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Environment, Biodiversity and Climate Change
Module-5: Environment Related Issues and Concepts-2

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Chapter 1. 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.)

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, polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, and toxaphene.
The list enlarged later with inclusion of some more chemicals.

Common Characters of the POPs

The persistant 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.*

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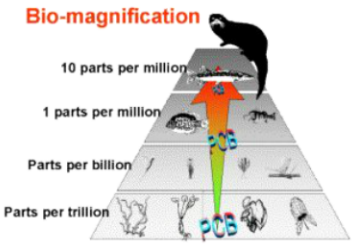
Biomagnification

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:



Stockholm Convention on Persistent Organic Pollutants

Stockholm Convention is first ever-concerted global effort to save mankind from the adverse impact of Persistent Organic Pollutants (POP). It was called in 1995 by the Governing Council of the United Nations Environment Programme (UNEP), following its study on the Dirty Dozen. The Intergovernmental Forum on Chemical Safety (IFCS) and the International Programme on Chemical Safety (IPCS) prepared an assessment of dirty dozen. The negotiations began in 2001 and the convention came into being in 2004 after ratification by 128 parties.

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.

As of April 2013, there are 179 parties to the Convention.

- ✓ 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.

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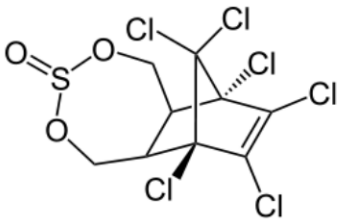
India and Stockholm Convention

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 Endusulphan

Endosulfanis a diastereomeric mixture of two isomers i.e. alpha-endosulfan (64-67%) and beta-endosulfan (29-32%). in the ratio 7:3 along with some impurities. It belongs to the **organochlorine group of pesticides**, under the Cyclodiene subgroup with chemical formula $C_9H_6Cl_6O_3S$. It has chemical name – 6,7,8,9,10,10- hexa chloro- 1,5,5a,6,9,9a- hexahydro– 6,9- methano- 2,4,3-benzodioxathiepine -3-oxide.



- ✓ 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
- ✓ Mixable with most fungicides and compatible with most pesticides

Toxicity Classification

- ✓ The U S Environmental Protection Agency (EPA) classifies endosulfan as Category Ib – Highly Hazardous.
- ✓ The European Union also rates it Highly Hazardous.
- ✓ World Health Organisation (WHO) classifies endosulfan in Category II – Moderately Hazardous.
- ✓ The Industrial Toxicological Research Centre (ITRC) in India the nodal centre for the Regional Based Assessment of Persistent Toxic Substances (PTS) for the Indian Ocean region by the United Nations Environment Programme-Global Environment Facility (UNEP-GEF) classifies endosulfan as Extremely Hazardous.

Endosulphan is used as an organochlorine insecticide and **acaricide (killing tickes and mites).** Endosulphan belongs to organochlorine group of pesticides such as DDT. 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.

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In India it is produced by Hindustan Insecticides Limited. Currently, a global ban on the use and manufacture of endosulfan is being considered under the Stockholm Convention. India is the largest user of Endosulphan.

- ✓ In 2011, the Supreme Court banned the use of Endosulphan due to some peculiar health impacts seen after aerial spray of in **Cashew Plantations in Kerala**.
- ✓ The court had on May 13, 2011 ordered a complete ban on the manufacture, sale and use of endosulfan after a PIL had brought to the court's notice the hazardous effects of the pesticide on human and plant life in Kerala, Karnataka and other states.
- ✓ India's stand was not clear in the Persistent Organic Pollutants' Review Committee (POPRC) of the Stockholm Convention that began in Geneva, Switzerland that held in October 2010.

International Programme on Chemical Safety

In 1980, the **three UN bodies viz**. World Health Organization, the International Labour Organization and the United Nations Environment Programme formed the "International Programme on Chemical Safety". The idea was to establish the basis of safe use of the chemicals and strengthen the national capabilities for chemical safety.

Under this framework of this programme, the WHO publishes the Concise International Chemical Assessment Document, describing the toxicological properties of the chemical substances.

Rotterdam Convention on Hazardous Substances

The most important international convention in context with the Hazmats is Rotterdam Convention. Formal name of the multilateral Rotterdam Convention is "***The Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade***". This convention was signed on September 10, 1998 and became effective from February 24, 2004.

Theme of this convention is to promote **shared responsibilities** in relation to importation of hazardous chemicals. It promotes open exchange of information, proper labeling, include directions on safe handling, and inform purchasers of any known restrictions or bans.

> 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.

The Rotterdam Convention is **not a legally Binding convention** and the parties can decide whether to allow or ban the importation of chemicals listed in the treaty, and exporting countries are obliged make sure that producers within their jurisdiction comply. Most important Hazmats such as 245-T, Aldrin, Asbestos, DDT etc. are covered under this convention. It has 128 parties.

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India also ratified the Rotterdam Convention on Prior Informed Consent Procedure for certain hazardous Chemicals and Pesticides in International Trade on May 24, 2006. India is now party to both the conventions viz. the Stockholm Convention and the Rotterdam Convention.

Chapter 2. Marine Pollution, Oil Spills, Marine Protected Areas

Spread of chemicals, particles, industrial, agricultural and residential waste, noise or the invasive organisms in the marine is the Marine Pollution. The 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 has the formal title of "*Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter*". This convention was signed in 1972 and entered into force in 1975. It has 78 parties. India is not a party to this convention.

> What is Cultural Eutrophication?
> 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.

This is a **non-legally binding convention** which covers the problem of deliberate disposal at sea of wastes or other matter from vessels, aircraft, and platforms. But it does 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.

Mercury Poisoning in Fishes

Fishes concentrate mercury in their bodies, often in the form of methylmercury, 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.

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Minimata Disease

The disease was searched in the seaside town of Minimata, in Japan in late 1950s when a strange behavior in animals was seen. The abnormal behavior 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 soil, the insulating ability is reduced drastically and the birds became 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.
- ✓ **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.
- ✓ The most important methods are discussed here:

Bioremediation of Oil Spills

Bioremediation uses the microorganisms or biological agennts such as oil eating bacteria. There are three kinds of oil-consuming bacteria.

- ✓ Sulfate-reducing bacteria (SRB)
- ✓ Acid-producing bacteria are anaerobic
- ✓ General aerobic bacteria (GAB)

Out of them, Sulfate-reducing bacteria (SRB) and acid-producing bacteria are anaerobic, while general aerobic bacteria (GAB) are aerobic.

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Oil Zapper

The new technique of using the bacteria to get rid of oil spill has been called "Oil Zapping". Oil Zapping is a bio-remediation technique involving the use of 'oil zapping' bacteria. It was recently employed to clean up the Mumbai shoreline affected by the oil spill that occurred in August 2010.

There are **five different bacterial strains** that are immobilized and mixed with a carrier material such as powdered corncob. This mixture of five bacteria is called Oil Zapper. Oilzapper feeds on hydrocarbon compounds present in crude oil and the hazardous hydrocarbon waste generated by oil refineries, known as Oil Sludge and **converts them into harmless CO2 and water**. The Oilzapper is neatly packed into sterile polythene bags and sealed aseptically for safe transport. The shelf life of the product is three months at ambient temperature.

The technique was used successfully and 130,000 tons of oily sludge/ oil contaminated soil was treated as per the leading news sources.

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. 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.

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- **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.

Marine Protected Area

The Convention on Biological Diversity defines the "Marine and Coastal Protected Area" as follows:
Any defined area within or adjacent to the marine environment, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by legislation or other effective means, including custom, with the effect with the effect that its marine and/or coastal biodiversity enjoys a higher level of protection then its surroundings.

As of 2010, there are more than 5,000 MPAs, encompassing 0.8% of the ocean's surface. Traditionally, the Marine Protected areas have been established by individual nations. The World Summit on Sustainable Development in 2002 called for the establishment of marine protected areas consistent with international laws and based on scientific information, including representative networks by 2012.

The Evian Agreement of 2003 (among G-8 nations) and Durban Action Plan 2003 calls for regional action and targets to establish a network of protected areas by 2010 within the jurisdiction of regional environmental protocols. There were calls for establishing protected areas for 20 to 30% of the world's oceans by the goal date of 2012.

India's Marine Protected Areas

India has at present **5 designated Marine Protected Area**s as follows:

- Gulf of Mannar National Park, Tamil Nadu
- Gulf of Kutch Marine National Park, Gujarat
- Gulf of Kutch Marine Sanctuary, Gujarat,
- Mahatma Gandhi Marine National Park, Andaman & Nicobar Islands
- Gahirmatha Sanctuary, Orissa.

India has only five marine Protected Areas. Comparing to the marine diversity, is it too less and there is a greater need to have more marine Protected Areas in the country with well-developed

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management plans. Since, most of the marine species are migratory and not confined to one area only, management plans have to be based on large areas, rather than confining them to a Protected Area.

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.

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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.

Chapter 3. Climate Change Concepts & Questions

What is Climate?

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).

What are Forcings in context with Climate?

The climate system evolves in time under the influence of its own internal dynamics and due to changes in external factors that affect climate (called 'forcings'). External forcings include natural phenomena such as volcanic eruptions and solar variations, as well as human-induced changes in atmospheric composition. Solar radiation powers the climate system.

What is 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 shortwaves 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

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- ✓ AG = Radiation trapped as Green House Effect.

Various internal and external factors are 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).

The amount of energy reaching the top of Earth's atmosphere each second on a surface area of one square meter facing the Sun during daytime is about 1,370 Watts, and the amount of energy per square metre per second averaged over the entire planet is one-quarter of this. About 30% of the sunlight that reaches the top of the atmosphere is reflected back to space. Roughly two-thirds of this reflectivity is due to clouds and small particles in the atmosphere known as 'aerosols'. Light-coloured areas of Earth's surface – mainly snow, ice and deserts – reflect the remaining one-third of the sunlight.

Implications of Radiation Balance

The Climate responds directly to changes in the Radiation Balance, as well as indirectly, through a variety of feedback mechanisms.

What are 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.

What is 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

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have been the focus of a great deal of research by scientists unravelling the complexities of Earth's climate.

How Climate can be predicted but Weather can not?

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.

What is Polar amplification?

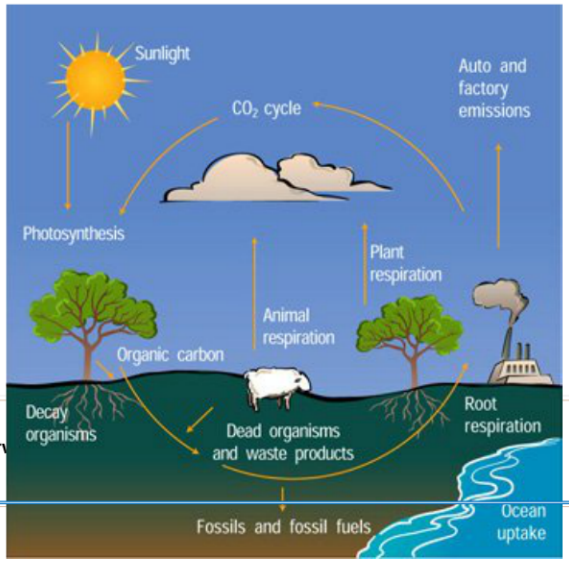
Climate models generally predict amplified **warming in polar regions due to climate feedbacks**. This is called Polar amplification. This can be understood by the fact that due to the climate changes, the Arctic has warmed much leading to Arctic Shrinkage. Most simple climate models predict warming 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.

What are Carbon Cycle and Global Carbon Budget?

The flux of the Carbon Dioxide between the Oceans, terrestrial biosphere, lithosphere and atmosphere is called the Carbon Cycle. The Human activities have added to new flux of CO2 in the atmosphere



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and out of which a part is absorbed by the plants while a part is taken by the Oceans.

The Carbon Cycle is of two types viz. Organic and Inorganic Carbon cycle. The Carbon Cycle as described for the first time by Joseph Priestley and Antoine Lavoisier is the interchange of CO_2 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

The Global Carbon Budget Refers to the balance of the exchanges of carbon between the carbon reservoirs. This may refer to one specific pathway such as atmosphere to biosphere or vice versa or many pathways. This is used to determine, whether a particular pool/ reservoir/ circle is working as a source of the Carbon dioxide or a sink of the Carbon Dioxide.

What is 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 ($H2CO_3$) and increases the Hydrogen Ion (H^+) concentration in the ocean. The absorption of the CO2 by the world's Oceans helps in mitigating the climatic effects of Carbon Dioxide emissions. But at the same time, 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 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.

The organisms such as corals, echinoderms, crustaceans and molluscs 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.

What is Carbon Footprint?

The term 'carbon footprint' has become tremendously popular over the last few years and is now in widespread use across the media. But surprisingly there is no unanimity in the definition of the

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Carbon Footprint. The common understanding is that the *carbon footprint stands for a certain amount of gaseous emissions that are relevant to climate change and associated with human production or consumption activities*. However, there are questions such as

- ✓ Should the carbon footprint include just carbon dioxide (CO2) emissions or other greenhouse gas emissions as well, e.g. methane (CH4)?
- ✓ Should it be restricted to carbon-based gases or can it include substances that don't have carbon in their molecule, e.g. N2O, another powerful greenhouse gas?

There have been several definitions and most of them restrict themselves to emission of CO2 only.

- ✓ The carbon footprint is the amount of carbon dioxide emitted due to your daily activities – from washing a load of laundry to driving a carload of kids to school.
- ✓ The carbon footprint was calculated by "measuring the CO2 equivalent emissions from its premises, company-owned vehicles, business travel and waste to landfill.
- ✓ "A carbon footprint is a measure of the amount of carbon dioxide emitted through the combustion of fossil fuels. In the case of a business organization, it is the amount of
- ✓ CO2 emitted either directly or indirectly as a result of its everyday operations. It also might reflect the fossil energy represented in a product or commodity reaching market.

As per the more broadly adopted definition, **'Carbon Footprint'** measures the **total greenhouse gas emissions** caused directly and indirectly by a person, organization, event or product. Now, here is an interesting observation. We should know that the Kyoto Protocol recognizes 6 GHGs as follows:

1. Carbon dioxide (CO^2)
2. Methane (CH_4)
3. Nitrous oxide (N_2O)
4. Hydrofluorocarbons (HFCs)
5. Perfluorocarbons (PFCs)
6. Sulphur hexafluoride (SF_6).

The question is- a **release of which among the above would be counted in the Carbon Footprint**? Here we have to notedown that *Carbon footprint considers all six of the Kyoto Protocol greenhouse gases* listed above. ☺ . However, to simplify matters—and since CO2 is the most prevalent GHG—**these emissions are expressed in terms of CO2 equivalent** based on a conversion table that uses the Intergovernmental Panel on Climate Change (IPCC) Global Warming Potential (GWP) factors.

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).

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There are two major types of carbon foot printing viz. organizational and product.

- ✓ **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.

One more relevent question is - **How I can reduce my carbon footprint?**

Everyone of us can take a small step to reduce our carbon footprint. Some examples are as follows:

- ✓ If we replace a regular light bulb with a compact fluorescent lamp (CFL), we can save 150 pounds of carbon dioxide each year.
- ✓ Instead of driving , if we walk, bike, carpool, or take mass transit, each of it would reduce the carbon footprint.
- ✓ Use of recycled products and recycling the materials would reduce carbon footprint.
- ✓ If we are using a vehicle, the properly inflated tires mean better gas mileage. If we are able to save gas, we are able to reduce carbon footprint.
- ✓ If we prefer to use cold water instead of hotwater, this would save energy bills and also reduce carbon footprint. Turning off electrical devices is another way to do it.
- ✓ Avoiding the products with lots of packaging will prevent waste in the first place and will also reduce resource consumption. Products will less packaging always reduce carbon footprint.
- ✓ Planting a tree is always a good idea. A single tree can absorb one ton of carbon dioxide over its lifetime.

What is 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.

What is Carbon sequestration?

Carbon sequestration refers to the "*process of removing carbon from the atmosphere and depositing it in a reservoir*". Sequestering carbon helps to reduce or slow the buildup of CO2 concentrations in the atmosphere.

Thus, Carbon sequestration removes carbon, in the form of CO_2 , either directly from the atmosphere or at the conclusion of combustion and industrial processes.

Sequestration encompasses all forms of carbon storage. Oceans, plants and underground geologic formations all

function as significant reservoirs for CO_2. They all exchange CO_2 with the atmosphere. These reservoirs will act as

carbon sinks if more carbon is flowing into them (or stored in them) than flows out of them.

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Three primary categories describe the primary types of sequestration.

Terrestrial Carbon Sequestration

Terrestrial sequestration is a form of 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

There are several types of geologic formations in which CO_2 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.

1. One approach is to enhance the productivity of ocean biological systems (e.g., algae) through fertilization.
2. Another approach is to inject CO_2 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 (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 referencet to Carbon sequestration, the soil is one of the largest reservoirs, where carbon could be restored.

Can Organic Farming help in Carbon Sequestration?

Organic agriculture has various positive environmental effects, chiefly enhancing biodiversity and reducing the energy use for agricultural production. In context with Carbon Sequetration, Organic farming has been subject matter of various studies. Most of these studies have found a higher soil carbon content in organic plots, as compared to conventional management practices. Thus, we can generally conclude that Organic Farming is supportive for Carbon Sequestration. One example is Organic Mulch. Organic mulch is bisically 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

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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.

What are Oxygen Minimum Zone (OMZ) and Dead Zones?

Oxygen minimum zone (OMZ) , also known as **shadow zone** is the zone in Oceans where the oxygen saturation is at its lowest. This refers to depths of about 200 to 1,000 meters, depending on local circumstances. The expansion of the OMZ as a consequence to anthropogenic emissions of CO2 is called **Ocean deoxygenation.**

Dead Zones

The Low oxygen areas in the world's oceans or large lakes where no aquatic life is supported are known as Dead Zones. So, the Dead Zones are formed due to low Oxygen or Hypoxia. As per the first Global Environment Outlook Year Book (2003), there are 146 dead zones in the world's oceans where marine life could not be supported due to depleted oxygen levels. In 2008, the number rose to 405. Currently the most notorious dead zone is a 22,126 square kilometre region in the Gulf of Mexico.

What is Global dimming?

The gradual reduction in the amount of global direct irradiance at the Earth's surface is called Global dimming. It is believed that it has been caused by the increase in particulates such as sulfate aerosols in the atmosphere due to human action. In 1990s, there was a trend from Global dimming to Global brightening , when the emission of the above particles got reduced.

What is Eutrophication?

In context with environment, the 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.

Some Observations

- ✓ Eutrophication derives from the Greek word *eutrophos*, meaning nourished or enriched.

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- ✓ 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 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.
- ✓ Cultural Eutrophication is caused by human activities. Which in turn 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 CO_2 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 blood 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 planet respectively.

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What is Green GDP?

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 **does not mean** the monetary value of the Forests etc.
- ✓ Green GDP **does not mean** the growth of Green Investments.
- ✓ 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.

This means that GDP may have some indicators such as Waste per capita or CO_2 emissions growth/ decline. China, a pioneer in the factoring in costs of environmental degradation into economic growth estimates, **first published its green GDP data for the year 2004** in 2006.

India has given the most promising national activity on the Green GDP. In 2009, India's former Environmental Minister, Jairam Ramesh had announced that "It is possible for scientists to estimate green GDP" As a consequent to this, an exercise was started under the country's chief statistician Pronab Sen. India's GDP numbers will be adjusted with economic costs of environmental degradation by 2015.

What is Ecological debt?

Ecological debt refers to the consumption of resources from within an ecosystem that exceeds the system's regenerative capacity. This is the overall depletion of the Global resources beyond the Earth's ability to regenerate them. The term is closely related to the **Carrying Capacity**. The concept of Ecological Debt has given rise to observation of **Ecological Debt Day**.

What is the Carrying Capacity?

In context with environment, the **Carrying Capacity** of a biological species in an environment refers to the **population size** of the species that the environment can sustain indefinitely, given the food, habitat, water and other necessities available in the environment. *The population of this species will increase below carrying capacity and will decrease above carrying capacity.*

How does it work?

Usually, the birth rate is higher than the death rate for organisms. This is known as Natural Increase. The carrying capacity is the number of individuals an environment can support without significant negative impacts to the given organism and its environment. When the population grows above the

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carrying capacity, the population tends to decrease. However, at that point there are regulating factors that keep equilibrium in the population.

Carrying capacity of an environment varies for different species is affected by food availability, water supply, environmental conditions and living space.

What is Ecological Foot print?

Ecological Footprint is a measure of human demand on the Earth's ecosystems and its ecological capacity to regenerate the resources consumed by Human. There are two closely related concepts.

- ✓ Humanity's Ecological Footprint
- ✓ Earth's biocapacity

Ecological Foot print represents the impact that entity (nation/ town/ individual/ entire world) made on the Earth that year by consuming a set amount of the Earth's resources. So, the over-consumption of the Earth's natural resources is unsustainable as the Earth's **biocapacity will eventually collapse** should this behavior continue.

In other words, Ecological Footprint is the measure of how much biologically productive land and water an individual, population or activity requires to produce all the resources it consumes and to absorb the waste it generates using prevailing technology and resource management practices.

The Ecological Footprint is measured in **global hectares**. Because trade is global, an individual or country's Footprint includes land or sea from all over the world.

What is a Global Hectare?

Global hectare is used to measure the ecological foot print **as well as biocapacity** of entire Earth. When we understand both the terms, we can arrive at **ecological deficit.**

In terms of **Ecological Footprint,** One global hectare refers to average productive land and water an individual, population or entity requires producing all the resources it consumes.

When we say that world-average ecological footprint in 2007 was 2.7 global hectares per person (18.0 billion in total), this means that **this was the** per person productive land and water **required for producing** all the resources he / she consumed.

In terms of **Biocapacity**, the Global Hectare refers to average **biocapacity** of any biologically productive areas on the planet. When we say, that the world-average biocapacity in 2007 was 1.8 global hectares per person (12 billion in total), this means that it is the amount of biologically productive land and water available per person on the planet.

What is Impact of Population on Biocapacity?

In 2005 there were 13.4 billion hectares of biologically productive land and water available and 6.5 billion people on the planet. This is an average of 2.1 global hectares per person. Since the world's

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population is growing rapidly, this number is rapidly decreasing. In 2008, it became 1.8 Global Hectare Per person. In 2011, it may be even lesser than that.

Thumb rule: Increasing population leads to decrease in the amount of biologically productive land and water available per person on the planet.

What is Water Footprint?

Water Footprint is defined as **the total volume of freshwater** that is **used to produce** the goods and services **consumed by** the individual or community or produced by the business. As per the use and source, it is of three kinds viz blue, green and grey water footprint.

- ✓ The **Blue Water Footprint** means volume of freshwater that **evaporated** from the global blue water resources such as **lakes, rivers, ponds, reservoirs and wells** in producing the goods and services consumed by the individual or community.
- ✓ **Green Water Footprint** means volume of freshwater that **evaporated** from the global green water resources such as **moist lands, wetlands, soil, farms** etc. in producing the goods and services consumed by the individual or community.
- ✓ **Grey Water Footprint** means volume of freshwater that **was polluted** in producing the goods and services consumed by the individual or community.

The water footprint is measured in terms of Cubic Meter / per person/ per year. Approximate Global Water Footprint is 1240 m^3 water/person/year.

What is Ecological Deficit?

The world-average ecological footprint in 2007 was 2.7 global hectares per person. In the same year, the world-average biocapacity was 1.8 global hectares per person. So, the difference between the Ecological Footprint and Biocapacity **was 0.9 Global hectares per person**. This is known as **Ecological Deficit**.

This means that ecological deficit occurs when the Footprint of a population exceeds the biocapacity of the area available to that population. Most of the countries in the world are ecogologically deficit.

When a country does not have enough ecological resources within its own territory, then there is a local ecological deficit and it is called an **ecological debtor country**. If the country has enough ecological resources in its territory, it has ecological remainder and it is called an **ecological creditor** country.

Here, we take example of some countries. First we take example of India.

As per the 2007 **Global Footprint Network** publication, India's Ecological Footprint was 0.91 Global Hectare Per Person. However, the biocapacity was 0.51 Global Hectare Per Person. So India's Ecological deficit was -0.40 Global Hectare Per Person. So India is a ecological debtor country.

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When we take example of Guyana, its Ecological Footprint was 2.38 Global Hectare Per Person. But its biocapacity was 62.13 Global Hectare Per Person. This country had Ecological deficit of +59.75. This is an example of ecological creditor country**. Guyana had the largest biocapacity in the word.**

The country with **largest Ecological Footprint** in 2007 was UAE. Its Ecological Footprint was 10.68 Global Hectare per Person. But the biocapacity was only 0.85 Global Hectare Per person. So, the ecological deficit of UAE was -9.83 Global Hectares per Person, which is **highest in the world.**

The latest Ecological Footprint Atlas was published by Global Footprint Network in October 2010.

Ecological Debt Day

Ecological Debt Day is also known as "Earth Overshoot Day". The Ecological debt date refers to the calendar date in which the total resources consumed by humanity will exceed the capacity for the Earth to generate those resources that year. It is arrived by dividing the world biocapacity, the number of natural resources generated by the earth that year, divided by the world Ecological Footprint, humanity's consumption of the Earth's natural resources for that year, and multiplied by 365. It is shown in the following formula:

World biocapacity ÷ World Ecological Footprintx365 = Ecological Debt Day

The first Ecological Debt Day was observed on December 19, 1987.

Latest Ecological Debt Day was observed on August 21, 2010.

Before that date, humanity's consumption of the Earth's natural resources was outweighed by the Earth's ability to regenerate its resources in that particular year.

In 2010, August 21 was seen as the Ecological Overshoot Day or Ecological Debt Day. This means that the from that day onwards till the end of year, the humanity enters deficit spending . The New Economics Foundation (NEF), which is an independent British think-tank, marks the Ecological Debt Day.

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