants who are too heavy to climb up into the canopy layer live in the dim light of the understory and forest floor.

Complex Ecosystem of Rainforests

In Rainforests, the plants and animals depend on each other for survival. For example, some insects can only survive in one type of tree, while some birds only eat one type of insect. If this tree is destroyed, the insects will have no home. If the insects die, the birds who rely on them for food will starve to death. Because of this interdependence, if one type of plant or animal becomes extinct, several others could be in danger of extinction as well.

Rainforest Soils

It would appear to us that tropical soils are very fertile in order to support this high productivity. But, it is incorrect to say so. If we closely look at the system, we find that *soils of Tropical Rain Forests are very thin* and the rock below them highly weathered. An analysis of soils of tropical regions shows them to be virtually devoid of soluble minerals. Rocks weather rapidly due to high temperatures and abundant moisture, and millennia of rapid weathering and torrential rains to wash away nutrients from the



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soils have left the soils very low in nutrient stocks.

It has also been supported by the analysis of stream water draining tropical regions, which likewise reveals a scarcity of dissolved nutrients. Most tropical soils are clays with little soluble mineral content, and moderate to strong acidity which interferes with the ability of roots to take up nutrients. Only about 20% of the humid tropics has soils that can support agriculture, and most of this area is already in use. In soils of the Tropical Rain Forests, the nutrients are found mainly in living plant biomass and in the layer of decomposing litter; there is little nutrient content of the deeper soil, as there is in temperate-zone ecosystems. This suggests that plants are intercepting and taking up nutrients the moment they are released by decomposition. Many organisms play role in decomposition process: termites, bacteria, fungi, various invertebrates.

Recycling of Nutrients

Due to the above mentioned reasons, the rainforest reuses almost everything that falls to the ground and decays.

When leaves fall from the trees, when flowers wilt and die, and when any animal dies on the forest floor, it decays and all of the nutrients in the decayed species are recycled back into the roots of the trees and plants. Only the top few inches of rainforest soil have any nutrients. Most of the nutrients are in the biomass, the bulk of animal and plant life above the ground. The roots of rainforest trees are not very deep; that way they can collect all of the nutrients in the top few inches of the soil. Rainforests even recycle their own rain. As water evaporates in the forest it forms clouds above the canopy that later fall as rain.

Biodiversity in Rainforests

Rainforests are home to half of all the living animal and plant species on the planet. High biodiversity appears related to high ecological specialization of species. The rainforests are home to more worldwide species than all other biomes added together.

Why a Tropical Rain Forest cannot be replaced very quickly?

A rainforest cannot be replaced as once it is destroyed; it is gone forever (almost thousands of years). We have read above that only the top few inches of rainforest soil have any nutrients. Below that it is *deficient in nutrients*. There is a high temperature and this high temperature leads to decomposition of the organic material as well as the inorganic parent material of the soil. There are frequent rains and these rains leach the decomposing material off the soil, out of the root zone quickly. So, the result is that the Tropical rain Forests have adapted themselves and quickly take up the nutrients and most nutrients in the tropical rain forests is stored in the vegetation.

When the forest is harvested for timber or other plant products, or the forest is burned, nutrients will be lost from the ecosystem, but the outputs cannot exceed inputs for very long because the stock of nutrient capital in the system will be depleted. When forests are burned, or the cut timber is



removed as in logging, the nutrients that were in the tree biomass are either washed out in the case of burning or simply removed from the system.

Because there was only a small stock of nutrients in the soil and most of the nutrients were in the biomass, there is little nutrient stock remaining to support regrowth.

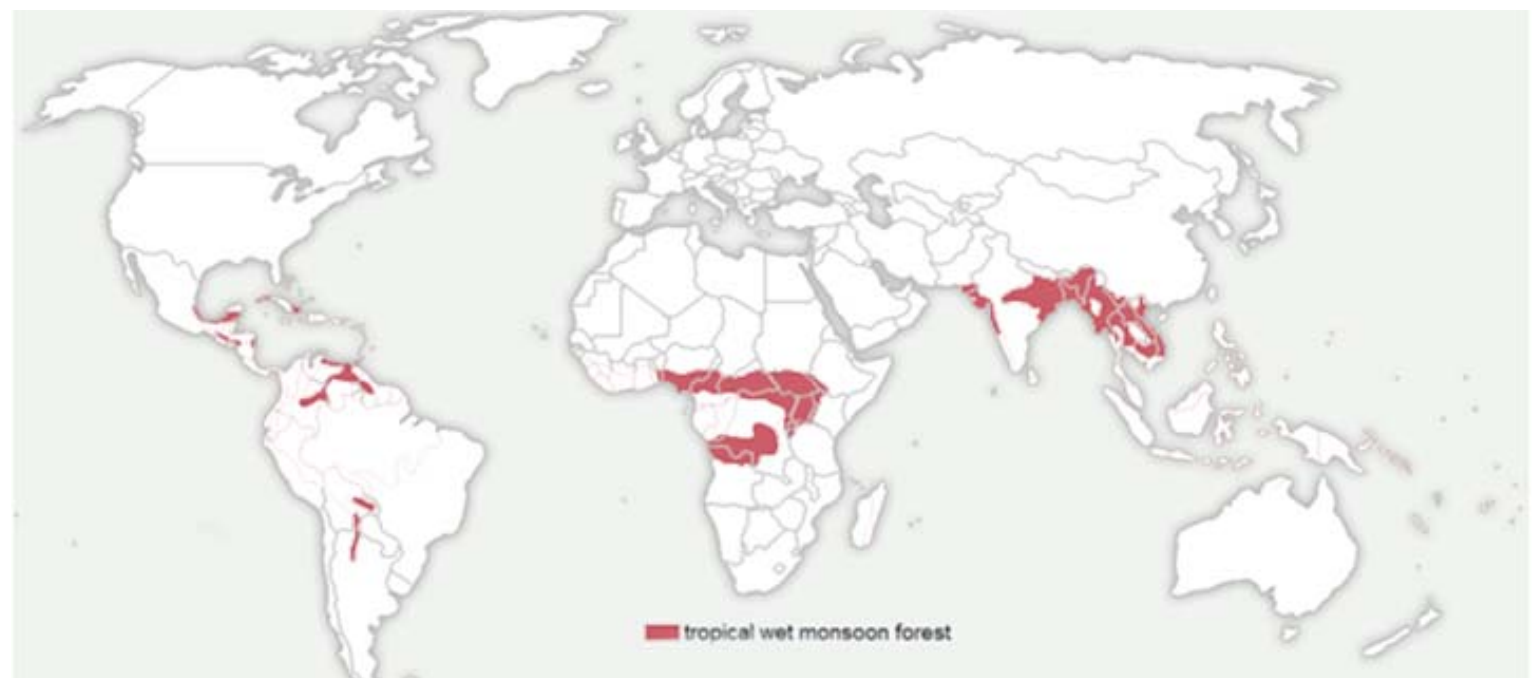
Thus, we can't simply "regrow" tropical forests once they are burned — once they are lost they are gone forever (or at least for 1000s of years, and even then the species that regrow will be different from the original forest species).

Tropical Monsoon Forests

Throughout the world, the tropical monsoon climate experiences abundant rainfall like that of the tropical rain forest climate, but it is concentrated in the high-sun season. Such forests are called Tropical Monsoon Forests.

Distribution of Tropical Monsoon Forests

They are located in the monsoon climate beyond the equatorial region between 10° and 25° and North and South of the equator. The countries are along the coastal regions of southwest India, Sri Lanka, Bangladesh, Myanmar, South western Africa, French Guiana, and northeast and south-eastern Brazil.



Salient Features of Tropical Monsoon Rainforests

The major controlling factor over the monsoon climate is its relationship to the monsoon circulation. Monsoon circulation of Asia exhibits an onshore flow of air (air moving from ocean towards land) during the summer or high-sun season, and offshore air flow (air moving from land toward water) during the winter or low-sun season. The change in direction is due to the difference in the way water and land heat. In India, the west coastal lowlands, the Western Ghats, and southern



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parts of Assam have this climate type. It is characterized by high temperatures throughout the year, even in the hills. The rainfall here is seasonal, but heavy and is above 78 cm in a year. Most of the rain is received in the period from May to November, and is adequate for the growth of vegetation during the entire year. December to March are the dry months with very little rainfall. The heavy rain is responsible for the tropical wet forests in these regions, which consists of a large number of species of animals. Evergreen forests are the typical feature of the region. The adjacent graphics shows the location of Tropical Rain Forests and Tropical Monsoon Rainforests throughout the world.

Temperate Rainforests

Temperate rainforests are dense rainforests that occur in the regions of high rainfall in the temperate zone.

Distribution of Temperate Rainforests

We know that the north temperate zone extends from the Tropic of Cancer (at about 23.5 degrees north latitude) to the Arctic Circle (at approximately 66.5 degrees north latitude). The South Temperate Zone extends from the Tropic of Capricorn (at approximately 23.5 degrees south latitude) to the Antarctic Circle (at approximately 66.5 degrees south latitude).



The regions in these latitudes, with annual precipitation over 1400 mm and mean annual temperature between 4 and 12 °C. (39 and 54 °F) are called Temperate Rain Forests. The adjacent graphics shows the distribution of the Temperate Rainforests throughout the world.

Tropical & Temperate Deciduous Forests

The deciduous biomes lie on the margin of equatorial and tropical rain forest. The deciduous trees lose their leaves during the dry season just a few months before the advent of summer rains. The



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monsoon forest average 15m high with no continuous canopy of leaves. Caatinga of Brazil is a suitable example. The others are Chaco in Paraguay and northern Argentina, the brigalow scrub of Australia, and the dorveld of South Africa. The tropical deciduous forest are also found in Angola, India, Indonesia, Malaysia, Myanmar, North-Eastern Thailand, Zambia, And Zimbabwe. The wood of the trees, especially teak wood is valuable for fine cabinetry. In addition, some of the trees with dry season adaption produce usable waxes and gums, such as carnauba and palm-hard waxes. Trees include Maple, many Oaks, Elm, Aspen, and Birch, among others, as well as a number of coniferous genera, such as Larch and Metasequoia. Deciduous shrubs include honeysuckle, viburnum, and many others.

Most temperate woody vines are also deciduous, including grapes, poison ivy, virginia creeper, wisteria, etc. The characteristic is useful in plant identification; for instance in parts of Southern California and the American Southeast, deciduous and evergreen oak species may grow side by side. Temperate deciduous forest has a temperate of 4 seasons. Temperate deciduous forests get about 950 to 1500 millimeters of rain annually, which is the second most of all the biomes. They have summer highs of about 27 to 32° Celsius with winter highs temperatures of around -1 to -15° Celsius.

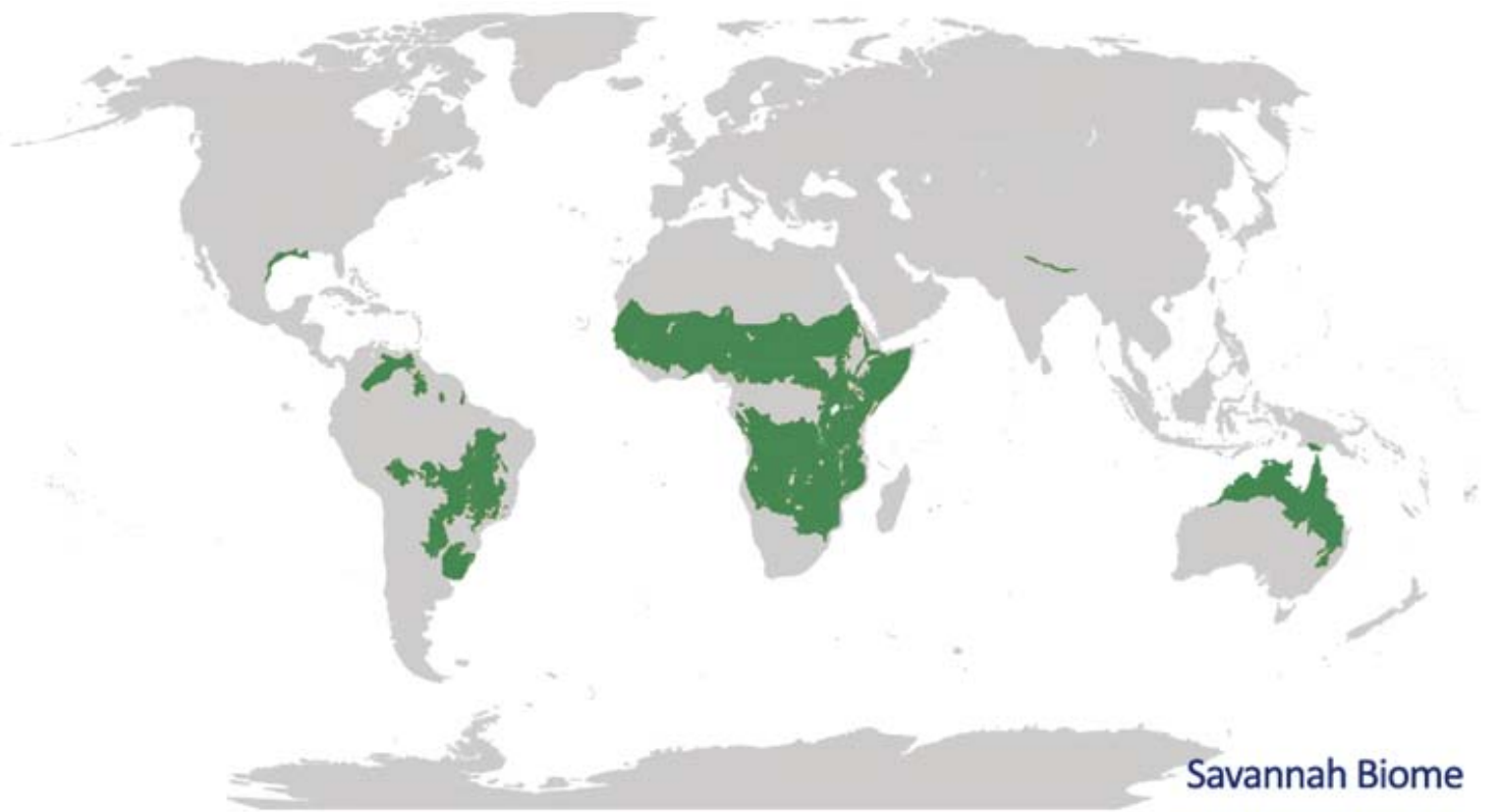
Savannah Biome

A Savannah is a grassland ecosystem. In Savannah, the trees are sufficiently small or *widely spaced so that the canopy does not close*. The open canopy allows sufficient light to reach the ground to support an unbroken herbaceous layer consisting grasses.

Distribution of Savannahs

Savannah covers approximately 20% of the Earth's land area. The largest area of Savannah is in Africa.

The following graphics shows Savannah as well as Rainforests so you are able to distinct the two regions.



Savannah Biome

Salient Features of Savannah

Savannahs are the grasslands with trees But this is not a strict definition and Savannah biome also includes treeless tracts of grasslands. The water availability in Savannahs is seasonal and majority of the rainfall is confined to one season.

Forest Fire as a feature of Savannah

Like Taiga, the forest fires are common in Savannahs also but that is mainly because of human interference and not because of the natural reasons as the lightning in case of Taiga Biome. In Taiga, usually the forest fires are crown fires which destroy the canopy, but in Savannahs, these fires are usually confined to the herbaceous layer and do little long term damage to mature trees. These fires either kill or suppress tree seedlings, thus preventing the establishment of a continuous tree canopy which would prevent further grass growth.

Large areas of Savannah have been cleared of trees, and this clearing is continuing today. For example until recently 480,000 ha of Savannah were cleared annually in Australia alone primarily to improve pasture production.

Types of Savannahs

There are several types of Savannahs as following:

Tropical and subtropical Savannahs

Tropical and subtropical grasslands and shrublands as the tropical and subtropical grasslands, Savannahs, and shrublands biome. The Savannahs of Africa, including the Serengeti, famous for its wildlife, are typical of this type.



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Temperate Savannahs

Mid-latitude Savannahs with wetter summers and drier winters. Examples are Great Plains of the United States.

Mediterranean Savannahs

Mid-latitude Savannahs in Mediterranean climate regions, with mild, rainy winters and hot, dry summers, part of the Mediterranean forests, woodlands, and scrub biome. The oak tree Savannahs of California, part of the California chaparral and woodlands eco-region are examples.

Flooded Savannahs

That are flooded seasonally or year-round.

Montane Savannahs

These are high-altitude Savannahs; example is highland Savannahs of the Angolan Scarp Savannah and woodlands ecoregions.

Threats to Savannahs

Savannah covered more than 40 per cent of the earth's surface once upon a time, before the human caused fire started damaging them. Fire occurs annually throughout the biome. The timing of these fires is important. Early in the dry season, they are beneficial and increase tree cover; if late in the season, they are very hot and kill trees and seeds.

Adaptations in Savannahs

Savannah shrubs and trees are xerophytes or drought resistant, with various adaptations like small thick leaves, rough bark, or waxy leaf surface to protect them from the dryness. Africa has the largest region of this biome, including the famous Serengeti plains and the Sahel region. Some of the local names of these grasslands include the

- Llanos in Venezuela,
- Campo cerrado in Brazil, and
- Pantanal of southern Brazil. They are also found in Australia, India, Ethiopia, Kenya, and Somalia.

Soil of Savannahs

Savannah grasslands are *much richer in humus than the equatorial forests*. The C4 grasses are found in majority in Savannah.

Animals in Savannahs

Savannah are the home of large mammals that graze on Savannah grasses or the Savannah grasses or feed upon the grazers themselves; these are lions, cheetah, zebra, giraffe, buffalo, gazelle, wild beast, antelope, rhinoceros, and elephant. Some of the animal species like the black and white rhino have become extinct during recent time.

Temperate grasslands

Temperate grasslands are found in the regions with temperate and semi-arid to semi-humid



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climates. The most important characteristic of the Temperate Grasslands is that they have almost no trees and large shrubs and have grasses as the dominant vegetation. Please note that the amount of rainfall is less in temperate grasslands than in Savannahs. The *Veldts of South Africa*, the *Puszta of Hungary*, the *Pampas of Argentina and Uruguay*, the *Steppes of the former Soviet Union*, and the plains and *Prairies of Central North America* are Temperate Grasslands.

Climate in Temperate Grasslands

Temperate grasslands have hot summers and cold winters. Rainfall is moderate. The amount of annual rainfall influences the height of grassland vegetation, with taller grasses in wetter regions. Akin to Savannah, seasonal drought and occasional fires are very important to biodiversity. However, their effects aren't as dramatic in temperate grasslands as they are in Savannahs. Few natural prairie regions remain because most have been turned into farms or grazing land. This is because they are flat, treeless, covered with grass, and have rich soil. Prairies are grasslands with tall grasses while steppes are grasslands with short grasses.

Soils of Temperate Grasslands

The soil of the temperate grasslands is deep and dark, with fertile upper layers. It is nutrient-rich from the growth and decay of deep, many-branched grass roots. The rotted roots hold the soil together and provide a food source for living plants. Each different species of grass grows best in a particular grassland environment (determined by temperature, rainfall, and soil conditions). The seasonal drought, occasional fires, and grazing by large mammals all prevent woody shrubs and trees from invading and becoming established. However, a few trees, such as cottonwoods, oaks, and willows grow in river valleys, and some nonwoody plants, specifically a few hundred species of flowers, grow among the grasses. The various species of grasses include purple Needlegrass, Blue Grama, Buffalo Grass, and Galleta. Flowers include asters, blazing stars, coneflowers, goldenrods, sunflowers, clovers, psoraleas, and wild indigos.

Rainfall in the Temperate Grasslands

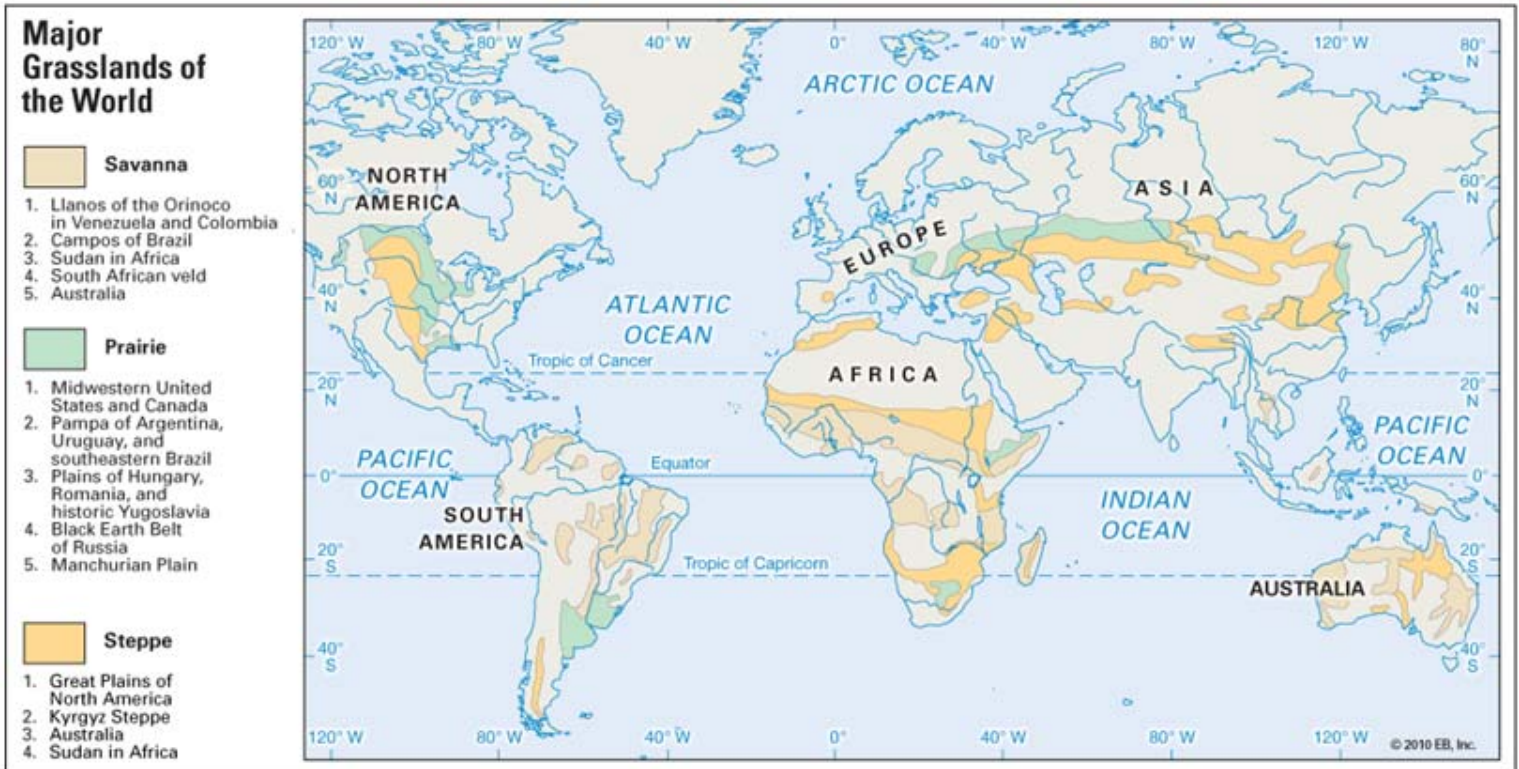
Precipitation in the temperate grasslands usually occurs in the late spring and early summer. The annual average is about 50.8 to 88.9 cm. The temperature range is very large over the course of the year. Summer temperatures can be well over 38° C (100 degrees Fahrenheit), while winter temperatures can be as low as -40° C (-40 degrees Fahrenheit).

Fauna in the Temperate Grasslands

Animals include gazelles, zebras, rhinoceroses, wild horses, lions, wolves, prairie dogs, jack rabbits, deer, mice, coyotes, foxes, skunks, badgers, blackbirds, grouses, meadowlarks, quails, sparrows, hawks, owls, snakes, grasshoppers, leafhoppers, and spiders. The following graphics sourced from Britannica online shows grasslands of the World.



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Mediterranean Shrublands (Chaparral Biome)

Mediterranean Shrublands or Chaparral biome is found along the coasts of the Mediterranean Sea, California, Central Chile, south-western part of South Africa and south-western parts of Australia.

Location

Mediterranean-type climate regions occur roughly between 30° and 40° latitude on the west coasts of continents, where offshore there are cold ocean currents. Each region in which the Mediterranean shrublands and woodlands occur is island-like in character and thus there is frequently a high degree of endemism.



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Climate

In Mediterranean regions, wet season coincides with the low sun or winter period. Summers are dry. Total annual precipitation ranges between 40 and 90 cms per year. Temperatures are those of the subtropics moderated by maritime influence and fogs associated with the cold ocean currents. The result is a very limited, but predictable, growing season when there is both sufficient soil moisture and adequately warm temperatures. Many plants are adapted to withstand drought.

The Mediterranean climate has hot and dry summers and mild-wet winters. The natural vegetation of this biome adapted according to the dry and hot summer conditions. Plant ecologists are of the opinion that this biome is well adapted to frequent fires, for many of its characteristically deep-rooted plants have the ability to re-sprout from their roots after a fire.

The dominant shrubs that occupy these regions are stunted and tough in their ability to with-stand hot-summer drought and due to this, the chaparral vegetation is also known as sclerophyllous. It averages as metre or two in height and has deep, well developed roots, leathery and uneven low branches.

Flora

Throughout the world, the Mediterranean biome is characterized by shrubs. In most regions these shrubs are evergreen and have small, leathery (sclerophyllous) leaves with thick cuticles. Sometimes the leaves are so reduced as to appear needle-like. Many typical members of the shrub flora are aromatic (for example, sage, rosemary, thyme, and oregano) and contain highly flammable oils. Mediterranean regions have long been impacted by humans especially through the use of fire and the grazing of livestock.

Other Regional Names



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- In the Mediterranean proper—Europe, North Africa, and Asia Minor, they are known as *Maquis*.
- In Chile, they are known as *Matorral*
- In Australia, they are expressed by the *Mallee* scrub vegetation of subtropical Australia.

The Mediterranean region of Europe and Asia has a significant concentration of cork-oak, olive, fig, and citrus fruits. In Australia the bulk of the eucalyptus species is sclerophyllous in form and structure.

Desert biome

Deserts and xeric shrublands are characterized by small amount of moisture. They receive an annual average rainfall of ten inches (25 cms) or less, and have an arid or hyper arid climate, characterized by a strong moisture deficit, where annual potential loss of moisture from evapotranspiration well exceeds the moisture received as rainfall.

The desert biome of the earth covers about 35 per cent of the total land area of the world. Desert are very dry, receiving less than 25cm. In the desert of Atacama of northern Chile, only a negligible amount of rain has ever been recorded—a 30-year annual average of only 0.005cm, making it driest part of Earth.

The area of the desert biome is increasing as there is increasing desertification because of human over interaction. Deserts and xeric shrublands occur in all tropical, subtropical, and temperate climate regions. Desert soils tend to be sandy or rocky, and low in organic materials. Soil is generally saline or alkaline.

Adaptations in Desert Biome

- Plants and animals in deserts and xeric shrublands are adapted to low moisture conditions. Hyper-arid regions are mostly devoid of vegetation and animal life, and include rocky deserts and sand dunes. Vegetation in arid climate regions can include sparse grasslands, shrublands, and woodlands. Deserts are inhabited by the Xerophytes which include succulent plants, geophytes, sclerophyll, and annual plants.
- Animals, including insects, reptiles, arachnids, birds and mammals, are frequently nocturnal to avoid moisture loss. In the southern Arizona, the unique Saguaro cactus grows to many metres in height and can survive up to 200 years of age if left undisturbed. First blooms do not appear until it is 50 to 75 years old.

Cold Deserts

Cold desert occur where seasonal shifting of the subtropical high is of some influence less than six months of the year. Specifically interior locations are dry because of their distance from moisture sources or their location in rain shadow areas on the leeward side of mountain ranges such as



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Himalayas and Andes. Winter snows occur in the cold deserts but are generally light. Summers are hot-with highs varying between 30° and 40°C. Night time lows-even in the summer, can cool 10° to 20°C from the daytime high.

General Knowledge Today



Environment-2: Biodiversity, Fauna and Flora

Target 2016: Integrated IAS General Studies

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Model Questions

Prelims MCQ Questions

Distribution of Biodiversity, Importance of Biodiversity, Ex situ / In Situ Conservation, Convention on Biological Diversity, Cartagena Protocol, Nagoya Protocol, Biosafety Clearing House, Advanced Informed Agreement, Aichi Targets, CITES, Bonn Convention, Biodiversity Hotspots, Biodiversity Hotspots in India, Biodiversity Act 2002, National Biodiversity Authority, Biodiversity Heritage Sites, Biodiversity Management Committee, People's Biodiversity Register, Features of Wildlife Protection Act 1972, Similarities / Difference between a National Park and Wildlife Sanctuary, Other Protected areas, Biosphere Reserves, Critical Wildlife Habitats, Project Tiger, Tiger states and Tiger landscape, Parts of a Tiger Reserve, National Tiger Conservation Authority, Project Snow Leopard, Project Elephant, Project Hangul. Other Fauna and Flora of India.



Biodiversity, Fauna & Flora

Biodiversity means the *diversity of life in all its forms*—the diversity of species, of genetic variations within one species, and of ecosystems. The importance of biological diversity to human society is hard to overstate. An estimated 40 per cent of the global economy is based on biological products and processes. Poor people, especially those living in areas of low agricultural productivity, depend especially heavily on the genetic diversity of the environment. The United Nations designated *2011-2020 as the United Nations Decade on Biodiversity*.

Distribution of Biodiversity

There is a considerable variation of biodiversity in ocean, terrestrial water bodies and land. Roughly 15 Lakh species of macroscopic organisms is known, out of which only 15% is supported by Oceans, 5% by freshwater bodies while 80% by terrestrial environments. The following points much be noted in this context:

- In the geological history, the Ocean biodiversity was much more than terrestrial as recently as 100 million years ago. During this period, terrestrial biodiversity has expanded dramatically.
- Biodiversity on earth is richest in tropics or low latitudes near the equator mainly because of warm climate and high primary productivity.
- The increase in species richness or biodiversity that occurs from the poles to the tropics, often referred to as the **Latitudinal Diversity Gradient** (LDG).

Marine biodiversity tends to be highest along coasts in the Western Pacific, where sea surface temperature is highest and in mid-latitudinal band in all oceans.

Importance of Biodiversity

Humans cannot exist without biodiversity as we use it directly and indirectly in a number of ways.

Biodiversity plays important role in the following:

- Formation of Soil
- Fertility of the soil
- Increase in overall crop yield and fodder production
- Increase in soil nutrient remineralisation
- Increases resistance to plant invasion
- Decreases disease prevalence on plants
- Increases soil organic matter

Primary Drivers of Biodiversity loss

The key primary drivers leading to loss of biodiversity include Habitat Change, Climate Change, Invasive Species, Over-exploitation of natural resources, Pollution etc.

Use and Non-Use value of Biodiversity



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Biodiversity is useful for humans in both direct and indirect way. Direct use includes things like food, fibers, medicines and biological control, whilst indirect uses includes ecosystem services such as atmospheric regulation, nutrient cycling and pollination. There are also non-use values of biodiversity, such as **option value** (for future use or non-use), **bequest value** (in passing on a resource to future generations), **existence value** (value to people irrespective of use or non-use) and **intrinsic value** (inherent worth, independent of that placed upon it by humans).

International Instruments to protect biodiversity

Ex situ / In Situ Conservation

In situ conservation means the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties.

Ex situ conservation means the conservation of components of biological diversity *outside their natural habitats*.

Examples of In situ Conservation

National Parks, Wild Life sanctuaries, Biosphere Reserves, Gene Sanctuaries

Examples of Ex situ Conservation

Captive Breeding, Gene Banks, Seed Banks, Zoos, Aquaria, In vitro fertilization, Cryopreservation, Tissue Culture

There are four major biodiversity related conventions as follows:

- Convention on Biological Diversity (CBD) with its two protocols viz. Cartagena Protocol and Nagoya Protocol.
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) aka. Washington Convention
- Convention on the Conservation of Migratory Species of Wild Animals (CMS) aka Bonn Convention
- Convention on Wetlands of International Importance, Especially as Waterfowl Habitats (Ramsar Convention)

All of them have all made significant contributions to the sustainable management and use of the world's biodiversity.

Convention on Biological Diversity

Convention on Biological Diversity is a *legally binding treaty*, which came as an outcome of Earth Summit in Rio de Janeiro on 5 June 1992 and entered into force on 29 December 1993. It is commonly known as "*Biodiversity Convention*".



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Objectives

Its objectives are:

- Conservation of biological diversity (or biodiversity);
- Sustainable use of its components; and
- Fair and equitable sharing of benefits arising from genetic resources

The idea is to develop national strategies for the conservation and sustainable use of biological diversity. The convention affirms the following:

1. Intrinsic value of biodiversity
2. Biodiversity conservation as common concern of humankind
3. Sovereign rights of States over their biological resources
4. Responsibility of States to conserve and sustainable use their biodiversity
5. Precautionary approach towards biodiversity conservation
6. Vital role of local communities and women
7. Need for provision of new and additional financial resources and access to technologies for developing countries to address biodiversity loss.'

Members and Signatories to CBD

There are 196 parties and 168 signatories to the CBD, including India. US has signed but not ratified the convention. Main concerns of United States are the CBD provisions, *which call for technology transfer to developing countries* US thinks that it could threaten US intellectual property interests. Further, there is another reason that the obligations for financial aid under the CBD are vague. Strangely, the other developed countries have not shared these concerns.

Administration

The governing body of CBD is the *Conference of the Parties* (COP), consisting of all governments (and regional economic integration organizations) that have ratified the treaty. So far twelve meetings of COP have taken place. The last meeting was held in October 2014, in Pyeongchang, South Korea. In 2012, India had hosted COP-11 at Hyderabad.

The *CBD Secretariat* is based in Montreal, and it operates under the United Nations Environment Programme. There is a Subsidiary body for Scientific, Technical and Technological Advice (SBSTTA), which has experts from member governments competent in relevant fields. It plays a key role in making recommendations to the COP on scientific and technical issues.

Importance of CBD

CBD is a land mark in international law on environment because:

- For the first time it recognized that the conservation of biological diversity is “a common concern of humankind” and is an integral part of the development process.
- It covers all ecosystems, species, and genetic resources.



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- It links traditional conservation efforts to the economic goal of using biological resources sustainably.
- It sets principles for the *fair and equitable sharing of the benefits arising from the use of genetic resources, notably those destined for commercial use.*
- It also covers the rapidly expanding field of biotechnology, addressing technology development and transfer, benefit-sharing and bio-safety.
- Since the Convention is legally binding; countries that join it are obliged to implement its provisions.

While past conservation efforts were aimed at protecting particular species and habitats, the Convention recognizes that ecosystems, species as well as genes must be used for the benefit of humans. The Convention also recognizes the close and traditional dependence of indigenous and local communities on biological resources and the need to ensure that these communities share in the benefits arising from the use of their traditional knowledge and practices relating to the conservation and sustainable use of biodiversity.

Protocols to CBD

The two protocols to CBD are Cartagena Protocol on Biosafety and Nagoya Protocol.

Cartagena Protocol on Biosafety

The Cartagena Protocol on Biosafety was adopted in 2000 and it is a legally binding protocol as part of CBD. It is related to "Biosafety measures", i.e. Biosafety concerns related to import & export of Living Modified Organisms (LMOs) and commodities made from them. There are two major components of Cartagena Protocol viz. Advanced Informed Agreement (AIA) Procedure and Biosafety Clearing House.

Advanced Informed Agreement (AIA)

AIA under the Cartagena Protocol ensures that the countries are provided with the information necessary to make informed decisions before agreeing to the import of Living Modified Organisms into their territory.

Biosafety Clearing House

Biosafety Clearing-House facilitates the exchange of information on living modified organisms and to assist countries in the implementation of the Protocol.

Rights of parties of Cartagena Protocol

Every country, which is a party to Cartagena Protocol on Biosafety as the following rights:

- To be told in advance if they are importing something that contains LMOs or commodities made of LMOs. This is done via the Advanced Informed Agreement.
- If they don't want to accept such imports, they will inform the world community via communicating the Biosafety Clearing House.



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- All commodities which may contain LMO elements should be clearly labeled by exporters.
- The exporter of such commodity must inform the importing country in advance the shipment will contain LMOs. The importer must authorize such shipment.
- Importing country has both opportunity and the capacity to assess risks involving the products of modern biotechnology.
- The protocol allows the countries to ban import of LMOs.

Nagoya Protocol

This protocol, also known as Biodiversity Accord, saves the developing countries from “foreign illegitimate bioprospecting”. In earlier times, such bioprospectors would come, search for natural substances, develop a drug, got it patented and sold in markets at high price. No benefit was given to the country from which that natural substance was sourced.

The Nagoya Protocol was adopted in 2010 and is a legally binding protocol. It addresses the problem source countries of genetic resources by recognizing their right to get a share in benefits reaped by foreign bioprospectors.

Right of parties to Nagoya Protocol

A source country has right to benefit from any commercial application of its bioresources. Such benefits may include:

- Share in Cash profits
- Sample of what was collected
- Participation or training of national researchers.
- Transfer of biotechnology

The Nagoya Protocol reaffirms that a sovereign country has full rights on its genetic resources and use of its bioresources should be done only by mutual consent. It provides legal certainty and transparency and also covers Traditional Knowledge.

Obligations of parties to Nagoya Protocol

Under the Nagoya Protocol, there are certain requirements or obligations, which each country is required to fulfill:

- Every country should create clear and unambiguous legal framework around access of its genetic sources. This framework should have clear laws, rules, procedures etc.
- Every country should make clear that its consent is taken while accessing its bioresources and terms on which monetary or non-monetary benefits are to be shared. The terms should be mutually agreed and both the contracting parties must have access to justice.

Other Important Notes on Nagoya Protocol

- The protocol is legally binding and open to only CBD ratified countries. (Excludes US and Andorra)

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- The protocol is applicable only when a country's bio-resources are 'used'. 'used' means to conduct research and development on the genetic and/or biochemical composition of genetic resources.
- Covers derivative products of bio resources including drugs, antibodies, vitamins, enzymes, active compounds and metabolites; however, term derivatives is not explicitly expressed.
- Does not apply to Human Genetic Material
- Does **not** make reference to patents or other Intellectual property rights.

Aichi Targets

Nagoya protocol ends up with a strategic plan with 20 targets called "Aichi Target". Objective of Aichi Target is to address the underlying causes of biodiversity loss, reduce the pressures on biodiversity, safeguard biodiversity at all levels, enhance the benefits provided by biodiversity, and provide for capacity-building. Some of the Aichi targets include:

- Bringing down rate of loss of natural habitats to half
- Commitments to conserve 17% of terrestrial and inland water areas and 10% of marine areas and coastal areas through establishing protected areas
- Restore of at least 15% of degraded areas
- Special efforts to reduce the pressures faced by coral reefs.
- substantial increase in the level of financial resources in support of implementation of the Convention.

CBD and India's Biodiversity Act

India enacted **Biological Diversity Act in 2002** for giving effect to the provisions of the CBD. The same is true for many other developing countries also.

CITES

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) came into force in 1975 and is the oldest convention for protection of biodiversity. It is also known as Washington Convention and is a legally Binding treaty.

This treaty control the international trade of wild animals and plant material. The objective is to ensure that international trade in specimens of wild animals and plants does not threaten the survival of the species in the wild. This treaty protects around 5000 species of animals and 29000 species of plants against over exploitation through international trade. The protected species are placed in three appendices as follows:

- **Appendix-1:** lists 1200 threatened to extinction species. International trade of animals listed in this list is banned worldwide.
- **Appendix-2:** list 21000 species which are not threatened but are close to threats. The



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international trade of these species is strictly regulated.

- **Appendix-3:** lists some 170 species which one country asked to others for help to control its trade.

We note here that CITES *does not take place of the national laws* on protection of wild flora and fauna. Rather it provides a framework to be respected by each Party, which has to *adopt its own domestic legislation to ensure that CITES is implemented at the national level.*

Convention on the Conservation of Migratory Species of Wild Animals (CMS)

This is also known as *Bonn Convention* and it aims to conserve terrestrial, marine and avian migratory species throughout their range. It is an intergovernmental treaty, concluded under the aegis of the United Nations Environment Programme. It came into force in 1983.

Biodiversity Hotspots

A biodiversity hotspot is an area with unusual concentration of species, many of which are endemic. It is marked by serious threat to its biodiversity by humans. The concept was given in 1988 by Norman Myers.

Qualification for Biodiversity Hotspot

To qualify as a hotspot, a region must meet two strict criteria:

- **Endemism:** it must contain at least 1,500 species of vascular plants (> 0.5 percent of the world's total) as endemics, and
- **Loss of Habitat:** it has to have lost at least 70 percent of its original habitat.

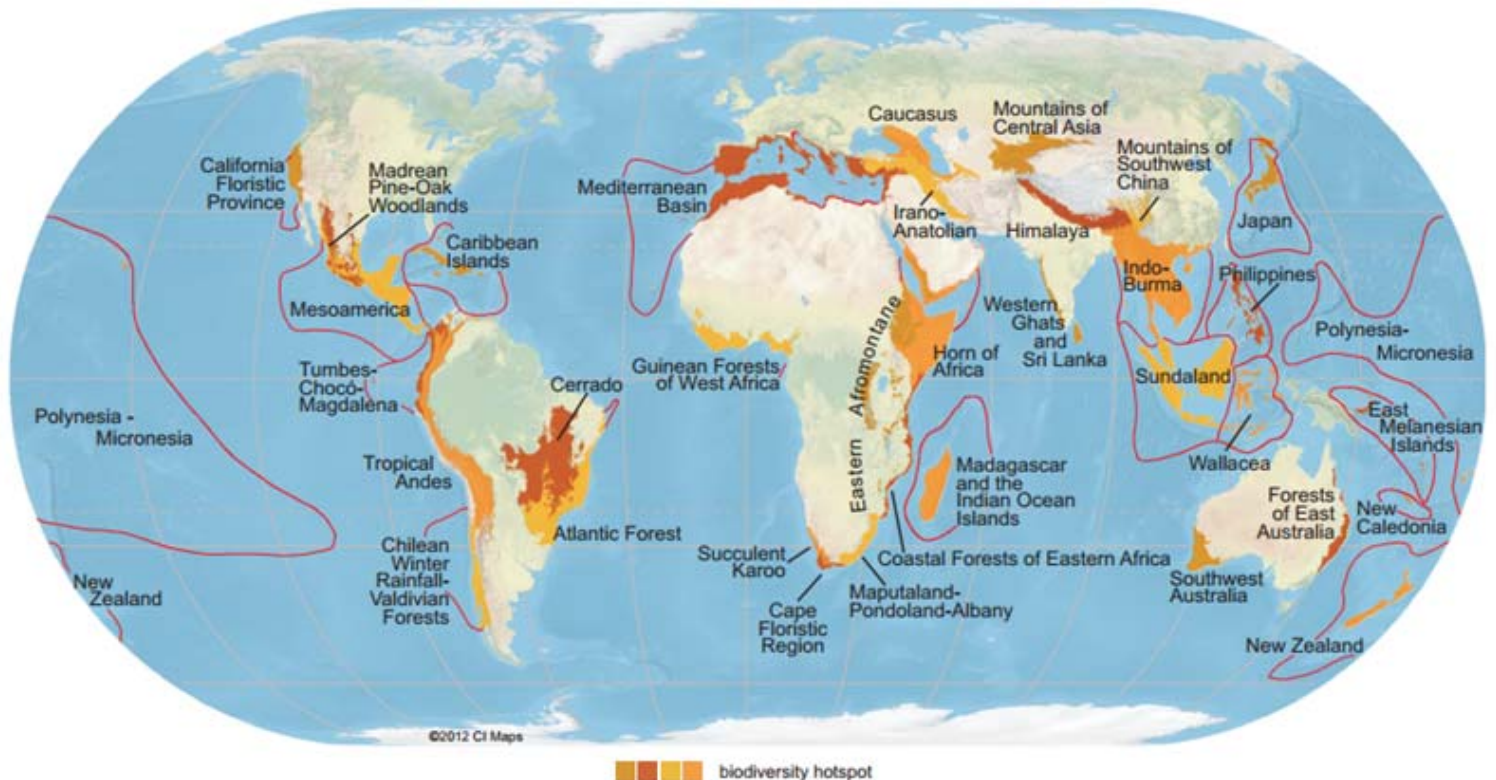
Accordingly, 34 biodiversity hotspots have been so far identified. Collectively, the Biodiversity hotspots support 60% of world's plant and animal species with a high share of endemics and cover around 2.5% of Earth's land surface.

List of Biodiversity Hotspots

- **North and Central America:** California Floristic Province, Madrean pine-oak woodlands, Mesoamerica
- **The Caribbean:** Caribbean Islands
- **South America:** Atlantic Forest, Cerrado, Chilean Winter Rainfall-Valdivian Forests, Tumbes-Chocó-Magdalena, Tropical Andes
- **Europe:** Mediterranean Basin
- **Africa:** Cape Floristic Region, Coastal Forests of Eastern Africa, Eastern Afromontane, Guinean Forests of West Africa; Horn of Africa; Madagascar and the Indian Ocean Islands; Maputaland-Pondoland-Albany; Succulent Karoo
- **Central Asia:** Mountains of Central Asia;

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- **South Asia:** Eastern Himalaya, Nepal; Indo-Burma, India and Myanmar; Western Ghats, India; Sri Lanka
- **South East Asia and Asia-Pacific:** East Melanesian Islands; New Caledonia; New Zealand; Philippines; Polynesia-Micronesia; Southwest Australia; Sundaland; Wallacea;
- **East Asia:** Japan; Mountains of Southwest China
- **West Asia:** Caucasus; Irano-Anatolian



What Biodiversity Hotspots don't do?

The Biodiversity Hotspots are often criticized on the following arguments

- Do not adequately represent other forms of species richness (e.g. total species richness or threatened species richness).
- Do not adequately represent taxa other than vascular plants (e.g. vertebrates, or fungi).
- Do not protect smaller scale richness hotspots.
- Do not make allowances for changing land use patterns. Hotspots represent regions that have experienced considerable habitat loss, but this does not mean they are experiencing ongoing habitat loss. On the other hand, regions that are relatively intact (e.g. the Amazon Basin) have experienced relatively little land loss, but are currently losing habitat at tremendous rates.
- Do not protect ecosystem services
- Do not consider phylogenetic diversity.

Biodiversity Hotspots in India

India shares its territories into three biodiversity hotspots viz. Eastern Himalaya, Western Ghats and Indo-



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Burma. Out of them, Eastern Himalaya and Western Ghats are mostly located within India's territory. In the Indo-Burma Biodiversity hotspot, India shares only a small part in north East India. The Indo-Burma Biodiversity hotspot includes parts of northeastern India, Bangladesh and Malaysia as shown in the below map.

Figure 1. Boundaries of the Indo-Burma Hotspot Defined by Mittermeier et al. (2004)



However, Biodiversity Hotspots also work as *funding regions* for Conservation International for its Critical Ecosystem Partnership Fund (CEPF). The Northeastern India is included in a separate CEPF funding region (Eastern Himalayas Biodiversity Hotspot), while Bangladesh and Malaysia only extend marginally into the Indo-Burma hotspot. For this purpose, officially, the Indo-Burma Hotspot is defined as all non-marine parts of Cambodia, Lao PDR, Myanmar, Thailand, Vietnam plus some parts of southern China.

This is the reason that India has only two biodiversity hotspots viz. Eastern Himalayas and Western Ghats.

Legal Framework for Biodiversity Protection



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Biodiversity Act 2002

India enacted **Biological Diversity Act in 2002** for giving effect to the provisions of the CBD. Objective of this act is to *regulate the access to genetic resources* and protection of biodiversity. This act provides for establishment of statutory bodies such as National Biodiversity Authority, State Biodiversity Boards, National and State Biodiversity Funds, Biodiversity Management Committee etc.

National Biodiversity Authority

National Biodiversity Office has been established in Chennai as per provisions of the BDA-2002.

Structure of NBA

- One chairman, seven Ex-officio members and five non-official members; all to be appointed by central government.
- Chairman appointed by Central Government. He / she shall be an eminent person having adequate knowledge and experience in the conservation and sustainable use of biological diversity and in matters relating to equitable sharing of benefits. The chairman can be removed by the Central government.
- Seven Ex-officio members are from the following fields:
 - Agricultural Research and Education;
 - Biotechnology;
 - Ocean Development;
 - Agriculture and Cooperation;
 - Indian Systems of Medicine and Homoeopathy;
 - Science and Technology;
 - Scientific and Industrial Research;
- Five non-official members will also be appointed. These will be persons with good domain knowledge in biodiversity.

Powers and Functions of NBA

- **All foreign nationals** require approval from NBA for obtaining Biological Resources from India.
- All Indian individuals/entities are required to seek NBA approval before transferring knowledge / research and material to foreigners.
- Prior approval of NBA before applying for any kind of IPR based on research conducted on biological material and or associated knowledge obtained from India.

State Biodiversity Board

The Biodiversity Act 2002 mandates each state to notify its State Biodiversity Board. We note here that there is no provision for a Biodiversity Board for a Union Territory because Union Territories have been



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placed under National Biodiversity Authority.

Functions of State Biodiversity Board include:

- To advise state governments on matters of biodiversity conservation
- Regulate commercial use of bio-resources in the state by Indians. This has two exceptions:
 - Vaid and Hakims, who are practicing Indian medicinal system.
 - Local People, who use the bioresources for local use.

National Biodiversity Fund

Whatever money National Biodiversity Authority receives as fees, fines etc. and whatever money it gets as grants etc. is kept in the National Biodiversity Fund. The money from this fund is used to benefit the claimers and promotion of conservation and socio-economic development in source areas.

State Biodiversity Fund

This fund has to be created at state level to credit any grants and loans made to the State Biodiversity Board by the National Biodiversity Authority and money from other sources. The money is used in the management and conservation of heritage sites; compensating or rehabilitating any section of the people economically affected when an area is declared Biodiversity Heritage Sites; and conservation and promotion of biological resources.

Biodiversity Heritage Sites

Under Section 37 of Biological Diversity Act, 2002 (BDA) the State Government in consultation with local bodies may notify in the official gazette, areas of biodiversity importance as Biodiversity Heritage Sites (BHS).

“Biodiversity Heritage Sites” (BHS) are well defined areas that are unique, ecologically fragile ecosystems – terrestrial, coastal and inland waters and, marine having rich biodiversity comprising of any one or more of the following components:

- richness of wild as well as domesticated species or intra-specific categories
- high endemism
- presence of rare and threatened species
- keystone species
- species of evolutionary significance
- wild ancestors of domestic/cultivated species or their varieties
- past pre-eminence of biological components represented by fossil beds and
- having significant cultural, ethical or aesthetic values and are important for the maintenance of cultural diversity, with or without a long history of human association with them

Biodiversity Management Committee

Biodiversity Management Committee is constituted by a local body within its area for the purpose



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of promoting conservation, sustainable use and documentation of biological diversity including preservation of habitats, conservation of land races, folk varieties and cultivars, domesticated stocks and breeds of animals and microorganisms and chronicling of knowledge relating to biological diversity.

The National Biodiversity Authority and the State Biodiversity Boards need to consult the Biodiversity Management Committees while taking any decision relating to the use of biological resources and knowledge within jurisdiction of the Biodiversity Management Committee.

The Biodiversity Management Committees may levy charges by way of collection fees from any person for accessing or collecting any biological resource for commercial purposes from areas falling within its territorial jurisdiction.

People's Biodiversity Register

One of the most significant provisions in the Biological Diversity Act is that the Biodiversity Management Committees have been mandated to prepare People's Biodiversity Register in consultation with local people. This register would have comprehensive information on availability and knowledge of local biological resources, their medicinal or any other use or any other traditional knowledge associated with them.

Other Notes on Biodiversity Act

- If a dispute arises between the National Biodiversity Authority and a State Biodiversity Board, the said Authority or the Board, as the case may be, may prefer an **appeal to the Central Government** within such time as may be prescribed.
- National Biodiversity Authority shall have the same powers as are vested in a civil court under the Code.
- Violation of this act invites penalties viz. imprisonment for a term which may extend to five years, or with fine which may extend to ten lakh rupees and where the damage caused exceeds ten lakh rupees such fine may commensurate with the damage caused, or with both

Wildlife Protection Act 1972

The Wildlife Protection Act 1972 is first umbrella act to protect plants as well as animals. It was last amended in 2006 to give statutory status to Project Tiger. Currently, Wild Life (Protection) Amendment Bill, 2013 is pending in parliament.

Key Provisions of the Wildlife Protection Act

The act extends to the whole of India, except the State of Jammu and Kashmir which has its own wildlife act. It defines five types of protected areas viz. *National Parks, Wildlife Sanctuaries, Community Reserves, Conservation Reserves and Tiger Reserves*. The act has six schedules with varying degrees of protection to different kinds of animals and plants.



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Wild Life Sanctuary

A wildlife sanctuary is defined by State Government via a Notification. There is no need to pass a legislation (act) by the state assembly to declare a wildlife sanctuary. Fixation and alternation of boundary can be done by state legislature via resolution. No need to pass an act for alternation of boundaries. No alternation of boundaries in wildlife sanctuaries can be done without approval of the NBWL (National Board of Wildlife) Limited human activities are permitted in the sanctuary.

National Parks

Similar to the Wildlife Sanctuaries, a National Park is defined by state government via notification. The state government can fix and alter boundaries of the National Parks with prior consultation and approval with National Board of Wildlife. There is no need to pass an act for alternation of boundaries of National Parks. No human activities are permitted in a National Park.

Similarities / Difference between a National Park and Wildlife Sanctuary

Similarities

Commercial exploitation of forest produce in both areas is NOT allowed; except for local communities. No wild mammal, bird, amphibian, reptile, fish, crustacean, insects, or coelenterates listed in four Schedules of the WLPA can be hunted either within or outside both of them, and also other conservation areas.

Differences

No grazing or private tenurial rights land rights are allowed in National Parks. In Wildlife sanctuaries, they may be provided at the discretion of Chief Wildlife warden.

Conservation Reserves and Community Reserves

These areas provide a *greater role and opportunity for local communities, stakeholders and civil society* to protect many areas of conservation value that cannot be designated under strict categories such as wildlife sanctuaries or national parks.

Tiger Reserves

Tiger Reserves are declared by National Tiger Conservation Authority via Wild Life (Protection) Amendment Act, 2006 under centrally sponsored scheme called **Project Tiger**. To declare an area as Tiger Reserve, the state governments can forward their proposals in this regard to NTCA. Central Government via NTCA may also advise the state governments to forward a proposal for creation of Tiger Reserves. Tiger Reserves are managed by National Tiger Conservation Authority (NTCA). *No alternation of boundary can be done without the recommendation of National Board for Wild Life and without the advice of the Tiger Conservation Authority.*

Schedules of the Wild Life Protection Act

There are **six schedules** in wildlife protection act with varying degrees of protection. Out of the six schedules, Schedule I and part II of Schedule II provide absolute protection and offences under these are prescribed the highest penalties. The penalties for Schedule III and Schedule IV are less and these



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animals are protected. Schedule V includes the animals which may be hunted. Such animals include Common crow, Fruit bats, Mice & Rats only. Schedule VI contains the plants, which are prohibited from cultivation and planting. These plants are as follows

- Beddome's cycad (*Cycas beddomei*)
- Blue Vanda (*Vanda soerulec*)
- Kuth (*Saussurea lappa*)
- Ladies slipper orchids (*Paphiopedilum* spp.)
- Pitcher plant (*Nepenthes khasiana*)
- Red Vanda (*Rananchera inschootiana*)

Whose permission is needed to hunt a man-eater?

India does not have a robust scientific or policy mechanism to minimise tiger human conflicts. A Standard Operating Procedure was released by the National Tiger Conservation Authority a few years back to deal with emergency arising due to straying of tigers to human settlements. The guidelines prohibit killing the tiger unless it has been declared a man-eater. Only the chief wildlife warden of a state can permit hunting of man-eaters.

Biosphere Reserves

Biosphere reserves are areas of terrestrial and coastal ecosystems which promote the conservation of biodiversity with its sustainable use. They are internationally recognized within the framework of UNESCO's Man and Biosphere (MAB) programme and nominated by national governments. There are over 500 biosphere reserves in over 100 countries around the world.

Selection Criteria of Biosphere Reserves

The concept of Biosphere Reserves, especially its **zonation**, into Core Area(s) (dedicated to conservation), Buffer Area(s) (sustainable use) and Transition Area(s) (equitable sharing of benefits) were later broadly adopted under the Convention on Biological Diversity (CBD) process which entered into force on 29th December, 1993. There are primary and secondary criteria to select a biosphere reserve as follows:

Primary Criteria:

- A site that must contain an effectively protected and minimally disturbed core area of value of nature conservation and should include additional land and water suitable for research and demonstration of sustainable methods of research and management.
- The core area should be typical of a biogeographical unit and large enough to sustain viable populations representing **all trophic levels in the ecosystem**.

Secondary Criteria

- Areas having rare and endangered species
- Areas having diversity of soil and micro-climatic conditions and indigenous varieties of biota.



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- Areas potential for preservation of traditional tribal or rural modes of living for harmonious use of environment.

Legal Backing to Biosphere Reserves

There is no comprehensive legislation in India dealing with all aspects of the Biosphere Reserves. The wildlife protection act is complementary to the set up of Biosphere Reserves to the extent that it has considerable flexibility and latitude to establish such reserves. It does not define a Biosphere Reserve.

Financial Assistance

The Ministry of Environment and Forest provides financial assistance to the respective State governments for conservation of landscape and biological diversity and cultural heritage.

Does MAB programme provide any funds for Biosphere Reserves?

Normally, the MAB-related activities are nationally financed. However, some seed funding is provided to assist countries in developing projects and/or to secure appropriate partnership contributions. Further, not all Biosphere reserves of the country are come under the Man & Biosphere Programme.

Differences between Biosphere Reserves and National Parks/ Sanctuaries

The Key differences are as follows:

- While National Parks, Wildlife Sanctuaries, Conservation Reserves, Community Reserves and Tiger Reserves are established as per provisions of Wildlife Protection Act, there is no law as such under which Biosphere Reserves are established.
- No grazing or private tenurial rights land rights are allowed in National Parks. In Wildlife sanctuaries, they may be provided at the discretion of Chief Wildlife warden. However limited economic activity (sand and stone mining) is permitted in biosphere reserves. Further, Biosphere reserves serve as 'living laboratories' for testing out and demonstrating integrated management of land, water and biodiversity.
- While wildlife sanctuaries and national parks are set up for the protection of mammals normally, biosphere reserves envisage protection of plant species, Invertebrates and biotic community as a whole.

Number of Biosphere Reserves in India

There are 18 notified Biosphere reserves in India. As of now, only Nine viz. Nilgiri (2000), Gulf of Mannar (2001), Sunderban (2001), Nanda Devi(2004), Nokrek (2009), Pachmarhi(2009), Similipal (2009), Achanakmar-Amarkantak Biosphere Reserve (2012) and Great Nicobar Biosphere Reserve (2013) are in the UNESCO's MAB world network.

List of Biosphere Reserves in India



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No.	Year	Name	States	Type	Area
1	2008	Kachchh Biosphere Reserve	Gujarat	Semi-Arid	12454
2	1989	Gulf of Mannar	Tamil Nadu	Coasts	10500
3	1989	Sunderbans	West Bengal	Gigantic Delta	9630
4	1988	Nanda Devi	Uttaranchal	West Himalayas	5860
5	1986	Nilgiri Biosphere Reserve	Tamil Nadu, Kerala and Karnataka	Western Ghats	5520
6	1998	Dehang Debang	Arunachal Pradesh	East Himalayas	5112
7	1999	Pachmarhi	Madhya Pradesh	Semi-Arid	4926
8	1994	Similipal	Orissa	Deccan Peninsula	4374
9	2005	Achanakamar - Amarkantak	Chhatisgarh, Madhya Pradesh	Semi-Arid	3835
10	1989	Manas	Assam	East Himalayas	2837
11	2000	Kanchanjunga	Sikkim	East Himalayas	2620
12	2001	Agasthyamalai	Kerala	Western ghats	1701
13	1989	Great Nicobar	Andaman and Nicobar Islands	Islands	885
14	1988	Nokrek	Meghalaya	East Himalayas	820
15	1997	Dibru-Saikhowa	Assam	East Himalayas	765
16	2009	Cold Desert	Himachal Pradesh	West Himalayas	NA
17	2010	Sheshachalam Hills	The hill ranges spread in parts of Chittoor and Kadapa districts of Andhra Pradesh have been designated as Seshachalam Biosphere Reserve in Andhra Pradesh on 20th September, 2010.	Eastern Ghats	4755



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No.	Year	Name	States	Type	Area
18	2011	Panna Biosphere Reserve	Part of Panna and Chhattarpur districts in Madhya Pradesh		NA

Rationale Behind Biosphere Reserves

It appears that the Biosphere reserves mean the duplication of the conservation efforts of the protected areas, but it is not so. The idea is the “Biosphere Reserves” is to strengthen the “National Efforts” in conformity to the “International Practices”. The basic truth is that “most of the National parks in India were previously hunting grounds. Most of the wildlife sanctuaries are declared by the state governments out of a vague idea of protecting a particular species”. The present domestic legislations don’t represent a “systematic selection of the ecosystems”. Neither the wildlife sanctuaries nor the national parks focus on conservation of plant species, Invertebrates and biotic community as a whole. This is the major shortcoming of the present system. Further _

- The focus of WS/NP is on conservation of mammals. No focus to the other species which may be ecologically more vital.
- The focus of the MAB and Biosphere Reserves is to protect the “threatened Habitats” and not “a particular threatened species”.
- Through an Internationally recognized mechanism, the Research and Monitoring of the existing protected areas can be carried out on regular basis.

How a Biosphere Reserve is declared?

Biosphere reserves are declared by state or central governments by notification. Once established, the National Governments can nominate them under the UNESCOs Man & Biosphere (MAB) Programme. This programme was launched in 1971. If UNESCO accepts the proposal, the biosphere reserve is entered World Network of Biosphere Reserves (WNBR) under the MAB Programme. Within this network, exchanges of information, experience and personnel are facilitated. Department of Environment is nodal agency for Biosphere Reserve programmes. It carries out detailed scientific investigation, maps the biogeographical regions and vegetation types, identified the critical areas. Botanical Survey of India and Zoological Survey of India assist in this work. The central Government assumes the responsibility of meeting the costs of set up while the state government would set up desired machinery.

Critical Wildlife Habitats

The Critical Wildlife Habitats have been envisaged in Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006. This act defines the Critical Wildlife Habitats (CWH) as the “*areas of national parks and sanctuaries where it has been specifically and clearly established,*



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case by case, on the basis of scientific and objective criteria, that such areas are required to be kept as inviolate for the purposes of wildlife conservation...”.

The above definition makes it very clear that the Critical Wildlife Habitats are absolutely free of human presence. But the same act duly recognizes the traditional rights of the Forest dwellers.

How CWHs are designated?

The power to notify the rules to designate a CWH rests with **Ministry of Environment and Forests**. The State Government are needed to initiate the process for notification of a critical wildlife habitat by submitting an application on a *case by case basis*, to the Ministry of Environment and Forests, which is the nodal agency under the said Act. Critical Wildlife Habitats are thus, declared by Central Government ONLY.

CWH and Rights of Forest Dwellers

The rights of the forest dwellers is a key issue related to the Critical Wildlife Habitats, mainly because they are envisaged as totally inviolate areas. Before a critical wildlife area is notified, not only do the rights of the tribals and forest dwellers have to be settled, but also scientific evidence has to be provided to establish that people’s presence would adversely impact the wildlife in area. We note here that consent of affected Gram Sabha is also required for creating these inviolate areas or critical wildlife habitats. The free informed consent of the Gram Sabha must be given before any relocation of the forest dwellers is carried out.

Conservation Projects in India

Project Tiger

Around 70% of tigers of the world are in India. As per official data of Tiger Census-2014, there are more than 2200 tigers in India.

States and Landscapes with Tiger Population

As per Status of Tigers in India, 2014, there are 18 states in India with Tiger Population. The entire area of tiger population has been divided into five tiger landscape complexes viz. *Shivalik Hills & Gangetic Plains, Central Indian Landscape & Eastern Ghats, Western Ghats, North-Eastern Hills & Bhramaputra Flood Plain and Sundabans*.

The below table shows the population of Tigers as per 2014 Census:

State	2006	2010	2014
Shivalik-Gangetic Plain Landscape Complex			
Uttarakhand	178 (161-195)	227 (199-256)	340
Uttar Pradesh	109 (91-127)	118 (113-124)	117



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State	2006	2010	2014
Bihar	10 (7-13)	8 (-)	28
Shivalik-Gangetic	297 (259-335)	353 (320-388)	485(427-543)
Central Indian Landscape Complex and Eastern Ghats Landscape Complex			
Andhra Pradesh (Including Telengana)	95 (84-107)	72 (65-79)	68
Chhattisgarh	26 (23-28)	26 (24-27)	46
Madhya Pradesh	300 (236-364)	257 (213-301)	308*
Maharashtra	103 (76-131)	169 (155-183)	190
Odisha	45 (37-53)	32 (20-44)	28
Rajasthan	32 (30-35)	36 (35-37)	45
Jharkhand	-	10 (6-14)	3+
Central India	601 (486-718)	601 (518-685)	688(596-780)
Western Ghats Landscape Complex			
Karnataka	290 (241-339)	300 (280-320)	406
Kerala	46 (39-53)	71 (67-75)	136
Tamil Nadu	76 (56-95)	163 (153-173)	229
Goa	-	-	5
Western Ghats	402 (336-487)	534 (500-568)	776(685-861)
North Eastern Hills and Brahmaputra Flood Plains			
Assam	70 (60-80)	143 (113-173)	167
Arunachal Pradesh	14 (12-18)	-	28*
Mizoram	6 (4-8)	5	3+
Northern West Bengal	10 (8-12)	-	3



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State	2006	2010	2014
North East Hills, and Brahmaputra	100 (84-118)	148 (118-178)	201 (174-212)
Sundarbans	-	-	76 (62-96)
All India	1411 (1165-1657)	1706 (1520-1909)	2226(1945-2491)

As per 2014 Tiger Census, maximum number of Tigers are found in Karnataka followed by Uttarakhand and Madhya Pradesh. The Mudumalai-Bandipur-Nagarhole-Wayanad complex holds the world's single largest tiger population currently estimated over 570 tigers.

Parts of a Tiger Reserve

Each tiger reserve has two areas viz. Core area (Critical Area) and Buffer Area. Core area is kept as inviolate as possible, *without affecting the rights of the Scheduled Tribes or such other forest dwellers*. Buffer Area is peripheral to the Core area. It has a lesser degree of habitat protection and promotes co-existence between wildlife and human activity. Please note that Gram Sabha is consulted in management of buffer areas.



Alternation of Boundaries of Tiger Reserves

The alternation of boundaries of Tiger Reserves is done via notification by state governments. Prior approval of NTCA and National Board for Wild Life is needed. Kindly note that the *State Government has power to de-notify* a tiger reserve in public interest but only with the prior approval of the Tiger Conservation Authority and the National Board for Wild Life.

Special Tiger Protection Force (STPF)

This is a Centrally sponsored scheme in which the central government provides 100% financial assistance to the states for raising, arming and deploying the STPF in sensitive tiger reserves. Karnataka was the first state to raise a STPF.



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India's Tiger Reserves

As of January 2016, there are 48 Tiger Reserves in India. Corbett National Park was the first national park of India to be covered under Project Tiger on April 1st, 1973.

- *Nagarjunsagar-Srisaïlam is the largest tiger reserve in terms of Area, while currently, Bor Tiger Reserve in Maharashtra is smallest in area.*
- Manas (Assam) , Similipal (Orissa), Sunderbans (West Bengal) are Biospheres having Tiger reserves.
- Manas Tiger Reserve is the only tiger reserve which is also a World Heritage Site

List of Tiger Reserves

Sl. No.	Name of Tiger Reserve	State	Total area (KM ²)
1	Bandipur	Karnataka	1456.3
2	Corbett	Uttarakhand	1288.31
3	Kanha	Madhya Pradesh	2051.791
4	Manas	Assam	3150.92
5	Melghat	Maharashtra	2768.52
6	Palamau	Jharkhand	1129.93
7	Ranthambore	Rajasthan	1411.291
8	Similipal	Odisha	2750
9	Sunderbans	West Bengal	2584.89
10	Periyar	Kerala	925
11	Sariska	Rajasthan	1213.342
12	Buxa	West Bengal	757.9038
13	Indravati	Chhattisgarh	2799.07
14	Namdapha	Arunachal Pradesh	2052.82
15	Dudhwa	Uttar Pradesh	2201.7748
16	Kalakad-Mundanthurai	Tamil Nadu	1601.542



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Sl. No.	Name of Tiger Reserve	State	Total area (KM ²)
17	Valmiki	Bihar	899.38
18	Pench	Madhya Pradesh	1179.63225
19	Tadoba-Andhari	Maharashtra	1727.5911
20	Bandhavgarh	Madhya Pradesh	1598.1
21	Panna	Madhya Pradesh	1578.55
22	Dampa	Mizoram	988
23	Bhadra	Karnataka	1064.29
24	Pench	Maharashtra	741.22
25	Pakke	Arunachal Pradesh	1198.45
26	Nameri	Assam	344
27	Satpura	Madhya Pradesh	2133.30797
28	Anamalai	Tamil Nadu	1479.87
29	Udanti-Sitanadi	Chattisgarh	1842.54
30	Satkosia	Odisha	963.87
31	Kaziranga	Assam	1173.58
32	Achanakmar	Chattisgarh	914.017
33	Dandeli-Anshi	Karnataka	1097.514
34	Sanjay-Dubri	Madhya Pradesh	1674.502
35	Mudumalai	Tamil Nadu	688.59
36	Nagarahole	Karnataka	1205.76
37	Parambikulam	Kerala	643.662
38	Sahyadri	Maharashtra	1165.57



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Sl. No.	Name of Tiger Reserve	State	Total area (KM ²)
39	Biligiri Ranganatha Temple	Karnataka	574.82
40	Kawal	Telangana	2019.12
41	Sathyamangalam	Tamil Nadu	1408.4
42	Mukandra Hills	Rajasthan	759.99
43	Nawegaon-Nagzira	Maharashtra	653.674
44	Nagarjunsagar Srisailam (part)*	Andhra Pradesh	3296.31*
45	Amrabad	Telangana	2611.39*
46	Pilibhit	Uttar Pradesh	730.2498
47	Bor	Maharashtra	138.12
48	Rajaji Tiger Reserve	Uttarakhand	1075.17

* After Reorganization of Andhra Pradesh, the Nagarjunsagar-Srisailam Tiger Reserve is to be divided among the two states and the Telanagan Part is to be known as Amrabad Tiger Reserve as India's 45th Tiger Reserve

National Tiger Conservation Authority

Project Tiger was launched in 1973 with nine reserves in 1973-74. The project was first started as a central scheme. Later, it was transformed into Centrally Sponsored Scheme, whereby centre and states shared equal expenditures. The National Tiger Conservation Authority was launched in 2005, following recommendations of the Tiger Task Force. It was given statutory status by 2006 amendment of the Wildlife Protection Act.

Structure of NTCA

Environment Minister is the Chairman of the NTCA. Below chairman are eight experts or professionals having qualifications and experience in wildlife conservation and welfare of people including tribals, apart from three Members of Parliament (1 Rajya Sabha, 2 Lok Sabha). The Inspector General of Forests, in charge of project Tiger, serves as ex-officio Member Secretary.

Functions

NTCA is the overarching body for conservation of tigers in India. Its main administrative function is to approve the Tiger Conservation Plan prepared by the State Governments and then evaluate and assess various aspects of sustainable ecology and disallow any ecologically unsustainable land use such



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as, mining, industry and other projects within the tiger reserves.

*As per the WLPA, every State Government has the authority to notify an area as a tiger reserve. However, the Tiger Conservation Plans sent by state government need to be approved by the NTCA first. Alternatively, Central Government via NTCA may advise the state governments to forward a proposal for creation of Tiger Reserves. Every year, the Central Government puts the **annual report** of the National Tiger Conservation Authority in **each House of Parliament**.* Other Functions of NTCA are as follows:

- Regulation and standardization of tourism activities
- Provide for management focus and measures for addressing conflicts of men and wild animals.
- Provide information on protection measures.
- Ensure that the tiger reserves and areas linking one protected area or tiger reserve with another protected area or tiger reserve are not diverted for ecologically unsustainable uses, except in public interest and with the approval of the National Board for Wild Life and on the advice of the Tiger Conservation Authority.
- Facilitate and support the tiger reserve management in the State.
- Ensure critical support including scientific, information technology and legal support for better implementation of the tiger conservation plan.

Project Snow Leopard

Taxonomically, snow leopards belong to the family of cats called Felidae. However, until few years ago, it was not kept in the genus of Big cats (Panthera) and was named *Uncia uncia*. In recent times, it has been seen as one of the Big Cats, but still there is one difference between the snow leopard and other Big Cats such as Lion, Tiger and Leopard that – it does not roar, thanks to its different structure of vocal chords and absence of specially adapted larynx and hyoid apparatus.

Distribution of Snow Leopards

It is found in Central Asia and South Asia. Being a predator like tiger, snow leopard is **apex predator** of ecological pyramid. There are around 7000 snow leopards worldwide.

- In India, they are between 500 to 700 found in Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh states.

Snow Leopard has suffered mainly on account of its relatively smaller population (less number of reproducing adults) and also because of man-animal conflict. It is listed as endangered on the IUCN Red List of Threatened Species.

Project Snow Leopard

This project was launched in 2009 to safeguard and conserve India's unique natural heritage of high-altitude wildlife populations and their habitats by promoting conservation through participatory



policies and actions.



Save Our Snow Leopards (SOS)

Save Our Snow Leopards' (SOS) is a project launched by WWF India, in partnership with Tata Housing Development Company in January 2014.

Ladakh becoming role model in protecting Snow leopard

The Ladakh region is setting an example for the rest of the country, to protect the endangered Snow Leopard. It is estimated that there are more than 400 wild cats within the Indian Territory in Ladakh. With the help of local people, the Wildlife Department and several Non-Governmental Organizations (NGOs) succeeded in preventing man-animal conflict and discouraged killing of the exotic wild cats (or Snow leopards) found in Trans Himalayan-Karakorum mountains of the region and central Asia.

Project Elephant

Taxonomically, elephants belong to family Elephantidae. There are ONLY two genera extant from this species viz. *Elephas* and *Loxodonta*. Genus *Elephas* is of the Asian Elephants. There is only one surviving species of this Genus viz. *Elephas maximus* and elephants of this species are found in natural conditions only in Asia. This species has three subspecies as follows:

- Indian Elephant: *Elephas maximus indicus*
- Sri Lankan Elephant: *Elephas maximus maxicus*
- Mainland Asian Elephants: *Elephas maximus sumatranus*

Asian elephants are the largest living land animals in Asia. The key differences between Asian Elephants and African Elephants are shown in below table. (Key differences marked red)

Conservation of Elephants in India – Project Elephant

In our country there are approximately 30 thousand elephants spread in 16 Elephant states. Maximum number of elephants is in Kerala, followed by Karnataka and Assam. Project Elephant was



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launched in 1991-92 as a centrally sponsored scheme to assist the States on three key areas

- Protection of wild elephants, their habitat and corridors
- Address the issue of man-animal conflict and
- welfare of domesticated elephants

This Project Elephant is being implemented in 13 states.

Elephant Reserves

A total of 28 elephant reserves covering 58000 km² have been so far notified in India by the state governments. They cover not only the forest patches of different kinds but also villages, townships, agricultural land, tea plantations and revenue land. Sighbhum Elephant Reserve in Jharkhand was the first reserve to be notified in 2001. Out of 28 ERs, maximum number is in Assam and Odisha with five each.

Elephant Corridors

Elephant corridors are narrow strips of land that allow elephants to move from one habitat patch to another. There are 183 identified elephant corridors in India. Out of this 138 are State Elephant Corridors, 28 Inter-State Elephant Corridors and 17 are International Elephant Corridors. Among state corridors, maximum number of them are located in **Meghalaya**. Among, inter-state corridors, maximum are shared by **Jharkhand and Odisha**. Maximum International corridors India shares with **Bangladesh**.

Elephant as National Heritage Animal of India

On the basis of recommendations from the In 2010, Elephants have been declared as national heritage animal by the government with an aim to step up measures for their protection. The status was recommended by a task force on elephant project. The government is still mulling over to amend the Wildlife (Protection) Act to pave way for setting up of National Elephants Conservation Authority (NECA) on the lines of the NTCA that has been constituted for the tiger conservation.

Project Hangul

'Hangul' (Kashmiri stag) is the only surviving species of the red deer family in Kashmir. The rare animal's strength fell from 5,000 in the beginning of last century to 900 in 1980s, when militancy broke out in the border state. With the help of World Wildlife Fund's 'Project Hangul' started in the 70's, their population had gone to 340 by the 80's. But it was short lived.

Many factors are responsible for the failure of this project.

1. There was no local people participation in the project. It was carried without the involvement of local communities such as Gujjars, Bakerwals, Nambardars, Chowkidars and Patwaris.
2. The project was confined focus around Dagwan, in a radius of 10 kms crying foul of Sheep breeding Farm.



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3. The government departments allowed establishing Cement factories around Dachingam National Park. They disturbed the wild areas.
4. There was illegal and reckless unscientific extraction of limestone stretching over miles after miles was carried under its nose. Those areas created death traps for animals.
5. The onset of militancy dealt a blow to conservation efforts.

Later the project was rechristened as “Save Kashmir’s Red Deer Hangul” in 2009. Another attempt to save the Hangul was to breed it in captivity. Funds were sanctioned for captive breeding. Under the Species Recovery Programme, conservation breeding centres are opened at Sikargah Tral, Pulwama District and Kangan. But there not much progress on increasing the numbers.

Important Short Notes on Fauna and Flora for Prelims

Big Cats

Which are Big Cats?

Taxonomically, Big Cats are members of Felidae family represented by three genera viz. Panthera (included Lion, Tiger, Jaguar, Leopard and Snow Leopard), Acinonx (includes Cheetah) and Puma (includes Cougar).

Clouded Leopard (*Neofelis nebulosa*) is not a big cat but is considered to be an evolutionary link between small and big cats.

Big Cats Found in India

Four big cat species are found in India in wild viz. Gir Lion, Bengal tiger, Indian leopard, Snow leopard. Further, clouded leopard is also found in India. The Big Cats that are not found in their natural habitats in India are Jaguar and Cheetah. Cheetah got extinct as back as 1940s.

Only cat that lives in group

Lions are the only cats that live in groups, called prides. Prides are family units that may include up to three males, a dozen or so females, and their young.

Last habitant of Asiatic Lion

The last surviving population of the Asiatic lions occupies a compact tract of dry deciduous forest and open grassy scrublands in south-western part of Saurashtra region in Gujarat and are found in Gir forests and thorny thickets.

Major difference between Asiatic Lion and African Lions

The Asiatic lions have belly fold and distinctive tuft of hair on elbow which are absent in their African counterparts.

Clouded Leopard in India

Clouded Leopard is widely found in Himalayan Foothills in India, Nepal and Bhutan along with some other countries. It is considered to be most talented climbers among the cats, it can climb upside down and hang from branches with its hind feet.



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Deers and Antelopes

Similarities and differences between Deer and Antelopes

Similarity

Taxonomically, both deer and antelopes belong to same order called Artiodactyla or Even-toed ungulates. In the even-toed animals, the weight of the body of the animal is borne by 3rd and 4th toe of the forefeet. Most of the four-footed animals belong to this order. Common examples are cows, goats, sheep, Buffaloes, Pigs, Camels, deers, antelopes etc.

In the Odd Toed animals, the weight of the body is borne by the third toe only. Common example of such animals is Horse.

Difference

Going down the taxonomical hierarchy, Deer belongs to family Cervidae (family of deers), while Antelopes or Gazelle belong to family Bovidae (family of cattle, sheep, water buffalo, and bison). While the male deer (and female reindeer) grow and shed new antlers each year Antelope is permanently horned. Antelopes also have a white streak down each side of the face and a dusky patch above the nose.

Common Examples of two families:

Common animals of these two families are as follows:

- Deer Family: All kinds of deers including pudú and chital and except musk deer and mouse deer.
- Antelopes: Gazelles, Blackbucks, Hangul, Chikkara, Nilgai, Tibetan Antelope (Chiru) etc.

Black Buck

The near threatened blackbuck is found in Central – Western India (Madhya Pradesh, Rajasthan, Gujarat, Punjab, Haryana, Maharashtra, and Odisha) and Southern India (Karnataka, Andhra Pradesh, and Tamil Nadu). In Andhra Pradesh, it is the state animal.



It is the only living species of the genus *Antelope*. The horns of the blackbuck are ringed with one to four spiral turns and the female is usually hornless.

The Bishnoi community of Rajasthan is known worldwide for their conservation efforts to

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Blackbuck and Chinkara. A very effective conservation plan for Black bucks has been taken at IIT Madras in Chennai. It's a flagship scheme at IIT-M campus. Black Buck is also the title of the monthly newsletter of Madras Natural Society.

Sangai

Sangai is an endangered brow-antlered deer found in its natural habitat only at Keibul Lamjao National Park, Loktak Lake, Manipur. It is the state animal of Manipur. It is one of the critically endangered species of deers in India.

Chinkara or Indian Gazelle

This is the smallest Asiatic antelope. They can go without water for long periods and can even get sufficient fluids from plants and dew drops

Chiru

Tibetan antelope of Chiru (*Pantolops hodgsonii*) is endemic to the Tibetan Plateau, this antelope is found mainly in Chinese regions although some individuals migrate to Ladakh in India.

The Shahtoosh Threat

Chiru is well known for possessing the finest and warmest wool (Shahtoosh) in the animal kingdom. This adaptation provides warmth in the harsh climate of the Tibetan plateau, but has contributed greatly to this species' decline. The principal cause of this decline is to supply the 'shahtoosh' trade; the production of shawls made from the fine, warm wool of this species. Shahtoosh stands for 'king of wools' in Persian and became a sought-after fabric in the fashion capitals of the world towards the end of the 20th Century. Up to five antelope are needed to produce a single shawl, which is quite costly in international markets. Until 2002, shahtoosh shawls were legally produced in the states of Jammu and Kashmir in India but a vital ban on manufacture has now been introduced.

Protection of Chiru

To enhance protection of Chiru, its prime habitats have been declared as Wildlife Sanctuaries viz. Karakorma Wildlife Sanctuary and Changthang Cold Desert Wildlife Sanctuary. Jammu & Kashmir Government has its own wildlife Protection act of 1978. Chiru is in list I of that act and it is also protected by the Indian wildlife act. Thus it **one of the few species** which are protected by the two acts.

Barasingha

The Barasingha (*Rucervus duvaucelii*), also called swamp deer is an endangered deer species currently found in isolated localities in northern and central India, and south-western Nepal. It has already got extinct in Pakistan and Bangladesh.

The most striking feature of a Barasingha is its antlers, with 10 to 14 times on a mature stag, though some have been known to have up to 20.

Barasingha used to inhabit the basins of the Indus, Ganges and Brahmaputra Rivers, as well as central



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India as far as the Godavari River. Today, Barasingha have disappeared entirely from the western part of their range. In 1964, the total population in India was estimated at 3000 to 4000 individuals. In north-eastern India, the surviving animals are found in Assam.

Tibetan Gazelle / Goa

The Tibetan gazelle (*Procapra picticaudata*) is a small and slender gazelle with a compact body and long, thin limbs. Male Tibetan gazelles have slender, ridged horns that are relatively straight with just a slight arch.

The Tibetan gazelle is native to China and India. Although over 99 percent of its range lies in the Qinghai-Tibet Plateau of China, populations do also occur in small areas of India neighbouring the plateau

The population of the Tibetan gazelle in the region of Ladakh in India is particularly at risk. Severely reduced by hunting in the past, it is continuing to decline due to intensive livestock grazing, and may also face threats from feral dogs and from diseases transmitted by livestock.

The Tibetan gazelle population in Ladakh may now number only around 50 individuals in an area of just 100 square kilometres, while populations in some other parts of India have recently become extinct.

Mouse Deer (*Tragulus meminna*)

Mouse Deers are found in India, Sri Lanka and perhaps Nepal, and have pale-spotted or -striped upper parts unlike the other Asian members of the family. All species in the family lack horns, but both genders have elongated canine teeth. It is basically a forest species, being found commonly in all forest types within the dry zone, and also in coconut plantations and home garden.

Musk Deer (*Moschus moschiferus*)

Musk deer are responsible for the production of musk, a strong-smelling substance that is one of the most expensive animal products in the world. The male musk deer does not possess antlers, but instead has two prominent, tusk-like canine teeth. Lichen forms an important part of the Siberian musk deer's diet. The musk deer is found in the Russian Federation, Kazakhstan, northern and western China, the Democratic People's Republic of Korea, the Republic of Korea, and Mongolia. The main threat to the musk deer comes from being hunted for the musk trade, because it has been a highly valued ingredient in the production of medicines and perfumes.

Musk deer in India

The species of musk deer found in India is *Moschus leucogaster*, commonly known as White-bellied musk deer

Four-horned antelope

The four-horned antelope or Chousingha, is a species of small antelope found in open forest in India and Nepal. It is the only species currently classified in the genus *Tetracerus*. Their range extends



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south of the Gangetic plains down to the state of Tamil Nadu, and east as far as Odisha. They also occur in the Gir Forest National Park of western India. Living in a densely populated part of the world, the four-horned antelope is threatened by loss of its natural habitat to agricultural land. In addition, the unusual four-horned skull has been a popular target for trophy hunters. Only around 10,000 four-horned antelope are estimated to remain alive in the wild. The species is listed as Vulnerable by the IUCN due to habitat loss.

Hangul

Hangul or Kashmir Stag is the only surviving race of the Red Deer and is found only in India's Jammu & Kashmir and Himachal Pradesh. In J & K, its state animal. The last individuals of these animals are found in Dachigam National Park in Jammu & Kashmir.

They were threatened, due to habitat destruction, over-grazing by domestic livestock, and poaching. The Government of India is running a Species Recovery Plan for Hangul since 2009.

Ant Eaters (Pangolins)

Pangolins are a highly endangered species and they are hunted for their scales. Though, the use its scales for medical or other purposes is banned internationally, yet they are used illegally to treat arthritis and stomach ailments in countries like China and Thailand.

Indian Pangolin

The Indian pangolin is a mammal found in the tropical regions of India, Pakistan, Sri Lanka and Nepal. It is an scaled insectivore that feeds on ants and termites. It can curl itself into a ball as a form of self-defence against predators such as the tiger.



A pangolin's tongue is extremely elongated. Large pangolins can extend their tongues up to 40 centimetres with a diameter of 0.5 centimetres. The nocturnal animal uses its sense of smell while digging to reach nests or mounds and also when foraging for food. The lifespan of the ant-eaters is about 12 years.

Currently, the Indian pangolin is listed as near-threatened by IUCN. This species is included in Schedule 1 of the Wildlife Protection Act 1972.



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Chinese Pangolin

Chinese Pangolin is also found in several parts of India and other countries. It is also an ant eater, classified as endangered by the IUCN. It is highly specialised in feeding solely on ants and termites.

Aquatic Mammals

Sea Cow / Dugong

Dugong or Sea Cow is a sea-grass eating mammal which is found in waters of as many as 37 countries. It is now on verge of extinction, because it has been hunted for meat and oil. In India also, its meat is considered to be aphrodisiac.

Maximum Population of Dugong is found in Red Sea, followed by the Persian Gulf.



Largest Dugong was as long as 13.5 ft and was found in Gulf of Katch in India. In India, they are found in Gulf of Kutch, the only population remaining in western India and Gulf of Mannar. The Gulf of Mannar Biosphere (GoMB) has the largest population of dugongs in India. They are also found near the Andaman and Nicobar Islands.

With fewer than 200 dugongs (commonly known as sea cow) in its waters, India is strongly encouraging its neighbours in South Asia to sign the Dugong United Nations Environment Programme/Convention of Migratory Species (UNEP/CMS) MoU as early as possible.

Currently classified as vulnerable to extinction under the IUCN Red List of Threatened Species, the dugongs are vulnerable to human-related influences due to their life history and dependence on sea grasses that are restricted to coastal habitats under increased pressure from human activities.

Reasons for the decline in population are: sea grass habitat loss and degradation, gill netting, chemical pollutants, indigenous use and hunting.

Ganges River Dolphin

Indian Government has notified the Ganges River Dolphin (*Platanista gangetica gangetica*) as India's National Aquatic Animal. It is also known as Susu because of the sound it produces when breathing.

Population and Distribution

The Total population of Ganges River Dolphin is estimated to be around 2000 and they inhabit the



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Ganges-Brahmaputra-Meghna and Karnaphuli-Sangu river systems of Nepal, India and Bangladesh.



These dolphins are found in Assam, Uttar Pradesh, Madhya Pradesh, Rajasthan, Bihar, Jharkhand and West Bengal (7 states) and ideal habitats are in the Ganga, Chambal, Ghaghra, Gandak, Sone, Kosi, the Brahmaputra and Kulsi rivers.

Threats

Ganges River Dolphin is placed under “Endangered Category” in the IUCN Red List. It lives in one of the world’s most densely populated areas, and is threatened by removal of river water and siltation arising from deforestation, pollution and entanglement in fisheries nets. They have been poached over for their oil. The habitat degradation due to declining flow, heavy siltation and construction of barrages causing physical barrier for this migratory species is also one of the reasons behind decline of their numbers.

India’s National Aquatic Animal

The decision to declare the Ganges river dolphin India’s national aquatic animal was taken Oct 5 2009 during the first meeting of the newly-constituted National Ganga River Basin Authority.

India’s First Dolphin Community Reserve

In October 2015, the West Bengal government decided to establish India’s first Dolphin Community Reserve in the state at Hooghly River between Malda and Sundarbans.

Other River Dolphins

There are only four true freshwater river dolphins found around the world viz. Ganges River Dolphin, Indus River Dolphin, Amazon River Dolphin and Yagtze River Dolphins. Further, the Irrawady river dolphins can survive in both fresh and marine waters.

Indus River Dolphin (*Platanista minor minor*) is found in Indus river in Pakistan and also in Beas and Sutlej rivers in India. Both Ganges River Dolphin and Indus river Dolphin are now taxonomically considered one species since 1998.

The Amazon River Dolphins are is found in plenty number in Amazon river. The Yangtze river dolphins have not been seen in last one decade and it is believed that they have gone extinct. The Irrawady river dolphins, which can survive both in fresh water and marine water are found in



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Myanmar, Indonesia and the Mekong river delta in south-east Asia. Some of the Irrawady River Dolphins are also found in Bangladesh and India's Chilka Lake in Odisha.

Goats

Himalayan Ibex

Himalayan Ibex or *Capra sibirica hemalayanus* is found in the mountain ranges of central and north-eastern Afghanistan, China and North India at altitudes of 500-6,700 meters. They are adapted to rocky terrain and open alpine meadows and crags, seeking out lower elevations during the winter. Their diet consists of alpine grasses and herbs, and it feeds in early morning and evenings. In India, they are found in Jammu and Kashmir – Kishtwar and Hemis National Parks.

Threats

Poaching also occurs in some areas by military personnel, road maintenance workers, and others, especially in areas accessible by vehicle.

Himalayan Tahr

The Himalayan tahr is a relative of the wild goat and is specially adapted to life on the rugged mountain slopes of the Himalayas, extending from the montane to alpine zones. Tahrs are predominantly grazers, feeding on grasses and herbs, but they do browse the leaves of shrubs particularly when pastures are snow-covered.

In its native range, the Himalayan tahr is threatened by habitat loss as people exploit resources (e.g. medicinal plants) in more marginal areas and military conflicts in northern India, which has also contributed to the tahr's decline.

There are plans to extend the Great Himalayan National Park's range and establish the Srikhand National Park as a reserve for tahr.



Himalayan Ibex



Himalayan Tahr

Nilgiri Tahr (*Hemitragus hylocrius*)

Nilgiri Tahr (*Nilgiritragus hylocrius*) or Nilgiri Ibex is a stocky goat endemic to the Nilgiri Hills and

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the southern portion of the Western Ghats in the states of Tamil Nadu and Kerala. Nilgiri Tahr is the state animal of Tamil Nadu.

Population

The global population of Nilgiri Tahr is estimated to be between 2,000 and 2,500 individuals and shows a decreasing trend. Currently they are found in Kerala and Tamil Nadu only at high elevations on cliffs, grass-covered hills, and open terrain in the Western Ghats. Largest population of Nilgiri Tahr is found within the *Eravikulam National Park*, Munnar, Kerala.



Threats

IUCN has put them in endangered species. Principal threats are habitat loss due to domestic livestock and spread of invasive plants and poaching. The population of these animals is small and isolated, making them vulnerable to local extinction. The species faces competition from domestic livestock, according to the IUCN.

Distribution

Present distribution of the Nilgiri tahr is limited to approximately 5 per cent of the Western Ghats in southern India, in In the beginning of this century, the range probably extended northward at least to the Brahmagiri hills of southern Karnataka.

Markhor (*Capra falconeri*)

The markhor is a skilled, nimble climber, and will often be seen perched on precipitous rock faces, away from the threat of predators, such as snow leopards, wolves and lynxes.

Distribution

The markhor is found in the mountains of central Asia, with populations scattered through north eastern Afghanistan, northern India and Pakistan. It happens to be the National Animal of Pakistan.

They may be found in a range of environments including steep gorges, rocky areas, scrub forest and grassy meadows.



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Threats

Markhor has been classified as Endangered (EN) on the IUCN Red List. The main cause of the precipitous decline has been excessive hunting, both for meat and for its impressive horns, which are also used for traditional medicine in the East Asian market.

Ass

Kiang / Tibetan Wild Ass

The Kiang or Tibetan Wild Ass is the *largest of the all African and Asiatic wild asses*.

Distribution

Kiang is found in China, India, Nepal and Pakistan. Outside China, most of the kiang populations are found in Ladakh and Sikkim, India. Its coat is reddish in summer to dark brown in winter with almost white under parts.

Key Features

Kiang is considered closer to a horse than ass due to its short ears, large tail tuft and broad hooves. Like all wild asses, Kiangs have short upright mane and a dark stripe along the back extending from nape to tail. The habitat of the Kiang extends from Tibet, some regions in China to east Ladakh and north Sikkim in India. Kiang is an agile animal and can run long distances at a speed of more than 50 kms per hour. Kiangs live in herds and feed upon sparsely growing sturdy grasses.

Threats

It is a species of 'Least Concern' on the IUCN red list of threatened animals. The animal was also harvested for meat in India in the past, but presently no one consumes it. Many pastoralists claim that the population of kiang has exploded as a result of reduced hunting in the last few decades.

Indian Wild Ass

The Indian Wild Ass (*Equus hemionus khur*), also called Ghor Khar or Ghud Khur is found predominantly in the Little Rann of Kutch and its surrounding areas in Gujarat. It is also found in southern Pakistan, Afghanistan, and south-eastern Iran. Saline deserts (Rann), arid grasslands and



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shrub lands are its preferred environment.

Key Features

It is one of the fastest Indian animals. The coat of the animal is usually sandy and may vary from reddish grey, fawn, to pale chestnut. It possesses an erect, dark mane which runs from the back of the head and along the neck followed by a dark brown stripes running along the back, to the root of the tail. It feeds on grass, leaves and fruits of plant, crop and saline vegetation.

- Wild asses graze between dawn and dusk. The animal feeds on grass, leaves and fruits of plant, crop, *Prosopis pods*, and saline vegetation.
- They live either solitarily, or in small groups of twos and threes while family herds remain large.

Threats and Conservation Status

In August 2015, the IUCN Red List has moved the Indian wild ass from the 'vulnerable' to 'endangered' category, indicating the need for heightened protection measures.

Indian Wild Ass Sanctuary located in the Little Rann of Kutch is the largest wildlife sanctuary in India.

A few years back, the Gujarat Ecological Education and Research Foundation (GEER) report had recommended that the Thar desert in Rajasthan should be developed as an alternative site for re-establishing the Indian wild ass by reintroduction a few of them.



Tibetan Wild Ass



Indian Wild Ass

Primates

Lion-tailed Macaque (*Macaca silenus*)

Lion-tailed macaque (*Macaca silenus*) also known as Wanderloo is one of the smallest and ~~most~~ *most endangered of the macaque species* Lion-tailed Macaque is the only Indian macaque with a black coloured coat.

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Distribution

Lion Tailed Macaque is endemic to Western Ghats and is found only in evergreen broadleaf monsoon forest in Western Ghats states of Karnataka, Kerala and Tamil Nadu.

Behaviour

These macaques spend the majority of their time in the trees, huddling together to sleep at night high up in the forest canopy. The mainstay of the lion-tailed macaque diet is fruit, although they will also forage for seeds, young leaves, flowers, buds and even fungi.



Threats

The lion-tailed macaque ranks among the rarest and most threatened primates, listed as endangered in IUCN red list. The main threat is the destruction of their forest home. Only 1% of the original habitat remains today due to widespread deforestation for timber, cultivation of tea, coffee, teak and cinchona, construction of water reservoirs for irrigation and power generation, and human settlements to support such activities.

Another reason that becomes threat to them is the slow reproduction cycle of Lion-tailed Macaques. A female macaque gives birth only once in three years. Further not all but only dominant females give birth. The low birth rate and high age at first birth, gives little chance for their population to bounce back.

Nilgiri Langur

The Nilgiri langur is classified as Vulnerable on the IUCN Red List and it is endemic to Western Ghats. It has a glossy, dark brown coat and long, thick golden to brown fur on the head. It inhabits tropical wet evergreen, semi-evergreen and riparian forests as well as teak plantations, at altitudes of between 300 – 2,000 m above sea level.

This langur species form groups with one male and up to 23 females and young, who move through the forest eating the leaves of 102 plant species as well as some of their fruit, flowers and seeds.



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Gee's Golden Langur

Gee's golden langur, or simply golden langur, is found in western Assam and the Black Mountains of Bhutan.

It is one of the most endangered primate species of India. Long considered sacred by many Himalayan people, the golden langur was first brought to the attention of science by the naturalist E. P. Gee in the 1950s. In 1988, two captive groups of golden langurs were released into two protected areas of the western region of the state of Tripura, India. As of 2000, one of these groups, consisting of six (and possibly eight) individuals in the Sepahijala Wildlife Sanctuary, had survived. Golden langurs are currently considered to be an endangered species in India. Presently, their population is around 10,000 only.

Hoolock Gibbon

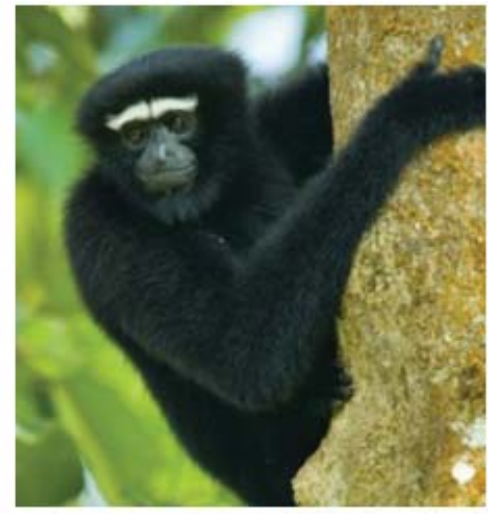
Hoolock gibbons are the *only apes found in India*. They are found in all seven states of northeast India, Eastern Bangladesh and South-West China. There are two species of Hoolock Gibbons viz. Western Hoolock Gibbon (*Hoolock hoolock*) and Eastern Hoolock Gibbon (*Hoolock leuconedys*) and both species are found in India.



Nilgiri Langur



Gee's Golden Langur



Hoolock Gibbon

Other Important Mammals

Red Panda

- Western Red Panda is found in Nepal, Assam, Sikkim and Bhutan states of India. Red pandas are one of the few animals whose *diet is composed almost entirely on bamboo*.

Malabar Civet (*Viverra zibetha*)

- Critically Endangered Malabar Civet is endemic to the Western Ghats of India. It is listed as Critically Endangered by IUCN

Salim Ali's fruit bat (*Latidens salimalii*)

- Critically Endangered Salim Ali's fruit bat is one of the world's rarest bats and is the only species in the genus *Latidens*. It is found to Western Ghats.

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- Under the Indian Wildlife Protection Act all species of fruit bat are classified as pests and it is therefore legal to persecute them outside of protected reserve.

Pygmy Hog

- Pygmy hog is the smallest of all the pig family. These small hogs have relatively short limbs. It is critically endangered animal and is currently found only in Indian state of Assam. The Pygmy Hog Research and Breeding Centre is located in Basistha, Assam, which along with Assam State Zoo is endeavouring captive breeding of this hog.

Sloth Bear (*Melursus ursinus*)

- Sloth bears are found in a wide variety of habitats on the subcontinent, from grasslands and thorn scrub to evergreen forest.

Small Travancore Flying Squirrel (*Petinomys fuscocapillus*)

- Listed as Near Threatened because its extent of occurrence is probably approximately 30,000 km², and the extent and quality of its habitat are probably declining, and it occurs as severely fragmented populations.
- This species is restricted to the Western Ghats of southern India and to the island of Sri Lanka.
- It is an arboreal and nocturnal species. It occurs in evergreen, deciduous and montane forests.
- Travancore flying squirrels were thought to be extinct but rediscovered in 1989 after a gap of 100 years.

Namdapha flying squirrel

- Critically endangered Namdhapa Flyng Squirrel is endemic to North East India.

Wild Yak

- The wild yak was domesticated about 2,000 years ago. Unfortunately, the number of wild yak is decreasing very quickly, due to uncontrolled hunting, and by their pastures being taken over by domestic yak. There are probably only a few hundred wild yak, and they have been categorized by the IUCN as endangered. Wild yak are now officially protected in China. In India, a few wild yaks are found in Chang Chemmo Valley of Ladakh.

Tibetan Wolf

- The Tibetan wolf is found in Tibet and Ladakh and there it is known as chánkú or shanko.

Desert Lynx / Caracal

- Caracal or Desert Lynx is a wild cat widely distributed across Africa, Central Asia and southwest Asia into India. Caracals can survive without drinking for a long period—the water demand is satisfied with the body fluids of prey. They have been used in India for the purpose of hunting and blood sports.

Giant squirrel

- The grizzled giant squirrel (*Ratufa macroura*) is found in Sri Lanka and Western Ghats of



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southern India. It is highly territorial and is very vocal upon encountering an intruder. It is usually found alone or occasionally in pairs.

Reptiles

Gharial (*Gavialis gangeticus*)

As per Indian mythology, Gharial is the *vahana* of Goddess Ganga and Varuna, the god of water. It is a river dwelling fish-eater, but usually harmless to humans.

It lives in deep fast-flowing rivers. The bulbous 'ghara' on the tip of the snout of mature males just above the nostrils, helps in creating a *snorting hiss to advertise the animal's presence, and dominance*.

Distribution

Gharials are endemic to the Indian sub-continent. Once found abundantly in all the major river systems of South Asia, the Gharial is now extinct in Pakistan, Bangladesh, Burma and Bhutan. Nepal has only a remnant breeding population.

In India too, the major breeding populations are confined to two rivers only *Girwa and the Chambal*. The two rivers run along the borders of Uttar Pradesh, Madhya Pradesh and Rajasthan. A few non-breeding populations exist in small pockets in other rivers in India.

Gharial is listed as 'Critically Endangered' in the IUCN Red List of Endangered Species. Between 2007-2008, over 100 Gharials in the Chambal perished in a mystery die-off attributed to a *nephrotoxin possibly originating from contaminated fish in the Yamuna*.

Turtles

Loggerhead, Hawksbill and Leatherback are common names of the Turtles found in India. Turtles are placed in reptiles. The five species are Green turtle (*Chelonia mydas*), Loggerhead (*Caretta caretta*), Olive Ridley (*Lepidochelys olivacea*), Hawksbill (*Eretmochelys imbricata*) and Leatherback (*Dermochelys coriacea*). Leatherback is Critically Endangered.

Olive Ridley Turtles

In November 2015, the Odisha Government has imposed seven-month ban till May, 2016 on fishing along the Puri coast in order to protect the endangered Olive Ridley turtles.

Olive Ridley Turtles (*Lepidochelys olivacea*) are found in warm and tropical waters, primarily in the Pacific and Indian Oceans. They are listed as "Vulnerable" in the IUCN Red List. In India, they have been included in Schedule-I of the Wildlife (Protection) Act, 1972.

Astaranga coast and Gahirmatha Marine Sanctuary both in Odisha, are home to Olive Ridley Turtles. The coastal waters of Gahirmatha have been designated as a *Marine Sanctuary*, and thus, its only Marine sanctuary of Odisha. This sanctuary boasts of possessing the world's largest known rookery of Olive Ridley sea turtles.

The Odisha state government is taking steps for patrolling and other measures for their protection.



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These turtles are best known for their behavior of synchronized nesting in mass numbers, termed **arribadas**. The winter seasons is the mating and breeding season of these turtles. Due to thus, the Odisha Government imposes a ban on fishing activities inside the Gahirmatha Marine Sanctuary as well as 20 kms off the shore from November to May under the state laws such as Orissa Marine Fishing Regulation Act, 1982 and Orissa Marine Fishing Rules, 1983.

But since this is a vast area, there is a heavy fishing pressure from local vessels as well as vessels from the neighbouring states like West Bengal and Andhra Pradesh and vessels from the neighbouring countries like Sri Lanka, Bangladesh and Thailand etc. The state government tries to deal with them to extent possible with available manpower and resources. Despite a ban continual illegal fishing using mechanized trawlers on Astaranga coast and Gahirmatha beaches, is posing serious threat to the endangered Olive Ridley turtles.

Kachuga dhonkoga

Kachuga dhonkoga is the Three-striped Roofed Turtle, also known as Batagur dhongoka and is a species of turtle mostly found in Nepal and North East India.

This turtle has been classified in the IUCN Red List of Threatened Species. It is under threat because of the consumption for subsistence by the local population, degradation of the riverine habitat and disturbance of the breeding sites.

Captive Breeding Programme for Kachuga Dhonkoga

In order to augment the population of species, head start and captive breeding programmes have been taken up at the following places:

- Kukrail Centre Lucknow, Uttar Pradesh
- Deori Crocodile and Turtle Rearing Centre, Madhya Pradesh
- Freshwater Turtle Conservation and Education Centre in National Chambal Sanctuary, Garhaita, Itawah, Uttar Pradesh.

Birds

Great Indian Bustard

The Great Indian Bustard (*Ardeotisnigriceps*) was once widely spotted across 11 Indian states, but now only less than 250 birds are left all across India. The destruction of the habitat is a primary threat to the bird's endurance. This critically endangered bird is endemic to the Indian subcontinent. The Great Indian Bustard lives in short-grass plains and deserts in large arid landscapes.

Threats

Key reasons for the decrease in count of the Great Indian Bustard are enumerated below:

- Habitat destruction- The change of land use from grassland to farmland, thus shrinking the bird's habitat.
- Degradation and disturbance in existing grassland habitat



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- Hunting
- Lack of importance for natural grassland conservation in policy, law and PA network due to incorrect perception on ecological value vis-a-vis forests
- Lack of protection for many 'lekking' and nesting sites
- Lack of cooperation between different departments/stakeholders in GIB habitats
- Lack of awareness and support from local communities
- Livestock overgrazing and feral dogs
- Disturbance by photographers — there is now plenty anecdotal evidence to demonstrate that photography of the species causes substantial disturbance

Current Status

The Great Indian Bustard is now confined to only eight pockets in 6 Indian states — Rajasthan, Gujarat, Maharashtra, Madhya Pradesh, Karnataka and Andhra Pradesh. The largest population (~50%) can be found in Jaisalmer, Barmer, and Bikaner districts of Rajasthan. Great Indian Bustard is the State Bird of Rajasthan.

Other Birds

Jerdon's Courser

- The Jerdon's Courser (*Rhinoptilus bitorquatus*) is a nocturnal bird endemic to Andhra Pradesh. It is a flagship species for the extremely threatened scrub jungle. The species was considered to be extinct until it was rediscovered in 1986 and the area of rediscovery was subsequently declared as the **Sri Lankamaleswara Wildlife Sanctuary**.

Forest Owlet

- The Forest Owlet (*Heteroglaux blewitti*) had been lost for more than a century. When not sighted for decades, posters were printed and Salim Ali, the premier ornithologist of India made a public appeal to look for the bird. After 113 long years, the owlet was rediscovered in 1997 and reappeared on the list of Indian birds. It is thinly distributed in South Madhya Pradesh, in north-west Maharashtra and north-central Maharashtra.

White-bellied Heron

- The White-bellied Heron (*Ardea insignis*) is an extremely rare bird found in five or six sites in Assam and Arunachal Pradesh, one or two sites in Bhutan, and a few in Myanmar. It is inherently rare, and populations have never been known to be very high.

Himalayan Quail

- The Himalayan Quail (*Ophrysia superciliosa*) is presumed to be extinct since no reliable records of sightings of this species exist after 1876.
- Intensive surveys are required as this species is hard to detect due to its reluctance to fly and its preference for dense grass habitats. Possible sighting of this species was reported in



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Nainital in 2003.

Sociable Lapwing

- Sociable Lapwing (*Vanellus gregarious*) is a winter migrant to India. This species has suffered a sudden and rapid population decline due to which it has been listed as critically endangered.
- It is found in fallow fields and scrub desert and is native to Central Asia, South Asia some countries in Middle East. In India, distribution is restricted to the north and north-west of the country.

Spoon Billed Sandpiper

- Spoon Billed Sandpiper (*Eurynorhynchus pygmeus*) requires highly specialized breeding habitat, a constraint that has always kept its population scarce.
- India is home to some of the last existing wintering grounds of this species (estimated at only 150-320 breeding pairs worldwide).

Siberian Crane

- Siberian Crane (*Grus leucogeranus*) is a large, strikingly majestic migratory bird that breeds and winters in wetlands.
- They are known to winter at Keoladeo National Park, Rajasthan. However the last documented sighting of the bird was in 2002.

Narcondam hornbill

- Narcondam hornbill is an IUCN red list species of hornbill in the Bucerotidae family endemic to the Indian island of Narcondam in the Andaman's. It is a small hornbill at 66 cm long and males and females differ in their plumage features, the male has a rufous head and neck, black body and upper parts glossed with green but females are all black.
- The entire population is restricted to the single island of Narcondam in the Andaman Island chain at a height of about 2300 feet above sea level and is largely devoid of human presence.
- The island is often hit by cyclonic storms in the Bay of Bengal and human activities have created threats to the species in contemporary times. Several Conservationists and groups protested to take care of the species owing to small area of island and much exposure to the species in tropical forests.

Biogeographic Regions of India

India is a megadiverse country. With only 2.4 per cent of the total land area of the world, the known biological diversity of India contributes 8 per cent to the known global biological diversity. In terms of Biogeography, India has been divided into 10 biogeographic zones as shown in the below table:

India has been divided into **ten recognizable biogeographic zones** as follows:



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Biogeographic Region	%*
Andaman & Nicobar Island	0.3
Coastal region	2.5
North East Region	5.2
Gangetic Plains	10.8
Deccan Plateau	42
Western Ghats	4
Semi Arid Region	16.6
Indian Desert Zone	6.6
Himalayan Zone	6.4
Transhimalayan Region	5.6
Total	100
*Of total geographic area	

Trans-Himalayan Region

It constitutes 5.6 per cent of the total geographical area, includes the high altitude, cold and arid mountain areas of Ladakh, Jammu & Kashmir, North Sikkim, Lahaul and Spiti areas of Himachal Pradesh. This zone has sparse alpine steppe vegetation that harbours several endemic species and is a favourable habitat for the biggest populations of wild sheep and goat in the world and other rare fauna that includes **Snow Leopard** and the migratory Blacknecked Crane (*Grus nigricollis*). The cold dry desert of this zone represents an extremely fragile ecosystem.

Himalayan Zone

It constitutes 6.4 per cent of the total geographical area includes some of the highest peaks in the world. The Himalayan zone makes India one of the richest areas in terms of habitats and species. The alpine and sub-alpine forests, grassy meadows and moist mixed deciduous forests provide diverse habitat for endangered species of bovids such as Bharal (*Pseudois nayaur*), Ibex (*Capra ibex*), Markhor (*Capra falconeri*), Himalayan Tahr (*Hemitragus jemlabicus*), and Takin (*Budoreas taxicolor*). Other rare and endangered species restricted to this zone include Hangul (*Cervus eldi eldi*) and Musk Deer (*Moschus moschiferus*).

Indian Desert Zone

Indian Desert Zone, constituting 6.6 per cent of the total geographical area, includes the Thar and the Kutch deserts and has large expanses of grassland that supports several endangered species of mammals such as Wolf (*Canis lupus*), Caracal (*Felis caracal*), Desert Cat (*Felis libyca*) and birds of conservation interest viz., Houbara Bustard (*Chamidotis undulate*) and the Great Indian Bustard



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(*Ardeotis nigriceps*).

Semi Arid Region

Semi-arid Region, constituting 16.6 per cent of the total geographical area, is a transition zone between the desert and the dense forests of Western Ghats.

Peninsular India has two large regions, which are climatically semi-arid. *This semi-arid region also has several artificial and natural lakes and marshy lands.*

The dominant grass and palatable shrub layer in this zone supports the highest wildlife biomass The cervid species of **Sambar** (*Cervus unicolor*) and **Chital** (*Axis axis*) are restricted to the better wooded hills and moister valley areas respectively. The Lion (*Leo persica*), an endangered carnivore species (restricted to a small area in Gujarat), Caracal (*Felis caracal*), Jackal (*Canis aureus*) and Wolf (*Canis lupus*) are some of the endangered species that are characteristic of this region.

Western Ghats

Constitutes 4.0 per cent of the total geographical area. It is one of the major tropical evergreen forest regions in India and represents one of the two biodiversity 'hot spots'. Western Ghats are home to viable populations of most of the vertebrate species found in peninsular India, besides an endemic faunal element of its own.

Significant species endemic to this region include **Nilgiri Langur** (*Presbytis jobni*), **Lion Tailed Macaque** (*Macaca silenus*), **Grizzled Giant Squirrel** (*Ratufa macroura*), **Malabar Civet** (*Viverricula megaspila*), **Nilgiri Tahr** (*Hemitragus bylocrius*) and **Malabar Grey Hornbill** (*Ocyerous griseus*). The Travancore Tortoise (*Indotestudo forstem*) and Cane turtle (*Heosemys silvatica*) are two endangered taxa restricted to a small area in central Western Ghats.

Deccan Plateau

Deccan Plateau is India's largest biogeographic region making 42 per cent of the total geographical area. It's a semi-arid region that falls in the rain shadow area of the Western Ghats. This biogeographic zone of peninsular India is by far the most extensive zone, covering India's finest forests, particularly in the States of Madhya Pradesh, Maharashtra and Odisha.

Majority of the forests are deciduous in nature but there are regions of greater biological diversity in the hill ranges. The zone comprising of deciduous forests, thorn forests and degraded scrubland support diverse wildlife species.

Species found in this region are **Chital** (*Axis axis*), **Sambar** (*Cervus unicolor*), **Nilgai** (*Boselaphus tragocamelus*) and **Chousingha** (*Tetracerus quadricornis*), **Barking deer** (*Muntiacus muntjak*) and Gaur (*Antilope cervicapra*), Elephant (*Elephas maximus*) in Bihar-Orissa and Karnataka-Tamil Nadu belts, Wild Buffalo (*Bubalus bubalis*) in a small area at the junction of Orissa, Madhya Pradesh and Maharashtra and the hard ground Swamp Deer (*Cervus duvauceli*), now restricted to a single locality



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in Madhya Pradesh.

Gangetic Plain

Gangetic plain constitutes around 10.8 per cent of the total geographical area. The Gangetic plain is topographically homogenous for hundreds of kilometers. The characteristic fauna of this region include Rhino (*Rhinoceros unicornis*), Elephant (*Elephas maximus*), Buffalo (*Bubalus bubalis*), Swamp Deer (*Cervus duvauceli*), Hog-Deer (*Axis porcinus*) and Hispid Hare (*Caprolagus hispidus*).

North East Region

North East Region constitutes 5.2 per cent of the total geographical area. This region represents the transition zone between the Indian, Indo-Malayan and Indo-Chinese bio-geographical regions as well as being a meeting point of the Himalayan mountains and peninsular India. The North-East is thus the biogeographical 'gateway' for much of India's fauna and flora and also a biodiversity hotspot (Eastern Himalaya). Many of the species contributing to this biological diversity are either restricted to the region itself, or to the smaller localized areas of the Khasi Hills.

Coastal Region

Coastal region constitutes 2.5 per cent of the total geographical area with sandy beaches, mangroves, mud flats, coral reefs and marine angiosperm pastures make them the wealth and health zones of India. The coastline from Gujarat to Sunderbans is estimated to be 5,423 km long. A total of 25 islets constitute the Lakshadweep, which are of coral origin, and have a typical reef lagoon system, rich in biodiversity. However, the densely populated Lakshadweep islands virtually have no natural vegetation.

Andaman and Nicobar Islands

This constitutes 0.3 per cent of the total geographical area and are one of the three tropical moist evergreen forests zones in India. *The islands house an array of flora and fauna not found elsewhere.* These islands are centres of high endemism and contain some of India's finest evergreen forests and support a wide diversity of corals. In India, *endemic island biodiversity is found only in the Andaman and Nicobar Islands.* Some of the endemic fauna of Andaman & Nicobar islands include Narcondam hornbill, South Andaman krait etc.

Fauna and Flora of Biodiversity Hotspots in India

Eastern Himalaya

Eastern Himalaya forms a distinct phytogeographic region comprising Nepal, Bhutan, states of East and North-East India, and a contiguous sector of Yunnan province in South-Western China. The Eastern Himalayas harbor a staggering 10,000 plant species, 300 mammal species, 977 bird species, 176 reptiles, 105 amphibians and 269 types of freshwater fish. The region also has the highest density of Bengal tigers in the world and is the last bastion of the charismatic greater one-horned rhino.



Environment-2: Biodiversity, Fauna and Flora

Flora of Eastern Himalaya

- In the whole of Eastern Himalaya, out of the 10000 plant species, around 39% are endemic.
- At least 55 flowering plants endemic to this area are recognised as rare, for example, the **Pitcher Plant** (*Nepenthes khasiana*).
- Eastern Himalaya is a rich centre of primitive flowering plants and is popularly known as the '**Cradle of Speciation**'. The floral diversity in this region includes a vivid spectrum of diverse species including monocots and dicots.
- This region is also known as as the **centre of origin and diversification of five palms of commercial importance** *coconut, arecanut, palmyra palm, sugar palm and wild date palm*.
- Tea (*Thea sinensis*) has been cultivated in this region for the last 4,000 years. Many wild and allied species of tea, the leaves of which are used as a substitute for tea, are found in the North East, in their natural habitats.
- The **Taxol plant or Himalayan Yew** (*Taxus wallichiana*) is sparsely distributed in the region and is listed under the red data category due to its overexploitation for extraction of a drug effectively used against various kinds of breast and ovarian cancer.

Fauna of Eastern Himalaya

- More than half (63%) of the genera of land mammals in India are found in Eastern Himalaya. During the last four decades, two new mammals have been discovered from the region viz. **Golden Langur** from Assam-Bhutan region, and **Namdapha Flying Squirrel from Arunachal Pradesh**.
- Not only that, a 100-million year-old gecko, the oldest fossil gecko species known to science, was discovered in an amber mine in the Hukawng Valley in the northern Myanmar.
- More than 60 per cent of the bird species found in India have been recorded in the North East. The region also hosts two endemic genera of lizards, and 35 endemic reptilian species, including two turtles. Of the 240 Indian amphibian species, at least 68 species are known to occur in the North East, 20 of which are endemic.
- From Namdapha National Park itself, a new genus of mammal, a new subspecies of a bird, six new amphibians species, four new species of fish, at least 15 new species of beetles and six new species of flies have been discovered.

Western Ghats

Western Ghats is one of the richest centres of endemism in the world. Due to varied topography and microclimatic regimes, some areas within the region are considered to be active zones of speciation.

Flora of Western Ghats

- The region has 490 arborescent taxa, of which as many as 308 are endemic. About 1,500 endemic species of dicotyledonous plants are reported from the Western Ghats. 245 species



Environment-2: Biodiversity, Fauna and Flora

of orchids belonging to 75 genera are found here, of which 112 species in ten genera are endemic to the region.

Fauna of Western Ghats

- As many as 315 species of vertebrates belonging to 22 genera are endemic, including 12 species of mammals, 13 species of birds, 89 species of reptiles, 87 species of amphibians and 104 species of fish.
- The extent of endemism is high amongst amphibian and reptile species. There occur 117 species of amphibians in the region, of which 89 species (76 per cent) are endemic. Of the 165 species of reptiles found in Western Ghats, 88 species are endemic
- Many of the endemic and other species are listed as threatened. Nearly 235 species of endemic flowering plants are considered endangered. Rare fauna of the region include –**Lion Tailed Macaque, Nilgiri Langur, Nilgiri Tahr, Flying Squirrel, and Malabar Gray Hornbill.**

General Knowledge Today



Environment-3: Wetlands and Forests

Target 2016: Integrated IAS General Studies

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Model Questions

Prelims MCQ Questions

Prelims MCQ Questions

Wetlands in India, Types of Indian Wetlands, Ramsar Convention, India's Ramsar sites, State of Forests Report – 2015, Forest Area versus Forest Cover, Types of Forest Covers, Forest Rights Act 2006, Forest Village and a Revenue Village, Coral Reefs in India.



Wetlands

Wetlands

India has over 27000 wetlands of which over 23000 are inland wetlands while around 4000 are coastal wetlands. [Number of inland wetlands > Number of coastal wetlands]. Wetlands occupy 18.4% of the country's area of which 70% are under paddy cultivation.

Further, out of an estimated 4.1 m ha of wetlands, 1.5 m ha are natural, while 2.6 m ha are manmade. This implies that majority of the wetlands in India are Manmade.

The coastal wetlands occupy an estimated 6,750 sq km, and are largely dominated by mangrove vegetation.

Types of Indian Wetlands

Wetlands in India are distributed in different geographical regions. Based on their origin, vegetation, nutrient status and thermal characteristics, they are classified into different types. The following list shows a wetland type and its examples in India.

- Glaciatic Wetlands
 - Tsomoriri (J&K)
 - Chandertal (Himachal Pradesh)
- Tectonic Wetlands
 - Nilnag in Jammu and Kashmir
 - Khajjiar in Himachal Pradesh
 - Nainital and Bhimtal in Uttarakhand.
- Oxbow Wetlands
 - Dal Lake, Wular Lake in Jammu & Kashmir
 - Loktak Lake in Manipur
 - Deepor Beel in Assam
 - Kabar in Bihar
 - Surahtal in Uttar Pradesh
- Lagoons
 - Chilika in Odisha
- Crater Wetlands
 - Lonar lake in Maharashtra
- Salt Water Wetlands
 - Pangong Tso in Jammu and Kashmir
 - Sambhar in Rajasthan
- Urban Wetlands



- Dal Lake in Jammu and Kashmir
- Nainital in Uttarakhand
- Bhoj in Madhya Pradesh
- Ponds/Tanks, Man-made Wetlands
 - Harike in Punjab
 - Pong Dam in Himachal Pradesh.
- Reservoirs
 - Idukki, Hirakud dam, Bhakra-Nangal dam
- Mangroves
 - Bhitarkanika in Odisha
- Coral reefs, creeks and estuaries.

There are more than 100 identified wetlands under the National Wetland Conservation & Management Programme (NWCMP).

Legal Framework Around Wetlands

As of now there is no specific legal framework for wetland conservation, management and their wise use in India. Currently, wetlands come under the Environment (Protection) Act, 1986 and other various legal instruments, related to environment and forests.

Ramsar Convention on Wetlands

Ramsar Convention is formally known as *Convention on Wetlands of International Importance, especially as Waterfowl Habitat*. It was signed on 2 February 1971 at Ramsar in Iran. That date is celebrated as *World Wetland Day* now.

Objectives

Ramsar Convention has two fold objectives viz. Conservation and sustainable utilization of wetlands; and stop the encroachment and loss of wetlands.

This treaty is not a legal binding treaty and is not a part of UN & UNESCO conventions.

Key Facts

There are around 2100 Ramsar sites around the world of which maximum are in UK. The Largest area covered by Ramsar Sites is in Canada. Ramsar secretariat is hosted by IUCN World Conservation Union in Gland, Switzerland.

How does it work?

First of all a country joins the Ramsar Convention. With this, it gets itself listed into the international effort for the conservation and wise use of wetlands. Once a country has joined, there are three commitments which it has to fulfill as obligations:

- It has to designate at least one of its wetlands into the List of Wetlands of International



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Importance called “Ramsar List”. Once that is done, it can later designate more such wetlands.

- The above designation has to be based upon criteria that take into account the ecology, botany, zoology, limnology^(freshwater science) or Hydrology. Thus, not every wetland becomes a Ramsar site but only those which have significant values related to these fields.
- The country has to make all efforts for wise use and conservation of the Ramsar Sites in its territory. Being a part of Ramsar convention gives it access to know-how of conservation in different parts of the world.
- If the ecological character of any Ramsar wetland has changed, or is changing or is likely to change as the result of technological developments, pollution or other human interference, it will inform without delay to the Ramsar Secretariat.
- Once this information has been provided to Ramsar Secretariat, it will do the following
 - Enter the wetland into its **Montreux Record** (a record for such sites where there has been or likely to be adverse ecological change)
 - Send a Ramsar Advisory Mission to the country. This mission will analyse the situation and define how to tackle the threats to the wetland.
 - Once the appropriate measures have been taken, the site will be removed from Montreux Record.

The Ramsar convention also makes the countries cooperate in matters of conservation of the trans-boundary wetlands, shared water systems, and shared or migratory species, and to share expertise and resources with Parties less able to meet their commitments.

India's Ramsar sites

India became a contracting party to the Ramsar Convention in October 1981 and designated Chilika Lake (Odisha) and Keoladeo National Park (Rajasthan) as its first two Ramsar Sites. Four additional sites were designated in 1990: Sambhar Lake (Rajasthan), Loktak Lake (Manipur), Harike Lake (Punjab) and Wular Lake (Jammu & Kashmir). Currently, India has 26 Ramsar Sites as follows:

- Andhra Pradesh
 - Kolleru Lake
- Assam
 - Deepor Beel
- Himachal Pradesh
 - Chandertal Wetland
 - Pong Dam Lake
 - Renuka Wetland (This is smallest wetland of India)
- Jammu & Kashmir



- Hokera Wetland
- Surinsar-Mansar Lakes
- Tsomoriri
- Wular Lake
- Kerala
 - Ashtamudi Wetland
 - Sasthamkotta Lake
 - Vembanad-Kol Wetland (Largest Wetland of India)
- Madhya Pradesh
 - Bhoj Wetland
- Manipur
 - Loktak Lake (Montreux Record)
- Odisha
 - Bhitarkanika Mangroves
 - Chilika Lake
- Punjab
 - Harike Lake (Harike Wetland and the lake are manmade and were formed by constructing the head works across the Sutlej river, in 1953)
 - Kanjli
 - Ropar
- Rajasthan
 - Keoladeo National Park (Montreux Record)
 - Sambhar Lake
- Tamil Nadu
 - Point Calimere Wildlife and Bird Sanctuary
- Tripura
 - Rudrasagar Lake
- Uttar Pradesh
 - Upper Ganga River (Brijghat to Narora Stretch)
- West Bengal
 - East Calcutta Wetlands
- Gujarat
 - Nalsarovar Bird Sanctuary (Latest wetland added)

Current wetlands in Montreux Record



Currently, two wetlands of India are in Montreux record viz. Keoladeo National Park, Rajasthan and Loktak Lake, Manipur. Further, Chilka lake was placed in the record but was later removed from it.

National Wetland Conservation Programme (NWCP)

This programme was launched in 1986 and has identified some 115 wetlands for urgent protection and conservation.

Forests

State of Forests Report – 2015

State of Forests Report is published by the Forest Survey of India (FSI) on a biennial basis since 1987. Forest cover of the country is mapped through indigenous RESOURCESAT -2 satellite data with a LISS III sensor.

Key Definitions

Canopy and Canopy Density

The cover of branches and Foliage formed by the crown of trees is called Canopy. The *percentage area of land* covered by the canopy of trees is called *Canopy density*.

Forest Cover

All lands which are more than 1 hectare in area and with *Canopy density* of more than 10% irrespective of the ownership and legal status is called *Forest Cover*. Also it does not make any distinction whether the forest is natural or manmade forest, government or private, recorded or not recorded. It includes bamboo, orchards, palm etc.

Recorded Forest Area and Forest Blank

The area recorded as “forests” in the Government records is called *Forest Area* or *Recorded Forest Area*. The patches within the forest area which have little or no trees are called “*Forest Blank*”. The recorded Forest Area denotes the legal status of the land. It is defined as the geographic area recorded as forest in government records, state law or any local law. It is different from the forest cover as forest area may include areas with less than 10% of tree canopy density and may exclude areas more than 10% of tree canopy density.

E-Watch

It is a web based GIS application developed for monitoring various activities funded under CAMPA (Compensatory Afforestation Fund Management and Planning Authority) CAMPA is meant to promote afforestation activities in order to compensate for forest land diverted to non-forest uses).

Carbon Stock

It is defined as the amount of carbon stored in the ecosystem of the forest especially in living biomass and soil.

Best Season to get Satellite Data of Forests

October – December is the best season. The reflectance from the forests is dependent on the crown



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foliage and its chlorophyll content. Due to seasonal variability of the tree phenology over the year, season of satellite data acquisition is of utmost importance for forest cover assessment.

Deciduous forests allow more reflectance from the ground surface during leafless period thus making their own detection and classification difficult. Hence, data of the spring-summer season is not suitable for interpretation of such forest types. During rainy season, the situation is compounded due to non availability of cloud-free data and mixing of agricultural and other green covers with forest cover due to similarity in their spectral reflectance. Taking these limitations into consideration, satellite data of the period October to December is considered to be the most suitable for forest cover mapping of the entire country. However, in cases where cloud free data is not available for this period, data of January to March is procured.

Types of Forest Covers

The degraded forest lands which have a Canopy density of less than 10% are called Scrubs. The Lands with Canopy density of 10-40% are called Open Forests. The Land with forest cover having a canopy density of 40-70% is called the Moderately Dense Forest (MDF) The Lands with forest cover having a canopy density of 70% and more are called Very Dense Forests (VDF).

State of Forests Report 2015: Key Findings

- Total forest cover in India: 7,01,673 sq km (increase of 3775 sqkm)
- Total forest cover as percentage of geographical area: 21.34 per cent
- Total tree cover in India: 92,572 sq km (increase of 1306 sq km)
- Total tree cover as percentage of geographical area : 2.82 per cent
- State with largest total forest cover: Madhya Pradesh having 77, 462 sq km
- State having highest forest cover as % of its area: Mizoram (88.93 per cent)
- Increase in carbon sink:103 million tonnes CO₂ equivalent

Top five states with maximum forest cover

India's top five states with maximum forest cover (in km²) are as follows:

1. Madhya Pradesh (77,462)
2. Arunachal Pradesh (67,248)
3. Chhattisgarh (55,586)
4. Maharashtra (50,628)
5. Orissa (50,354)

Top five states with maximum forest cover as part of their area

Top five states / UTs with maximum forest cover as percentage of their own geographical area are as follows:

1. Mizoram (88.93%)
2. Lakshadweep (84.56%)



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3. A&N islands (81.84%)
4. Arunachal Pradesh (80.30%)
5. Nagaland (78.21%)

Forest Cover in Altitude Zones

Altitude Zones	% of forest found
0-500m	52.50
500-1000m	28.27
1000-2000m	10.88
2000-3000m	5.76
3000-4000m	2.46
Above 4000m	0.13

Important Observations

- Out of the total forest cover, the maximum share is of Moderate Dense Forests, followed by Open Forests. The very dense forests in India are in just around 2.5% of total geographical area of the country.
- Among all the states of India the states which have shown considerable improvement in their forest cover are: Tamil Nadu, Jammu and Kashmir, Uttar Pradesh, Kerala, Karnataka.
- The states where forest cover has decreased substantially are Mizoram, Telangana, Uttarakhand, Nagaland, Arunachal Pradesh.
- The total forest cover in the hill districts of the country is 283,015 sq km which is 39.99 % of total geographic area of these districts. In the latest report the hill districts have recorded a net increase of 1680 sq km area.
- North east constitutes only 7.98% of geographical area of the country but it occupies one fourth of the forest cover. However according to the current report there is a decrease in the forest cover in the north east by 628 sq km which is primarily because of shifting cultivation and increase in biotic pressure.

Mangroves Cover

In world's total mangrove vegetation, India's share stands at 3%. Currently Mangrove cover in India is 4740 km² which is 0.14 % of the country's geographical area. Sundarbans in West Bengal accounts for almost half of the total area. As compared to 2013 there is a net increase of 112 sq km in the mangrove cover. Top five states with maximum Mangrove cover are as follows:

1. West Bengal (2106)
2. Gujarat (1107)



3. Andaman & Nicobar Island (617)
4. Andhra Pradesh (367)
5. Odisha (231)

Mangroves are also found in Tamil Nadu, Goa, Kerala, Daman & Diu, Karnataka and Puducherry.

Total Carbon Stock

The total carbon stock has also increased by 103 million tonnes or an increase of 1.48 in percentage terms compared to previous assessments. The total carbon stock in the country's forest is around 7,044 million tonnes. The increase in the carbon stock shows the commitment of the country towards achieving INDC target of additional carbon sink of 2.5 to 3.0 billion tonnes of CO₂.

Types of Forests on the basis of Administration

On the basis of administration, the forests in India are of three categories:

Reserved Forests

These forests are under the direct supervision of the government and no public entry is allowed for collection of timber or grazing of cattle. About 53 per cent of the total forest area falls in this category.

Protected Forests

These forests are looked after by the government, but the local people are allowed to collect fuel-wood/timber and graze their cattle without causing serious damage to the forests. These forests occupy about 29 per cent of the total forest area of the country.

Unclassified Forests

The unclassified forests are those in which there is no restriction on the cutting of trees and grazing of cattle. About 18 per cent of the total forest area of the country falls under this category.

Policy towards Forests Rights in India

Before India was established as a British Colony, there was no forest policy. Each ruler of various states in India had his or her own approach to manage the forest resources in their territories. The British imposed the so called **scientific forest management** in India whereby their sole agenda was focused on continuous commercial production of the timber. The formula of the forest management at that time in India was a typical European production based forestry model for, the pressure of man on forests was not as high as in current times.

Conflict over Forest Rights and tribal revolts

The permanence settlement of 1757, the forest act of 1865 and 1878 and the forest policy of 1894 were one of the root causes of rebellions and revolts of the indigenous communities in India. These revolts began from 1794 and continued till 1920s. The target of these rebellions was the new land and forest policies which left them devoid of their traditional rights over forests. But the rebellions were crushed ruthlessly and



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British kept bringing fresh areas under state control, formulating new laws for legitimizing the property rights transferred from communities to state.

In due course of time, forests were **declared state property** and the rights of the forest dwellers vis-a-vis the commercially valued species were curtailed. In some of the forest areas, there was a complete ban on the human activities such as collection of firewood, fodder, medicinal plants, bamboo etc.

In 1864, the Forest Department was established which strongly asserted the state monopoly over forest resources and exclusion of the tribal communities from almost all kinds of rights over forest produce. This was the foundation of modern principles of Forest Administration in our country.

In 1894, the **first Indian Forest Policy** was adopted by the colonial regime. The policy viewed the forests as the potential sources for generating profits and 'stressed' on the need to preserve forests of the hilly regions. But the hidden agenda was to consolidate the state's property rights over the forests. The forest dwellers were not only denied their traditional rights but no role was given to them in the preservation of the forests. This was the beginning of marginalization of the forest dwellers in India.

Following the independence of India, the Forest Policy Resolution 1952 called for the protection of wildlife and preservation of fauna by demarcating the forests for sanctuaries and national parks. This culminated in the enactment of **Wildlife Protection Act in 1972**. *The Forest Policy 1988 deviated from the economic importance for the first time and treated them as ecological necessity as source of goods for local populations.* These goods were called **Non Timber Forest Produce (NTFP)**. This policy also set the target of increasing India's forest cover to 33%.

The 1988 Forest policy paved the way for implementation of the **Joint Forest Management (JFM)** which included the involvement of local village communities and voluntary agencies in the regeneration of the degraded forests. This was for the first time in centuries that the rights of the local communities over the forest lands were specified.

- But the **Wildlife Protection Act** of 1972 had already criminalized the forest people and taken away their traditional NTFP and fishing rights, while poaching could never be effectively stopped.

Forest Rights Act 2006

In 1990, a Joint Forest Management Circular was released by the Government of India, which recommended the involvement of village communities, voluntary agencies in the regeneration of the degraded forest lands. However this circular had no force of law behind it.

However, the **Forest Act 2006** marked a real water shade in the history of the forest communities in India. For the first time, the Government of India via the **Scheduled Tribes and the Other Forest**



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Dwellers (Recognition of Forest Rights) Act 2006, admitted that ‘forest rights on the ancestral lands and their habitat were not adequately recognized in the consolidation of state forests during the colonial periods as well as in Independent India resulting in Historical injustice with the scheduled tribes and other traditional forest dwellers, who are integral to the very survival of the forest ecosystem’.

This Forest Rights Act 2006 provides the following:

- Tenurial Security and access rights to forest dwellers
- Right to hold and live in forest land under individual or common occupation for habitation or for the self-cultivation for livelihood.
- Right of ownership access to collect, use and dispose of minor forest produce that has been traditionally collected within or outside the village boundaries.
- Other community rights such as on fish and water bodies.
- Rights of settlement and conversion of forest villages into revenue villages.

As per this act, **Gram Sabha plays pivotal role** in ensuring the rights of the forest dwellers, decision making, planning and management for Joint Forest Management.

Defining a Forest Village and a Revenue Village

Forest Village

As per the Forest Act 2006, “forest villages” means the settlements which have been established inside the forests by the forest department of any State Government for forestry operations or which were converted into forest villages through the forest reservation process and includes forest settlement villages, fixed demand holdings, all types of *taungya settlements*, by whatever name called, for such villages and includes lands for cultivation and other uses, permitted by the Government.

Revenue Village

A Revenue Village is a small administrative region in India, with defined borders, that is recognized by the District Administration. One revenue village may contain many hamlets.

In the rural areas the smallest area of habitation, viz., the village generally follows the limits of a revenue village that is recognised by the normal district administration. The revenue village need not necessarily be a single agglomeration of the habitations.

Thus, a revenue village has a definite surveyed boundary and each village is a separate administrative unit with separate village accounts. It may have one or more hamlets. The entire revenue village is one unit.

A Revenue Village versus a Hamlet

Normally in India, the ‘village’ is taken to mean the revenue village administrative unit. However due to immense variation in the sizes of revenue villages in different states, larger revenue villages can contain several hamlets spread over a large area.



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Impact on Lives of Forest Dwellers living in Forest Villages

The most significant difference in living standards of the tribals living in forest and revenue villages in India is that the tribals of the Forest villages have lived in the state of insecurity and bondage. The dwellers of Forest Villages can't access various schemes of the state and central governments which are implemented on the basic level of revenue villages. Over 60 years after Independence, the residents of 'forest villages' and other settlements and unsurveyed villages in forests remain deprived of access to most development programmes due to the land on which these are located continuing to be recorded as 'forest'.

- Whereas officially there are an estimated 2500 to 3000 Forest Villages, unofficial estimates suggest their number to be over 10,000.
- As no agency other than forest departments can undertake any development work on forest land, most of these settlements remain outside the jurisdiction of any local government, and their residents in some states cannot obtain even domicile certificates (as only the revenue department can issue these, but it does not have jurisdiction over forest land) or even voting rights.

Due to their residents lacking any legal rights over the land, they are treated like 'non-citizens' ever vulnerable to eviction or displacement without entitlement to compensation or rehabilitation.

Conversion of Forest Villages into Revenue Villages

The 1990 Circular of Ministry of Environment and Forests (MOEF), Government of India had for the first time mandated the conversion of forest villages into revenue villages and settlement of other old habitations. But this circular was lacking legislative backing. Section 2F of the Forest Rights Act 2006 reiterated the MoEF's 1990 guidelines, and enabled the residents of all 'forest villages' as defined above, many created by the forest departments themselves in the past to ensure availability of bonded labour for forestry operations, to get their villages/settlements converted into revenue villages.

Conclusive Note

In 2010, Surma, a tribal village housing around 360 *Tharu* tribe families, in Uttar Pradesh witnessed to become the first tribal village in a forest reserve area to be converted into a revenue village. This means tribals will now get all the constitutional rights given to a citizen of India.

Coral Reefs in India

The major reef formations in India are restricted to the Gulf of Mannar, Gulf of Kachchh, Andaman and Nicobar and Lakshadweep Islands. Scattered coral growth has also been reported along certain inter-tidal belts and submerged banks both on the east and west coasts of the country.

Conditions Required for Healthy Growth of Coral Reef

Coral reefs are huge deposits made up dead shells and secretions of marine organisms like Corals, Calcareous algae, stomatopteroids, gartopods Mollusca etc. The deposits are mostly made up of



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Calcium Carbonate. Conditions required for their growth:

- Warm tropical oceans located between 30 degree north and 25 degree south latitudes where a minimum temperature of 20 degree is found and this temperature favour the growth of coral organisms.
- Oceanic water free of sedimentation.
- Transparent parts of ocean bodies.
- Relatively low salinity ocean bodies.

The reefs at present are important to the local community only to the extent of sustenance fishing. Tourism is being developed at some places though local communities do not benefit much from the revenue generated. The health of corals, as deduced from the literature records since 60s has been on steady decline mainly due to stress from anthropogenic pressures and interference.

General Knowledge Today



Environment-4: Pollution Related Topics

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Model Questions

Prelims MCQ Topics

Primary and Secondary Topics, Formation of Ground Level Ozone, Green House Effect, Various Factors Affecting Green House Effects, Anti-Green House Effect, Ozone Depletion – Process and various Factors, Vienna Convention, Acid Rain – Chemistry and Impacts, Land Degradation, Shifting Cultivation, Soil Pollution, Indiscriminate Use of Fertilizers, Vermicompost, Biofertilizers, Pesticides and Insecticides, Biopesticides, Persistent Organic Pollutants (POPs), Bio-accumulation, Bio-concentration and Bio-magnification, Stockholm Convention, Hazardous substances and Rotterdam Convention, Various Treaties on Marine Pollution, Wadden Sea Agreement, Accobam, Marpol, Oil Spills, UNCLOS, Thermal Pollution of Water, Eutrophication,



Air Pollution Topics

Primary & Secondary Air Pollutants

Air borne emissions emitted from various industries are a cause of major concern. These emissions are of two forms, viz. solid particles (SPM) and gaseous emissions. Thus, Air Pollutants can be solid particles, liquid droplets, or gases. They can be natural or manmade. The pollutants have been classified into primary and secondary categories.

- The *primary pollutants* are “directly” emitted from the processes such as fossil fuel consumption, Volcanic eruption and factories. The major *primary pollutants* are Oxides of Sulphur, Oxides of Nitrogen, Oxides of Carbon, Particulate Matter, Methane, Ammonia, Chlorofluorocarbons, Toxic metals etc.
- The *secondary pollutants* are not emitted directly. The secondary pollutants form when the primary pollutants react with themselves or other components of the atmosphere. Most important *secondary level Air Pollutants* are Ground Level Ozone, Smog and POPs (Persistent Organic Pollutants).

Primary Air Pollutants

Oxides of Sulphur

Sulphur Oxides are generally a product of the Volcanoes, Industrial processes, Coal and petroleum, because most of them have Sulphur as a component. The Sulphur Dioxide in presence of a catalyst such as NO₂ causes Acid Rain, because of the formation of Sulphuric Acid. The *Indian Coal is though low in sulphur content* but still coal consumption is a major danger of acid rain because of the coal based power plants.

Oxides of Nitrogen

Most of the Nitrogen Oxides are produced due to high temperature combustion. In the cities the brown haze dome above the cities is mostly because of the Nitrogen Oxides. The most important toxic gas is Nitrogen dioxide which is brown, with sharp odour.

Oxides of Carbon

Carbon Monoxide, which is colourless, odourless and non irritating but very poisonous gas is the product of incomplete combustion of the natural gas, coal or wood. The vehicle exhaust is the major source of CO.

The Carbon Dioxide is associated with the Ocean Acidification and is emitted from combustion, factories and respiration of living organisms.

Then, we have primary pollutants such as *Volatile Organic Compounds or VOCs* which are methane (CH₄) and *non-methane (NMVOCs)*.

- Methane is a GHG which contributes to Global Warming.



Environment-4: Pollution Related Topics

- The NMVOCs include the aromatic compounds such as Benzene, Toluene, Xylene which are proved or suspected carcinogens.
- Another dangerous compound is the 1,3-butadiene, often associated with industrial uses.

Particulate Matter

The particulate matters are the fine particles which may be either solid or liquid, suspended in a gas. They are different from the Aerosols. Aerosols are particle and gas referred together. The aerosols which are created by the Human activities are anthropogenic aerosols. They account for around 10% of the total aerosols in the atmosphere.

Other Primary Pollutants

Another category of the primary air pollutants is toxic metals such as Cadmium, Lead and Copper, which are products of the Industrial processes. The Chlorofluorocarbons (CFCs) are proved to be harmful to the ozone layer emitted from products currently banned from use. In agriculture process, Ammonia is emitted which has characteristic pungent odor. It is a precursor to foodstuffs and fertilizers. Ammonia is also a building block for the synthesis of many pharmaceuticals.

Secondary Air Pollutants

Ground Level Ozone

The most important secondary pollutant is the Ground Level Ozone or Tropospheric Ozone. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapours, and chemical solvents are some of the major sources of Nox and VOC. Ground Level Ozone forms due to reactions of the NO_x, Carbon Monoxide and VOCs in presence of sunlight.

Smog

Another most important secondary pollutant is the Smog, which has made up of Smoke and Fog. Traditionally, the smog has resulted from large amounts of coal burning in an area caused by a mixture of smoke and sulphur dioxide. Now-a-days, the Vehicle emissions and Industrial emissions that are acted on in the atmosphere by ultraviolet light from the sun to form secondary pollutants that also combine with the primary emissions to form photochemical smog.

Ground Level Ozone

The most important secondary pollutant is the Ground Level Ozone or Tropospheric Ozone. Ground Level Ozone is formed by the reactions of the oxides of Nitrogen (NO_x), Carbon Monoxide (CO) and Volatile Organic Compounds (VOCs) and NMVOCs such as Xylenen in the atmosphere in the presence of sunlight. Thus culprits for Ground Level Ozone are NO_x, CO, VOCs and NMVOCs.

In the last 100 years, the emission of *Methane* (a Volatile Organic Compound) has increased dramatically and it has contributed to the increased concentration of Ground Level Ozone.

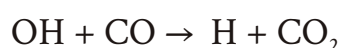
Formation of Ground Level Ozone



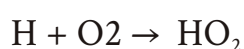
Environment-4: Pollution Related Topics

The formation of the Ground Level Ozone involves a long complex series of the reactions in which carbon monoxide and VOCs are oxidized to water vapour and carbon dioxide. The series of the reactions begins with the Hydroxyl OH radicals, which is one of the main chemical species controlling the oxidizing capacity of the global Earth atmosphere. They are produced by many pathways but most notably they are formed from the decomposition of hydro peroxides (ROOH) and by reaction of excited atomic oxygen with water. The reaction involves the following steps:

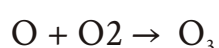
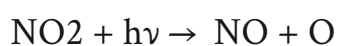
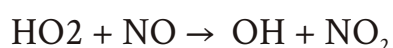
The Carbon Monoxide reacts with the Hydroxyl Radical, producing a Hydrogen atom.



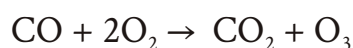
The hydrogen atom formed by this reacts rapidly with oxygen to give a peroxy radical HO_2



Peroxyradical then reacts with the NO and gives NO_2 which, in presence of Sunlight is photolysed to give atomic oxygen and through reaction with oxygen a molecule of ozone.



In total, the reaction is as follows:



The above reaction is simple demonstration. The Chemical processes that involve the VOCs are the complex ones. But the result of these reactions is the Ozone. From the above, kindly note that Carbon Dioxide DOES NOT play a role in formation of Ground level Ozone.

Sources and Health Effects of Ground Level Ozone

Breathing ozone can trigger a variety of health problems, particularly for children, the elderly, and people of all ages who have lung diseases such as asthma. Ground level ozone can also have harmful effects on sensitive vegetation and ecosystems.

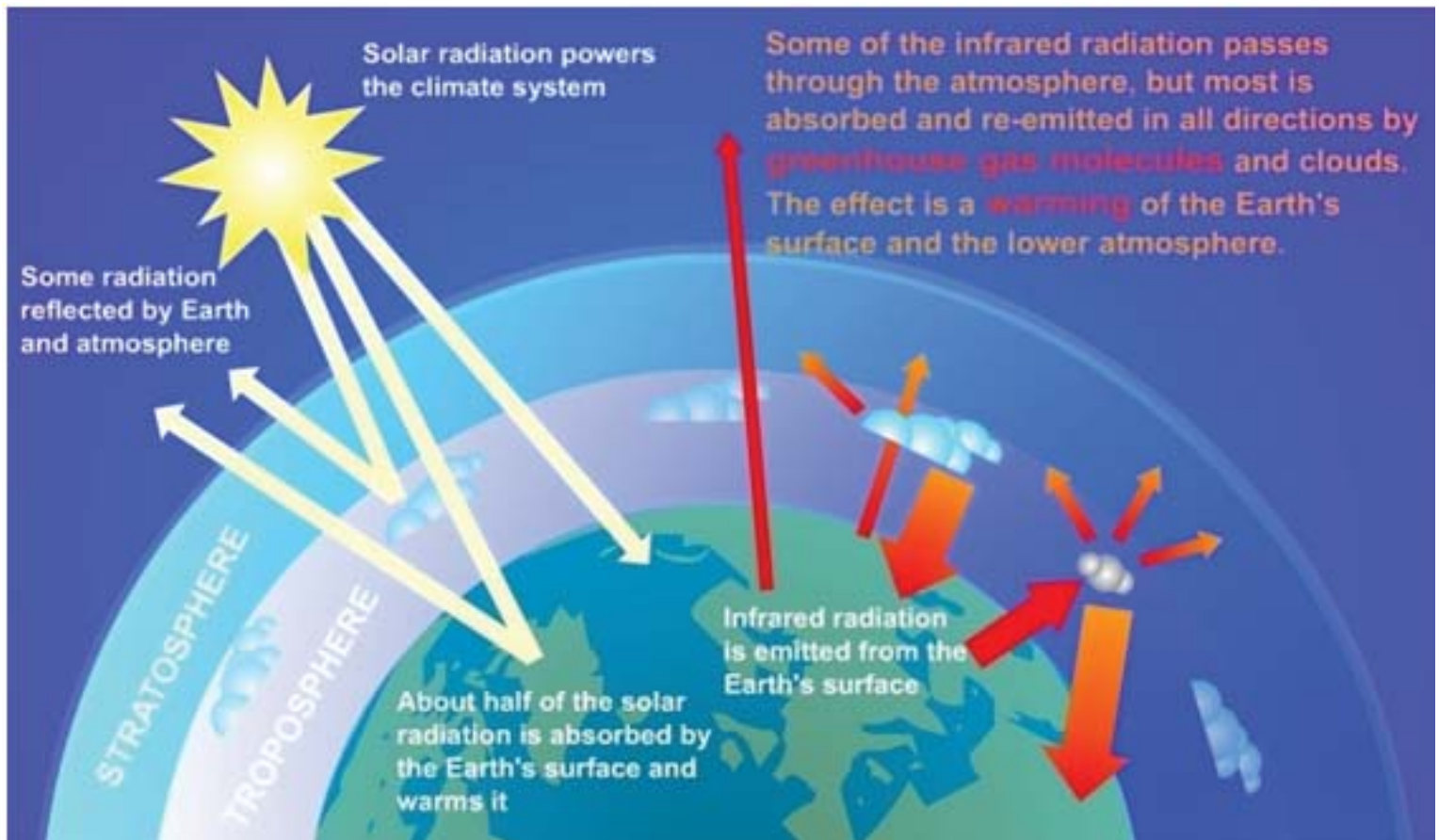
Green House Effect

In the Green House Effect, the thermal radiation from a planetary surface is absorbed by atmospheric greenhouse gases, and is re-radiated. Due to this, the temperature of the body is higher than what it would have been if there was no atmosphere.

Process of Green House Gas on Earth



Environment-4: Pollution Related Topics



Earth receives the energy from Sun in the form of Ultraviolet, Visible and Near Infra Red radiation. Except most of the UV radiation, almost all of them pass through the atmosphere without being absorbed. Out of this 50% is absorbed by the surface of the Earth. When surface becomes warm, it radiates the far Infrared thermal radiation, which has longer wavelengths than that of the radiation absorbed. This thermal radiation is absorbed by the atmosphere, and the atmosphere reradiates it both upwards and downwards. The radiation that is sent downward again raises the temperature of the Earth.

Thus, the long wave radiation is trapped and the equilibrium temperature of earth is higher than if there was no atmosphere.

The Incoming sun light is mostly in the form of visible light and nearby wavelengths, in the range $0.2-4 \mu\text{m}$. The loss of the Radiation is almost nothing at the surface level but maximum at higher in the atmosphere because of the decreasing concentration of water vapor, an important greenhouse gas. While the major atmospheric components (Nitrogen and Oxygen) absorb little or no radiation, some of the minor components are effective absorbers. Particularly effective is water vapor and CO_2 which absorb effectively in the IR wavelength range.

These absorbing gases and their surrounding air warm up, emitting radiation downward, towards the Earth's surface, as well as upward, towards space. This effectively traps part of the IR radiation between ground and the lower 10 km of the atmosphere. This reduction in the efficiency of the



Environment-4: Pollution Related Topics

Earth to lose heat causes the surface temperature to rise above the effective temperature until finally, enough heat is able to escape to space to balance the incoming solar radiation. The effect is analogous to that of a blanket that traps the body heat preventing it from escaping into the room and thus keeps us warm on cold nights.

Green House Effect versus Planetary Albedo

If Earth was an ideal black body which absorbs all the radiation from the Sun and emit the radiation due to this heating, its temperature would have been approximately 5.3 °C. The Earth and other planets are not perfect black bodies, as they do not absorb all the incoming solar radiation but reflected part of it back to space. The ratio between the reflected and the incoming energies is termed the planetary albedo. Earth reflects 36-37% of this incoming light and it corresponds to the Earth Albedo 0.367. So, Earth's mean temperature is 14 °C. If there were no atmosphere and no radiation was lost due to reflection, its mean temperature would have been -18 or -19 °C. This difference is due to the Green House Effect.

Green House on higher altitudes

At high elevations, air temperatures are generally cooler and have a greater day- to-night range. Since both the thickness and density of the air column decrease with elevation; the greenhouse effect is weaker at high elevations.

Green House Gases

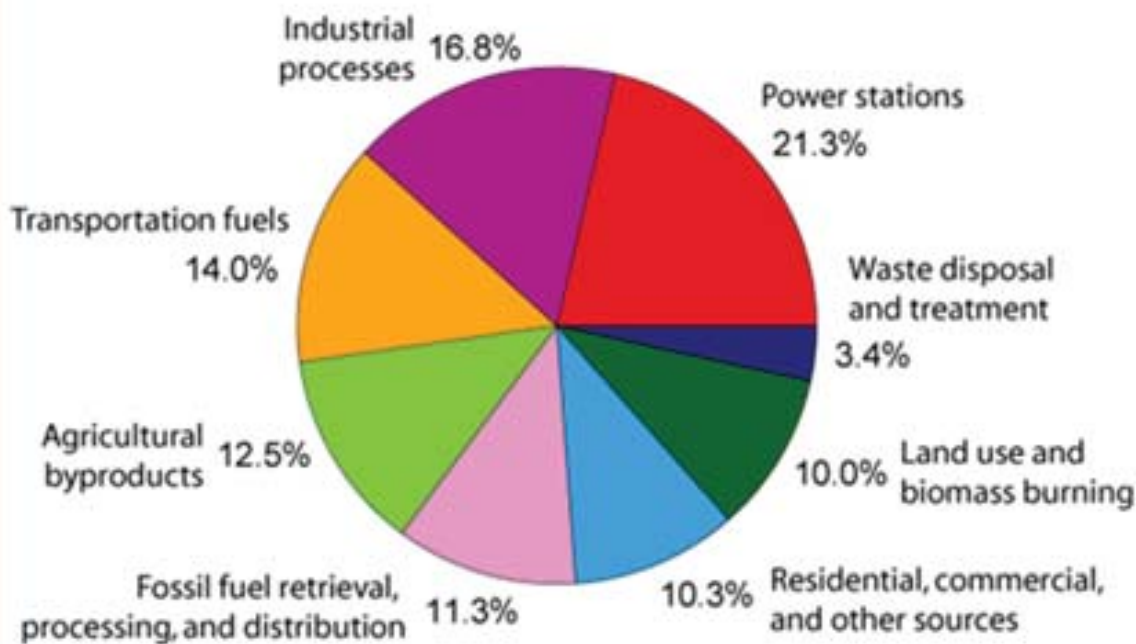
The Major Green House Gases are Methane, Water Vapour, Carbon dioxide, Nitrous Oxide (N₂O), Ozone, Sulphur Hexafluoride (SF₆), Hydrofluorocarbons (HFCs) and Perfluorocarbons (PFCs). Out of them, most potent greenhouse gas is water vapour, which causes about 36-70% of the greenhouse effect. Carbon dioxide (9-26%), methane (4-9%) and Ozone (3-7%) are other major greenhouse gases.

GHG Emission by sectors



Environment-4: Pollution Related Topics

GHG Emission by Sectors



Maximum anthropogenic GHG emission is by Power Stations (over 21%) as shown in the following chart. It is followed by the Industrial Processes (around 17%).

Anti-greenhouse effect

In Solar system, Mars and Venus show the Green House Effect, but Titan (the largest planet of Saturn) and Pluto, show Anti-Green House Effect.

Greenhouse effect occurs because the atmosphere transparent to solar radiation, but largely opaque to infrared and far infrared emitted by the planet / body. But in anti-greenhouse effect, the atmosphere is opaque to solar radiation but lets out infrared. The effect is that the body is cooler than the actual temperature would have been.

In case of Titan, both Green House Effect and Anti Green House Effect have been proved. Due to Green House Effect, the temperature goes up by 21K while, due to Anti-Green House effect, the temperature goes down by 9K. The result is that surface temperature is 12 K warmer than without atmosphere.

At Pluto, there is different mechanism. Here, the sunlight causes the Nitrogen ice to sublime which cools the body.

Ozone Depletion

Ozone or Triooxygen is an allotrope of oxygen that is much less stable than the diatomic allotrope (O₂), paramagnetic compared to the diamagnetic O₂; and is present in low concentration in atmosphere.

At ground level, it has harmful effects on the respiratory systems of animals. However, in upper



Environment-4: Pollution Related Topics

atmosphere, it creates ozonosphere, which prevents potentially damaging ultraviolet light from reaching the Earth's surface. Ozonosphere is located 10-18 kilometres above Earth's surface.

Factors Affecting Thickness of Ozone Layer

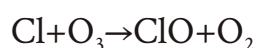
The thickness of the ozone layer-that is, the total amount of ozone in a column overhead-varies greatly worldwide, being thin at equator and thickest at poles. It also varies with season, being in general thicker during the spring and thinner during the autumn in the northern hemisphere. The reasons for this latitude and seasonal dependence are complicated, involving atmospheric circulation patterns as well as solar intensity.

Creation of Ozone Hole

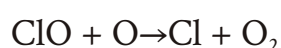
Ozone depletion has been seen everywhere beyond tropics and there is a severe depletion in the Polar Regions due to some reasons. The polar regions get a much larger variation in sunlight than anywhere else and during the 3 months of winter spend most of time in the dark without solar radiation. Due to this, the temperatures in Polar Regions go very much down.

The extremely low temperatures in Polar Regions in winter cause formation of so called Polar Stratospheric Clouds (PSCs) in the otherwise dry stratosphere there. These clouds are made of ice crystals which provide surface of many of chemical reactions. A complex interplay of chemistry, dynamics, and radiation lead to conditions conducive to significant ozone loss in the Polar Regions.

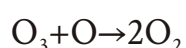
The culprit compounds are Chlorofluorocarbons as we all know. Upon reaching the stratosphere. They CFCs are subject to higher levels of ultraviolet radiation that decompose them and release atomic chlorine. Atomic Chlorine reacts with Ozone and gives out Oxygen as follows:



In the above reaction, atomic Chlorine (Cl) gets removed once it has converted an ozone molecule to Oxygen molecule but then it is regenerated through reaction of Chlorine Monoxide (ClO) with oxygen atom (O) as follows:



The net reaction in above two sets is as follows:



The net result of the two reactions is the depletion of ozone.

Role of Chlorine Compounds

Atomic Chlorine gets regenerated again and again in the above reaction and thus plays a catalytic role. This role was not discovered until 1973. Once discovered, the efforts to bring down / ban use of Chlorofluoro Carbons was started.

Antarctic Ozone Hole

Antarctic ozone hole is an area of the Antarctic stratosphere in which the recent (since about 1975) ozone levels have dropped to as low as 33% of their pre- 1975 values. This hole occurs during



Environment-4: Pollution Related Topics

Antarctic Spring (September to Early December) as the strong westerly winds start to circulate around the continent and create an atmospheric container. In this container over 50% of the lower stratospheric ozone is destroyed.

Arctic Ozone Hole

Every March to April during the Northern Hemisphere springtime similar, but less pronounced ozone hole forms above the Arctic. There are several reasons as to why the arctic ozone hole is less prominent in comparison to the antarctic hole. Firstly, Polar Vortex, a natural circulation of wind that isolates Antarctica from rest of the world during winter is less developed over arctic. Secondly, stratospheric temperatures at Arctic, are not as low as in the Antarctic. This is a lucky proposition because formation of even a moderate ozone hole above the Arctic region can give cause for considerable concern due to the greater populations in the higher latitudes of the Northern Hemisphere. Thirdly, **Earth's magnetic field** directs more positively charged solar wind particles to Earth's south pole. These are largely hydrogen, hydrogen oxidizes to water vapor, and water vapor both destroys ozone, and blocks one path of ozone production (not really important when UV-C is not available to make ozone anyway).

Dobson units in context with Ozone Depletion

Please note that ozone in the atmosphere can be measured in the PPT but that is not the units of Ozone Depletion. The Ozone hole is measured in terms of reduction in the total column ozone, above a point on the Earth's surface, expressed in "Dobson units".

One DU is 2.69×10^{16} ozone molecules per square centimetre, or 2.69×10^{20} per square meter or 0.4462 milli moles of ozone per square meter. **The base unit for an ozone hole was fixed 220 DU** because total ozone values of less than 220 Dobson Units were not found in the historic observations over Antarctica prior to 1979.

Vienna Convention

Vienna convention was the first multilateral Environmental Agreement in context with the Ozone depletion. It was agreed upon at the Vienna Conference of 1985 and entered into force in 1988, thus paving the way for a legally binding treaty as its protocol called Montreal protocol. Vienna Convention itself has not placed legally binding reduction goals for the use of CFCs. Its protocol called Montreal Protocol is legally binding to all signatories.

Montreal Protocol 1989

"Montreal Protocol on Substances That Deplete the Ozone Layer" or simply Montreal Protocol is the protocol to the Vienna Convention for the Protection of the Ozone Layer. This international treaty was designed to protect the ozone layer by phasing out the production of substances believed to be responsible for ozone depletion.

- Opened for signature on September 16, 1987



- Ratified by 197 Countries
- Entered into force on January 1, 1989.

The Montreal Protocol opened for signature on September 16, 1987. This date is observed as International Ozone Day every year.

Montreal Protocol stipulates that the production and consumption of compounds that deplete ozone in the stratosphere—chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform—are to be phased out by 2000 (2005 for methyl chloroform). These compounds significantly deplete the stratospheric ozone layer that shields the planet from damaging UV-B radiation. To date, 197 countries have signed the Protocol. As per the latest amendment, the treaty calls for complete phase out of HCFC by 2030.

It is believed that if the international community adheres to this treaty, the ozone layer will be recovered by 2050. Thus, this protocol is hailed as most successful international agreement to date.

HCFC versus HFC

Montreal Protocol currently calls for a complete phase-out of HCFCs (Hydrochlorofluorocarbons) by 2030, but does not place any restriction on HFCs (Hydrofluorocarbons). The difference between these two is of Chlorine. Hydrofluorocarbons contain only one or a few fluorine atoms are the more common type of organofluorine compounds used as refrigerants, their atmospheric concentrations are rapidly increasing, causing international concern about their rising contribution to anthropogenic radiative forcing emissions. All the HCFCs, HFCs & CHCs are now considered to be the Global Warming Potential.

India and Montreal Protocol

India became a party to the Montreal Protocol in 1992 and has been sharing the global concern for phasing out Ozone Depleting Substances. India has emerged as a global leader in promoting smooth transition for phasing out Ozone Depleting Substances (ODS).

Acid Rain

Acid rain refers to the precipitation with elevated levels of hydrogen ions or a low pH. When fossil fuel is burnt, some of the elements within their molecules combine with oxygen and form oxides. The oxide produced in a large quantity is carbon dioxide, followed by smaller quantities of Sulphur Oxides and Nitrogen Oxides. All of these oxides form the acidic solution when they dissolve in water. Out of these oxides, the Nitrogen oxides can also be produced naturally by lightning strikes. Similarly, the Sulfur Dioxide can also be produced by the volcanic eruptions *But these natural phenomena did not contribute the acidic rains as compared to the anthropogenic activities.* The Acid Rains have been seen in many parts of the world more prominently since 1970s. In some parts of the world the Acid Rains with as low as 1.5pH has been witnessed.



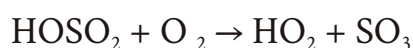
Chemistry of Acid Rains

The three kinds of Oxides matter in the Acid Rains. They are Oxides of Sulphur, Oxides of Nitrogen and Oxides of Hydrogen viz. water and Hydroxyl Radicals.

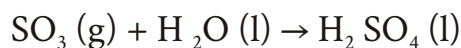
The sulphur dioxide is oxidized by reaction with the hydroxyl radical via an intermolecular reaction shown below:



HOSO₂ is unstable and it reacts with atmospheric Oxygen as follows:



The Sulfur Trioxide SO₃ produced so quickly reacts with the water and forms the Sulphuric acid as follows:



The Nitrogen Dioxide also reacts with the OH to produce the Nitric Acid



The above reactions may take in the cloud drops as follows:



Impacts of Acid Rain

Impact on Biota and Human Life

The Acid Rains show adverse impact on the forests, freshwaters, soil and aquatic life forms. The acid rain eliminates the insect life in the lakes and ponds. It kills the soil organisms and thus changes the soil chemistry.

Impact on Soil Chemistry:

In the soil, there is an adverse impact on the nutrients such as Magnesium. This is because, Calcium and Magnesium are leached away by the Hydronium ion of the acids.

Impact on Buildings

Acid rain is capable of damaging the buildings and historic monuments which are made up of rocks such as limestone and marble. This is because these rocks contain a large amount of Calcium Carbonate, which reacts with the Sulfuric Acid to create Gypsum. Gypsum flakes off easily. This is shown in the following reaction:



How to control Acid Rain?

The best approach to combat acid rain is to reduce the amount of NO_x and SO₂ being released into the atmosphere. Fitting a catalytic converter a catalytic converter to a car can reduce the emission of NO_x by up to 90%, but they very expensive, and cause more carbon dioxide to released, which



Environment-4: Pollution Related Topics

contributes to the greenhouse effect. SO_2 emissions from power stations can be reduced before, during, or after combustion. In addition there are several methods to controls SO_2 and NO_x in the environment. Acid rain may be controlled by

- When fuel with low sulphur content (such as North Sea gas or oil) is burnt, not much sulphur dioxide will be formed. However, low sulphur fuels are more expensive because they are in greater demand and although high-sulphur fuels can be treated to reduce their sulphur content, it is very expensive
- The SO_2 created during combustion can be absorbed if an appropriate chemical (such as limestone) is present while the fuel burns.
- Once the fuel has been burned, the SO_2 can be removed from the exhaust gases. Most system spray a mixture of limestone and water onto the gases. This mixture reacts with the SO_2 to form gypsum, useful building materials
- Another option is not to burn fossil fuels, but to use alternative energy sources.
- All these methods for reducing acid gases are expensive, and have draw-backs, so have been passed to use them. The best way to reduce them is not to use as much energy in the first place. One can save energy by turning off-lights when you leave a room, avoiding short journeys by car, insulating the house properly and using electric and related appliances which use less energy.

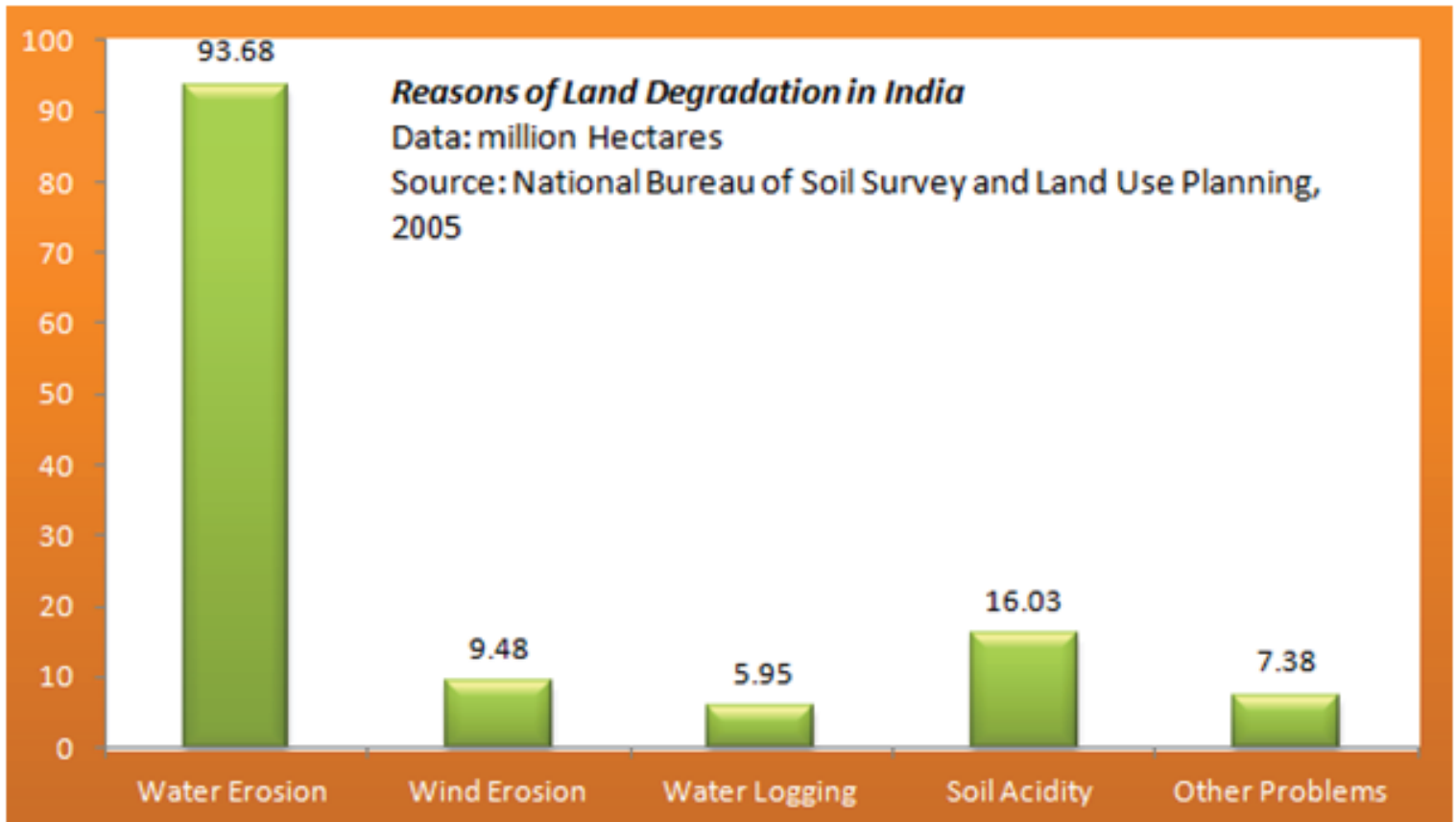
Land, Soil & Water Pollution Topics

Land Degradation

Land degradation is any change or disturbance to the land perceived to be deleterious or undesirable. Land degradation can be caused by both manmade and natural reasons such as floods and forest fires. It is estimated that up to 40% of the world's agricultural land is seriously degraded.

Causes of Land Degradation

The main causes of the land degradation include Climate Change, Land clearance and deforestation, Depletion of soil nutrients through poor farming practices, Overgrazing and over grafting, inappropriate irrigation, Urban sprawl and commercial development and Soil Pollution. In our country, water erosion is the most prominent reason of land degradation, followed by Soil acidity; as shown in below graphics:



Consequences of Land Degradation

The major outcomes of land degradations are as follows:

- Decline in the productive capacity of the land (temporary or permanent)
- Decline in the lands “usefulness”.
- Loss of biodiversity
- Increased vulnerability of the environment or people to destruction or crisis
- Accelerated soil erosion by wind and water
- *Soil acidification* and the formation of acid sulphate soil resulting in barren soil
- *Soil alkalinisation* owing to irrigation with water containing sodium bicarbonate leading to poor soil structure and reduced crop yields
- *Soil salination* in irrigated land requiring soil salinity control to reclaim the land
- *Soil water logging* in irrigated land which calls for some form of subsurface land drainage to remediate the negative effects.
- Destruction of soil structure including loss of organic matter.

Shifting Cultivation

Under Shifting cultivation, a piece of land is used for quite some years until the fertility is dropped. After that the farmers move to the new plots. It is practiced by tribal and also known as *Burn and Slash cultivation*. It is known as Jhoom in Assam, Onam in Kerala, Podu in Andhra Pradesh and Odisha. The same is known as Bewar in Madhya Pradesh.



Key Features of Shifting Cultivation

Over a large part of North East India, chief characteristics of shifting cultivation, while having different local names are found to be the same. These are

- Rotation of fields
- Use of fire for clearing the land
- Keeping the land fallow for regeneration for a number of years
- Use of human labour as main input
- Non-employment of draught animals
- Non-use of the plough, but instead very crude and simple implements such as dibble sticks and scrapers, are used, and
- All the crops being grown are mixed together.

Furthermore, in most parts of Northeast India it is found that hunting and gathering is an important subsidiary occupation of the shifting cultivators.

Extent of Shifting Cultivation in India

According to recent estimates, India's 0.59 percent of the total geographical area is under shifting cultivation. The effects of shifting cultivation are devastating and far-reaching in degrading the environment and ecology of these regions. The earlier 15–20 years cycle of shifting cultivation on a particular land has reduced to two or three years now. This has resulted in large-scale deforestation, soil and nutrient loss, and invasion by weeds and other species. The indigenous biodiversity has been affected to a large extent. The current statistics say that India's largest area under shifting cultivation is in the state of Odisha.

Impacts on Hilly Terrains

Most states of north east India are covered by dense forests. The topography of the region apart from fertility of the soil can be attributed as one of the factors for widespread practice of Jhum cultivation. The sloppy hills, fertile soil and accessibility to the forests are an ideal site for jhuming. The hilly areas of north East are becoming more and more barren due to jhuming.

Other Names of Shifting Cultivation

Shifting Cultivation is known as Ladang in Indonesia, Caingin in Philippines, Milpa in central America & Mexico, Ray in Vietnam, Taungya In Myanmar , Tamrai in Thailand, Chena in Sri Lanka, Conuco in Venezuela, Roca in Brazil, Masole in central Africa. Chinook is a local wind.

Soil Pollution

Soil pollution is defined as the build-up in soils of persistent toxic compounds, chemicals, salts, radioactive materials, or disease causing agents and other xenobiotic (man-made) chemicals or other alteration in the natural soil environment. Pollution in soil is mainly associated with__:

- Indiscriminate use of fertilizers



Environment-4: Pollution Related Topics

- Indiscriminate use of pesticides, insecticides and herbicides
- Dumping of large quantities of solid waste
- Deforestation and soil erosion

The most common chemicals involved in soil pollution are petroleum hydrocarbons, solvents, pesticides, lead, and other heavy metals. A soil pollutant is any factor which deteriorates the quality, texture and mineral content of the soil or which disturbs the biological balance of the organisms in the soil. Pollution in soil has adverse effect on plant growth.

Effect of Soil Pollution

- Pollutants runs off into rivers and kills the fish, plants and other aquatic life
- Crops and fodder grown on polluted soil may pass the pollutants on to the consumers
- Polluted soil may no longer grow crops and fodder
- Soil structure is damaged (clay ionic structure impaired)
- Corrosion of foundations and pipelines
- Impairs soil stability
- May release vapours and hydrocarbon into buildings and cellars
- May create toxic dusts
- May poison children playing in the area

Land Rehabilitation

Land rehabilitation is the process of returning the land to some degree of its former state, after some process (industry, natural disasters, etc.) has resulted in its damage.

Land rehabilitation has been a major priority since Independence, and several policies and government agencies address desertification and degradation.

These include various programmes such as Desert Development Programme; Integrated Wasteland Development; National Watershed Development Project for Rainfed Areas; Soil Conservation in the Catchment of River Valley Projects; National Afforestation Programme; Arid Zone Research; Mahatma Gandhi National Rural Employment Guarantee Scheme; National Rural Drinking Water Programme etc.

Indiscriminate Use of Fertilizers

Fertilizers contaminate the soil with impurities, which come from the raw materials used for their manufacture. Mixed fertilizers often contain ammonium nitrate (NH_4NO_3), phosphorus as P_2O_5 , and potassium as K_2O . Further, over use of NPK fertilizers reduce quantity of vegetables and crops grown on soil over the years.

Pollution by Indiscriminate use of Urea

Since Urea is more subsidized in comparison to the P and K fertilizers, there is much more use of



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Urea and this brings in nitrogenous pollution. The nitrogen from fertilizers and manures are eventually converted by bacteria in the soil to nitrates. These nitrates can be leached into the groundwater or be washed out of the soil surface into streams and rivers. High nitrate levels in drinking water are considered to be dangerous to human health.

Pollution by indiscriminate use of Phosphorus

Phosphorus cannot be readily washed out of the soil, but is bound to soil particles and moves together with them. Phosphorus can therefore be washed into surface waters together with the soil that is being eroded. The phosphorus is not considered to be dangerous, but *it stimulates the excessive growth of plants and this process is called eutrophication*. These algae eventually die and decompose, removing the oxygen from the water which in turn kill the fish. Further, *the Arsenic, Lead and Cadmium present in traces in rock phosphate mineral get transferred to super phosphate fertilizer.*

Since the metals are not degradable, their accumulation in the soil above their toxic levels due to excessive use of phosphate fertilizers, becomes an indestructible poison for crops.

Indiscriminate use of Potassium

Potassium, the third major nutrient in fertilizers, *does not cause water quality problems because it is not hazardous in drinking water and is not a limiting nutrient for growth of aquatic plants.* It is tightly held by soil particles and so can be removed from fields by erosion, but generally not by leaching. However, too much use of Potassium inhibits the absorption of other nutrients, which leads to the symptoms caused by the deficiency of these nutrients.

It also **reduces the protein content of wheat, maize, grams** etc., grown on that soil. The carbohydrate quality of such crops also gets degraded. Excess potassium content in soil decreases Vitamin C and carotene content in vegetables and fruits. The vegetables and fruits grown on overfertilized soil are more prone to attacks by insects and disease.

Vermicompost

Vermicompost is the product or process of composting utilizing various species of worms, usually red wigglers, white worms, and earthworms to create a heterogeneous mixture of decomposing vegetable or food waste, bedding materials, and vermicast.

Benefits of Vermicompost for Soil

- Vermicast, similarly known as worm castings, worm humus or worm manure, is the end-product of the breakdown of organic matter by a species of earthworm.
- Vermicompost is an excellent, nutrient-rich organic fertilizer and soil conditioner.
- Vermicompost improved the physical make up of upper layers of soil, enriches soil with micro-organisms (adding enzymes which help to use complex matters such as phosphate and cellulose).



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- The microbial activity in worm castings is 10 to 20 times higher than in the soil and organic matter that the worm ingests, it also attracts deep-burrowing earthworms already present in the soil and the mucus present in vermicast improves water holding capacity

Benefits of Vermicompost for Plant growth

- Vermicompost enhances germination, plant growth, and crop yield and improves root growth and structure.
- It enriches soil with micro-organisms (adding plant hormones such as auxins and gibberellic acid)

Economic Benefits of Vermicompost:

- Biowastes conversion reduces waste flow to landfills. Elimination of biowastes from the waste stream reduces contamination of other recyclables collected in a single bin (a common problem in communities practicing single-stream recycling).
- The production also creates low-skill jobs at local level. Vermicompost has low capital investment and relatively simple technologies make vermicomposting practical for less-developed agricultural regions

Environmental Benefits of Vermicompost:

- Vermicompost helps to close the “metabolic gap” through recycling waste on-site. Large systems often use temperature control and mechanized harvesting, however other equipment is relatively simple and does not wear out quickly. Production reduces greenhouse gas emissions such as methane and nitric oxide (produced in landfills or incinerators when not composted or through methane harvest)

Disadvantages / Issues of Vermicompost:

- Moisture, air circulation and compost quantity need regular monitoring otherwise the Vermicompost will smell like an old garbage. The quality of Vermicompost deteriorates in anaerobic environment.
- Vermicompost can be carried out at relatively low temperatures (under 25 °C) only. It is vitally important to keep the temperature below 35 °C, otherwise the earthworms will be killed.
- Vermicompost is time consuming. It can take many months, or even years, to build up a large working population of earthworms capable of vermicomposting significant quantities of waste. As well as this, earthworms (sometimes in large numbers) tend to escape during damp weather conditions or when food is in short supply.

Biofertilizers

There are five biofertilizers viz. Rhizobium, Azotobacter, Azospirillum, Phosphate Solubilizing Bacteria and mycorrhiza, which have been incorporated in India's Fertilizer Control Order (FCO),



1985.

- Rhizobium, Azotobacter, Azospirillum and blue green algae (BGA) have been traditionally used as Biofertilizers. Rhizobium inoculant is used for leguminous crops such as pulses.
- Azotobacter can be used with crops like wheat, maize, mustard, cotton, potato and other vegetable crops.
- Blue green algae such as Nostoc, Anabaena, Tolypothrix and Aulosira fix atmospheric nitrogen and are used as inoculants for paddy crop.
- Phosphate solubilizing bacteria like *Pantoea agglomerans* strain P5, and *Pseudomonas putida* strain P13 are able to make the phosphate usable by solubilize it from inorganic sources.

Pesticides and Insecticides

Man is using the pesticides since the evolution and development of agriculture and civilization began. The word pesticide comes from Latin *pestis*, which means the destructive agent or plague. Pesticides are generally oily or waxy substances in the form of dust, granules, pellets, emulsified concentrates, aerosols, soluble powders, wettable powders etc.

Types of Chemical Pesticides

According to their chemical nature, pesticides can be classified in below categories:

Organochlorines

Organochlorines are very slowly decomposing chlorinated organic compounds, which are *lipophilic* (show much affinity for the fatty tissue of animals). Examples of Organochlorines are DDT, BHC, Aldrin, Endosulphan etc.

- DDT is the most famous chemical in the world and is oldest synthetic pesticide.
- Benzene hexachloride (BHC) also known as Lindane or Gammexane was used in agriculture and Pharma until its farm use was banned under the Stockholm convention on Persistent Organic Pollutants. However, it is still used in second-line pharmaceutical treatment for lice and scabies.
- Aldrin is applied to foundations of buildings to prevent termite. D

Organophosphates

Organophosphates are organic esters of phosphoric, thiophosphoric and other phosphoric, thiophosphoric and other phosphoric acids. Common examples are Malathion, Parathion, Fenitrothion etc.

Malathion is widely used in agriculture, residential landscaping, public recreation areas, and in public health pest control programs such as mosquito eradication. In some countries, it is the most commonly used organophosphate insecticide. Malathion / Organophosphates are harmful and of concern to both scientists and regulators because they work by irreversibly blocking an enzyme that's critical to nerve function in both insects and humans. Thus, their effect is mostly visible on nervous



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system.

Carbamates

Carbamates are organic compounds derived from carbamic acid (NH_2COOH). They are having structural resemblance with acetylcholine. Examples of Carbamates are Aldicarb (Temik), Carbofuran (Furadan), Carbaryl (Sevin), Ethienocarb, Fenobucarb, Oxamyl And Methomyl. These insecticides kill insects by reversibly inactivating the enzyme acetylcholinesterase.

Pyrethroids

Pyrethroids are synthetic derivatives of pyrethrin. Pyrethrin is obtained from a plant botanically called *chrysanthemum cineraiifolium*. These compounds are the fastest growing groups of chemicals today. They are highly toxic and quite expensive.

Common example is Pyrethrin, which is a natural insecticide and least harmful of all. It is one of the insecticides based on learning how wild plants, especially tropical species produce chemical compounds that repel insects or inhibit their feeding. There are two major types of these compounds pyrethrins from wild chrysanthemum type plants and rotenoids produced by the roots of rain-forest legumes. Both types of compounds are biodegradable, effective in low doses, and cause little harm to higher animals such as birds and mammals, including humans.

Triazines

Triazines are a group of herbicides derived from urea. They are used for controlling weeds in tea, tobacco and cotton. Examples are simazine, atrazine etc.

Environmental Hazards of Pesticides

Pesticides increase the crop yield manifold because the insects which destroy crops in bulk are killed. Further, insecticides have helped to counter the various insects that function as dreadful diseases such as Malaria.

However, pesticides / insecticides are poisons which kill all biota irrespective of their benefits or harms to the crops or animals or humans. Since these pests also make food chain in the ecosystem, their elimination disturbs the entire ecosystem. Further, many of the pesticides are persistent organic pollutants, which enter into the food chain and keep bioaccumulating. If they are soluble in water, they cause water pollution.

Labelling of Pesticides

The pesticide packet are labelled using square divided into two triangles with color in lower triangle and word poison in upper triangle. This categorization is as follows:



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Classification of pesticides	Colour of the lower triangle	Symbol and signal word* on upper triangle
Extremely toxic	Bright Red	Skull and cross bones 'POISON' in red
Highly toxic	Bright Yellow	'POISON' in red
Moderately toxic	Bright Blue	DANGER
Slightly toxic	Bright Green	CAUTION

* Signal words in Indian languages may also be given in addition to those in English

Examples



Biopesticides

Animals or plants used wilfully to destroy pests are called Biopesticides. For common knowledge, we can divide them into *bioherbicides* and *bioinsecticide*.

Bioherbicides

Pesticides destroying herbs are called bioherbicides. One example is insect *Cactoblastis cactorum*, which eats only cactus of *Opuntia* variety. The first bioherbicides, developed in 1981 was a mycoherbicide based on the fungus *Phytophthora palmivora*. It controls the growth of milk weed vines in citrus orchards.

Bioinsecticide

Bioinsecticides are animals (including insects) that kill other insects. For example, the *praying mantis* eats *aphids*. Similarly, *Gambusia fish* is used to feed on larvae of mosquitoes.

Examples of Biopesticides

- Daisy plants (*Chrysanthemum cinerariaefolium*) were first used centuries ago as a lice remedy in the Middle East, and this led to the discovery of pyrethrum insecticides. The seeds contain a natural insecticide called pyrethrin, a generic name for six related active compounds. It is one of the safer insecticides for several reasons: it decomposes rapidly in sunlight; it has few known effects on mammals; and insects do not develop resistance to it, the safer insecticides for several reasons: it decomposes rapidly in sunlight; it has few known effects on mammals; and insects do not develop resistance to it. It is used on foodstuffs, in head lice shampoos, and



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in many indoor insect sprays. Lakhs of tonnes of mosquito coils made from pyrethrum are sold each year. Scientists have synthesized similar compounds called pyrethroids, but the chemical synthesis produces all geometric isomers of the compounds, many of which are ineffective and are difficult to separate from the active forms. The plant material contains only the active isomers.

- In South America, the natives use an extract of a forest vine to stun fish; this led to the discovery of rotenone, a biodegradable insecticide.
- The bacterium *Bacillus thuringiensis* produces toxic proteins that kill certain insects but are apparently harmless to humans. These are being produced and marketed as biopesticides.
- The Neem tree, in India, has been found to be a source of the insecticide azadirachtin, as well as fungicides, spermicide, and agents potentially valuable in birth control such as materials that prevent implantation or cause abortion. The tree has been used in traditional agriculture, medicine and cosmetics for centuries.

Drivers of Water Pollution

Almost 70 per cent of India's surface water resources and a growing percentage of its groundwater reserves are contaminated by biological, toxic organic and inorganic pollutants. In many cases, these sources have been rendered unsafe for human consumption as well as for other activities such as irrigation and industrial needs. The high incidence of severe contamination near urban areas indicates that the industrial and domestic sector's contribution to water pollution is much higher. Besides rapidly depleting groundwater table, the country faces another major problem on the water front – groundwater contamination – a problem which has affected as many as 19 states, including Delhi. The geogenic contaminants, including salinity, iron, fluoride and arsenic have affected groundwater in over 200 districts spread across 19 states.

Driver of water pollution

Fertilizers

Rapid increase in agro-chemical use in the past five decades, has contributed significantly to the pollution of both surface and groundwater resources. Fertilizers and pesticides enter the water supply through run-offs and leaching into the groundwater table and pose a hazard.

- Some of these substances have been known to *bio-accumulate* in certain organisms, leading to an increased risk of contamination when used for human consumption and a persistence of the chemicals in the environment over long periods of time.
- Water enriched with nutrients leads to *eutrophication*. Decaying organic matter releases odourous gases and partially decomposed matter accumulates on the river or lakebed, thereby limiting water's suitability for human consumption and other uses.



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- High levels of fertilizer use has been associated with increased incidence of eutrophication in rivers and lakes in several of India's most important water bodies.

Industrial Sector

Though Industrial sector only accounts for three per cent of the annual water withdrawals in India, yet its contribution to water pollution, particularly in urban areas, is considerable. Wastewater generation from this sector has been estimated to be 55,000 million m³ per day, of which 68.5 million m³ are dumped directly into local rivers and streams without prior treatment. The government has called for the establishment of Common Effluent Treatment Plants (CETP) in industrial areas but their implementation has been slow, and most industries either are not connected to CETPs or only partially treat their wastewater before disposal.

Domestic Sector

The domestic sector is responsible for the majority of wastewater generation in India. Combined, the 22 largest cities in the country produce over 7,267 million litres of domestic wastewater per day, of which slightly over 80 per cent is collected for treatment. Inadequate treatment of human and animal wastes also contributes to high incidence of water-related diseases in the country. Till date, only 19.2 per cent of the rural and 70 per cent of the urban inhabitants have access to adequate sanitation facilities.

Persistent Organic Pollutants (POPs)

Persistence is an important characteristic of the environmental pollutants in an environmental medium (air/ water/ soil) or in a living tissue, in which the pollutants remain active for a longer time in a toxic form through chemical, biological, and photolytic processes.

Persistent organic pollutants (POPs) are organic compounds that, to a varying degree, resist photolytic, biological and chemical degradation.

Due to persistence, the pollutants are capable of long-range transport **bioaccumulation** and **biomagnification**. Most of the POPs include pesticides, Industrial solvents, polyvinyl chloride, and pharmaceuticals. The Other words used are PBTs (Persistent, Bioaccumulative and Toxic) or TOMPs (Toxic Organic Micro Pollutants.)

Common Characters of the POPs

The persistent Organic Pollutants generally have ___:

- Low Water solubility
- High lipid solubility: This property leads them to bioaccumulation in animal tissues.
- Semi volatile: The property of their physico-chemical characteristics that permit these compounds to occur either in the vapour phase or adsorbed on atmospheric particles, thereby facilitating their long range transport through the atmosphere
 - The POPs with higher Molecular weights are more toxic and more persistent



generally.

- Most of the POPs are halogenated and many have Chlorine as a component.

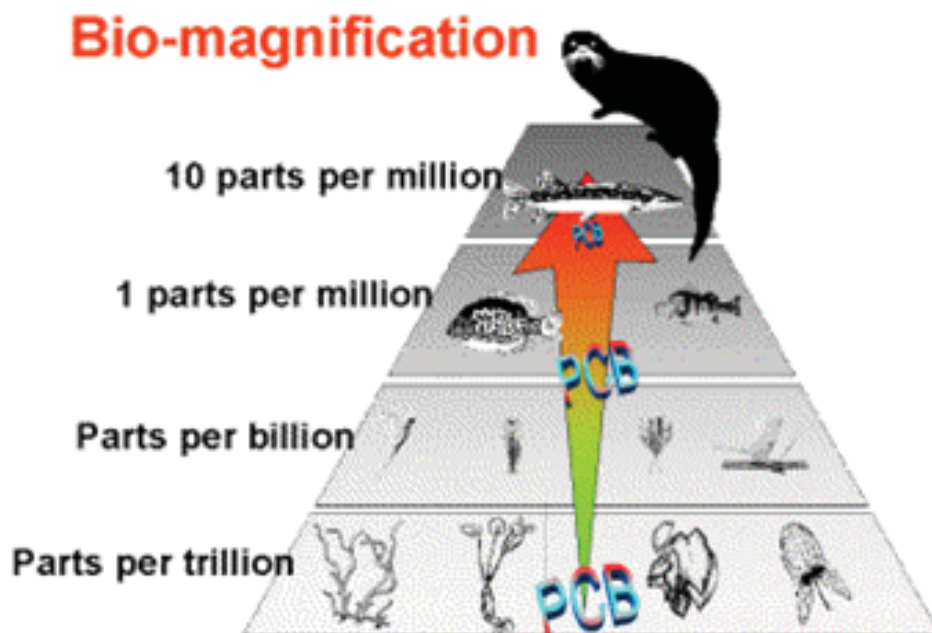
Bio-accumulation, Bio-concentration and Bio-magnification

The above three terms are different with each other.

- *Bio-accumulation* refers to increase in concentration of a substance in certain tissues of organisms body.
- While Bioaccumulation occurs when an organism absorbs a toxic substance from all sources at a rate greater than that at which the substance is lost *Bioconcentration* occurs when an organism absorbs a toxic substance from ONLY Water at a rate greater than that at which the substance is lost.
- Please note that *Bioaccumulation* and *Bioconcentration* are synonymous except the difference of the source. *Both Bioaccumulation and Bioconcentration occur in the same organism. But Biomagnification occurs across various trophic levels in a food chain.*

Biomagnification

Biomagnification refers to the is the INCREASE in concentration of the POPs such as DDT, that occurs in a food chain as a consequence of persistence, high lipid solubility and low water solubility. The substances become more and more concentrated in tissues or internal organs as they move up the chain. This is shown in the following picture:



Dirty Dozen

In May 1995, the United Nations Environment Programme Governing Council (GC) started investigations on the POPs. The process began with 12 POPs which were most common at that time. They were called “Dirty Dozen”.

The Dirty Dozen are: Aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex,



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polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, and toxaphene.

The list enlarged later with inclusion of some more chemicals.

Stockholm Convention on Persistent Organic Pollutants

Stockholm Convention is first ever-concerted global effort on Persistent Organic Pollutants (POP).

It was called in 1995 by UNEP. The convention calls to outlaw nine of the dirty dozen chemicals, *limit the use of DDT to malaria control*, and curtail inadvertent production of dioxins and furans. The convention listed twelve distinct chemicals in three categories in the beginning.

These includes

- Eight pesticides (aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex and toxaphene)
- Two industrial chemicals (poly chlorinated biphenyls and hexachlorobenzene)
- Two unintended byproducts (poly chlorinated dibenzo-p-dioxins and dibenzo furans, commonly referred to as dioxins and furans).

Countries are required to make efforts to identify, label and remove PCB-containing equipment by the year 2025, and manage the wastes in an environmentally sound manner, not later than 2028.

The Convention also seeks to continue minimization and, where feasible, ultimate elimination of the releases of unintentionally produced POPs, such as dioxins and furans. Stockpiles and wastes containing POPs must be managed and disposed off in a safe, efficient and environmentally sound manner, taking into account international rules, standards and guidelines. Each Party is required to develop a plan for implementing its obligations under the Convention.

India and Stockholm Convention

India is a party to the Stockholm convention since 2005. The Convention will enable India to participate in the It will also enable India to avail technical and financial assistance for implementing measures to meet the obligations of the Convention.

Stockholm Convention and Endosulphan

Endosulphan belongs to the **organochlorine group of pesticides** such as DDT. In pure form it exists as colourless crystals, slightly soluble in water, dissolves readily in xylene, chloroform, kerosene and most organic solvents and is a non-combustible solid. It is mixable with most fungicides and compatible with most pesticides

It is used as an organochlorine insecticide and **acaricide (killing ticks and mites)**. It causes endocrine disruption and neurotoxic impacts. It is also supposed to be a genotoxic and may lead to genetic mutation, however, it has not been found to be a carcinogenic. Because of its threats to environment as a POP, it is banned in more than 63 countries but still is widely used.

Currently, a global ban on the use and manufacture of Endosulphan is being considered under the Stockholm Convention. India is the largest user of Endosulphan, and had sought a 10 year remission from ban. However, in 2011, the Supreme Court banned the use of Endosulphan due to some



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peculiar health impacts seen after aerial spray of in **Cashew Plantations in Kerala**. The court ordered a complete ban on the manufacture, sale and use of Endosulphan after a PIL had brought to the court's notice the hazardous effects of the pesticide on human life as well as biodiversity in Kerala, Karnataka and other states.

Hazardous substances

The Hazardous material or Hazmats are the solids, liquids and gases which can harm people, organisms, property and environment. The Hazardous Materials are often subject to various legislations. The Hazmats may be radioactive, flammable, explosive, corrosive, oxidizing, asphyxiating, biohazardous, toxic, pathogenic, or allergenic.

International Programme on Chemical Safety

This programme was launched in 1980 by **three UN bodies viz.** WHO, ILO and UNEP. The idea was to establish the basis of safe use of the chemicals and strengthen the national capabilities for chemical safety. WHO publishes some awareness documents on toxicological properties of the chemical substances under this programme.

Rotterdam Convention on Hazardous Substances

The most important international convention in context with the Hazmats is "Rotterdam Convention" on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade". This is a non-legally binding convention that promotes *shared responsibilities* in relation to importation of hazardous chemicals. It promotes open exchange of information, proper labelling, include directions on safe handling, and inform purchasers of any known restrictions or bans.

Various Treaties on Marine Pollution

Spread of chemicals, particles, industrial, agricultural and residential waste, noise or the invasive organisms in the marine is the Marine Pollution. Toxins bioaccumulate in Zooplankton and phytoplankton and then get biomagnified in the ocean food chains. They cause Eutrophication, ocean acidification etc. leading to problems such as algal bloom, hypoxia and anoxia. There are four main types of inputs of pollution into the ocean:

- Direct discharge of waste into the oceans such as rivers
- Runoff into the waters due to rain
- Pollutants that are released from the atmosphere
- Ship Pollution which includes many ways including the oil spills.

London Convention on Marine Pollution

The London Convention or LC-72 is a non-binding treaty which seeks address the problem of deliberate disposal at sea of wastes or other matter from vessels, aircraft, and platforms. But it does



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not cover discharges from land-based sources such as pipes and outfalls, wastes generated incidental to normal operation of vessels, or placement of materials for purposes other than mere disposal, providing such disposal is not contrary to aims of the Convention.

One regional type of convention is Barcelona Convention, which covers the same problems in the Mediterranean sea.

International Convention for the Regulation of Whaling

International Convention for the Regulation of Whaling is an international environmental agreement which governs the commercial, scientific, and aboriginal subsistence whaling practices of fifty-nine member nations. It was signed in 1946. By this convention, International Whaling Commission (IWC) was set up to “provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry”.

This organization has been active against the commercial whaling. In 1986, it adopted a moratorium on commercial whaling. This ban still continues. In 1994, it created the Southern Ocean Whale Sanctuary surrounding the continent of Antarctica. Here, the IWC has banned all types of commercial whaling. Only two such sanctuaries have been designated by IWC till date. Another is Indian Ocean Whale Sanctuary by the tiny island nation of the Seychelles.

Wadden Sea Agreement

Wadden Sea is located between the coast of northwestern continental Europe and the range of Frisian Islands. It is a World Heritage site (Dutch and German part) which forms a shallow body of water with tidal flats and wetlands, thus very rich in biodiversity. Wadden Sea is famous for its rich flora and fauna, especially birds such as waders (shorebirds), ducks, and geese. Wadden Sea is protected in cooperation of all three national parks, and cooperation between three countries as follows:

- Schleswig-Holstein Wadden Sea National Park
- Hamburg Wadden Sea National Park
- Lower Saxony Wadden Sea National Park

The three countries viz. **Netherlands, Germany and Denmark** concluded the Wadden Sea Agreement for protection of the Wadden Sea in 1990.

ACCOBAMS

ACCOBAMS refers to “Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic area”. So, it is a cooperation for the protection of Cetaceans in the Black Sea and Mediterranean Sea. It was concluded on the sidelines of Convention on the Conservation of Migratory Species of Wild Animals, in 1996 and came into force in 2001. Currently 21 countries in the Black Sea, Mediterranean Sea and contiguous Atlantic area are parties



to this convention.

MARPOL 73/78

MARPOL refers to Marine Pollution. MARPOL 73/78 is the International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. It entered into force on 2 October 1983 and it has 169 parties. It is one of the most important environment conventions on marine pollution and prevents the pollution from Oil Spill, Noxious Liquid Substances carried in Bulk, Harmful Substances carried in Packaged Form, Sewage, Garbage and Air Pollution.

It centers around minimizing the pollution of the seas, including dumping, oil and exhaust pollution.

There are 150 countries party to this agreement.

India is a party to MARPOL 73/78. India's enshrined the obligation to inform contravention of provision of MARPOL 73/78 in the Sec 356 (H) of Merchant Shipping Act 1948.

Mercury Poisoning in Fishes

Fishes concentrate mercury in their bodies, often in the form of methyl mercury, a highly toxic organic compound of mercury. The mercury is absorbed, usually as methylmercury, by algae at the start of the food chain. It gets magnified to about 0.01 ppm in the herring, tuna etc. The same fishes when consumed by the human get more concentration of mercury. In Sharks, the mercury gets accumulated to the extent of 1 ppm.

Minimata Disease

The disease was searched in the seaside town of Minimata, in Japan in late 1950s when a strange behaviour in animals was seen. The abnormal behaviour was seen in the Cats, Birds and also in Humans. Investigations found that a petrochemical company had been discharging mercury waste into the sea. Around 5,000 people were killed and perhaps 50,000 have been to some extent poisoned by mercury. Thus, this disease got famous as Minimata disease.

Oil Spills

In Oil Spills, the oil is released into the ocean or coastal waters. The Oil may be crude oil from the tankers, offshore platforms, drilling rigs, Oil wells, ships or in any other form.

Impacts on Marine Life

- **Plumage:** The most important impact of the oil spills on the sea organisms is on the plumage of the birds. The seabirds, when their plumage gets penetrated by the oil, the insulating ability is reduced drastically and the birds become vulnerable to minor change in temperature. The oil penetration also makes them less buoyant in water.
- **Ingestion:** The ingestion of the oil by the seabirds and sea mammals causes Kidney Failure, dehydration and other metabolic disorders.
- **Furs:** The furs of the sea otters and other marine animals are affected in several ways.



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- **Photosynthesis:** The oil floats on the top of the water and this reduces the penetration of sunlight in the sea water.

Recovery

The Recovery from the oil spill is difficult and depends upon many factors. The clearing and recovery depends upon the following factors:

- Type of the oil spilled
- Temperature of the water which may affect the evaporation and biodegradation.
- Type of shore line involved.

Largest Oil Spills

As per records, Kuwaiti oil fires of 1991 is the largest Oil spill of the world till date. It included 14-20 crore tons of crude oil. The top largest oil spills are as follows:

- Kuwaiti oil fires 1991
- Lakeview Gusher 1910-1911
- Gulf War oil spill 1991
- Deepwater Horizon 2010
- Ixtoc I , Mexico Oil Spill of 1979

Bioremediation of Oil Spills

Bioremediation uses the microorganisms or biological agents such as oil eating bacteria. There are three kinds of oil-consuming bacteria viz. Sulfate-reducing bacteria (SRB), Acid-producing bacteria are anaerobic and General aerobic bacteria (GAB). Out of them, Sulfate-reducing bacteria (SRB) and acid-producing bacteria are anaerobic, while general aerobic bacteria (GAB) are aerobic.

Oil Zapper

In 2010, a new technique of using the bacteria to get rid of oil spill became popular called Oil Zapper. Oil Zapping is a bio-remediation technique involving the use of 'oil zapping' bacteria.

United Nations Convention on the Law of the Sea (UNCLOS)

United Nations Convention on the Law of the Sea (UNCLOS) is also known as **Law of the Sea treaty**. The latest UNCLOS is UNCLOS III which covers all the vital issues regarding the maritime boundaries. This convention introduced a number of provisions and covered the most significant issues such as setting limits, navigation, archipelagic status and transit regimes, exclusive economic zones (EEZs), continental shelf jurisdiction, deep seabed mining, the exploitation regime, protection of the marine environment, scientific research, and settlement of disputes. This treaty defines the following terms:

Internal waters

Internal Waters refers to the all water and waterways on the landward side of the baseline of a country. In the internal waters a country is free to set laws, regulate its use and use of its resources.



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There is *no interference of the foreign countries*.

Territorial waters

Territorial waters refer to 12 Nautical Miles from the baseline. In this area the countries are free to set laws, regulate use and also use its resources. However, the foreign vessels are NOT given all rights to passage through except “Innocent Passage”.

The innocent passage refers to the passing through the waters which is not prejudicial to peace and security. However, the nations have right to suspend the innocent passage. The submarine while passing through other country’s territorial waters has to navigate on the surface and show their flags.

Archipelagic waters

If the country is an archipelago or has an archipelago under it, a baseline is drawn between the outermost points of the islands, provided that these islands are close to each other. All water inside this is called *Archipelagic Waters*. The state has full sovereignty over these waters very much similar to the internal waters and the foreign vessels are allowed for innocent passage through archipelagic waters.

Contiguous Zone

The contiguous zone refers to the area 12 Nautical Miles beyond the Territorial waters. This means that it is 24 Nautical Miles from the baseline limit. In this zone the country can enforce laws only in 4 areas viz. pollution, taxation, customs, and immigration.

Exclusive Economic Zones (EEZs)

Exclusive Economic Zones refers to the area from the edge of the territorial sea out to *200 nautical miles* from the baseline. In this area, the country has sole exploitation rights over all natural resources. The most important reason to introduce EEZ was to halt the clashes over the Fishing Rights and Oil Rights. In the EEZ, the foreign vessels have freedom of navigation and over flight, subject to the regulation of the coastal states Foreign states are allowed to lay submarine pipes and cables.

UNCLOS and problem of Arctic

As per the current international law, no country owns the North Pole or the region of the Arctic Ocean surrounding it.

- There are five countries that surround the Arctic viz. Russia, United States (Via Alaska), Canada, Norway & Denmark (Via Green Land).
- However they are limited to an Exclusive Economic Zone (EEZ) which refers to an area of 200 Nautical Miles (370 kilometers) adjacent to their coasts.

The dispute in Arctic Seas is between these 5 countries viz. Russia, United States, Canada, Norway & Denmark. The UNCLOS had given every country a ten year period to make claims to an extended continental shelf which, if approved, gives it exclusive rights to resources on or below the seabed in



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the vast circumpolar territories. In this context, on October 15, 2010, the Russian scientists have opened a floating polar research station in the Chuckchi Sea at the margin of the Arctic Ocean. The name of the station is Severny Polyus-38 and will be home to 15 researchers for a year. They will conduct polar studies and gather scientific evidence 'to reinforce Russia's claims to the Arctic'.

Thermal Pollution of Water

Thermal pollution is the degradation of water quality by any process that changes ambient water temperature. A common cause of thermal pollution is the use of water as a coolant by power plants and industrial manufacturers. When water used as a coolant is returned to the natural environment at a higher temperature, the change in temperature decreases oxygen supply and affects ecosystem composition. Urban runoff-storm water discharged to surface waters from roads and parking lots-can also be a source of elevated water temperatures.

Ecological Impacts of Thermal Pollution of Water

Thermal pollution, the release of liquid or gas that increases heat in a surrounding area, has far-reaching and damaging ecological effects by impacting aquatic organisms and animal populations.

When a power plant first opens or shuts down for repair or other causes, fish and other organisms adapted to particular temperature range can be killed by the abrupt change in water temperature known as "thermal shock." This problem is particular for marine / cold blooded organisms because they are adapted to specific temperature ranges If water temperatures change too much, metabolic processes break down. Unlike humans, who can adapt to wide temperature ranges, most organisms live in narrow temperature niches.

Eutrophication

Eutrophication derives from the Greek word eutrophos, meaning nourished enriched. Eutrophication refers to the addition of artificial or non-artificial substances, such as nitrates and phosphates, through fertilizers or sewage, to a fresh water system. It can be anthropogenic or natural. It leads increase in the primary productivity of the water body or "bloom" of phytoplankton. The overgrowth causes the loss of oxygen in the water leading to severe reductions in fish and other animal populations.

- Please note that some animals such as **Nomurai Jellyfish** show an increase in population that negatively affects other species in the local ecosystem.

Important Notes on Eutrophication

- Eutrophication escalates rapidly when high nutrients from fertilizers, domestic and industrial wastes, urban drainage, detergents and animal, sediments enter water streams.
- Eutrophication is mainly divided into natural and cultural Eutrophication.
 - In natural Eutrophication, a lake is characterized by nutrient enrichment. During this



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process an oligotrophic lake is converted into an eutrophic lake. It permits the production of phytoplankton, algal blooms and aquatic vegetation that in turn provide ample food for herbivorous zooplankton and fish.

- When the process of Eutrophication is increased by the human activities, it is called cultural Eutrophication. This is because the human activities (mainly development in nature) increase the surface run off and the nutrients such as Phosphates, Nitrates are supplied to the Ocean water. They may be supplied by Constriction works, treatment plants, golf courses, fertilizers, and farms. Human activities are responsible for addition of 80% nitrogen and 75% phosphorus to lake and streams.
- Eutrophication causes several physical, chemical and biological changes, which considerably deteriorate the water quality.
- It creates algal bloom, releases toxic chemicals that kill fish, birds and other aquatic animals.
- Decomposition of algal bloom leads to the depletion of oxygen in water. Thus with a high CO₂ level and poor oxygen through reduction of nitrates.
- On complete exhaustion of nitrate, oxygen may as last resort be obtained by reduction of sulphate yielding hydrogen sulphide causing foul smell and putrefied taste of water. Many pathogenic microbes, viruses, protozoa and bacteria and grow on sewage products under anaerobic conditions. It results into the spread of fatal water-borne disease such as polio, dysentery, diarrhoea, typhoid and viral hepatitis.

Control of Eutrophication

- Several prevention and technical devices have been used to control Eutrophication. The wastewater must be treated before its discharge into water streams.
- Recycling of nutrients can be checked through harvest. Removing nitrogen and phosphorous at the source, division of nutrient-rich waters from the receiving bodies and dilution of these elements can minimize Eutrophication.
- Algal bloom should be removed upon their death and decomposition. Limiting the dissolve nutrients can control algal growth. The most suitable, feasible and effective method involves the use of chemicals to precipitate additional phosphorus.
- Precipitants like alum, lime, iron and sodium aluminate may be used. Physicochemical methods can be adopted to remove nutrients. for example phosphorous can be removed by precipitation and nitrogen by nitrification or denitrification.
- Electrodialysis, reverse osmosis and ion exchange methods. Cooper-sulphate and sodium arsenite are employed for killing algae and rooted plant respectively.

General Knowledge Today



Environment-5: Domestic Laws on Pollution

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Model Questions

Prelims MCQ Topics

Constitutional Provisions on Environment, Air pollution control areas, Air Quality Control and Monitoring, National Air Quality Index, Water in Constitution of India, Inter-State Water Disputes, National Green Tribunal, Coastal Regulation Zone Notification, Eco-sensitive Zones, Fly Ash, Environmental Impacts of Concrete, Indicator Species, Photochemical Smog, Environmental Concerns of PET Bottles, Biofuels, Green GDP, Biodigester Technology and Biotoilet, Bharat Stage Emission Standards.



Legal Framework around Pollution

Environment and Constitution of India

The provisions related to environment in the constitution of India are found among Fundamental Duties, Directive Principles as well as Fundamental Rights.

Fundamental Duties

Article 51-A(g) says that *“It shall be duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wild life and to have compassion for living creatures.”*

Directive Principles

Article 48-A of the constitution in Directive Principles focuses on protection and improvement of environment and safeguarding of forests and wild life. This article says: *“The State shall endeavour to protect and improve the environment and to safeguard the forests and wild life of the country”*

Further, article 47 and 48 also commensurate with the healthy environment. Article 47 provides that the *“State shall regard the raising of the level of nutrition and the standard of living of its people and the improvement of public health as among its primary duties.”* Protection and improvement of environment is necessary for improving the public health. Article 48 directs the state to take steps to organize agriculture and animal husbandry on modern and scientific lines.

Fundamental Rights

Under Fundamental Rights (Part-III), Articles 21, 14 and 19 have been used by judiciary to establish Right to clean environment as one of the implied fundamental rights. Article 21 which says: *no person shall be deprived of his life or personal liberty except according to procedure established by law*, has been subject to maximum scrutiny by Supreme Court, which has mandated for more than once that the right to environment, free of danger of disease and infection are inherent in this act. The right to healthy environment was first recognized by Supreme Court as inherent in article 21 in the *Dehradun Quarrying Case* in 1988. In this case, Supreme Court gave direction to stop quarrying under Environment Protection Act. Similarly, the *M.C. Mehta vs. Union of India, 1987* case also, the Supreme Court treated the right to live in pollution free environment as a fundamental right inherent under Article 21.

Supreme Court has also interpreted Article 19(1) to tackle the menace of noise pollution. The court has maintained in *PA Jacob case 1993* that freedom of speech does not include freedom to use loud speakers or sound amplifiers. Further, Article 19(1) (g) confers the fundamental right over citizens to practice any occupation, trade or business. But this fundamental right is subject to reasonable restrictions and citizens can not practice the business activities that case health hazards to public.

Apart from the above, Supreme Court (Via article 32) and High Courts (Via article 226) have frequently admitted to public interest litigation related to environment.



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Air (Prevention and Control of Pollution) Act, 1981

The Parliament enacted the Air (Prevention and Control of Pollution) Act, 1981 to arrest the deterioration in the air quality.

The notable points from this act are as follows:

- The Act makes provisions for the establishing of **Central Pollution Control Board (CPCB)** at the apex level and State Pollution Control Boards at the state level.
- The CPCB advises the Central Government on any matter concerning the improvement of the quality of the air and prevention, control and abatement of air pollution. It also helps to plan and cause to be executed a nation-wide programme for the prevention, control and abatement of air pollution. It provides technical assistance to and guidance to the State Pollution Control Board. It also lays down the down standards for the quality of air.
- The SPCBs plan a comprehensive programme for prevention, control and abatement of air pollution and to secure the execution thereof. They also advise the State Government on any matter concerning prevention, control and abatement of air pollution.
- Kindly note that according to this act, the “**air pollutant**” means any solid, liquid or gaseous substance (**including noise**) present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment.

What are Air pollution control areas?

- This act provides that the State Government may, after consultation with the State Board, by notification declare any area or areas within the State as air pollution control areas. The state government is also powered to make any alternations in the area pollution control areas such as merging the areas. If the state government, after consultation with the State Board, is of opinion that the use of any fuel or burning of any non-fuel material other than an approved fuel, in any air pollution control area or part thereof, may cause or is likely to cause air pollution, it may, by notification, prohibit the use of such fuel in such area.
- The further provisions of the act say that no person shall, without the previous consent of the State Board, establish or operate any industrial plant in an air pollution control area. Every person to whom consent has been granted by the State Board, shall comply with the conditions and norms prescribed by the board such as prevention and control of the air pollution. Failure to do so brings penalty including jail term of at least 1.5 years.

Air Quality Control and Monitoring

Central Pollution Control Board (CPCB) with the help of concerned State Pollution Control Boards (SPCBs) and Pollution Control Committees (PCCs) is monitoring the ambient air quality in the



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country at 346 stations covering 130 cities and towns. This is done under the National Air Quality Monitoring Programme (NAMP).

Under this programme, Central Government provides funds through CPCB for National Air Monitoring Programme to various SPCBs and PCCs.

The objectives of the NAMP are to determine the status and trends of ambient air quality; to ascertain whether the prescribed ambient air quality standards are violated; to assess health hazards and damage to materials; to continue the ongoing process of producing periodic evaluation of air pollution situation in urban and industrial areas of the country; to obtain the knowledge and understanding necessary for developing preventive and corrective measures and to understand the natural cleansing processes undergoing in the environment through pollution dilution, dispersion, wind based movement, dry deposition, precipitation and chemical transformation of pollutants generated.

Under the NAMP, four air-pollutants viz., SO_x, NO_x, Suspended Particulate Material (SPM) and Respirable Suspended Particulate Matter (RSPM) have been identified for regular monitoring at all the locations.

National Air Quality Index (NAQI)

The NAQI was prepared by an expert group, set up the Ministry of Environment and Forests, comprising of renowned medical practitioners from hospitals and research agencies.

The index is a part of the government's Swachh Bharat Mission. The index measures eight major pollutants, namely, particulate matter (PM 10 and PM 2.5), nitrogen dioxide, sulphur dioxide, ozone, carbon monoxide, ammonia and lead. Currently, only particulate matter, nitrogen dioxide and sulphur dioxide.

The index is based on real time monitoring, and the health risks are easily identified through a colour coded system. The risks will be signified through six levels – good, satisfactory, moderately polluted, poor, very poor, and severe. Air quality is qualified as good if the level of air pollution is at least 50% below the permissible limits set by the Pollution Control authorities.

The index will be extended to 46 cities having a population of more than one mn, and 20 state capitals over the next five years.

Purpose of the NAQI

The NAQI allows for easy dissemination of information pertaining to air quality and risks associated with it. The simplicity of the NAQI also makes it accessible to the common man. The use of the colour coded system makes it easier for people to comprehend instantly.

The index will also update the currently outdated system of monitoring air quality. 246 cities in India monitor their air quality in some form, however, only 16 cities have real time monitoring. Eventually, the index will be expanded to cover cities with a population of more than half a million. The real



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time information will help the authorities deal immediately and effectively to counter the impacts of the air pollution.

Legislation on water

Water in India is governed under three different Acts: the Environmental Protection Act (1986), the River Boards Act (1956) and the Inter-State Water Disputes Act (1956). Other Acts and Regulations affect water resources in different ways by addressing its importance for agriculture, biodiversity and conservation and drinking water. These three Acts, however, have the broadest scope in terms of how they affect all aspects of water management.

Water in Constitution of India

Water is a state subject via Entry 17 of State List, thus states are empowered to enact legislation on subject of water. But this entry is subject to the provisions of Entry 56 of Union List. The specific provisions in this regard are as under:

- Entry 56. Regulation and development of inter-State rivers and river valleys to the extent to which such regulation and development under the control of the Union is declared by Parliament by law to be expedient in the public interest.
- Entry 17. Water that is to say, water supplies, irrigation and canals, drainage and embankments, water storage and water power subject to the provisions of Entry 56 of List – I.

At the same time, the Articles 131 and 136 of the Constitution have been used by the States frequently for bringing the matters related to inter-State rivers before the Supreme Court via the *Special Leave Petitions*. Further, Article 143(1) of the Constitution has been used by the Central Government (via President) for seeking opinion of the Supreme Court on the matters related to inter-State rivers, under the advisory jurisdiction of the Supreme Court.

River Boards Act

The regulation and development of inter-state rivers and river valleys was to be entrusted to various River Boards when this Act was adopted in 1956. The River Boards were designed to advise the central government on development opportunities, coordinate activities and resolve disputes. Under their mandate, the Boards were required to provide advice to the government on various issues related to rivers. The Indian government has been unable to constitute a River Board since the Act was enacted, almost fifty years ago.

Inter-State Water Disputes (ISWD) Act, 1956

Interstate River Water Disputes Act, 1956 (IRWD Act) was enacted by the parliament of India under Article 262 of Constitution to resolve the water disputes that would arise in the use, control and distribution of an interstate river or river valley.



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Article 262 of the Constitution has made the following provisions:

- The power of legislation conferred upon Indian parliament for adjudication of any dispute or complaint with respect to the use, distribution or control of the waters of, or in, any inter-State river or river valley.
- By making a law, the parliament can also provide that neither the Supreme Court nor any other court shall exercise jurisdiction in respect of inter-state water disputes.

Thus, the constitution provides a role to the Central government in adjudicating conflicts surrounding inter-state rivers that arise among the states/regional governments. This Act further has undergone amendments subsequently and its most recent amendment took place in the year 2002.

Scope of the Act

IRWD Act is applicable **only to interstate rivers / river valleys**. If the action of one state affects the interests of one or more other states, then only water dispute is deemed to have arisen under IRWD Act. The action of the state can be of two types:

- Actions of a downstream state affecting the interest of an upstream state
- Actions of an upstream state affecting the interest of a downstream state

Here we note that the action of the downstream state's action can affect the upstream state only when the downstream state is bulding a dam or barrage near the boundary or a submerging territory of the upstream state. However, the actions of the upstream state can affect the downstream state in many ways, which includes:

- Consumption and storage of water by upstream state
- Onstruction in flow of non-flood water by upstream state
- Alternation in the quality of water due to anthropogenic activities by upstream state

These come under the purview of the legal causes of water dispute to the downstream states.

Creation of the Tribunal

When the riparian states are not able to reach amicable agreements on their own in sharing of an interstate river waters, section 4 of IRWD Act provides dispute resolution process in the form of Tribunal.

The tribunal such created as a **power of a Civil Court** but its **verdict is equivalent to Supreme Court verdict** when pronounced in the ambit of IRWD Act. When the tribunal final verdict issued based on the deliberations on the draft verdict is accepted by central government and notified in the official gazette, the verdict becomes law and binding on the states for implementation. But at the same time, you must note that the verdict of the tribunal can be challenged in Supreme court via civil suits.

The IRWD act was amended in 2002 for the following purposes

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- If there is any Tribunal award which predates 2002, it **can not be altered by new tribunals**
- If there is any tribunal award which post dates 2002, **can be altered by new tribunals.** The idea is to resolve fresh water disputes which were not addressed by earlier tribunals/agreements as and when they surface.

So far, the awards of four Inter-State Water Tribunals have been notified.

- Godavari Water Disputes Tribunal (April 1969)
- Krishna Water Disputes Tribunal (April 1969)
- Narmada Water Disputes Tribunal (October 1969)
- Cauvery Water Disputes Tribunal (June 1990)

Out of them, the first three tribunal awards were issued before the year 2002 which cannot be altered by the new tribunals. The tribunals formed on sharing water of Ravi & Beas rivers, Vamsadhara River, Mahadayi / Mandovi River and Krishna River-2 are either yet to pronounce the verdicts or the issued verdicts are to be accepted by the Government of India.

National Green Tribunal

National Green Tribunal is a statutory body established by a Government Notification using the powers of Section 3 of the *NGT Act 2010*. It has replaced National Environment Appellate Authority.

Objective

The objective of establishing a National Green Tribunal was as follows:

- To provide effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other natural resources including enforcement of any legal right relating to environment.
- Giving relief and compensation for damages to persons and property
- Other Related Matters.

Chairperson and Members of NGT

- It has a full time chairperson and following members:
- At least 10 and maximum 20 Full time Judicial members
- At least 10 and maximum 20 Full time Expert Members

Qualification for Chairperson

- The person should have been either a Judge of India's Supreme Court or Chief Justice of a High Court in India.

Qualification for Judicial member

- A Judge of Supreme Court of India, Chief Justice of High Court, Judge of a High Court

Qualification for Expert members

- Either a degree in Master of Science (in physical sciences or life sciences) with a Doctorate degree or Master of Engineering or Master of Technology

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- Or an experience of fifteen years in the relevant field and administrative experience of fifteen years in Central or a State Government or in a reputed National or State level institution.
- Post retirement jobs
- Once retired, the chairman or judicial members can not take up any job related to matters of this tribunal for at least 2 years.

Other Notes

- Appointment of members is done by Central Government.
- Chairperson of NGT is appointed by the Central Government in consultation with the Chief Justice of India.
- Judicial Members and Expert Members of the Tribunal are appointed on the recommendations of such Selection Committee.
- Chairperson, Judicial Member and Expert Member hold office for 5 years.
- Maximum age of the chairman 70 years if he has been a Supreme Court Judge and 67 years, if he has been a high court judge.
- Chairperson can be removed from his office via an order made by the Central Government after an inquiry made by a Judge of the Supreme Court in which such Chairperson or Judicial Member has been informed of the charges against him and given a reasonable opportunity of being heard in respect of those charges.

Jurisdiction

The National Green Tribunal has jurisdiction over all civil cases where a substantial question relating to environment (including enforcement of any legal right relating to environment), is involved and such question arises out of the implementation of the enactments specified in Schedule I of the National Green Tribunal Act 2010. The acts listed in Schedule 1 are:

- The Water (Prevention and Control of Pollution) Act, 1974;
- The Water (Prevention and Control of Pollution) Cess Act, 1977;
- The Forest (Conservation) Act,
- The Air (Prevention and Control of Pollution) Act, 1981;
- The Environment (Protection) Act, 1986;
- The Public Liability Insurance Act, 1991;
- The Biological Diversity Act, 2002.

It would deal with all environmental laws on air and water pollution, the Environment Protection Act, the Forest Conservation Act and the Biodiversity Act.

Coastal Regulation Zone Notification

Coastal Regulation Zone (CRZ) Notification, 2011 was notified in January, 2011 for the main land and also the Island Protection Zone (IPZ) Notification, 2011 for Lakshadweep, Andaman & Nicobar



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Islands. It replaced CRZ of 1991, which was amended for 25 times and needed an update.

Objectives

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

Limit of the CRZ Area

- CRZ area now includes the water area up to 12 nautical miles in the sea and the entire water area of a tidal water body such as creek, river, estuary, etc.

Does the above area impose any restriction on Fishing activities?

- No, it does not impose any restrictions of fishing activities.

What is CZMP?

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

What is the definition of the No development Zone?

- The “no development zone” definition has been changed. It is reduced from 200 metres from the high-tide line to 100 meters only. This has been done to meet increased demands of housing of fishing and other traditional coastal communities.

Importance of CRZ Notification

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

What is allowed and what is not allowed in Coastal Zones?

Mining of limestone and other similar minerals is prohibited in Coastal Regulation Zone (CRZ) area. The Coastal Regulation Zone (CRZ) Notification, 1991 and the recently issued CRZ Notification, 2011, prohibits the mining of sand, rocks and other substrata material including limestone except rare minerals like, monazite, rutile etc., and exploitation of oil and natural gas.

All activities which are permissible under these Notifications are required to obtain clearance under these Notifications. Mining of the sand, rocks and other substrata material is expected to cause damage to the Coastal environment including the Sea water intrusion.



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Eco-sensitive Zones

The Environment Protection Act, 1986 does not mention the word “Eco-sensitive Zones”.

The section 3(2)(v) of the Act, says that Central Government can restrict areas in which any industries, operations or processes or class of industries, operations or processes shall not be carried out or shall be carried out subject to certain safeguards

Besides the section 5 (1) of this act says that central government can prohibit or restrict the location of industries and carrying on certain operations or processes on the basis of considerations like the biological diversity of an area, maximum allowable limits of concentration of pollutants for an area, environmentally compatible land use, and proximity to protected areas.

The above two clauses have been effectively used by the government to declare Eco-Sensitive Zones or Ecologically Fragile Areas (EFA). The same criteria have been used by the government to declare No Development Zones.

The MoEF (Ministry of Environment & Forests) has approved a comprehensive set of guidelines laying down parameters and criteria for declaring ESAs. A committee constituted by MoEF put this together. The guidelines lay out the criteria based on which areas can be declared as ESAs. These include Species Based (Endemism, Rarity etc), Ecosystem Based (sacred groves, frontier forests etc) and Geomorphologic feature based (uninhabited islands, origins of rivers etc).

Other Topics Related to Pollution

Fly Ash

When coal is burnt (e.g. in coal fed power plants), two types of ash is produced. One that falls in the bottom of the boiler is called bottom ash. Another is made of fine particles that are driven out along with the flue gases. These fine particles are captured using the electrostatic precipitators or some other filtration equipments when the flue gases reach at Chimney of the plant. This is called Fly Ash and is made of Silica, Aluminium oxide, calcium oxide and some potentially toxic elements such as arsenic, beryllium, cadmium, barium, chromium, copper, lead, mercury, molybdenum, nickel, radium, selenium, thorium, uranium, vanadium, and zinc etc.

Uses of Fly Ash

Fly Ash was once discarded as a waste but today, it is increasingly emerging as a major input material in several industries including cement, agriculture, construction, Paints etc.

- Fly Ash is added as a mixture to cement for building construction, laying of roads and landfills.
- The bricks and blocks made of fly-ash are stronger and cheaper than conventional bricks
- Fly ash can help transform barren wasteland into lush green forests
- Pigments extracted from Fly Ash can be very useful in manufacturing of paints

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Fly Ash bricks

In construction industry, Fly ash is used in making of bricks and concrete. Fly Ash Bricks are well proven building material and can be used as an alternate to the ordinary burnt clay bricks with equivalent strength. The Government promotes the use of Fly Ash Bricks. BIS (Bureau of Indian Standards) has issued the code IS:12894-2002 for ash bricks.

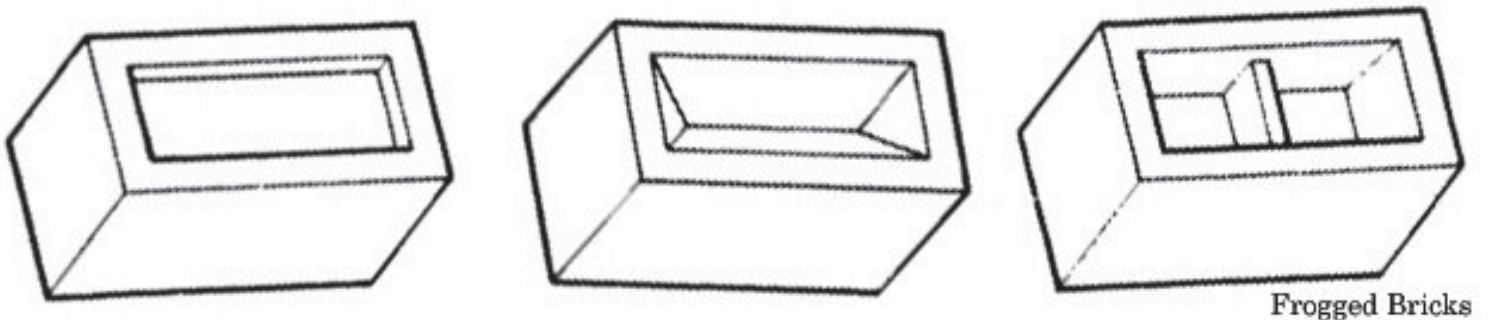
Further, an MOEF notification mandates that every construction agency engaged in the construction of buildings within a radius of 100 km. from a coal or lignite based thermal power plant shall use only fly ash based products for construction.

Construction of Fly Ash Bricks

The raw material to make Fly Ash bricks includes Fly Ash, Sand and Lime (or Cement). All of these are mixed with water in a pan mixer to produce a semi dry mix. It is then placed in moulds of a machine (a hydraulic or vibratory press) to produce bricks of uniform size. These bricks are air dried for one/two days in a shed and then water cured for 14-21 days.

Advantages of Fly Ash Bricks

Fly ash bricks are produced with/without frog. Frogged Bricks have depression in one face as shown below:



These bricks require less plaster thickness and save cement mortar. They are environment friendly because they are produced by by-product of thermal power stations. They save agriculture land used in brick kilns. In comparison to clay bricks, the Fly Ash bricks are less energy intensive. Further, they can be made at the construction site itself.

Fly Ash Concrete

In comparison to cement only, the Fly Ash improves the performance and quality when used in concrete. Fly ash as a part of the concrete saves water ; lowers heat of hydration; reduces the corrosion of steel and makes the concrete becomes strong quickly. This is because the fly ash reaches its maximum strength more slowly than concrete made with only Portland cement.

Environmental Impacts of Concrete

Surface concretization is one of the major environmental issues in urban areas around the world. Concretization is not always harmful but depends upon the circumstances. Since cement is major component of concrete; the it contributes a lot in the harmful environmental impacts caused by



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concrete. Such impacts include:

- Cement Industry is a major contributor for carbon dioxide, a major GHG. It leads to global warming and climate change.
- Concrete causes surface runoff of the water. This might result in soil erosion, water pollution and flooding.
- Concrete is a major contributor of Urban Heat Island because of the massive rise in temperatures since concretised surface gets heated up much faster and also loses heat at night at faster rate.
- Concretised surface emits / radiates harmful Ultraviolet-B rays, which are hazardous to human / animal health. Further, concrete has presence of many substances which might causes toxicity and health problems.
- Concrete can also lead to radioactive pollution because of presence of various natural radioactive elements (K, U and Th) in concrete dwellings. However, it depends on the type of raw material used for the creation of the concrete.
- Excessive concretised surface also causes 'visual pollution' as a concretised surface looks barren in contrast with the aesthetically beautiful green area.
- Concrete dust is a source of air pollution.

However, despite of various impacts listed above, planned use of concrete can help us to have many sustainable benefits. For example, concretization is used in creation of dams, diversion and deflection of flood water; so it is a valuable tool for flood control.

Indicator Species

Indicator species are those flora and fauna which define a particular trait or change in the environment. Such species are sensitive to environmental change and can act as early warning regarding adverse environmental changes in particular area.

Lichens as Indicator Species

Lichens are capable to indicate air pollution, water pollution, heavy metals as well as radioactive particles.

Algae as Indicator Species

Algae (seaweeds) are good indicators of heavy metal levels in marine environments and could be used for monitoring such pollutants in seas. According to a new study in the Gulf of Kutch, which receives discharges containing heavy metals from several industries, various species of brown, red and green algae accumulate heavy metals from seawater and sediments. Heavy metals enter various organisms and trigger tissue damage.

Birds as Indicator Species

Birds are considered to be excellent indicator species. There are three main reasons for this. *Firstly,*



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they live in every climate and biome; *Secondly*, they respond quickly to environmental change and *Thirdly*, they are relatively easy to track and count.

Other Notes

- Certain molluscs indicate water pollution, while some mosses indicate soil pollution.
- The Mussel Watch Programme is a global project to assess environmental impacts in coastal regions.

Photochemical Smog

Photochemical smog was first described in the 1950s. It is the chemical reaction of sunlight, nitrogen oxides and volatile organic compounds in the atmosphere, which leaves airborne particles and ground-level ozone. This noxious mixture of air pollutants can include the following:

- Aldehydes
- Nitrogen oxides, such as nitrogen dioxide
- Peroxyacyl nitrates
- Tropospheric ozone
- Volatile organic compounds

All of these harsh chemicals are usually highly reactive and oxidizing. Photochemical smog is therefore considered to be a problem of modern industrialization. It is present in all modern cities, but it is more common in cities with sunny, warm, dry climates and a large number of motor vehicles. Because it travels with the wind, it can affect sparsely populated areas as well.

Environmental Concerns of PET Bottles

Serious concerns and voices have been raised in recent times to ban the use of PET or Polyethylene terephthalate bottles.

Terephthalic acid- a major chemical precursor of PET increases the chances of breast cancer. PET leaches harmful chemical compounds like- di-ethylhexyl phthalate, endocrine disruptors, bisphenol A (BPA), antimony, acetaldehyde and other estrogenic compounds. BPA which acts as a faux-estrogen, interferes with various reproductive hormones in women- pre-term birth, low birth weight, congenital defects, pregnancy loss, impaired immune development, impairment of fertility and reproduction in both mother and child. Excessive and continued used of PET bottles can lead to leaching of endocrine disruptors which cause chromosomal abnormalities, birth defects and developmental disabilities in uterus like early onset of puberty in children. BPA can also cause hyperactivity disorders and aggressive behaviour in young girls. Another toxin DEHA di-(2-ethylhexyl)adipate is said to be leached and cause liver problems, cancer etc. in humans.

Biofuels

Biofuels are fuels which are in some way derived from biomass. The term covers solid biomass,



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liquid fuels and various biogases and also denotes Biodiesel, Bio alcohol and bio-gasoline.

Common Biofuel Crops

The most common Biofuel crops include Corn, Rapeseed/Canola, Sugarcane, Palm Oil, Jatropha, Soyabean, Cottonseed, Sunflower seeds, Wheat, Sugarbeet, Cassava, Algae, Coconut, Jojoba, Castor Beans etc.

Biodiesel

Biodiesel is vegetable oil- or animal fat-based diesel fuel consisting of long-chain alkyl esters. It is used as a blend to Petro Diesel and denoted by B factor. This means that 100% biodiesel is referred to as B100, while 20% biodiesel, 80% petro diesel is labelled B20. Similarly 5% biodiesel, 95% petro diesel is labelled B5.

Global biodiesel production was around 4 million tons in 2006 and around 85% of biodiesel production came from the European Union.

Jatropha Plant

- Belongs to family Euphorbiaceae, thus taxonomically related to Castor oil plant.
- Resistant to drought and pests, and produces seeds containing 27-40% oil.
- In India, Jatropha is known as Ratanjot shows resemblance with castor. Apart from Ratanjot, about nine species are reported out of which Jatropha Curcus has economic value by virtue of oil present in its seed.
- In 2006, the Indian Council of Agricultural Research identified first ever Jatropha variety, SDAUJ I (Chatrapati) with higher oil content and yield for commercial cultivation. The seeds contain 49.2 per cent oil and the non-edible protein in defatted seed case is 47.8 per cent.
- Farmers can get an average yield of 1000-1100 kg per hectare under rainfed conditions. The ICAR recommended it for the semi-arid and arid regions of Gujarat and Rajasthan. It is drought resistant and can be raised successfully in areas where annual rainfall is 300-500mm. The plant attains a height up to 8 feet and shows resistance to all major pests.

National Policy on Biofuels

National Policy on Biofuels was released in 2009. Its salient features are as follows:

- Bio-diesel production will be taken up from non-edible oil seeds in waste /degraded / marginal lands.
- Achieve 20% blending of bio-fuels, both for bio-diesel and bio-ethanol, by 2017.
- Announce Minimum Support Price (MSP) for non-edible oil seeds.
- Announce Minimum Purchase Price (MPP) for purchase of bio-ethanol and bio-diesel.
- Major thrust will be given to research, development and demonstration with focus on plantations, processing and production of bio-fuels, including Second Generation Bio-fuels.
- A National Biofuels Coordination Committee, headed by the Prime Minister, will be set up to

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provide policy guidance and coordination.

- A Biofuel Steering Committee, chaired by Cabinet Secretary, will be set up to oversee implementation of the Policy.

Cassava as source of Bioethanol

Cassava / Tapioca has been shown to have potential of being a feedstock for the production of *bio-ethanol as fuel*. This crop is cultivated in tropical and subtropical regions for its edible starchy, tuberous root, a major source of carbohydrates. It is the third-largest source of food carbohydrates in the tropics, after rice and maize. Cassava is a major staple food in the developing world, providing a basic diet for over half a billion people. It is one of the most drought-tolerant crops, capable of growing on marginal soils. *Nigeria is the world's largest producer of cassava.*

Cassava has a high energy content, low maintenance and ability to grow under a wide range of climatic conditions. All these qualities render it a potential for production of bio-ethanol. The technology for cassava alcohol, patented by the CTCRI in the 1980s, requires refinement for commercial scale production.

Biodiesel in Cold climates

Generally the biodiesel made from vegetable oil does not perform well in cold climates. This is because the vegetable oil is high in saturated fats and the ice crystals tend to form in the biodiesel. Further, the biodiesel obtained from certain crops such as *canola oil is low in saturated fat*, it is harder for ice to materialize in frigid temperatures, it is found to be showing excellent performance in cold climates too.

Green GDP

All uses of biodiversity are not incorporated in economic accounts and this leads humans to under-value biodiversity. Ecosystem services and resources such as mineral deposits, soil nutrients, and fossil fuels are capital assets but traditional national accounts do not include measures of the depletion of these resources. This means a country could cut its forests and deplete its fisheries, and this would show only as a positive gain in GDP (gross national product) without registering the corresponding decline in assets (wealth). This is where Green GDP comes into play. The green GDP is the measurement of GDP growth with the environmental consequences of that growth factored in.

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Green GDP Means

- 1 monetization of the loss of biodiversity
- 2 accounting for costs caused by climate change
- 3 subtracting resource depletion, environmental degradation from traditional GDP figures
- 4 helping to manage both economies as well as resources

Green GDP Does not mean

- 1 Monetary value of the Forests etc.
- 2 Growth of Green Investments.

The relationship between biodiversity and ecosystem function is clear but a major question in ecology is how much biodiversity is required to maintain ecosystem function.

Green Gross Domestic Product is the index of the Economic growth of a particular country which enshrines the environment consequences of the economic growth.

Kindly note the following observations:

- Green GDP means that it accounts the monetized loss of biodiversity, costs caused by climate change.
- Green GDP is conventional gross domestic product figures adjusted for the environmental costs of economic activities. It's a measure of how a country is prepared for sustainable economic development.

Biodigester Technology and Biotoilet

Biodigester Bio-toilets are an innovative technology, developed by the DRDE, Gwalior and Defence Research Laboratory (DRL), Tezpur under DRDO-Ministry of Defense, for disposal of human waste in eco-friendly manner. DRDO's bio-toilet is based on anaerobic biodegradation of organic waste by unique microbial consortium and works at a wide temperature range.

Features of Biotoilet

Technology used to decompose biological waste generated by soldiers deployed in high-altitude regions such as Siachen and Ladakh.

Low Cost

- Can function at any atmospheric temp between -55 to 60 degree C.
- Uses a bacterial consortium that degrades night soil at temp as low as -55 degree C and



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produces colorless, odorless and inflammable bio gas containing 50 – 70% methane.

- Disposes human waste in a 100 % eco-friendly manner and allows complete elimination of pathogens.
- Generates color less, odor less inflammable bio gas (can be used for cooking heating) and absolutely clear odor less water. Water is full of nutrients and minerals and is good for irrigation purpose of nearby gardens, lawns etc.
- Suitable for subzero temperature of Himalayan region, glaciers, railway coaches, Buses, highways, remote areas, sea ports, mining area, metro cities etc.
- 100% maintenance free, continuous biological process and economically viable.
- No dependence on the limited and costly conventional energy sources.
- Inoculums charging is only once during the entire life of bio-toilet.
- No need of connectivity to the sewage line, septic tank. No disposal of sludge is required.
- Routine cleaning chemicals like phenyl, soap, kerosene etc. do not harm bio-toilet or the inoculums.

The process involves the bacteria, which feed upon the faecal matter inside the tank, through anaerobic process which finally degrades the matter and releases methane gas that can be used for cooking, along with the treated water.

Bharat Stage Emission Standards

In the backdrop of rising industrial and vehicle pollution, air quality become an issue of social concern worldwide. Vehicular exhaust is one of the important sources of air pollution and there is an urgent need to check the extent of vehicular pollution in India.

History of vehicular emission control in India

In India, the vehicular emissions norms were first introduced in 1991. Fuel specifications based on environmental consideration were notified for the first time in 1996. They were incorporated in BIS 2000 standards. In 1999, the Supreme Court of India ordered that all the vehicles in India should have BIS 2000 or Euro I norms by June 1999. Based on the court order, the government had notified Bharat Stage I (BIS 2000) and Bharat Stage II vehicle emission norms which are equivalent to Euro I and Euro II respectively for introduction in rest of the India and NCR and other Metros respectively. Then, in 2002, the *Mashelkar committee* came up with a roadmap so that the emission can be phased in in India.

In 2003, the National Auto Fuel Policy was announced, a roadmap was created. In line with the National Auto Fuel Policy (2003) the BS III and BS II norms came into existence from April 2005 for 13 major cities and in the rest of the country respectively. Similarly, BS IV and BS III norms came into effect from April 2010 in 13 major cities and in the rest of the country respectively. In 2012,

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the government had constituted an *Expert Committee under Saumitra Chaudhuri* to draft Auto Fuel Vision and Policy, 2025 to bring country's fuel quality at par with global norms. The Committee submitted its report in May, 2014 and it has made various recommendations including a Roadmap for phased introduction of BS-IV and BS-V Auto Fuels in the entire country. Currently, BS-IV petrol and diesel are being supplied in whole of Northern India and the rest of the country has BS-III grade fuel. The rest of the country is scheduled to get supplies of BS-IV from April, 2017.

Recently, in January 2016, the government announced to skip the BS-V norms and directly move from the existing BS-IV to BS-VI by April 2020. As per the original timeline in the Auto Fuel Policy, BS-IV is to be adopted across the country by 2017, BS V by 2020 and BS-VI by 2024.

The Bharat Stage Standards

The evolution of the various stages is coterminous with decreasing amount of pollution a vehicle can cause. For example, the Euro 1 or BS I emits more amount of toxic gases than Euro 2 or BS II. In terms of stringency or emission limits, the Bharat Stage and Euro norms are equivalent. However, India uses Euro standards with only one modification — lower maximum speed of 90 km/h instead of 120 km/h as mandated in the EU norms. This is the maximum speed at which the vehicle is tested. The conditions of the road and general climate of India must have been taken into account while fixing this.

The harmful emissions that are identified for regulations in different Bharat Stages (BS) are carbon monoxide (CO), unburnt hydrocarbons (HC), Nitrogen Oxides (NO_x) and Particulate matter (PM). CO emissions are more prevalent in petrol engines. Continuous exposure to them can prevent oxygen transfer and increases nausea/headaches. HC emissions are also more prevalent in petrol engines. Short term exposure to them can cause headaches, vomiting and disorientation. NO_x emissions are more evident in diesel engines. Long Term exposure can cause Nose and eye irritation and damage lung tissue. PM is more prevalent in diesel engines and long term exposure to it can harm the respiratory tract and reduce lung function.

Another difference between each standard is the sulphur content. For example, BS-IV fuels contain far less sulphur than BS-III fuel. Sulphur in fuel makes it dirtier and lowers the efficiency of catalytic converters, which control emissions.

The following tables show the emission norms for different vehicles:

Emission norms for passenger cars (Petrol)

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Norms	CO(g/ km)	(HC+ NOx)(g/ km)
1991 Norms	14.3-27.1	2.0(Only HC)
1996 Norms	8.68-12.40	3.00-4.36
1998 Norms	4.34-6.20	1.50-2.18
Bharat stage-I	2.72	0.97
Bharat stage-II	2.2	0.5
Bharat Stage-III	2.3	0.35(combined)
Bharat Stage-IV	1.0	0.18(combined)

Emission norms for Heavy diesel vehicles:

Norms	CO (g/kwhr)	HC (g/kwhr)	NOx (g/kwhr)	PM (g/kwhr)
1991 Norms	14	3.5	18	-
1996 Norms	11.2	2.4	14.4	-
Bharat stage-I	4.5	1.1	8.0	0.36
Bharat stage-II	4.0	1.1	7.0	0.15
Bharat Stage-III	2.1	1.6	5.0	0.10
Bharat Stage-IV	1.5	0.96	3.5	0.02

Emission Norms for 2/3 Wheelers (Petrol)

Norms	CO (g/ km)	HC+NOx (g/ km)
1991 norms	12-30	8-12 (only HC)
1996 norms	4.5	3.6
Bharat stage-I	2.0	2.0
Bharat stage-II	1.6	1.5
Bharat Stage-III	1.0	1.0

As we can see from the tables, the content of harmful emissions reduces while moving to the next standard. The BS-VI norms not yet defined.

Issues in implementation of BS-VI by 2020

The two major industries that face problem in implementation of BS-VI norms are:

1. Oil refineries needs huge investment to upgrade the fuel.
2. Automobile manufacturers who have to manufacture emission norms compliant vehicles.

Though the Oil Ministry has assured the supply of BS-VI fuel by 2020, to meet this, two-thirds of India's state-owned refineries will need upgradation and it will cost them Rs. 60,000 crores.

Though there is no difference between BS-V and BS-VI norms, the engines have to be compliant to

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use the fuel. In BS-V, the vehicles have to be fitted with a diesel particulate filter and it needs to be optimised for road conditions in India. In BS-VI, selective catalytic reduction technology has to be optimised. And in each stage, the technology needs to be validated over 6-7 lakh km. Because of these complexities, the automobile firms said we can optimise the technologies in series but not simultaneously. They are resisting the direct move to BS-VI stage.

The nation-wide availability of BS-VI fuel will also be an issue. Without the uniform fuel availability, vehicles travelling across various states will face the difficulty.

Implications of BS-VI standard on environment

BS-IV fuels contain 50 parts per million (ppm) sulphur, while BS-V and BS-VI grade fuel will have 10 ppm sulphur. According to the Centre for Science and Environment, the move to Bharat Stage-VI will bring down Nitrogen Oxide emissions from diesel cars by 68 per cent and 25 per cent from petrol engine cars. Cancer causing particulate matter emissions from diesel engine cars will also come down by a phenomenal 80 per cent.

General Knowledge Today



Environment-6: Climate Change

Target 2016: Integrated IAS General Studies

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Model Questions

Prelims MCQ Topics

Climate Forcing, Radiation Balance of Earth, Carbon Cycle and Global Carbon Budget, Ocean Acidification, Carbon Footprint, Carbon sequestration, Blue Carbon, El-Nino and La Nina, Indian Ocean Dipole, Walker circulation, Madden-Julian Oscillation, Pacific Decadal Oscillation, United Nations Framework Convention on Climate Change, Kyoto Protocol and Paris Agreement.



Climate Change Concepts

Difference between Climate and Weather

Climate is often defined as 'average weather'. Climate is usually described in terms of the mean and variability of temperature, precipitation and wind over a period of time, ranging from months to millions of years (the classical period is 30 years).

Climate is defined as average weather, and as such, climate change and weather are intertwined. Observations can show that there have been changes in weather, and it is the statistics of changes in weather over time that identifies climate change.

- While weather and climate are closely related, there are important differences. A common confusion between weather and climate arises when scientists are asked how they can predict climate 50 years from now when they cannot predict the weather a few weeks from now.
- The chaotic nature of weather makes it unpredictable beyond a few days. Projecting changes in climate (i.e., long-term average weather) due to changes in atmospheric composition or other factors is a very different and much more manageable issue.

As an analogy, while it is impossible to predict the age at which any particular man will die, we can say with high confidence that the average age of death for men in industrialized countries is about 75. Another common confusion of these issues is thinking that a cold winter or a cooling spot on the globe is evidence against global warming.

Climate Forcing

Earth's climate system includes Oceans, Land surface, Cryosphere (polar ice), Biosphere and Atmosphere. This system evolves in time as per influences of its own internal dynamics. However, external factors also may affect the climate. Any external force / factor that can become a cause of climate change is called Climate Forcing. Such forcing originates from outside the climate system itself. The key examples of Climate Forcing are Albedo (surface reflectivity), Human induced changes in Green House Gases, Atmospheric aerosols due to human activity or volcanic eruption etc. The peculiar feature of all climate forcing is that they influence the balance of the energy entering and leaving the Earth system.

Radiation Balance of Earth

Earth's radiation balance is the equation of the incoming and outgoing thermal radiation. The Radiation Balance is shown by the following equation:

$$R_b = G - R - AE$$

In the above equation, G is the total incoming solar radiation, while R is the reflected portion of the incoming radiation which is generally known as Albedo. AE is known as Effective Radiation.



Effective Radiation

The radiation which is incoming is generally shortwave, while the surface and atmosphere of earth radiate back the short waves as well as long waves in the infrared spectrum (long wave radiation). This implies that part of the solar radiation is reflected back while part of it is absorbed by earth's surface which reflects infrared radiation in turn. Out of the total long wave reflected by earth, part is trapped as Green House Effect. Thus,

$AE = AO - AG$, where

AO = Radiation of the Earth's surface

AG = Radiation trapped as Green House Effect.

Factors influencing the radiation balance

Internal factors include all mechanisms affecting atmospheric composition (volcanism, biological activity, land use change, human activities etc.).

The main external factor is solar radiation. The sun's average luminosity changes little over time.

External and internal factors are also closely interconnected. Increased solar radiation for example results in higher average temperatures and higher water vapour content of the atmosphere. Water vapour, a heat trapping gas absorbing infrared radiation emitted by the Earth's surface, can lead to either higher temperatures through radiation forces or lower temperatures as a result of increased cloud formation and hence increased albedo.

Thus, the radiation balance of the Earth can change by

- By change in the incoming solar radiation (e.g., by changes in earth's orbit or in the sun itself)
- By change in the fraction of solar radiation that is reflected (called albedo'; e.g., by changes in cloud cover, atmospheric particles or vegetation)
- By alternation in the long wave radiation from earth back towards space (e.g., by changing greenhouse gas concentrations).

Implications of Radiation Balance

The Climate responds directly to changes in the Radiation Balance, as well as indirectly, through a variety of feedback mechanisms.

Climate Feedback mechanisms

There are many feedback mechanisms in the climate system that can either amplify ('positive feedback') or diminish ('negative feedback') the effects of a change in climate forcing.

For example, as rising concentrations of greenhouse gases warm Earth's climate, snow and ice begin to melt. This melting reveals darker land and water surfaces that were beneath the snow and ice, and these darker surfaces absorb more of the Sun's heat, causing more warming, which causes more melting, and so on, in a self reinforcing cycle.

Ice-albedo feedback

This feedback loop, known as the 'ice-albedo feedback', amplifies the initial warming caused by rising



levels of greenhouse gases. Detecting, understanding and accurately quantifying climate feedbacks have been the focus of a great deal of research by scientists unraveling the complexities of Earth's climate.

Polar amplification

Climate models generally predict amplified warming in polar regions due to climate feedbacks. This is called Polar amplification. This can be understood by the fact that due to the climate changes, the Arctic has warmed much leading to Arctic Shrinkage. Most simple climate models predict warming at both poles but please note that the Antarctic has not warmed as much as the Arctic.

- Polar amplification has led to the Arctic shrinkage.

Arctic Shrinkage refers to the decrease in size of the Arctic region and is agreed to be a result of global warming. As per the projections, Arctic may be free of the summer ice at anytime between 2060 and 2080. This is the reason that Arctic is often seen as a high-sensitivity indicator of climate change.

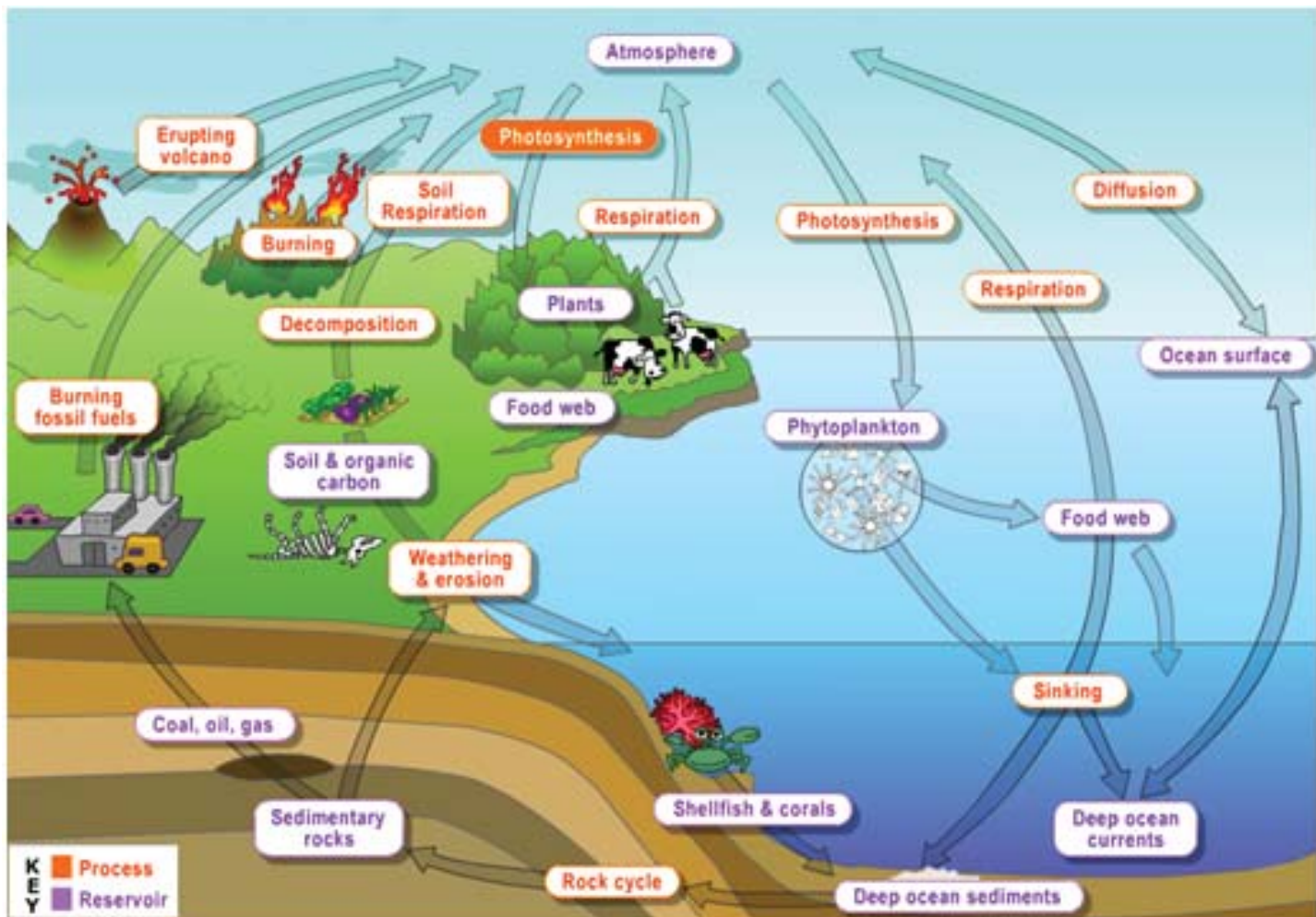
Topics Related to Carbon

Carbon Cycle and Global Carbon Budget

The Carbon Cycle is of two types viz. Organic and Inorganic Carbon cycle. The Carbon Cycle is the interchange of CO₂ in the following:

- Atmosphere
- Terrestrial biosphere, including fresh water systems and soil carbon.
- The oceans, including dissolved inorganic carbon and living and non-living marine biota,
- The sediments including fossil fuels.

The Earth's interior, carbon from the Earth's mantle and crust is released to the atmosphere and hydrosphere by volcanoes and geothermal systems.



Global Carbon Budget refers to the balance of the exchanges of carbon between the carbon reservoirs as shown in above graphics. This may refer to one specific pathway such as atmosphere to biosphere or vice versa or many pathways.

Ocean Acidification

Ocean acidification refers to the ongoing consistent decrease in the pH of the Ocean water. When CO_2 dissolved in the Ocean water, it creates Carbonic Acid (H_2CO_3) and increases the Hydrogen Ion (H^+) concentration in the ocean.

- The Ocean acidification has fastened only after the Industrialization.
- Pre-Industrialization pH of the ocean water was 8.179.
- In the 20th century, it came down to 8.1074, which corresponds to an increase of H^+ ions by 19%.
- **At present the pH of the Ocean water is 8.069** and this corresponds to an increase of 28.8% in the H^+ Ions since Industrialization of the 18th century.

Impacts of Oceanic Acidification

- The absorption of the CO_2 by the world's Oceans helps in mitigating the climatic effects of Carbon Dioxide emissions. But the decrease in the pH will give negative impact to the oceanic organisms such as the Calcifying animals.



- The result will be seen in the Ocean ecosystem and food chains.
- The organisms such as corals, echinoderms, crustaceans and mollusks will be severely affected. This is because the falling pH makes the oceans under saturated with the CaCO_3 , and the result is that rate of dissolution of calcareous material would increase.

The decreased pH may also lead to the **hypercapnia** in the ocean biota. **Hypercapnia** refers to the CO_2 induced acidification of body fluids, which may lead to adverse effects.

Carbon Footprint

Carbon Footprint refers to the GHG emission by an entity, event, product or person. It is expressed in terms of the amount of carbon dioxide, or its equivalent of other GHGs, emitted. Most common used unit is CO_2 equivalent. The carbon footprint seen as a subset of the ecological footprint.

- When we compare various forms of energy generation: Nuclear, Hydro, Coal, Gas, Solar Cell, Peat and Wind generation technology, we find that **Coal has the largest Carbon footprint among others**. Coal is followed by Oil, Natural Gas and Geothermal Energy. The hydroelectric, wind, and nuclear power always produce the least CO_2 per kilowatt-hour of any other electricity sources. That too in construction only and not in operation.

The Kyoto Protocol recognizes 6 GHGs and Carbon footprint considers all six of the Kyoto Protocol greenhouse gases viz. Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulphur hexafluoride (SF_6)

Measurement of Carbon Foot Print

A carbon footprint is measured in **tons of carbon dioxide equivalent (tCO_2e)**. The carbon dioxide equivalent (CO_2e) allows the different greenhouse gases to be compared on a like-for-like basis relative to one unit of CO_2 . CO_2e is calculated by multiplying the emissions of each of the six greenhouse gases by its 100 year global warming potential (GWP).

Types of Carbon foot Print

Two types of carbon foot printing. The main types of carbon footprint are:

Organizational

Emissions from all the activities across the organisation, including buildings' energy use, industrial processes and company vehicles.

Product

Emissions over the whole life of a product or service, from the extraction of raw materials and manufacturing right through to its use and final reuse, recycling or disposal.

What are the activities that can help our Carbon footprint?

Examples of the activities that reduce our carbon footprint are as follows:

- Replacing a regular light bulb with a compact fluorescent lamp (CFL)
- Walk instead of using bikes, Use Bicycles, carpool, or mass transit



- Use of recycled products
- Using properly inflated tyres (for better mileage)
- Using cold water instead of hotwater (save energy bills)
- Avoiding the products with lots of packaging
- Planting trees

Carbon Offsetting

Mitigation of carbon footprints through the development of alternative projects is known as Carbon offsetting. The alternative projects may be the solar, wind, Tidal energy or reforestation.

Carbon sequestration

Carbon sequestration refers to the *process of removing carbon from the atmosphere and depositing it in a reservoir*. In simple language, Carbon Sequestration encompasses all forms of carbon storage such as oceans, plants, soil and underground geologic formations. On this basis, Carbon sequestration is of three types as follows:

Terrestrial Carbon Sequestration

- Indirect sequestration whereby ecosystems (e.g., forests, agricultural lands, and wetlands) are maintained, enhanced or manipulated to increase their ability to store carbon.

Geologic Carbon Sequestration

- CO₂ can be stored, including oil reservoirs, gas reservoirs, unminable coal seams, saline formations and shale formations with high organic content.
- These formations have provided natural storage for crude oil, natural gas, brine and CO₂ over millions of years. Geologic sequestration techniques would take advantage of these natural storage capacities.

Ocean Carbon Sequestration

- Oceans absorb, release and store large amounts of CO₂ from the atmosphere.
- There are two approaches for oceanic carbon sequestration which take advantage of the oceans' natural processes. One approach is to enhance the productivity of ocean biological systems (e.g., algae) through fertilization. Another approach is to inject CO₂ into the deep ocean.

Soil Carbon and Carbon sequestration

Soil carbon refers to the carbon held within the soil, mainly as organic content. Soil carbon is the largest terrestrial pool of carbon (around 2,200 Gigatonnes). Soil carbon plays a key role in the carbon cycle and thus is important in global climate models. It has been shown that 1kg of carbon released from the soil constitutes 3.64kg of Co₂ in the atmosphere.

The exchange of carbon between soils and the atmosphere is a significant part of the world carbon cycle, which is extensive both spatially and temporally. Carbon, as it relates to the organic matter of



soils, is a major component of soil and catchment health.

With reference to Carbon sequestration, the soil is one of the largest reservoirs, where carbon could be restored.

What are the Farming Practices that help in Carbon sequestration?

- Mulching → because it helps to retain moisture and organic matter
- Zero Tillage → Does not help directly in carbon sequestration but helps in stopping release of soil Carbon
- Crop Rotation → Helps by increasing soil organic content, so foster Carbon sequestration
- Strip Cropping and Contour Bunding → Increase carbon inputs so help in carbon sequestration
- Switching from Field to Tree crops → Helps to retain carbon and nutrients in soil
- Rotational Grazing and Pasture Management
- Intercropping

Can Organic Farming help in Carbon Sequestration?

Organic Farming is supportive for Carbon Sequestration. One example is Organic Mulch. Organic mulch is basically a type of compost made from decaying plants or trees. It can be one of the ways of sequestering carbon. Organic mulching refers to covering the soil with any organic matter such as applying compost or farm yard manure over the soil surface followed by adding a layer of dry organic matter over it.

Here, the compost contains an array of beneficial microbes, where the dry matter is rich in carbon and the green matter is rich in nitrogenous substances. When decomposition of these components takes place the carbon nitrogen ratio in the soil becomes 10:1, ideal for the proliferation of microbes.

How dumping of Iron can Induce Carbon Sequestration?

Dumping of Iron to the upper ocean can significantly induce the Carbon sequestration in Oceans. This is because introduction of iron to the upper ocean will stimulate phytoplankton bloom. This is due to a phenomena called "Iron fertilization", whereby introduction of iron to the upper ocean to stimulate a phytoplankton bloom is adopted. Like all plants, phytoplankton takes up CO₂ from air and converts it to carbon compounds like carbohydrates. The plant quickly dies and starts sinking, taking the carbon with it. What happens thereafter is the key to the technique's efficacy: If it sinks well below the ocean surface, the carbon would effectively have been put away for a long period (Carbon sequestration). This has led to several experiments in recent times.

Blue Carbon

The 2014 study financed by central government has found that the Sundarbans Mangrove Forests are fast losing their capacity to absorb the CO₂ from the atmosphere due to an array of reasons including salinity of water, rampant deforestation and pollution. The report says that Sundarbans



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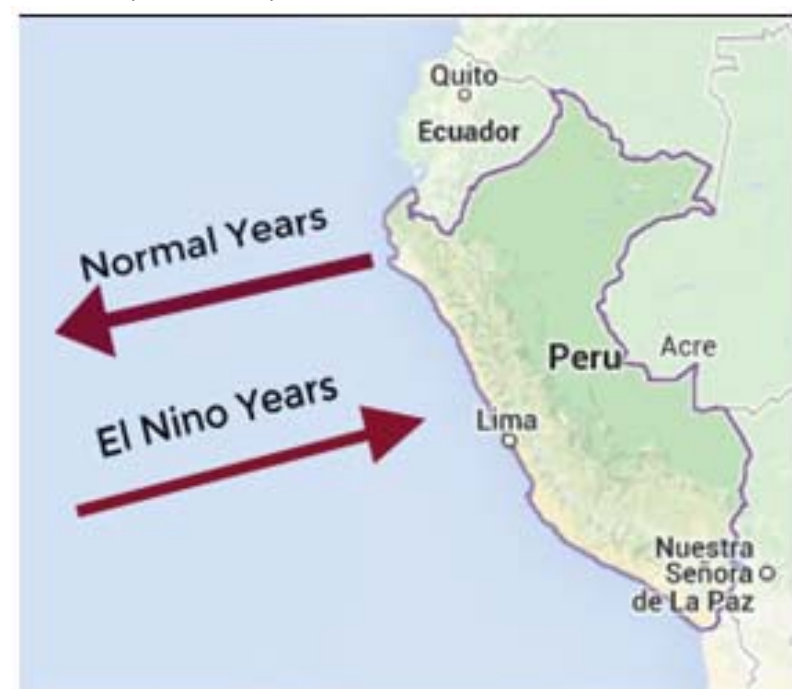
flora and fauna is losing its capability to store the so called **Blue Carbon**“ Blue carbon refers to the carbon captured by living organisms in oceans and stored in the form of biomass and sediments from mangroves, salt marshes and seagrasses.

El-Nino and La Nina

A recurring characteristic of the climate is called Climatic Pattern. The gap between two recurrences may be from one year to as long as tens of thousands of years. Some of the events are in regular cycle, while some are not. When they recur in the form of regular cycles of fluctuations in climate parameters, they are called **climate oscillations**. The term **oscillation** is used because such fluctuations are *not perfectly periodic*. For example, we say that El Nino returns every four and half years. But actually it may or may not return. Or it may return too early or too late. So, El Nino is quasi periodic.

El Niño

El Niño was originally recognized by fisherman off the coast of **Peru** in South America. The ocean off the coast of Peru is one of the world's richest fisheries regions. In most years trade winds flow from the southeast push warm surface water **away** from the coast. In its place, the cold water comes up on the surface *due to upwelling*. This cold water is full of nutrients and provides nourishments to planktons. These planktons serve as food for fishes. Fishes in turn provide food to the sea birds. Due to all this, not only there is a good catch of fishes but also good collection of the **Guano**, the bird excreta, used as a valuable fertilizer. This is what that made Peru number one fishing nation in the world by the early 1970s.



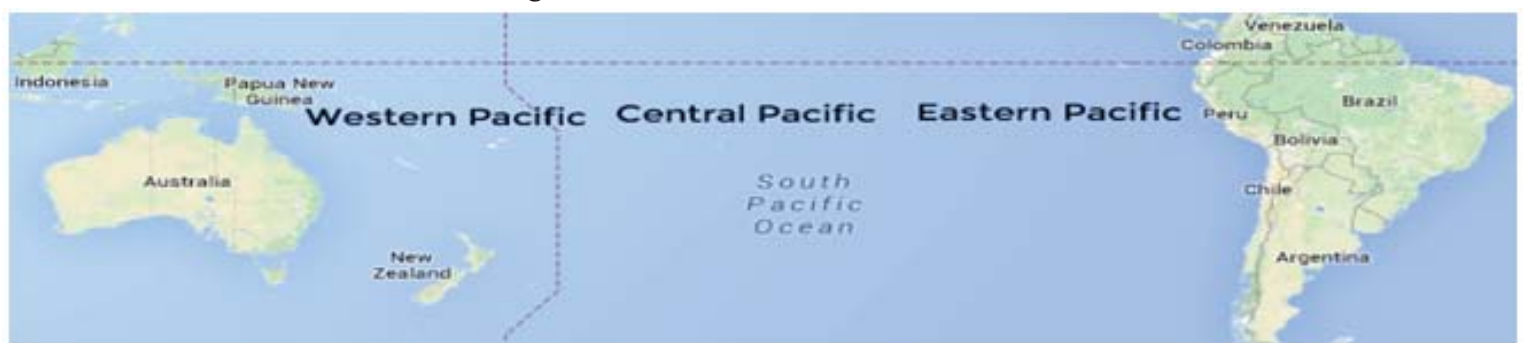
Pattern of flow of warm winds off the coast of Peru

However, every few years, there is a change in the pattern of air circulation. It changes in such a way



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that the trade winds reverse direction, blowing from west to east. Due to this reversal, the upwelling of the cold water gets weakened. The surface water is warm. This lowers the nutrients available to fish and thus poses problems to the economics of fisheries. The problems don't end here. The accumulation of large mass of warm water allows formation of more and more clouds and this would bring destructive rains that occur in normally dry areas of Peru and Chile. The same is also responsible for bring outbreaks of Malaria and Cholera in some parts of South America. Peru, as you may know is a **Hispanophone** country as many people speak Spanish out there. The above mentioned reversal of the winds occurred during Christmas times (Please note that we have Christmas in winter, but Peruvians have in summer, because they are in southern hemisphere), so they named it El Niño or "Christ Child" or "The Little Boy" in their own language. Before, you read further, please understand the location of Eastern, Central and Western Pacific on the map, otherwise it would be too confusing (earth is round...after all)



Now, here is how it affects the entire tropical region.

- Off the coast of Peru (read in Eastern Pacific and Central Pacific), there is normally cool surface water. But El Niño makes it go warm. When the water becomes warm, the trade winds, which otherwise flow from East to west, either reverse their direction or get lost. The warm water causes lots of clouds getting formed in that area, causing heavy rains in Peruvian desert during El Niño years.
- Due to this warm water, the air gets up and surface air pressure above Eastern Pacific gets down. On the other hand, the waters cool off in western Pacific and off Asia. This leads to rise in surface pressure over the Indian Ocean, Indonesia, and Australia
- So, while there is raining (read flooding) in Eastern Pacific; the drought sets in over Asia as high pressure builds over the cooler ocean waters.
- The net result is:
 - Normal or high rainfall in eastern / central Pacific.
 - Drought or scant rainfall in western Pacific / Asia.

Although El Niño originally referred to local conditions off the coast of Peru and Ecuador, the use of the term has been broadened by many scientists to represent all surface temperature warming in the



eastern and central Pacific. The impacts of El Niño, which have been well documented include the following:

- Heavy rains in Ecuador and Peru.
- Heavy rains in southern Brazil but drought in north East Brazil
- Drought in Zimbabwe, Mozambique, South Africa, Ethiopia
- Warm winter in the northern half of the United States and southern Canada
- Drought, Scant rains off Asia including India, Indonesia, and Philippines etc.
- Coral bleaching worldwide
- Drought in eastern Australia

La Niña

La Niña, which means “The Little Girl” or “El Viejo” or “anti-El Niño” or simply “a cold event” or “a cold episode is the cooling of water in the Eastern Pacific Ocean. Here is what happens in La Niña.

- The water in Eastern Pacific, which is otherwise cool; gets colder than normal. There is no reversal of the trade winds but it causes strong high pressure over the eastern equatorial Pacific.
- On the other hand, low pressure is caused over Western Pacific and Off Asia.
- This has so far caused the following major effects:
 - Drought in Ecuador and Peru. Low temperature, High Pressure in Eastern Pacific
 - Heavy floods in Australia; High Temperature in Western Pacific, Indian Ocean, Off coast Somalia and good rains in India.
 - Drought in East Africa (Somalia Drought of 2011 was linked to it)

ENSO

Both **El Niño** and **La Niña** are part of a larger cycle called ENSO, or **El Niño–Southern Oscillation**. The El Niño (warm event) and La Niña (Cold event) both have now established themselves as the integral part of the global climate system. It is a recurrent phenomenon with an average return period of $4^{1/2}$ years, but can recur as little as 2 or as much as 10 years apart. Such events have occurred for millennia, and can be expected to continue to occur in the future.

Impact of El Niño and La Niña on Indian Weather

- El Niño and La Niña are among the most powerful phenomenon on the Earth. These are known to alter climate across more than half the planet and dramatically impact weather patterns.
- Over Indian subcontinent, El Niño during winter results in development of warm conditions. During summer, it leads to dry conditions and deficient monsoon. It also leads to drought in Australia. On the other hand, La Niña results in better than normal monsoon in India. At the same time, in Australia it has caused floods.



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- In the recent past, India experienced deficient rainfall during El Nino years 2002 and 2009 whereas monsoon was normal during El Nino years 1994 and 1997. *This so far implies that in about 50 per cent of the years with El Nino during summer, India experienced droughts during monsoon.*
- This implies that El Nino is not the only factor that affects monsoon in India There are other factors that affect India's rainfall pattern. These include North Atlantic SST, Equatorial SE Indian Ocean SST, East Asia Mean Sea Level Pressure, North Atlantic Mean Sea Level Pressure and North Central Pacific wind at 1.5 km above sea level.

Difference between El Nino and La Nina

Feature	El-Nino	La-Nina
Meaning	El Nino is a Spanish term which represents "little boy"	La Nina is a Spanish term which represents 'little girl'.
Temperature at Sea Surface	Temperature at sea surface is warmer than normal sea-surface temperatures. El Nino is a warming of the Pacific Ocean between South America and the Date Line, centred directly on the Equator, and typically extending several degrees of latitude to either side of the equator.	Temperature at sea surface is cooler than normal sea-surface temperatures. La Nina exists when cooler than usual ocean temperatures occur on the equator between South America and the Date Line.
Pressure	It accompanies high air surface pressure in the western Pacific	accompanies low air surface pressure in the eastern Pacific
Trade winds	El Niño occurs when tropical Pacific Ocean trade winds die out and ocean temperatures become unusually warm	La Nina, which occurs when the trade winds blow unusually hard and the sea temperature become colder than normal
Seasons	Winters are warmer and drier than average in the Northwest of pacific, and wetter in Southwest of pacific and experience reduced snowfalls.	Winters are wetter and cause above-average precipitation across the Northwest of pacific and drier and below average precipitation in South west of pacific.
Coriolis force	El Nino results in a decrease in the earth's rotation rate (very minimal) , an increase in the length of day, and therefore a decrease in the strength of the Coriolis force	La Nino results in increase in the earth's rotation rate, decrease in the length of day, and therefore a increase in the strength of the Coriolis force.



Feature	El-Nino	La-Nina
Ocean waters in Pacific	Warm water approaches the coasts of South America which results in reduced upwelling of nutrient-rich deep water impacting impacts on the fish populations.	Cold water causes increased upwelling of deep cold ocean waters numbers of drought occurrence, with more nutrient-filled eastern Pacific waters.
Cyclones	Comparatively less compared to La Niña as wind speed is low	La Nina had a greater tendency to trigger intense tropical cyclones as wind direction changes pilling up water between Indonesia and nearby areas as winds from Africa onwards gets blocked.

Do El Nino and La Nina explain most of the unusual climatic happenings?

It is undeniable that the El Nino has been used to explain unusual climatic changes across the globe. But, modern climatology taken into account various other phenomena also. However, El-Nino has far-reaching and varied effect on climate across the world. The major reason for these unusual climatic happenings is the shifting in tropical rainfall, which in turn affect the wind patterns across the world. When the El-Nino effect causes the rainy areas centered around Indonesia and the Pacific region to move eastward, the subsequent changes result in unseasonable weather in many regions of the world. The El Nino is typically characterized by warm ocean currents and heavy rains, however, it also plays havoc with the normal weather conditions in different areas of the world. Also, the increase in temperatures affects fishing adversely, disrupts local weather and indigenous marine life in the areas concerned, other than having an effect on climatic conditions worldwide. When the linkage between El Nino and climate effects were initially suggested by the British scientist, Gilbert Walker, it was deemed ridiculous that one phenomenon could have an effect on regions as far off as Australia, India etc and Canada. However, the occurrence of El Nino in the past few decades has proved without a doubt, their far-reaching consequences. Some of the effects of El Nino in the past have been causing of droughts and forest fires in South Asia (Indonesia and Philippines) and Australia, floods in the South American countries in the eastern Pacific region, increased rain in certain other areas of the world etc.

Indian Ocean Dipole

Indian Ocean Dipole (IOD) also known as Indian Nino is an irregular oscillation of sea-surface temperature, in which the Western Indian Ocean becomes alternately warmer and then colder than the eastern part of the ocean.

Positive IOD

During the Positive IOD, the eastern equatorial Indian Ocean off Sumatra in Indonesia becomes colder than normal while the western tropical part of the Indian Ocean near the African coast becomes



unusually warm. Such an event has been found to be beneficial for the monsoon.

Negative IOD

In this case the opposite of the above mentioned case occurs. The eastern equatorial Indian Ocean off Sumatra in Indonesia becomes abnormally warm while the western tropical part of the ocean near the African coast becomes relatively colder. This effect obstructs the progression of monsoon over India.

Interplay between IOD and El Nino on Indian Monsoon

Indian monsoon depends upon not only El Nino La Nina but also IOD and other such ocean phenomena. As mentioned above, an IOD can either aggravate or weaken the impact of El Nino on Indian monsoon. If there is a positive IOD, it can bring good rains to India despite of an El Nino year. For example, positive IOD had facilitated normal or excess rainfall over India in 1983, 1994 and 1997 despite an El Nino in those years. Similarly, during years such as 1992, a negative IOD and El Nino had cooperatively produced deficient rainfall.

The positive IOD in 2007 appeared together with La Niña which is a very rare phenomenon that has happened only once in the available historical data (in 1967).

Walker circulation

Walker circulation is a conceptual model of the air flow in the tropics. It is caused by the pressure gradient force that results from a high pressure system over the eastern Pacific Ocean, and a low pressure system over Indonesia, that is why also called Pacific Walker Circulation. When the Walker circulation weakens or reverses, an El Niño results, causing the ocean surface to be warmer than average, as upwelling of cold water occurs less or not at all. An especially strong Walker circulation causes a La Niña, resulting in cooler ocean temperatures due to increased upwelling.

Impact on India Monsoon

The researchers in the Potsdam Institute for Climate Impact Research and Potsdam University concluded that Walker circulation, on average, brings more high pressure over India and suppressing the monsoon, especially in spring when the monsoon begins to develop.

The recent studies find that the increasing temperatures and a change in strength of the Pacific Walker circulation in spring could cause more frequent and severe changes in monsoon rainfall.

Madden-Julian Oscillation

Madden-Julian Oscillation is a major fluctuation in tropical weather on weekly to monthly timescales of 30-60 days or 40-50 days. The MJO can be characterized as an eastward moving “pulse” of cloud and rainfall near the equator that typically recurs every 30 to 60 days and is a feature of the tropical atmosphere. MJO effects are most evident over the Indian Ocean and western equatorial Pacific. It influences the timing, development and strength of the major global monsoon patterns, including the Indian and Australian monsoons. In the tropics weather is not as predictable as in mid-latitudes.



In 1971 two scientists, Roland Madden and Paul Julian stumbled upon a 40-50 day oscillation when analysing zonal wind anomalies in the tropical Pacific. They used ten years of pressure records at Canton south of Pacific and upper level winds at Singapore. The oscillation of surface and upper-level winds was remarkably clear in Singapore which became known as the Madden and Julian Oscillation (MJO).

Pacific Decadal Oscillation

The “Pacific Decadal Oscillation” (PDO) is a long-lived El Niño-like pattern of Pacific climate variability.

Both PDO and ENSO have similar spatial climate fingerprints yet the major difference is that PDO persists for 20-30 years while the typical ENSO persists for 6 to 18 months.

The primary climatic fingerprints of the PDO are most visible in the North Pacific/North American sector, while secondary signatures exist in the tropics. On the contrary, the primary climatic fingerprints of the ENSO are visible in tropics while secondary are visible in North Pacific/North American sector.

The PDO has two cycles, viz. Cold Cycle and Warm Cycle, very much similar to La Nina and El Nino of the ENSO cycle.

Major changes in northeast Pacific marine ecosystems have been correlated with phase changes in the PDO; warm eras have seen enhanced coastal ocean biological productivity in Alaska and inhibited productivity off the west coast of the contiguous United States, while cold PDO eras have seen the opposite north-south pattern of marine ecosystem productivity.

Reasons

PDO is under studies. Causes for the PDO are not currently known. Potential predictability for this climate oscillation are also not known.

Influences

The PDO has a major influence on Alaskan and for those matter global temperatures. The positive phase favors more El Ninos and a stronger Aleutian low and warm water in the north Pacific off the Alaskan coast. The negative phase more La Ninas and cold eastern Gulf of Alaska waters. Note the strong similarity of the positive phase with El Nino and the negative with La Nina.

PDO is responsible for bringing colder surface water temperatures and thus beginning the overall cooling effect in recent times in Alaska. This oscillation has brought a weakening of the ‘Aleutian Low’, the breeding ground for storms that end up regulating weather systems in the rest of the 48 states. With a less active Aleutian Low, cold winter storms have been sticking around Alaska longer and keeping the temperatures chilly.



Climate Change Negotiations

Brief Historical Background

Earth Summit 1992 was the first major global summit on environment held June 1992 at Brazilian city of Rio de Janeiro. Outcome of this summit were five documents viz. Rio Declaration, Agenda 21, Convention on Biological Diversity (CBD), Forest Principles and UN Framework Convention on Climate Change (UNFCCC).

Rio Declaration

The Rio Declaration consisted of some 27 principles focusing on major topics related to human role in protection of the environment. The declaration was comprehensive and was hailed by some as *Third Generation Human Rights*.

Agenda-21

Agenda 21 was a voluntary action plan and a comprehensive blue print with 40 points for role to be played by local, national and global organizations in every area in which humans directly affect the environment. For implementation of these points, a *Commission on Sustainable Development* was established.

Forest Principles

The forest principles came as non-legally binding document that makes several recommendations for conservation and sustainable development forestry.

Convention on Biological Diversity

The CBD came out as a legally binding treaty with three clear objectives viz. Conservation of biological diversity (or biodiversity); Sustainable use of its components; and fair and equitable sharing of benefits arising from genetic resources. It was followed up by two protocols viz. Cartagena Protocol and Nagoya Protocol.

United Nations Framework Convention on Climate Change

UNFCCC was signed as a non-legally binding framework agreement *to stabilize greenhouse gas concentrations* in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Later, Kyoto Protocol was adopted as a legally binding protocol under UNFCCC. The Kyoto Protocol is to be replaced by newly agreed Paris Agreement.

UNFCCC

The United Nations Framework Convention on Climate Change (UNFCCC) was one of the five outcomes of the Rio Summit 1992. Its objective was *to stabilize greenhouse gas concentrations* in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

The convention itself was not a legally binding agreement and did not set any mandatory limits on green house gas emissions for individual countries. Neither it contained any enforcement



mechanism. But it set that its protocols would be legally binding enforcements. One such protocol was the Kyoto Protocol.

This convention has been ratified by 197 countries and sub-national entities which includes all United Nations members. Its secretariat is located in Bonn, Germany.

Conference of Parties

The parties to the convention meet annually since 1995 in Conferences of the Parties (COP) to assess progress in dealing with climate change. Till now 21 Conferences have been concluded. The Kyoto Protocol was concluded and established at COP-3 in 1997 as a legally binding obligation for developed countries to reduce their green house gas emissions.

Classification of Parties

To reduce the GHG emissions, the UNFCCC primarily targeted the industrialized countries. Accordingly, the UNFCCC divided the countries into three groups viz. Annex-I, Annex-II and Developing countries.

In Annex-I, 40 industrialized economies including US, UK, Australia, Germany, France, Japan, Russia, Canada and countries of European Union were kept.

The Annex-2 was created as a subgroup of 23 Annex-I countries which *could play financial role in the development of the developing countries and pay the cost of development*. These included Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States of America.

Rest of the countries were kept in developing category and did not require to reduce emission levels unless the developed countries supply enough funding and technology for their development.

Rationale for no emission targets for Developing countries

The rationale for not imposing reduction targets for developing countries was that it would hamper their development. Since emissions are strongly linked to industrial capacity emission cut requirements should be there for Industrialized nations. This is how the world was divided into two factions of developed and developing countries on climate change negotiations issue. The developed countries alleged that this convention created an unfair split because both the developing and developed countries need to reduce their emissions unilaterally.

Kyoto Protocol

Kyoto Protocol was adopted in 1997 and came into force in 2005. It is currently in force, however, its first commitment period had expired on 31 December 2012. It was signed and ratified by 192 countries including all UN member states except Canada, South Sudan, United States and Andorra. Out of 40 Annex-I Countries, 37 signed it but only 7 ratified it. Those who signed and ratified committed for reduction of six GHG gases viz. carbon dioxide, methane, nitrous oxide, sulphur



hexafluoride, hydrofluorocarbons and perfluorocarbons. The agreed target was to reduce emissions by 5.2% from the 1990 levels.

Position of US and Canada

The United States signed but did not ratify the Protocol and Canada withdrew from it in 2011. United States was responsible for 36.1% of the 1990 emission levels of Annex I countries. It was required to reduce its total emissions an average of 7% below 1990 levels. To reduce these emissions, they needed to almost halt their highly polluting industries. This was not possible and thus they rejected it outrightly calling it “economically irresponsible”. Almost same was the case with Canada.

Position of India, China, Brazil

India, China and Brazil are the most advanced developing countries. Since they did not fall in annex-I, they did not have any binding obligations to reduce or limit the CO₂ emissions.

Kyoto mechanisms

The Kyoto mechanisms are mechanisms which define how the developed countries would support the developing countries while reducing their emission targets. There are three kinds of mechanisms viz. Emission Trading, Joint Implementation and Clean Development Mechanism.

Emission Trading

The concept of emission trading (also called Cap & Trade) is simple – *the polluter pays while those who don't pollute get rewarded.*

In this, the governments launch schemes in which they set limit (called emission permit) on pollutants that can be emitted by the industries. The industries need to buy the emission permits to be eligible to emit specific volume of pollutants. The industries that pollute more need to spend more on such permits. Thus, it is a self regulatory system that results in pollution control by increasing cost of causing pollution. The emission permit represented the so called Carbon Credit or Kyoto Units. One Kyoto Unit referred to one tonne of Carbon dioxide or the mass of another greenhouse gas with a carbon dioxide equivalent to one tonne of carbon dioxide.

Joint Implementation

Article 6 of the Kyoto protocol provided that any Annex-I country can invest in emission reduction projects in any other Annex I country as an alternative to reducing emissions domestically. The idea is to lower the cost of complying with their Kyoto targets by investing in greenhouse gas reductions in an Annex I country where reductions are cheaper, and then applying the credit for those reductions towards their commitment goal.

Clean Development Mechanism

Under the Clean Development Mechanism, the annex-I countries can implement an emission-reduction project in developing countries and thereby earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO₂, which can be counted towards meeting Kyoto targets. This has been by far the most popular Kyoto Mechanism. It helps the Non-Annex parties in



achieving sustainable development and Annex parties to achieve compliance with their quantified emission limitation and reduction commitments.

Extension of Kyoto Protocol Beyond 2012

First commitment period of Kyoto Protocol lasted from 2008-2012. Second commitment (2013-2020) period was agreed in 2012 as Doha Amendment to the Kyoto protocol. However, many annex-I parties started saying that they would withdraw from the Kyoto Protocol because of the forced target commitments. Since 2007, extension of Kyoto Protocol has been an issue in all UNFCCC annual conferences. In 2015, the Paris Agreement has been signed as a separate instrument under the UNFCCC rather than an amendment / update of the Kyoto Protocol. As of now, the Paris Agreement is not in force.

Paris Agreement on Climate Change

On 12 December 2015, the Paris Agreement was adopted as an agreement within the UNFCCC framework. As of January 2016, this agreement is not in force. It is to replace the Kyoto Protocol after its second commitment period ends on 31 January 2020.

Objectives of Paris Agreement

The Paris Agreement sets an over-arching target of keeping the emissions in control so that either the rise in global temperature remains below 2°C by the turn of 21st century or as low as 1.5°C. To achieve this goal, the countries will need to peak their emissions and then bring them down. The other purposes of Paris Agreement are as follows:

- Increasing ability to adapt to the adverse impacts of the climate change and foster climate change resilience
- Making finance flows consistent with the pathway towards low greenhouse gas emissions and climate-resilient development.

Emission Reduction Action

Under the Paris Agreement, developed countries will have to take emission reduction targets and actions but unlike the Kyoto Protocol – where such targets were mandatory; they shall be able to determine the nature and quantum of these targets nationally. Thus, each individual country is to contribute individually in the form of so called *Nationally Determined Contributions* (NDCs). As of now, the first set of such actions has been provided by more than 180 countries in the form of “Intended Nationally Determined Contributions (INDCs). When the Paris Agreement becomes operation in 2020, these targets will be called *Nationally Determined Contributions* (NDCs).

Climate Finance

Similar to Kyoto Protocol, the developed countries will need to provide finance to the developing countries for emission reduction actions as well as adaptation. The amount set by Paris Agreement is



at least USD 100 billion per year from 2020 onward. However, as of now, *there is no consensus on what exactly makes climate finance*. The countries will have to demarcate the details of these. Further, the Paris Agreement also provides that the developing countries can also voluntarily fund other developing countries.

Climate Change Adaptation

One of the objectives of the Paris Agreement is to increase the ability to adapt to the adverse impacts of the climate change and foster climate change resilience. The developing countries shall be able to seek funds from developed world in this direction.

Review Mechanism

The Paris Agreement provides that every five year, there shall be an assessment of how the emission reduction actions of all the countries are able to succeed towards achieving the goal of keeping global temperatures under control. Every fifth year, the assessment will also be made on kind and volume of funds.

Technology Mechanism

Paris agreement has set up a technology mechanism, which would help the countries to cooperate in developing and deploying clean technologies. However, this would face some issues of intellectual property rights of existing clean technologies.

Market mechanism

Countries are open to become part of existing global market-based mechanisms to reduce the emissions. The agreement would allow a global carbon-trade which shall provide the countries chance to take credit for emission reduction by making payments for the same in the countries where reduction is cheaper to achieve. The difference between Kyoto Protocol and Paris Agreement in this context is that earlier / currently, such trade exists in limited regions and countries and Paris agreement might have a chance to make it a global market place.

Transparency

As per the Paris Agreement, a uniform system will be built for the countries to report what they have been doing towards the fight against climate change. It will also track the achievements of the countries towards Nationally Determined Contributions. However, there are no punitive actions for non-compliance of such reporting.

Loss and Damage

Prior to the Paris Agreement, a Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts (called Loss and Damage Mechanism) was adopted at Warsaw in COP-19 in 2013. Objective of this L&D mechanism is to address the loss and damage associated with the impacts of the climate change, including the extreme events such as hurricanes, heat waves etc and slow onset events such as desertification, ocean acidification etc. This mechanism provides



technical assistance in case of loss and damage.

Under the Paris Agreement, this L&D would continue. However, the practical issue is that there is little money. Countries also do NOT have right to file for compensation or liability.

Key Issues on Paris Agreement

There are three key issues looming large over the Paris Agreement viz. maintaining the difference between developing and developed countries; issue of climate finance and loss & damage; and mitigation.

Maintaining the difference between developing and developed countries

The world is divided into two factions or rich and poor / developed and developing countries over climate change negotiations. An important principle in this context called common but differentiated responsibility (CBDR) was enshrined in the Principle 7 of the Rio Declaration. This principle implies that the interest of all countries towards sustainable environment are common, but due to the historical reasons, the developed countries have done more damage to the climate and thus, the responsibility towards climate change is “differentiated”. It implies that *while all countries should take sustainable development actions, the developed countries have to take the leading role in environmental protection, as they have contributed the most to environmental problems.*

Also they should support developing countries with finance and technology in their sustainable development efforts. India has always held that the eradication of poverty should be the overarching goal of sustainable development. India together with other developing countries has played an instrumental role in establishing CBDR as a principle.

In the Paris agreement, definition of CBDR has been expanded and it now includes the phrase “in the light of different national circumstances”. It appears to have diluted the notion of hitherto “historical responsibility” of the developed countries. How this is going to break the wall between developed and developing countries, is yet to be seen.

Issue of Climate Finance and Loss & Damage

The Paris Agreement maintains that the developed countries would keep providing support to the developing countries through the finance, technology and capacity building to the tune of at least USD 100 billion per year from 2020 onward. Further, the developed countries are required to provide transparent information also on support to developing countries and biennially communicate their plans for mobilisation of additional finance. The onus to mobilize these funds cannot be placed entirely on bilateral assistance and the Green Climate Fund. The developing countries would need to virtually de-link the greenhouse gas emissions from economic growth and devise innovative ways to mobilize funds.

Mitigation

Towards mitigation, the developed countries are needed to take lead in setting absolute emission



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reduction targets. However, the developing countries are “encouraged to move over time towards economy-wide emission reduction or limitation targets in the light of different national circumstances”. Under this so called “enhanced transparency framework”, all the countries are required to provide updates on their achievements towards NDCs. There might be some practical problem in the periodical review or global stocktake for developing and least developed countries.

General Knowledge Today



Environment-7: Short Questions for Prelims

[Target 2016: Integrated IAS General Studies](#)

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Model Questions

Prelims MCQ Topics

Ecosystem Approach, Ecophene, Various stages of Ecological Succession, Commensalism and Mutualism, Pioneer Community, Captive Breeding, First and Second Generation Alcohols, Categories in IUCN Red List of Threatened Species, India's Natural World Heritage Sites, Biological Nitrogen Fixation, Oxygen-18 use in Palaeoclimatology, Salt Mines use in Radioactive Waste Disposal, Pardhi community's initiative to save lesser floricans, Global Warming Potential, Producer Gas, Difference between Alligators and Crocodiles, Fishes that are not actually fishes, Tiger Range Countries, Southern Birdwing, Leq symbol, Seabuckthorn, Animals that show Hibernation, Hope Spots, Nepenthes and Tropical Sundew, Bio-stimulation, Bioventing, Bioaugmentation, Soil sealing, Dwindling numbers of House Sparrows, Sunn Hemp in soil Improvement, Albedo, Lessepsian migration, Polar ice packs in the environment of earth, Invasive Species, Holocene Extinction, Bioprospecting, Biopiracy, Japanese Whaling Issue, Use of Oxytocin in Veterinary



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What is Ecosystem Approach?

The Ecosystem Approach places human needs at the centre of biodiversity management. It aims to manage the ecosystem, based on the multiple functions that ecosystems perform and the multiple uses that are made of these functions. The ecosystem approach does not aim for short-term economic gains, but aims to optimize the use of an ecosystem without damaging it.

What is Ecophene?

The range of phenotypic modifications produced by one genotype within the limits of the habitat under which the genotype is found in nature.

What are Various stages of Ecological Succession?

The ecological succession refers to more or less predictable and orderly changes in the composition or structure of an ecological community. Its various stages are:

- Nudation: Succession begins with the development of a bare site, called Nudation (disturbance).
- Migration: It refers to arrival of propagules.
- Ecesis: It involves establishment and initial growth of vegetation.
- Competition: As vegetation becomes well established, grow, and spread, various species begin to compete for space, light and
- Reaction: During this phase autogenic changes such as the buildup of humus affect the habitat, and one plant community replaces
- Stabilization: A supposedly stable climax community forms.

What is difference between Commensalism and Mutualism?

In ecology, commensalism is a class of relationships between two organisms where one organism benefits from the other without affecting it adversely or favourably. This is in contrast with mutualism, in which both organisms benefit from each other, amensalism, where one is harmed while the other is unaffected, and parasitism, where one benefits while the other is harmed.

Examples of Commensalism

- Once a lion has finished its meal, a vulture swoops down and finishes off the carcass. The relation between lion and vulture is commensalism.
- Many orchids use trees as a surface to grow.

What is a Pioneer Community?

A pioneer community is a collection of organisms able to colonize bare rock. Lichens help break down rock and accumulate debris, helping to form a thin soil layer. The soil layer begins to support small forms of life.

What is Green Washing?

Greenwashing is green marketing, deceptively used to promote the perception that an organization's



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aims and policies are environmentally friendly. Whether it is to increase profits or gain political support, green-washing may be used to manipulate popular opinion to support otherwise questionable aims.

What is Captive Breeding?

Captive breeding is the process of breeding animals in human controlled environments with restricted settings, such as wildlife reserves, zoos and other conservation facilities; sometimes the process is construed to include release of individual organisms to the wild, when there is sufficient natural habitat to support new individuals or when the threat to the species in the wild is lessened.

Captive Breeding is an Ex-situ mode of conservation.

Captive breeding programs facilitate biodiversity and may save species from extinction. *However, such programs may also reduce genetic diversity and species fitness. Captive breeding techniques are usually difficult to implement for highly mobile species like some migratory birds (e.g. cranes) and fishes (e.g. Hilsa). Species like large cetaceans (whales, dolphins, etc.) may also have some difficulties as it would be hard to meet their biological requirements in captivity, especially the vast amount of space required to keep large populations.*

What are First and Second Generation Alcohols?

The first generation is produced from *various sources of carbohydrates* such as Sugarcane, Potato, Wheat, Rice etc. Second generation is the Lignocellulogic alcohol produced from Cellulose. The sources can be stalks, leaves, bagasse, and husks of rice, wheat, wood chips, sawdust etc. It is very difficult to commercially produce second generation alcohol.

What are different Categories in IUCN Red List of Threatened Species?

Various Categories in IUCN Red List of Threatened species are as follows:

- Extinct (EX) – No individuals remaining.
- Extinct in the Wild (EW) – Known only to survive in captivity
- Critically Endangered (CR) – Extremely high risk of extinction in the wild.
- Endangered (EN) – High risk of extinction in the wild.
- Vulnerable (VU) – High risk of endangerment in the
- Near Threatened (NT) – Likely to become endangered in the near future.
- Least Concern (LC) – Lowest risk.

What are India's Natural World Heritage Sites?

The Natural properties of India in World Heritage List are: Kaziranga National Park (1985), Keoladeo National Park (1985), Manas Wildlife Sanctuary (1985), Nanda Devi and Valley of Flowers National Parks (1988) and Sundarbans National Park (1987).

Which elements play role in Biological Nitrogen Fixation?

Iron, Molybdenum as well as Phosphorous play important role in BNF. Nitrogen fixation needs an



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enzyme called nitrogenase. The nitrogenase enzyme has two kinds of proteins viz. Iron Protein, and Iron-Molybdenum protein. Similarly, leguminous plants that are N₂ fixing will usually require more P than similar plants supplied fertilizer N. Nodules are an important P sink, and commonly have the highest concentration of that element in the plant. This is because of the high energy cost of N₂ fixation and the cost of building and maintaining functioning nodules.

Why Oxygen-18 is used in Palaeoclimatology?

The Mountain Glaciers and the polar ice caps/ice sheets have been widely used in paleo-climatology. This is done by studying the Ice Cores. Ice Cores are samples of the accumulated snow and ice over many years which got recrystallized and trapped air bubbles from previous time periods. The presence of Hydrogen and Oxygen Isotopes in these ice cores has helped to redraw a picture of the climate at the time. This is called Ice Coring. The ice coring projects have yielded data of the climates of hundreds of years back and European Project for Ice Coring in Antarctica has yielded data of over Siakh years back. The changes in the Oxygen-18 quantity in the ice layers represent changes in average ocean surface temperature. This is because the water molecules containing the heavier O-18 evaporate at a higher temperature than water molecules containing the normal Oxygen-16 isotope. The ratio of O-18 to O-16 is relatively higher as temperature increases and relatively less as temperature decreases. This ratio can be used to determine the temperature of precipitation through time.

Why Salt Mines are used as safest means of Radioactive Waste Disposal?

Currently, the Salt mines are considered to be the safest means for the disposal of the Radioactive Wastes. The reasons are that salt heals its own fractures because of its plastic quality; and good quality salt beds are separated from ground water. Further, the salt Beds have property of great seismic stabilit. *Kindly note that Salt does not absorb any radiation.*

What is Pardhi community's initiative to save lesser floricans?

The Pardhi community in central India has been a nomadic community of hunters. Phase Pardhis, one of the subgroups within the community, were known for their skill in catching birds with phase (traps). Traditional hunters Phase Pardhis are part of an initiative to save critically endangered lesser floricans.

Why coal is worst environmental polluter?

Coal is considered to be the worst environmental pollutant when burnt because of its sulphur content and traces of mercury *as well as radioactive material.*

What is Global Warming Potential?

Global-warming potential (GWP) is a relative measure of how much heat a greenhouse gas traps in the atmosphere. It compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide.



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What are components of Producer Gas?

Producer gas is created out of the biomass gasification i.e. incomplete combustion of biomass resulting in production of combustible gases consisting of Carbon Monoxide (CO), Hydrogen (H₂) and traces of Methane (CH₄). Producer gas can be used to run internal combustion engines (both compression and spark ignition) in vehicles; as a substitute for furnace oil in direct heat applications; produce methanol in an economically viable way.

What is Difference between Alligators and Crocodiles?

Both these reptiles belong to same order Crocodylia, alligators are classified under Alligatoridae family, whereas crocodiles are members of the Crocodylidae family. In regards to the habitat comparison of alligators and crocodiles, both spend their life in and near water bodies and lay their eggs on land.

But the difference is alligators prefer a freshwater habitat, while crocodiles prefer to live in brackish water or saltwater. Alligators have a broader 'U' shaped snout, whereas the snout shape of crocodiles is narrow and form a V towards the end.

The tooth placement is also a distinguishing feature to demarcate alligators and crocodiles. The jaw placement of an alligator is such that the upper jaw is wider and covers the lower jaw completely. In case of a crocodile, the width of the upper and lower jaw are the same, hence, the teeth in the lower jaw become apparent after the mouth is closed. Dermal Pressure Receptors (DPRs) are small, black, sensory pits that help in detecting changes in the water pressure. Both in alligators and crocodiles, DPRs serve as an important organ for locating their prey. In alligators, DPRs are present only around the jaw, whereas in crocodiles, these sensory organs are present in nearly every scale of the body.

Both alligators and crocodiles have structurally modified salivary glands (salt glands) in the tongue. The crocodiles use these salt glands for excreting excess salt from the body, whereas in alligators, these salt glands are non functional. This is the reason as to why, a crocodile can tolerate saline water, whereas an alligator cannot.

What are the fishes that are not actually fishes?

Some of the animals whose name is suffixed by fish but none of them is a true fish.

- Jelly fish- Aurelia (Coelenterate)
- Shell fish- a) oyster and other mollusks b) Lobster and other crustaceans
- Razor fish- Used both for a true fish Xyrichthyes species as well as Solen, a bivalve.
- Silver fish – Lepisma (a mollusc)
- Cuttle fish- Sepia (a mollusc)
- Devil fish- Octopus(a mollusc)
- Whale – Whale (Aquatic mammal)



- Starfish- Asterias (Echinoderm)

What are the Tiger Range Countries?

The 13 Tiger Range Countries (TRCs) are Bangladesh, Bhutan, China, India, Indonesia, Cambodia, Laos, Malaysia, Myanmar, Nepal, Russia, Thailand and Vietnam. In these countries, only 6 subspecies exist viz. Sumatran, Bengal, Amur, Indochinese, South China and Malayan tiger.

What is Southern Birdwing?

The Southern Birdwing is a large and striking Swallowtail butterfly endemic to Peninsular India. With a wingspan of 140–190 mm, it is the largest butterfly found in southern India. You may note that Grass Jewel is the smallest butterfly of India and Atlas Moth is the largest moth found in India.

What is Leq symbol in context with Noise Pollution?

As per the ambient noise standards, that have been notified for different categories like, industrial, commercial and residential areas and silence zones etc, for residential areas, 55 dB (A) Leq during 'day time' and 45 dB (A) Leq during 'night time' for residential areas have been fixed. Leq is a symbol that represents "Equivalent Continuous Noise Level". Usually the signal that you are measuring is varying in amplitude. Leq noise levels are logarithmic (dB) values and cannot be added directly. A doubling of sound level results in a measured increase of 3 dB, four identical sources in a room would increase the noise level by 6 dB and so on.

What are importance of Seabuckthorn?

Seabuckthorn is a medicinal plant found in the Himalayan region. Our country holds tremendous potential in respect of Seabuckthorn fruit production and diverse varieties which have health-promoting properties and can play a crucial role in preventing soil erosion and help nitrogen fixation in cold and desert areas. This is the most important environmental benefit of the Seabuckthorn. Seabuckthorn fruit grows in the cold deserts of Ladakh region of Jammu and Kashmir, Lahul-Spiti in Himachal Pradesh and some parts of Arunachal Pradesh. The UPA Government had launched a National Mission on Seabuckthorn.

What are the Animals that show Hibernation?

Select species of animals enters into the state of animal dormancy to avoid damage from adverse season. Examples of such animals are Polar Bear, Tortoises, Crocodiles, Salamanders etc.

During Hibernation period metabolic rate is reduced. In fact, it is a mechanism of survival. Amphibians like toad and frog undergo hibernation. Hibernation is also seen in female polar bears. Aestivation is an opposite process of hibernation. Some animals go under the ground during the dry season of summer. In zoology it is a state of inactivity and reduced metabolic activity that occurs during the dry season in species such as lungfish and snails.

What are Hope Spots?

The International Union for Conservation of Nature (IUCN) declares some places around the world



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as “Hope Spots”. Hope Spots are the places which are critical to the health of Ocean Life. A Hope Spot is an area of ocean that merits special protection because of its wildlife and significant underwater habitats.

What is common in Nepenthes and Tropical Sundew?

Both *Nepenthes khasiana* & Tropical sundew (*Drosera burmannii*) plants are found in the Khasi Hills of North East India. Both are insectivorous and both are endangered.

What are various Impacts of Tillage on soil health?

Tillage is an important factor that decreases soil quality. Reduced tillage practices could increase Soil Organic Matter and moisture content of the soil, and also improve the soil food web. However, there is a great disadvantage in reduced tillage that it requires a greater use of herbicides due to the increased spread of weeds and soil pathogens. If this is not taken into account, it may affect the crop yields due to the increased prevalence of pathogens, pests, diseases and weeds. Reduced tillage often leads to retention of soil residues and reduction in the emission of carbon dioxide to the atmosphere. This can sustain the soil biota in a healthy state and also maintains the physical and chemical properties of the soil.

What is Bio-stimulation?

Bio-stimulation refers to addition of nutrients to soil to stimulate the growth of indigenous microflora

What is Bioventing?

Bioventing refers to addition of gases such as oxygen or methane to stimulate activity of microflora

What is Bioaugmentation?

Bioaugmentation refers to inoculation of soil with exogenous microorganisms

What is Soil sealing?

Soil sealing refers to mixing toxic soil with healthy soil.

How cell phone towers are responsible for dwindling numbers of House Sparrows

- The House sparrow (*Passer domesticus*) was once a common sight in our cities and its number has gone down drastically in recent years. The electromagnetic pollution from mobile phone towers *harms its reproductive cycle*.
- Further, while the older ones feed on grains, the younger ones peck on insects. Due to the rapid encroachment of green space, use of insecticides, pesticides and herbicides food has become scarce for the birds. Starvation has killed a majority of them.
- Nesting was another problem. Due to the rapid growth in the high-rise buildings, nesting became a big issue for the birds. [The Hindu]

What is importance of Sunn Hemp in soil Improvement?

Sunn hemp has been used extensively as a soil improvement or green manure crop in the tropics



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because of its ability to produce large amounts of biomass in as little as 60 to 90 days. Because of this, it has the potential to build organic matter levels and sequester carbon. Also, as a legume it can fix large amounts of nitrogen. Used as a cover crop, sunn hemp can improve soil properties, reduce soil erosion, conserve soil water, and recycle plant nutrients. 'Tropic Sun' is also resistant to root-knot nematodes. [[The Hindu](#)]

What is Albedo?

Albedo is the fraction of the solar radiation reflected back. Increased air pollution would cause global dimming and would reduce the solar radiation reflected back. Polar Ice Caps increase the Earth's albedo. When Polar Icecaps get melted, the bare earth will reflect less solar light. Thus first two options are incorrect.

We should note that over-pastured land and bare soil are more reflective of solar radiation than are crops and vegetation. A desert is much more reflective than a savanna or forest. If economic pressure on soil and vegetation increases, and drought then occurs, the effect overall is to increase the albedo of the surface.

What is Lessepsian migration?

Lessepsian migration is the ongoing migration of marine species across the Suez Canal, usually from the Red Sea to the Mediterranean Sea, more rarely in the opposite direction. It is named after Ferdinand de Lesseps, the engineer in charge of the canal's construction. Invasive species originated from the Red Sea and introduced into the Mediterranean by the construction of the canal have become a major component of the Mediterranean ecosystem, and have serious impacts on the Mediterranean ecology, endangering many local and endemic Mediterranean species.

What is a Zoophyte?

A zoophyte is an animal that visually resembles a plant. An example is a sea anemone

What is contribution of Polar ice packs in the environment of earth?

There are two distinct roles played by Polar Ice Packs towards Earth's Environment. *Firstly*, the Polar ice packs restrain the release of methane from the arctic permafrost. Arctic methane release triggered by a breakdown in sea ice could cause an abrupt climate change event, potentially similar in some ways to the Paleocene-Eocene thermal maximum event, or to the great dying, a mass extinction event. *Secondly*, Polar ice packs reduce heat loss from the oceans. Sea ice has an important effect on the heat balance of the polar oceans, since it insulates the (relatively) warm ocean from the much colder air above, thus reducing heat loss from the oceans. Sea ice has a high albedo — about 0.6 when bare, and about 0.8 when covered with snow — compared to the sea — about 0.15 — and thus the ice also affects the absorption of sunlight at the surface. The sea ice cycle is also an important source of dense (saline) "bottom water". While freezing, water rejects its salt content (leaving pure ice). The remaining surface water, made dense by the extra salinity, sinks, leading to the productions of dense

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water masses such as Antarctic Bottom Water. This production of dense water is a factor in maintaining the thermohaline circulation, and the accurate representation of these processes is an additional difficulty to climate modelling.

Which countries share Amazon Rainforest?

The Amazon Rainforest covers most of the Amazon Basin of South America. This region includes territory belonging to nine nations. The majority of the forest is contained within Brazil, with 60% of the rainforest, followed by Peru with 13%, Colombian Amazon with 10%, and with minor amounts in, Venezuela, Ecuador, Bolivia, Guyana, Suriname and France (French Guiana). States or departments in four nations bear the name Amazonas after it. The Amazon represents over half of the planet's remaining rainforests, and it comprises the largest and most species-rich tract of tropical rainforest in the world.

What are Invasive Species?

Invasive species are those that are introduced—intentionally or unintentionally—to an ecosystem in which they do not naturally appear and which threaten habitats, ecosystems, or native species. These species become invasive due to their high reproduction rates and by competing with and displacing native species, that naturally appear in that ecosystem. Unintentional introduction can be the result of accidents (e.g. when species escape from a zoo), transport (e.g. in the ballast water of a ship); intentional introduction can be the result of e.g. importing animals or plants or the genetic modification of organisms.

Examples of Invasive Species

Congress Grass

The Congress Grass (*Parthenium hysterophorus*) inhibits the germination and growth of many plants and induces hay fever, asthma, skin rashes, and eczema in human beings. Toxic to animals, it can also taint mutton and make dairy milk unpalatable owing to its odour.

Water hyacinth (*Eichhornia crassipes*):

Aquatic plant of tropical South America that flourishes in warm climates in Central America, North America, Africa, Asia, Australia and New Zealand. The hyacinth grows in thick rafts, deoxygenating the water for other species and impeding water flow and navigation.

What is Holocene Extinction?

Holocene is a geological epoch which began around 12,000 to 11,500 years ago and continues to the present. The scientists propose that a Sixth Extinction of biodiversity is going on currently in this Holocene epoch, which started around 10,000 BC. The large number of extinctions span numerous families of plants and animals including mammals, birds, amphibians, reptiles and arthropods. The Holocene extinction includes the disappearance of large mammals known as megafauna, starting between 9,000 and 13,000 years ago, the end of the last Ice Age. Such disappearances are considered



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to be results of both climate change and the proliferation of modern humans. These extinctions are sometimes referred to as the Quaternary extinction event. All of us are witnessing this Holocene extinction.

What is Bioprospecting?

Bioprospecting is the process of discovery and commercialization of new products based in biological resources. Bioprospecting often draws on indigenous knowledge about uses and characteristics of plants and animals. Thus, Bioprospecting includes Biopiracy, the exploitative appropriation of indigenous forms of knowledge by commercial actors, as well as the search for previously unknown compounds in organisms that have never been used in traditional medicine.

What is Biopiracy?

In Biopiracy, indigenous knowledge of nature, originating with indigenous peoples, is used by others for profit, without permission from and with little or no compensation or recognition to the indigenous people themselves.

Representing one of the most agriculturally bio-diverse nations in the world, India has become a primary target for biopiracy. In a first, in 1995, a firm in United States had successfully applied for a patent on a technique to extract an antifungal agent from the neem tree (*Azadirachta indica*), which grows throughout India and Nepal. This was a case of biopiracy as the Indian people have long understood the tree's medicinal value. The efforts on part of Government of India led to cancellation of the patent. Similarly, in 2000, US Corporation RiceTec attempted to patent certain hybrids of basmati rice and semi dwarf long-grain rice. The Indian government intervened and several claims of the patent were invalidated.

The most recent case of biopiracy is the first ever bio-piracy case by National Biodiversity Authority against the developers of Bt brinjal, which has been discussed later in these modules.

What is the Japanese Whaling Issue?

Japan has a long tradition of whale hunting "because eating whale meat is an old and impenetrable Japanese tradition". Earlier they used to trap whales into nets or harpooned them; the commercial whaling received a boost with the introduction of steam ships and grenade tipped harpoon guns.

The whaling was confined to Pacific Ocean until 1934, but since then, the Japanese expanded their whaling to Antarctica. Whales helped keep Japanese citizens fed both during and after World War 2. In 1947 whale meat made up almost half of all animal protein consumed by the country. Nearly 20 years later, whales continued to make up nearly one-quarter of the Japanese diet.

In 1946, International Convention for the Regulation of Whaling was signed. This convention governs commercial, scientific, and aboriginal subsistence whaling practices of fifty-nine member nations. By this convention, International Whaling Commission (IWC) was set up to "provide for the proper conservation of whale stocks and thus make possible the orderly development of the



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whaling industry”.

In 1986, IWC had adopted a moratorium on commercial whaling. This ban still continues but somehow Japanese continue doing commercial whaling. Why? Japan has exploited an ambiguity in the 1986 global moratorium that allows “lethal research on the mammals”. What Japanese do is to keep hunting the whales in the name of this “lethal research”.

Why Oxytocin is used in Veterinary?

Bihar State Health Society (BSHS) has imposed an immediate ban on over-the-counter sale of oxytocin injections which are illegally manufactured in some parts of the state. Dairy farmers use oxytocin to increase milk in pregnant cows and farmers use it to ripen fruits and vegetables. But food laced with oxytocin can have adverse health effects in humans. It can reduce heart rate, cause low blood pressure, damage the brain, cause seizures in foetuses and lead to uterine rupture.

What is Double digging?

Double digging is a gardening technique used to increase soil drainage and aeration. It involves the loosening of two layers of soil, and the addition of organic matter. Double-digging is a key component of the biodynamic method of cultivation.