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Introduction

The term sustainable was development and introduced by the World Commission on Environment and Development (The Brundtland Commission), in its seminal report of 1987, Our Common Future. The concept has terrifically worked out in creating public awareness for sustaining the planet with better management. The sustainable development has been
defined as "meeting the need of the present generation without compromising the needs of future generation". The concept precisely emphasizes upon using the earth resources judiciously and compensating for it in some sense e.g. if we cut few trees to support our lives, we should also implant some new ones at some site. This would result in. maintaining the
earths fine balance between resource consumption and resource generation.
In understanding this concept, we very often encounter two terms- sustainable and development. These are summarized below as:

Sustainable

The literal meaning of sustainability is "that can be maintained" or "keep goal
continuously". In ecological sense it refers to "conservation of ecological balance by avoiding
depletion of natural resources". Hence, we can understand it as something, which has got
to do with longevity (long life) of a resource, commodity, species, ecosystem, earth etc.

Development

The literal meaning of development is "the act or instance of growth/advancement". So the growth can be of many types viz., growth of education, growth of industry, growth of population, growth of forests and many other. But what type of growth are we addressing to? Here we are addressing to one of the most sensitive issue of growing concern 'about
improving the well-being of human beings. This could be achieved only through compromising with some of our comforts and luxuries. The generation of comforts and luxuries brings environment under great pressure. The Nation's economic growth should not stand upon the
fragile foundation of earth's resources. Mahatma Gandhi, a great social scientist, rightly pointed out that, "The earth provides enough to satisfy everyone's need, but not everyone's
greed".

In the context of economic and technical development the world always had been
better today than yesteryears and will always be better tomorrow than today. But the
condition of environment will always be poorer than before. Hence, the concept of sustainable development raises certain questions for the present generations to answer. What is our present? Are we happy with our present? Prospective changes of the magnitude described above raises fundamental questions about the kind of world we will bequeath to our children and about the nature and goals of development. The present in which we live is important as it shapes our future. Nothing much can be done to recover the damages imposed on nature in the past. But if we shape our surroundings based on environmental ethics and
economically exploit our present environment we would lend a healthier tomorrow to our
children. As we have examined some environmental issues in the previous chapters, we

would commonly agree that human population growth, loss of biodiversity, habitat destruction, ozone depletion, global climate change, pollution (air, water, noise etc.) and limited food & energy supply are environmental concerns of global scale. In the past two decades a great deal of work from researchers, ecologists, environmental scientists, social scientists, geographers and demographers have built up a very clear picture of what our tomorrow would be like: Some initiatives have been taken up both at government and non-government level. Still promising environmental concern at individual level is far lacking beyond sustainable needs. Although population growth continues to expand at an unsustainable pace but still certain countries have achieved a demographic transition to zero population growth. However, positive signs from developing nations are still absent. We have achieved breakthroughs in renewable energy sources, agroforestry schemes and better pollution control advancements. Increased man awareness, resourcefulness and enterprise will help eliminate poverty and resource wastage and will make our environment a much better place to live in. Until environmental concerns do not find space in our hearts, we would never be able to delicately handle our surroundings when we are at home or public. We should recognize things at personal and collective grounds to protect nature and to create a sustainable environment.

Climate Change

Climate change is a newcomer to the international political and environmental agenda, having emerged as a major policy issue only in the late 1980s and thereafter. It has emerged since the 19th century that Carbon dioxide (CO_2) in the atmosphere is a 'greenhouse gas', that is, its presence in the atmosphere helps to retain the incoming heat energy from the sun, thereby increasing the earth's surface temperature. Of course, CO_2 is only one of several such greenhouse gases in the atmosphere. Others include methane, nitrous oxide and water vapour. However, CO_2 is the most important greenhouse gas that is being affected by human activities. CO_2 is generated by a multitude of processes. Since the Industrial Revolution, when our usage of fossil fuels increased dramatically, the contribution of CO_2 from human activities has grown large enough to constitute a significant perturbation of the natural carbon cycle.

The concentration of CO_2 in the Earth's atmosphere was about 280 parts per million by volume (ppmv) in 1750, before the Industrial Revolution began. By 1994 it was 358 ppmv and rising by about 1.5 ppnw per year. If emissions continue at the 1994 rate, the concentration will be around 500 ppmv, nearly double the pre-industrial level, by the end of the 21st century.

Rising Concentrations

The effect is that the atmosphere retains more of the Sun's heat, warming the Earth's surface. While the pattern of future warming is very much open to debate, it is indisputable that the surface of the Earth has warmed, on average, 0.3 to 0.6 °C since the late 19th century when reliable temperature measurements began. Under the existing scenarios of economic growth and development leading to greenhouse gas emissions, on a worldwide average, temperatures would rise by 1 to 3.5 °C by the year 2100, and global mean sea level by about 15 to 95 cm. It is likely that changes of this magnitude and rapidity could pose severe problems for many natural and managed ecosystems. Indeed, for many low-lying and deltaic areas and small islands, a sea level rise of one meter could threaten complete loss of land and extinction of habitation.

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Extreme Weather Events

In addition, most of the ill effects of climate change are linked to extreme weather events, such as hot or cold spells of temperature, or wet or dry spells of rainfall, or cyclones and floods. Predictions of the nature and distributions of such events in a changed climate are even more uncertain- to the extent that virtually no authoritative predictions exist at all. While there are costs as well as benefits associated with climate change, the scientific consensus is clearly that the overall effects are likely to pose a significant burden on the global community. Unlike many other environmental issues, such as local air or water pollution, or even stratospheric ozone depletion caused by chlorofluorocarbons (CFCs), global warming poses special challenges due to the spatial and temporal extent of the problem covering the globe and with decades to centuries time scales.

Analysis and assessment of just what steps needed to be taken to limit greenhouse gas emissions. This process resulted in the negotiation of a protocol, the final details of which were completed at the third meeting of the Conference of the Parties to the Framework Convention held December 1-12, 1997, in Kyoto, Japan. The Kyoto Protocol to the United Nations Framework Convention on Climate Change commits industrialized nations to specific, legally binding emission reduction targets for six greenhouse gases: carbon dioxide, methane, nitrous oxide, hydro fluorocarbons, per-fluorinated compounds and sulphur hex fluoride.

First, although India does not currently have any obligations under the Convention to reduce its greenhouse gas emissions. It is important for us to develop a clear understanding of our emission inventory. We also need to document and analyse our efforts in areas such as renewable energy, wasteland development and a forestation - all of which contribute towards either reducing CO2 emissions or increasing CO2 removal from the atmosphere. Considering that these efforts may often be undertaken for a variety of reasons not directly related to global warming, but yet has benefits as far as climate change is concerned, we may be able to leverage such efforts in the international context. The Research community could contribute substantially in this regard. We need to significantly improve our ability to plan and adapt to extreme events such as floods, droughts, cyclones and other meteorological hazards. Any robustness that we build into the system in this regard will always stand us in good stead no matter what climate change actually transpires.

Global Warming and the Greenhouse Effect

In the late 1900's researchers realized that the world may be getting warmer. The last two decades of the 1900's witnessed some warm and cool years. However, not enough evidences were available to support the theory of global warming. But this a well-known fact that accumulation of several greenhouse gases can lead to a rise in temperature (global warming). If a global warming phenomenon sets in this would result in major changes in world's climate. The increase in temperature might lead melting of snow on poles, which would terrifically add, to ocean waters. Hence the level of seas, and oceans would rise, this would largely affect the coastal areas. These would submerge under coastal Waters due to expansion of seas and oceans. Besides the Temperate climate pattern would shift northward and present temperate regions would become hot & dry.

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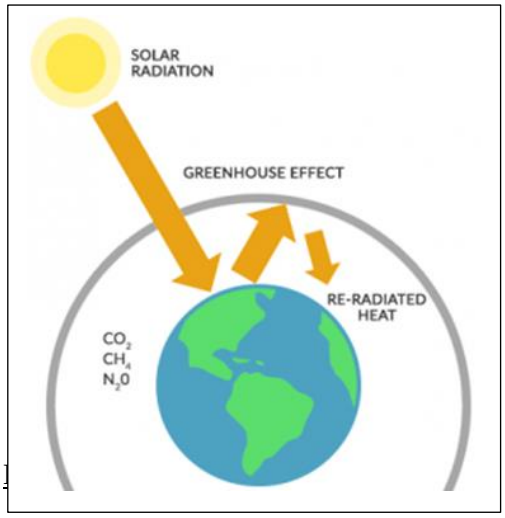
The Greenhouse Effect is a natural phenomenon that plays a central role, in determining the earth's climate. The hot surface of the sun radiates heat and light energy. Several gases in the atmosphere are transparent to light but absorb infrared radiation. These allow sunlight to pass through the atmosphere and be absorbed by the earth's surface. This energy is again radiated as heat energy, which is absorbed by the gases. As the effect is similar in nature to what happens in a botanical greenhouse (the glass panes allows the light energy to enter inside but diminishes the loss of heat), these gases are called greenhouse gases and the resultant warming from their increase is called the greenhouse effect. Anthropogenic activities add to the phenomenon accelerating greenhouse gas building process. Global increase of greenhouse gases in the atmosphere viz., carbon dioxide, nitrous oxide, methane and chlorofluorocarbons are now well documented. Hence, global warming is a result of "enhanced greenhouse effect."



1. Melting of glaciers and ice-sheets of the Arctic and Antarctica, causing a rise in sea-levels and submergence of low-lying areas. Islands like Maldives and coastal areas in all the continents are threatened.
2. Loss of biodiversity- Many species unable to adapt to the rapidly changing climate would go extinct. Habitats like coral reefs are especially threatened.
3. Extreme weather events like floods, droughts and cyclones throw the normal life of people out of balance.
4. Some areas of earth might become uninhabitable, triggering mass migrations and social unrest.

Ozone layer depletion

Joseph Farman, of the British Meteorological Survey, and colleagues reported in the scientific journal Nature that concentrations of stratospheric ozone above Antarctica had plunged more than 40 percent from 1960s baseline levels during October, the first month of spring in the Southern Hemisphere, between 1977 and 1984. It meant that for several months of the year a hole forms in the ozone layer, which protects animals and plants from ultraviolet solar radiation. Suddenly it seemed that the chemical processes known to deplete ozone high in the earth's atmosphere were working faster and more efficiently than predicted.

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Chemistry of the Ozone Layer

Oxygen molecules (O2), abundant throughout the atmosphere, are split apart into individual atoms (O + O) when energized by radiation from the sun. These atoms are free to collide with other O_2 molecules to form ozone (O_3). The particular configuration of the ozone molecules allows them to absorb the sun's radiation in ultraviolet wavelengths that are harmful to life if they penetrate to the earth's surface. The ozone molecules formed by collision are partially removed by other naturally occurring chemical reactions, and so the overall concentration of stratospheric ozone remains constant. High above the stratosphere, the density of gases is. so low that oxygen atoms rarely find other molecules to collide with, and ozone does not form in abundance. Below the ozone layer, too little solar radiation penetrates to allow appreciable amounts of ozone to form. Thus, most of the world's ozone is in a stratospheric layer bulging with ozone at latitudes from 10 to 35 kilometres. Closer to the ground, in the troposphere, ozone produced through a series of chemical reactions involving hydrocarbons and nitrogen oxide emissions from vehicles and industrial activity is an effective greenhouse gas. Thus, ozone plays two very different roles in global environmental change: one in the stratosphere as a shield against harmful ultraviolet radiation, and another nearer the ground in the troposphere as a greenhouse gas find a health hazard. The researchers hypothesized in 1974 that increasing concentrations of chlorofluorocarbons (CFCs), synthetic compounds that are chemically very stable in the lower atmosphere, rise unchanged through the lowest atmospheric layer, the troposphere. Even though CFCs are produced mostly in the industrialized countries of Europe and North America—where they are used in a wide variety of applications such as for solvents and refrigerants. The researchers surmised that upon reaching the stratosphere, the CFCs encounter high-energy ultraviolet light', which breaks them down, releasing their chlorine atoms. The chlorine atoms can then engage with ozone in a catalytic reaction in which each chlorine fragment can destroy up to 100,000 ozone molecules before other chemical processes remove the chlorine from the atmosphere.

Effects of ozone layer depletion

1. Increased exposure to UV-radiations, causing increased incidence of skin cancer, cataract and reduced immunity.
2. Damage to exposed organisms in an ecosystem including plants, causing a decrease in photosynthesis and change in community structure.
3. Rapid decline in agricultural productivity.

Nations Joining hands to Protect the Ozone Layer

The Montreal Protocol on Substances That Deplete the Ozone Layer, negotiated in September 1987, calls for 50 per cent reduction in CFC production from 1986 levels by 1999. Forty-nine nations- including Canada, the United States Japan, and many nations in Europe, which together consume 80 percent of the chemicals controlled-have ratified the protocol. The protocol is a delicate balance between the most up-to-date scientific information, reliable industrial expertise, and committed political leadership, all supported by strong and informed public interest. The Montreal Protocol may prove to be a model for actions that span national boundaries and interests as the world addresses common environmental issues such as greenhouse warming and other forms of global change.

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Acid Rain

Acid rain literally means the presence of excessive acids in rain waters. Acid precipitation is a mixture of strong mineral acids sulphuric acid (H_2SO_4), nitric acid (HNO_3) and in some locations, hydrochloric acid (HCl). It usually has a pH of less than 5.6, the value of distilled water in equilibrium with atmospheric carbon dioxide. Acid rain problem is a result of anthropogenic activities. Most acids come from cars, homes, industries and power stations but some share is contributed by natural sources such as volcanoes, swamps and planktons. The acid problem is basically associated with the transport and subsequent deposition of oxides of sulphur, nitrogen and their oxidative products. These are produced by combustion of fossil fuels, power plants, automobile exhausts and domestic fires etc.

Formation of Acid Rain

Acid rain is one of the forms of acid deposition which can either be wet or dry, acid rain, snow, dew, fog, frost and mist are the wet form of deposition, while dust particles containing sulphate and nitrates which settle on ground is called dry deposition.

Wet Acid Rain

Coal, fuel wood or petroleum products have sulphur and nitrogen. These elements, when burnt in atmospheric oxygen,' are converted into their respective oxides (SO2 and NO3), which are highly soluble in water. By anthropogenic and by natural sources, oxides of sulphur and nitrogen enter the atmosphere.

Reactions

Reaction with Sulphur

$S + O_2 = SO_2$

$2SO_2 + O_2 = 2SO_3$

Reaction with Nitrogen

$NO + O_3 = NO_2 + O_2$

$NO_3 + NO_2 = N_2O_5$

When air is saturated with water droplets (humid conditions), N_2O_5 invariably reacts with water vapour to form droplets of HNO_3.

$N_2O_5 + H_2O = 2HNO_3$

Besides some HNO_2 is also formed

$N_2O_3 + H_2O = 2HNO_2$

SO_3 in humid conditions forms droplets of H_2SO_4.

$SO_2 + ½\ O_2 + H_2O = H_2SO_4$

HNO_3 and H_2SO_4 thus formed combine with HCl to generate precipitation, which is commonly referred to as acid rain.

Effects of Acid rain

1. Decline in biodiversity of aquatic ecosystems due to decrease in pH.
2. Decline in primary productivity in all the ecosystems due to damage to plants.
3. Skin burns and itching on humans and animals.
4. Decline in agricultural productivity due to direct impact on crop plants and a decrease in soil pH.
5. Damage to houses, buildings and monuments like Taj Mahal.

Nuclear accidents

Nuclear energy was researched and discovered by man as a source of alternate energy which would be clean and cheap compared to fossil fuels. And although this did happen, along with the benefits of nuclear energy came its downfalls. In the short history of nuclear energy there have been accidents that have surpassed any natural calamity or other energy source extraction in their impacts. A single nuclear accident can cause loss of life, long-term illness and destruction of property on a large scale for a long period of time. Radioactivity and radioactive fallout lead to cancer, genetic disorders and death in the affected area for decades after, thus affecting all forms of life for generations to come.

Nuclear disasters and leakages

In 1986 the Nuclear Power Station at Chernobyl in USSR developed a problem that led to a fire and a number of explosions in its Nuclear Reactor. The radioactive dust spread over many kilometres and covered not only Europe but North America as well. Three people died in the explosion and 28 shortly after due to radiation exposure. Some 259 sick were hospitalized. As the area had to be evacuated 1,35,000 people had to be moved immediately and another 1.5 lac by 1991. As radioactive fallout continued even more people had to be moved. An estimated 6.5 lakh people may have been seriously affected. They may get cancer, thyroid tumours, and cataracts, and suffer from a lowered immune mechanism.

As radioactivity passes from grass to herbivores, sheep in Scotland and Reindeer in Lapland were affected and were unfit for human consumption. Vegetable, fruit and milk were contaminated in Europe.

A French Nuclear Waste Processing Centre in Normandy may have affected the lives of children playing nearby. They may develop leukaemia (blood cancer) in later life.

Nuclear holocaust:

The use of nuclear energy in war has had devastating effects on man and earth. The Hiroshima and Nagasaki incident during World War II, the only use of nuclear power in war in history, is one of the worst disasters in history. In 1945, the United States dropped atomic bombs in Japan over the towns of Hiroshima and Nagasaki. These two atomic bombs killed thousands of people, left many thousands injured and devastated everything for miles around. The effects of the radiation from these nuclear bombs can still be seen today in the form of cancer and genetic mutations in the affected children and survivors of the incident.