Unit 5

Sustainable development:

- Issues on energy utilization, water conservation, concept of 3 Rs, Rain water harvesting- methods
- Global environmental issues: Population growth, Urbanization, Global warming, Acid rains, Ozone layer depletion & controlling measures.
- Environmental acts, Regulations, Role of state & central governments,
- Introduction to GIS & Remote sensing, their applications in environmental engineering practices
- Numerical problem on carbon foot print & rainwater harvesting

Social issues and the environment

From Unsustainable to sustainable development: Human beings interact both with the social world and nature. Both, economic development and stable environment are required for the continual improvement of lifestyle and living standards. But until now, the development was human oriented and limited to rich nations. The development was achieved by damaging the environment and over exploitation of natural resources which were non renewable. That caused instability of environment and crossed the threshold limit of environmental damage.

Sustainable development can be defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." It is effective use of resources for economic development while preserving the environment and ecosystem so that not only the needs of presents are fulfilled but also for the future generations. Sustainable development also interlinks the development and carrying capacity of environment and ecosystem

Causes for Unsustainable Development.

- Some people argue that developing countries responsible for the degradation. Others hold Developed Countries are responsible for them.
- The important issues is not rate of increase of National Pollution, it is the rate of increase of Total Pollution. In this regard developed countries contribute much more than developing countries.

- Some people argue that raising population in the third world countries to be the crucial pollutant and it is essential to control it by all means.
- People should look at environment as not only reserve of man but of all living organism. So development has to sustain not only for man but also for all living organisms.

True sustainable development:

It aims at optimum use of natural resources with high degree of sustainity, minimum wastage, least generation of toxic byproducts and maximum productivity.

i. Inter generational equity - We should minimize any adverse impacts on resources and environment for future generation.

ii. Intra generational equity - Technological development of rich countries should support economic growth of poor countries and lead to sustainability.

- Don't use high quality energy to do a job that can be done with low quality energy.
- Place more emphasis on pollution prevention and waste reduction.
- Recycle and reuse as many of our waste products and resources possible.
- Make more goods that last longer and easy to use, recycle and repair.
- Depend on renewable source of energy, sun wind, biomass, flowing water, geo thermal and tidal.
- Sustain Earths Biodiversity with emphasis on protecting vital habitats of the wild species.
- Use potentially renewable resources such as wastes soil, plants, animals no faster than they are renewed.
- Increase the usage of non renewable resources to minimize the resource depletion at a faster rate.
- Earth Degrading activities should be discouraged
- Reduce poverty and rate of population growth

Measures for sustainable Development:

a) Using appropriate technology – It is one which is locally adaptable, ecofriendly efficient and culturally suitable. It involves local labors, less resources and produces minimum waste. the Concept is ‘’Design with Nature’’.

b) 3-R Approach - Reduce, Reuse and Recycle approach.

   Reduce the usage and also reduce the wastage of resource by making things that last longer and are easier to recycle, reuse and repair.

c) Promoting environmental education awareness - Environmental education will help in changing the thinking and attitude of people towards environment.

d) Population stabilization - We can achieve sustainable development by controlling population.

e) Conservation of nonrenewable resources - It should be conserved by recycling and reusing.

f) Usage of renewable resources - Usage of renewable resources should not be faster than their regeneration capacity.

The following four rules can be defined as the key mantras of sustainability. These four rules are

- Reduce our dependency on heavy metals and fossil fuels such as coal, oil and natural gas.
- Reduce our dependency on synthetic chemicals.
- Reduce our destruction of nature which includes clearing of forest and natural habitats for human needs.
- The fourth principal is to ensure that we don’t stop people from meeting their needs in order to achieve environmental sustainability. We must maintain a balance between environmental and economic sustainability.

Sustainable development also looks at the equity between countries and continents, races and classes, gender and ages. It includes social development and economic opportunity on one

hand and the requirements of environment on the other. It is based on improving the quality of life for all, especially the poor and deprived within the carrying capacity of the supporting ecosystems. It is a process which leads to a better quality of life while reducing the impact on the environment. Its strength is that it acknowledges the interdependence of human needs and environment.

To ensure sustainable development, any activity that is expected to bring about economic growth must also consider its environmental impacts so that it is more consistent with long term growth and development. Many 'development projects', such as dams, mines, roads, industries and tourism development, have severe environmental consequences that must be studied before they are even begun. Thus for every project, in a strategy that looks at sustainable development, there must be a scientifically and honestly done EIA, without which the project must not be cleared. Large dams, major highways, mining, industry, etc. can seriously damage ecosystems that support the ecological health of a region.

Forests are essential for maintaining renewable resources, reducing carbon dioxide levels and maintaining oxygen levels in the earth's atmosphere. Their loss impairs future human development. Loss of forests depletes biodiversity which has to be preserved to maintain life on earth. Major heavy industries if not planned carefully lead to environmental degradation due to air and water pollution and generate enormous quantities of waste that lead to long term environmental hazards. Toxic and Nuclear wastes can become serious economic problems as getting rid of them is extremely costly.

In order to safeguard the existence of life and future of humanity, we have to change our approach from unsustainable to sustainable development. A judicious balance between developmental activities and environmental protection should be assured. It is possible only trough sustainable development.

Urban energy crisis: Economic growth coupled with a growing population necessitates an increase in energy consumption. The need of the hour, therefore, is to meet the energy needs of all segments in the most efficient and cost effective manner while ensuring long-term sustainability. Current pattern of energy use (especially based on fossil based fuels) raise serious concern for three reasons.

1. The finite natural reserves of such energy.
2. Its detrimental effects on the global environment.
3. The threat to long term sustainability.

There is an obligation to create an energy use pattern that ensures energy efficiency, protects environmental integrity and maintains and enhances the strength of economy. Three hey issues that are likely to define the shape and future of energy in cities are the following.

1. Sustainability: How much and at what rate is energy consumed and its effect on long term sustainability, the quality and quantity of available alternative/renewable form of energy and the effect of existing energy use on the global environment.
2. Efficiency: The technology, planning and management of energy systems that will facilitate efficient use of energy for human activity.
3. Equity: The appropriate financial mechanism for research, development and use of finite and alternative energy forms and their equitable distribution for all human kind.

Some important issues on energy utilization in urban planning:

1. To build a comprehensive inventory of energy use patterns, particularly in urban areas of developing countries
2. To explore alternative and renewable energy sources
3. To link energy with global environmental issues (including GHG emissions)
4. To co-relate environmental management efficiency with energy efficiency
5. To demonstrate energy efficiency through sustainable transportation management
6. To understand energy consumption patterns from both the supply and demand sides

Water conservation: Water conservation encompasses the policies, strategies and activities to manage fresh water as a sustainable resource to protect the water environment and to meet current and future human demand. Population, household size and growth and affluence all affect how much water is used. Factors such as climate change will increase pressures on natural water resources especially in manufacturing and irrigation. Some of the methods of water conservation are

1. **Never throw water away.** If you pour too much out or have some left in your glass, use it. Pour the surplus into your dog's water dish, water a plant, or add it to your water kettle.

2. **Don't leave the tap running needlessly.** If you are washing your face and you need to get the tap warm, use that initial cooler water to brush your teeth, and then wash your face.
3. **Choose and use your appliances wisely.** Use energy star appliances whenever possible and always use them at full capacity. Choose economy settings and don't run the dishwasher half-full.
4. **Install a low-flow toilet and don't flush it more than necessary.** If it's yellow let it mellow.
5. **Make sure every tap in your home has an aerator.** They restrict water flow.
6. **Stop that leaky toilet.** Not only does it sound annoying, it wastes loads of water. Leaks can often be fixed by making minor adjustments.
7. **Repair dripping faucets by replacing washers.** According to American water and energy savers, a faucet that drips at the rate of one drop per second will waste 2,700 gallons per year.
8. **Shorter showers**. At the very least **replace your shower head** with a low-flow one. These are designed to maintain water pressure while using much less water than the old-fashioned sort.
9. **Insulate your water pipes.** You won't have to wait as long for hot water as an added bonus.
10. **Set up a rain barrel this summer.** You can collect rain water from your eaves to water your garden.

Rainwater harvesting:

Rainwater harvesting is the technique of collection and storage of rainwater in under ground aquifers or in manmade underground storage tanks near the surface. Sine construction of pucca tanks for collection of rainwater, for directly using it subsequently, proves very costly, the originally existing temple tanks (such as those existing in South India) can be easily used for this purpose. Construction of pucca tanks in individual houses has, however, been adopted in our country since ancient times to collect rainwater for its subsequent use in water scarce areas in states like Gujarat, Rajasthan and parts of Tamilnadu and Kerala.Even the house of Mahatma Gandhi at Porabander in Gujarat, used to have such a tank in the courtyard, well

connected with the roof to collect the rainwater. Several such tanks have been constructed by local residents in the sacred town of Dwaraka in Gujarat where rich devotees of Lord Krishna, visiting this temple town, are requested and persuaded to donate construction of such a tank in the house of a priest or a local poor resident.

The requirement of water in modern days is much more, as lot of water is consumed in flushing of toilets, washing of clothes in cloth washing machines, watering of lawns, washing of cars etc.

The artificial recharge of ground water through rainwater harvesting techniques has become very necessary, because the under ground reservoirs has been badly depleted through over withdrawal of ground water, after the electricity became available to us on a large scale. The number of wells and tube wells installed to lift large quantities of ground water for using it for irrigation as well as for domestic needs has resulted in lowering of the ground water table almost throughout the country, on a large scale.

Methods of rainwater harvesting:

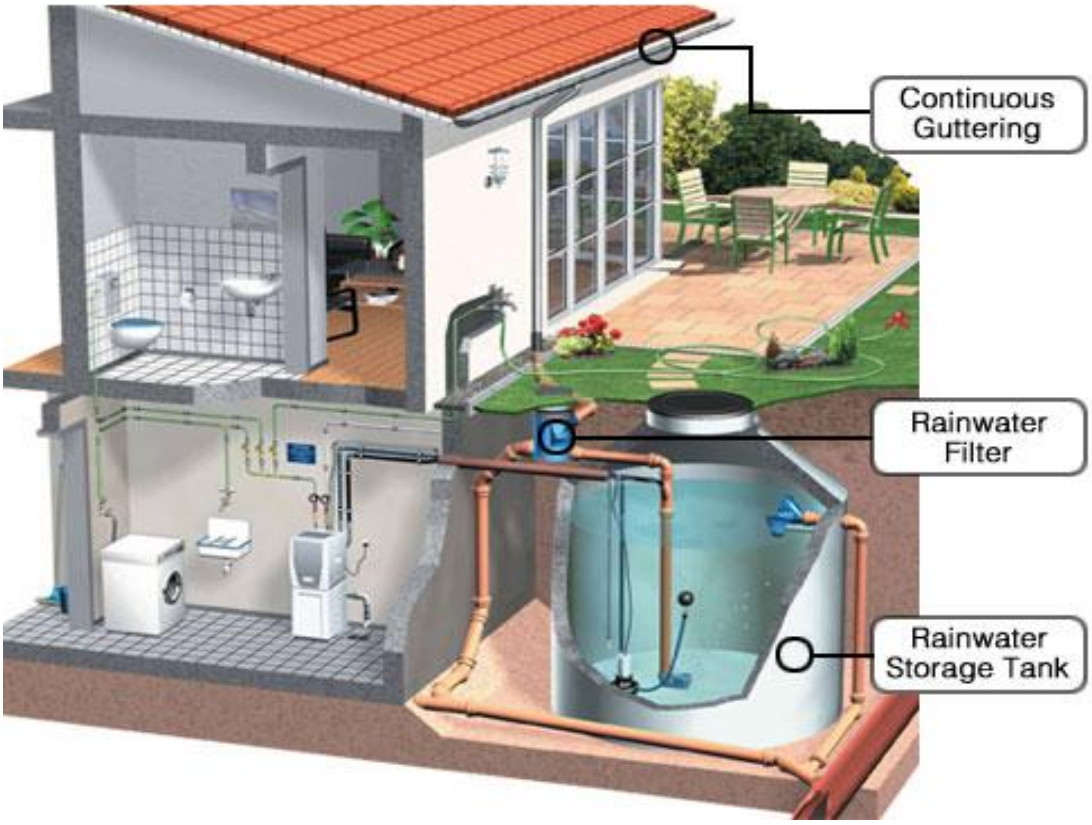
1. **On channel storage of rain water:** In this method, rain water is impounded in a long and large storm water drain, as to promote its infiltration to the under- ground reservoir. The stored water is also lifted sometimes through pumps and used for irrigation or for other purpose.
2. **Development and deepening of old village ponds:** In this method, the old existing village ponds are deepened and restored by removing encroachments and topping the inflow of sewage. This method, not only recharges the ground water, but also provides an aesthetic environment to the entire village.
3. **Creation of new water bodies:** In this method, abandoned courses of drains or escape channel are used to develop new water bodies, which are filled up by diverting the storm runoff.
4. **Construction of gabion bunds and check dams:** Gabion bunds or check dams are constructed across small streams to conserve flows, with practically no submergence above the normal water levels of the stream during rainy season. The structure is a small bund constructed across the stream by placing locally available boulders (stones).

5. **Construction of soil conservation bunds to create percolation tanks:** Earthen bunds are sometimes constructed across streams or lakes duly provided with masonry spillway. The percolation tanks are preferably constructed on streams located on highly fractured and weathered rocks, which have lateral continuity downstream. The recharged area downstream should have sufficient number of well and cultivable land to lift water from ground water table to avoid any abnormal rise in the water table and so as to keep the water logging and salinity away.

6. **Construction of recharge trenches or recharge shafts:** This is the most efficient and cost effective method to recharge an unconfined aquifer overlain by an impervious or poorly permeable strata. Recharge shaft may be dug manually if the strata are of non-caving nature or may be drilled through hand augers. The depth of the shaft will depend upon the availability of the first aquifer below the top impervious soil strata. The shaft should end in a permeable strata, though it may not touch the water table.

7. **Roof top rainwater harvesting:** Collection of rain water from the paved roofs or G.I. corrugated roofs and paved court yards of houses, either in storage tanks or in the ground water reservoir is known as roof top rainwater harvesting. The collected water serves as a good source of water in water scarce areas.

In its simplest form, the roof top water harvesting involves taking down a PVC or M.S.pipe from the roof's outlet to the ground floor, which can be connected to a water tank (placed either above the ground level or below the ground level) or to the under ground water table. The rain water before collection should, however, generally be passed through simple sand or charcoal filters for the removal of suspended particles and micro-organisms from the rain runoff being collected. These filters need to be periodically cleaned to prevent clogging of its pores. The roofs or court yards should be kept as clean as possible at the time of rains.



Acid rain: The term acid rain was first used by Robert Angus in 1872. It means the presence of more acid in rainwaters. Acid rain mainly contains sulfuric acid and nitric acids. The ratio of these two may vary depending upon the presence of oxides of sulphur and nitrogen in the atmosphere. Sulfuric acid is the major contributor (60-70%0, to the acid rain. Nitric acid ranks second (30-40%) followed by hydrochloric acid.

Acid rain is a form of air pollution, currently a subject of great concern because of the wide spread environmental damages due to corrosive nature. Acidification of environment is a man made phenomenon. The problem begins with the production of sulfur dioxide and nitrogen oxides from the burning fossil fuel, such as coal, natural gas and oil, and from certain kinds of manufacturing. Power stations and smelters are the major source of these pollutants. The volcanoes, swamps and plankton in the ocean and CO_2 are the natural sources that contribute to some amount of acid in rain. These acid pollutants reach high into the atmosphere, travel with the wind for hundreds of kilometer and eventually return to the ground by way of rain (acid rain), snow, dew, fog or mist that represent the wet form of precipitation, while dust particles containing sulphates and nitrates settled on earth, is called dry deposition (acid

deposition). The dry form of such precipitation is as just as damaging to the environment as the liquid form. However the wet rain is much more common.

Unpolluted rain is naturally acidic because CO_2 from the dissolves to a sufficient extent to form carbonic acid (H_2CO_3). Generally unpolluted rain is weakly acidic and has pH of 5.6. In some cases acid rain of as low as pH 3.0 is observed. The acid rain has a pH as low as 4.0 are 10 times as acidic as normal rain with pH 5.0. This is because pH scale is a logarithmic one and each smaller whole number represents a ten times increase in the level of acidity.

Acid rain formation: Unpolluted rainwater is slightly acidic due to the presence of CO_2

in the air. Its pH is 5.6.

$$CO_2 + H_2O \rightarrow H_2CO_3$$

Therefore, rainwater having pH lower than 5.6 is called acid rain. Sulfur dioxide is the primary cause of acid rain. The Sulphuric acid (H_2SO_4) forms in the atmosphere by the following reaction.

Burning coal

$$S + O_2 \rightarrow SO_2$$

Formation of Sulfur trioxide

$$2SO_2 + O_2 \rightarrow 2SO_3$$

Dissolved in water droplet

$$SO_3 + O_2 \rightarrow H_2SO_4$$

The formation of sulphur trioxide from SO_2 is influenced by the prevailing conditions such as temperature, humidity, sunlight, particulates, presence of hydrocarbons and nitrogen oxides. During the formation of sulphuric acid sulphurous acid is also formed.

$$SO_2 + H_2O \rightarrow H_2SO_3$$

Nitrogen oxides released from power plants and vehicular emissions.

Formation of Nitric acid

$$2NO + O_2 \rightarrow 2NO_2$$

NO_2 dissolves in water droplets.

$$4NO_2 + H_2O + O_2 \rightarrow 4HNO_3$$

Effects of acid rain:

a) Effect on soil:

- In soil, acid rain dissolves and washes away nutrients needed by plants.
- It also dissolves toxic substances such as aluminum and mercury that are naturally present in some soil and free them to pollute water or to poison plants that absorb them.

b) Effect on trees:

- By removing useful nutrients from the soil, acid rain slows the growth of plants, especially trees.
- It also attacks trees more directly on the waxy coating of leaves and needles, causing brown dead spots. If more such spots are formed a tree loses its ability to make prepare food through photosynthesis. Once the leaves are weakened, trees are more vulnerable to other stresses such as insect infestations, drought and cold temperature.

c) Effect on surface waters:

- Acid rain falls into drains, streams, lakes and marshes. Where there is snow cover in winter, local waters turns to be more acidic when the snow melts in the spring.
- In natural water bodies sediments contains metals such as zinc, cadmium, nickel, chromium, copper, mercury etc. The acidic P^H effects the mobility of the metals presents in sediments towards the over lying water through direct dissolution.
- As lakes becomes acidified the diversity of phytoplankton species decline due to stresses on acid sensitive organisms.

d) Effect on plants and animals:

- The effect of acid rain on wild life can be far reaching. If a population of one plant or animal is adversely affected by acid rain, animals that feed on that organism may also suffer. Ultimately entire ecosystem may become endangered.
- Some species that live in water are very sensitive to acidity and some are less sensitive. Fresh water clams and mayfly young die when the water P^H is less than6.0.
- Fish eggs of most species stop hatching at a P^H of 5.0.
- Water with P^H below 4.5 is unable to support any wild life.
- Land animals dependent on aquatic organisms are also affected.

e) Effect on materials:

- Acid rain and the dry deposition of acidic particles damage buildings, statues, automobiles and other structures made of stone, metal etc
- Both Parthenon in Athens, Greece and Taj Mahal in Agra, India is deteriorating due to acid pollution.
- Stones that contain calcium carbonate or calcium sulphate are particularly susceptible to acid pollution.

f) Effect on human health:

- In the air acids join with other chemicals to produce urban smog that can irritate the lungs and make breathing difficult, especially for people who already have asthma, bronchitis or other respiratory diseases.

Ozone layer depletion: Ozone layer depletion describes two distinct but related phenomena observed since the late 1970s: a steady decline of about 4% per decade in the total volume of ozone in Earth's' stratosphere (the ozone layer), and a much larger springtime decrease in stratospheric ozone over Earth's Polar Regions. The latter phenomenon is referred to as the ozone hole. In addition to these well-known stratospheric phenomena, there are also springtime polar troposheric ozone depletion events.

The details of polar ozone hole formation differ from that of mid-latitude thinning, but the most important process in both is catalytic destruction of ozone by atomic halogens The main source of these halogen atoms in the stratosphere is photo-dissociation of man-made halocarbon refrigerants, solvents, propellants, and foam-blowing agents (CFCs HCFCs, freons , halons). These compounds are transported into the stratosphere after being emitted at the surface. Both types of ozone depletion have been observed to increase as emissions of halo-carbons increased.

CFCs and other contributory substances are referred to as ozone-depleting substances (ODS). Since the ozone layer prevents most harmful UVB wavelengths (280–315 nm) of Ultraviolet light (UV light) from passing through the Earth's atmosphere, observed and projected decreases in ozone have generated worldwide concern leading to adoption of the Montreal Protocol that bans the production of CFCs, halons, and other ozone-depleting chemicals such as carbon tetrachloride and trichloroethane.

Impacts of ozone depletion:

Stratospheric ozone filters out most of the sun's potentially harmful shortwave ultraviolet (UV) radiation. If this ozone becomes depleted, then more UV rays will reach the earth. Exposure to higher amounts of UV radiation could have serious impacts on human beings, animals and plants, such as the following:

Harm to human health:

- More skin cancers, sunburns and premature aging of the skin.
- More cataracts, blindness and other eye diseases: UV radiation can damage several parts of the eye, including the lens, cornea, retina and conjunctiva.
- Cataracts (a clouding of the lens) are the major cause of blindness in the world. A sustained 10% thinning of the ozone layer is expected to result in almost two million new cases of cataracts per year, globally.
- Weakening of the human immune system (immunosuppression). Early findings suggest that too much UV radiation can suppress the human immune system, which may play a role in the development of skin cancer.

Adverse impacts on agriculture, forestry and natural ecosystems:

- Several of the world's major crop species are particularly vulnerable to increased UV, resulting in reduced growth, photosynthesis and flowering. These species include wheat, rice, barley, oats, corn, soybeans, peas, tomatoes, cucumbers, cauliflower, broccoli and carrots.
- The effect of ozone depletion on the Canadian agricultural sector could be significant.
- Only a few commercially important trees have been tested for UV sensitivity, but early results suggest that plant growth, especially in seedlings, is harmed by more intense UV radiation.

Damage to marine life:

- In particular, plankton (tiny organisms in the surface layer of oceans) are threatened by increased UV radiation. Plankton are the first vital step in aquatic food chains.
- Decreases in plankton could disrupt the fresh and saltwater food chains, and lead to a species shift in Canadian waters.

- Loss of biodiversity in our oceans, rivers and lakes could reduce fish yields for commercial and sport fisheries.

Animals:

- In domestic animals, UV overexposure may cause eye and skin cancers. Species of marine animals in their developmental stage (e.g. young fish, shrimp larvae and crab larvae) have been threatened in recent years by the increased UV radiation under the Antarctic ozone hole.

Materials:

- Wood, plastic, rubber, fabrics and many construction materials are degraded by UV radiation.
- The economic impact of replacing and/or protecting materials could be significant.

Steps to protect ozone layer:

Everyone should be responsible for the use and abuse of certain products that have a negative effect on nature.

There are many and simple ways in which we can save our ozone layer. With these simple rules we can create a chain of conciousness that will make manufactures stop creating non-environmentally friendly products.

Habits to care the ozone layer

Let's this well-known phrase "Any long trip begins with a first step" be part of our everyday life.

- Avoid buying and using aerosols and sprays composed of chlorofluorocarbon (CFC).
- Avoid using fire extinguishers with halogenated hidrocarbon since it is a very agressive substance for the ozone layer.
- Avoid buying insulating material made up of CFC. Instead you can use dark chipboard cork that performs the same function and does not contaminate the environment.

- Maintain air-conditioning clean because if they do not function properly, they emmit CFC to the atmosphere.
- Check the frezeer and car air-conditioning. If they do not function properly, have them repair because they may have leaks.
- Opt to buy a refrigerator or an air-conditioning without CFC.
- Report wether you know that products with bromomethane are used in some sown fields and crops because these substances are contaminating.

Climate change and global warming:

Climate: It is the average long-term weather of an area. Climate is region's general pattern of atmospheric or weather conditions, seasonal variations and weather extremes

(Such as rain or prolonged drought) averaged over a period of 30 years.

Weather: At any given place and time, earth (troposphere) has a particular set of physical properties, including temperature, pressure, humidity, sunshine, cloud cover, precipitation, wind direction and speed, which is called weather.

Temperature and precipitation of an area are the most important factors that determine the climate. The temperature and precipitation patterns that lead to different climates are caused mostly by the way air circulates over earth' surface. Heat and moisture in air are distributed over earth's surface by vertical convection currents that forms six large convection cells (called Hadley cells) at different latitudes. The direction of air flow, ascent or descent of air masses in these convection cells determines earth's general climatic zones. The uneven distribution of heat and moisture over the planet's surface lead to the grass lands, forests and deserts earth's Biomes.

Large variations in the climate are dictated by temperature, with its seasonal variations and by the quantity and distribution of precipitation. Thus climate and global air circulation are mainly affected by the properties of water and air. The water is recirculating in the environment. Addition of air pollutants (CO_2) to the atmosphere leads to change in composition of air. The addition of more quantity of CO_2 increases the temperature of air by retaining radiation and increases the temperature of the atmosphere. This effect is called green house effect or global warming.

Green House Effect:

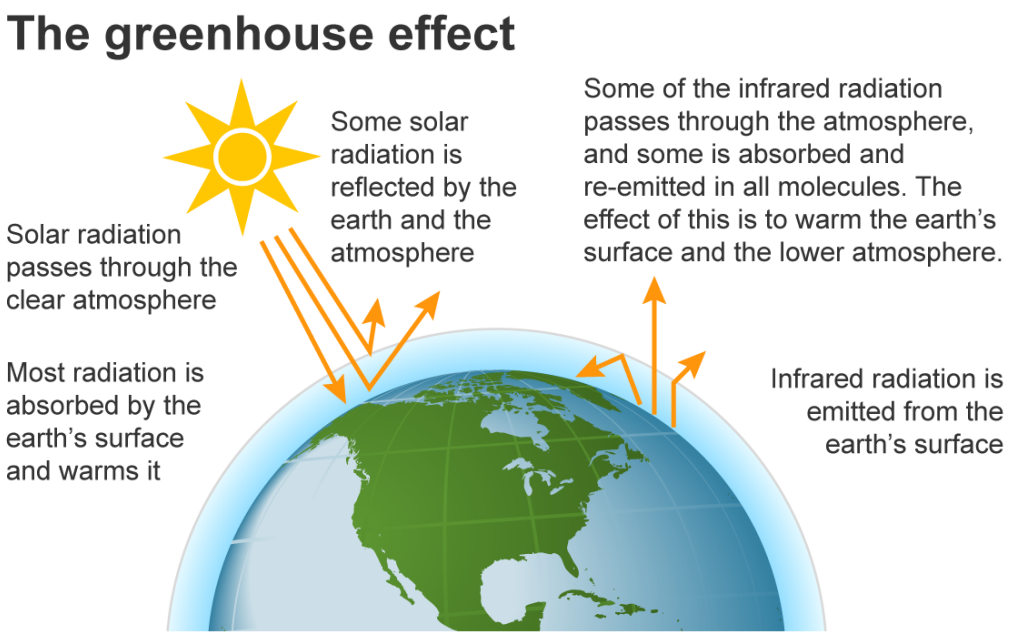


Fig: Greenhouse Effect

The green house effect is caused by atmospheric gases such as carbon dioxide, methane, nitrous oxide, water vapour, ozone and chlorofluorocarbons (CFCs) that trap infrared waves that radiate from the earth's surface. Collectively, these gases are called as green house gas. These gases act like a glass plate of green house. They allow light, infra red radiation and ultraviolet radiartion from the sun to pass through the troposphere and fall on the earth. Earth's surface absorb much of this solar energy and radiate back longer waves infrared radiations, i.e.,heat, into the outer space (troposphere).

However when concentration of green house gases (especially CO_2) in the atmosphere increases, the thick envelop of this gases prevents the heat from re-radiating out Some of this heat is absorbed by the molecules of green house gases and some escapes into the space and some radiated back towards the earth's surface. This process continues and the air gets warmed up. This process of trapping of heat in the troposphere is called green house effect.

The green house effect is a phenomenon based on the principle of infrared absorption characteristics of gases. Higher the concentration of green house gases, greater will be the absorption of thermal radiations. The absorbed infrared radiation is trapped and reemitted to earth's surface, resulting in a heat trap which has resulted in increased mean global temperature.

Effects of global warming:

a) Climate effects:

- There will be a warming of earth's surface at lower atmosphere and cooling at stratosphere.
- The warming of earth's surface is varied. Warming in the tropics is smaller than the global mean by about 2.3^0C depending on seasonal changes.
- Precipitation pattern will change. Some areas will be more wetted and some areas are drier.
- Soil moisture regimes will be changed due to changes in precipitation and evaporation.
- Seasonal pattern will change due to change in precipitation pattern and temperature.
- Wind direction and wind stress over the sea surface will change, which will alter the ocean current.

b) Rise in sea level: It is estimated that sea level will rise by 10-30 cm by the year 2030 and 30-100 cm by 2100. The direct effects are recession of shore line and wet lands, increased tidal and estuarine salt front intrusion and contamination of fresh water aquifer with salt water.

c) Water resources: The main consequence of climatic changes on water resources are changes in the global amount of water resources and its distribution, changes in extreme phenomena related to floods and droughts, changes in soil moisture, changes in sedimentation process and changes in water demand (for irrigation, domestic and industrial purposes, cooling systems, washing, gardening etc.).

d) Vegetation: Global warming exhibits direct and indirect geographical effects on vegetation. Direct effects occur through changes in the length of the growing seasons, the frequency of heat waves and altered patterns of rainfall. While indirect effects result from changes in topsoil management practices.

e) Human health: Human health effects are manifested by changes in morbidity and increase in mortality. Temperature changes may have an impact on respiratory diseases, cardiovascular diseases etc. Change in temperature and precipitation patterns has

potential impact on communicable diseases and it also provides new breeding sites for pests.

f) **Human settlement and society:** Due to the rise in sea water levels, hundreds of millions of people living in the coastal plains, islands and wet land areas would be displaced by the inundation of low lying areas. This leads to more concentrated population in urban areas and causes social problems.

g) **Energy:** Summer cooling electricity demands would increase while winter heating demands would decrease. Climate dependent energy uses such as space heating, cooling, water heating and refrigeration is affected by climate change.

h) **Clouds and water vapour:** Clouds are strong downward infrared radiators and short wave solar radiation reflectors. Global warming increases water vapour in the atmosphere. The water vapour is a known green house gas; this will lead to increase in the global warming.

Reduction of green house gases:

- Adopt clean electricity technologies such as wind energy, solar energy, hydrogen fuel etc.
- Biofuels such as biodiesel and ethanol could substantially cut down the CO_2 emissions from the automobiles.
- Conservation of energy and improving the energy efficiency will prevent the expansion and building of new power plants.
- Practicing sustainable farming and forestry techniques that reduce the CO_2 and CH_4 emissions.
- Phasing out the production of CFCs.
- Planting more trees around the world to help combat the excessive production of CO_2

ENVIRONMENT PROTECTION LAWS IN INDIA

The Constitution of India 1950 does not have any specific provision to deal with the problems of environmental pollution. Indirect mention of the environmental concern can be notice in Articles 21 and 47. A clear cut provision could find a place in the constitution only in the, year 1976 through the 42nd Amendment by inserting Article 48-A9 and a new Directive Principle of the State Policy, and creating a fundamental duty of every citizen under

Article 51-A(g)1O. By this, India was the first country to impose a Constitutional obligation on the state and citizens to protect and improve the environment as one of the prime duties. The constitution of India makes provisions for Environmental Protection in the Chapters on:

a) Fundamental Rights
b) Directive Principles of state policy
c) Fundamental Duties

The Article 21 deals with protection of life and personal liberty. It states " No person shall be deprived of his life or personal liberty except according to procedure established by law". The ambit and scope of "right to life" embodied in Article 21 is wide and far reaching. Article 47 of the constitution (1950) states that" State shall regard the raising of the level of nutrition and the standard of living of its people and improvement of public health as among its primary duties." Article 48A amended in 1976 states that "The state shall endeavor to protect and improve the environment and to safeguard the forest and wild life of the country".

The same Amendment was added as a fundamental duty to be observed by every citizen in Article 51-A(g): " To protect and improve the natural environment including forest, lakes, rivers and wild life and to have compassion for living creatures."

Central and state pollution control boards:

Functions of the Central Board

Main functions of the Central Board are as follows

1. To improve the quality of air and to prevent control or abate air pollution in the country.
2. To advise the central government on any matter concerning the improvement of the quality of air and the prevention control or abatement of air pollution.
3. To plan and execute a nationwide programme for the prevention control or abatement of air pollution and training programmes.
4. To coordinate the activities of the State Boards provide technical assistance carry ort and sponsor investigation and research relating to the prevention and control of air pollution.
5. Organize through mass media a comprehensive programme regarding prevention and control of air pollution.

6. Collect compile and publish technical and statistical data on air pollution and the measures devised for its prevention and control and compare manuals codes or guides.
7. Lay down standards for the quality of air.
8. Establish or recognize laboratories.

Functions of the State Boards

Main functions of the State Board are as follows:

1. To plan a comprehensive programme for prevention and control of air pollution and implement the same.
2. Advise the central government on any matter concerning air pollution including of any industry which is likely to cause air pollution.
3. Collect and disseminate information to collaborate with the Central Board in organizing training programmes and mass education programmes.
4. Inspect any control equipment industrial plants etc., and give by order such directions to such persons and may be necessary to take steps of prevention and control of air pollution.
5. Inspect air pollution control areas assess the quality of therein and take steps for prevention and control of air pollution.
6. Lay down in consultation with the Central Board standards for emissions of air pollutants into the atmosphere form industrial plants and automobiles.
7. To establish or recognize laboratories.

THE WATER (PREVENTION AND CONTROL OF POLLUTION) ACT, 1974.

According to this Act, "Pollution" means such contamination of water or such alternation of the physical, chemical or biological properties of water or such discharges of any sewage or trade effluent or of any other liquid, gaseous or solid substances into water (where directly or indirectly) as may, or is likely to create a nuisance or render such water harmful or injurious to public health or safety or to domestic, commercial, industrial, agricultural or other legitimate uses, or to the life and health of animals or plants or of aquatic organisms".

The Water Act was enacted by Indian Parliament Act in the year 1974. The objective of the Water Act was to prevention and control of water pollution and the maintaining or restoring of wholesomeness of water. This Act empower all the State Boards for prevention and

control of water pollution. Some salient features of this Act are:

- The assessing authority under the Act levies and collects cess based on the amount of water consumed by the industries; the rate is also determined by the purpose for which the water is used.
- Based on the cess, returns to be furnished by the industry every month, the amount of cess is assessed by the assessing authorities.
- Aggrieved persons may appeal against the assessment to the Appellate Authority..
- The Act also provides for a 25% rebate on the cess payable to these industries which consume water within the quantity prescribed for that category of industries and also comply with the effluent standards prescribed under the water or the Environment (Protection) Act.

THE AIR (PREVENTION AND CONTROL OF POLLUTION) ACT, 1981

This act was amended based on the decisions were taken at the United Nations Conference on the Human Environment, held in Stockholm in June 1972 in which India participated to take appropriate steps for the preservation of the natural resources of the earth which among other things, include the preservation of the quality of air and control of air pollution.

This is an Act to provide for the prevention, control and abatement of air pollution, for the establishment with a view to carrying out the aforesaid purposes of Board, for conferring on and assigning to such Boards powers and functions relating thereto and for matters connected therewith. Whereas it is considered necessary to implement the decision aforesaid in so-far as they relate to the prevention of the quality of air and control of air pollution. The objectives of this Air Act 1981, is to prevent, control and reduce air pollution including noise pollution and to establish Boards at the states I UTs for this purpose. Under the provision of this Act, no person shall establish, or operate any industrial plant without the consent of the SPCBI PCC.

For obtaining consent to establish an industry, the investor has to apply to the SPCB/PCC in the prescribed form (as per Act) accompanied by the prescribed fee. The Board is to grant consent to establish within 4 months of receipt of the application. The consent comprises of conditions relating to specifications of pollution control equipments to be installed. Other provisions of the Air Act are similar to the water Act 1974.

THE ENVIRONMENT (PROTECTION) ACT 1986 (EPA)

After the Bhopal gas tragedy, the Government of India enacted the Environment (Protection) Act 1986 (EPA), under article 253 of constitution of India. This act provides a frame work for central government co-ordination of the activities of various central and state authorities established under previous laws, such as Water Act and Air Act. The Environment (protection) Act, provides for the objectives; protection and improvement of environment (water, air and land) and prevention of hazards to all living creatures (human, plants, animals) and property, and maintenance of harmonious relationship between human beings and their environment. (The broad scope of this Act is with "Environment" defined to include water, air and land and the inter relationship which exist among them, human beings, other creatures, property plants and micro-organisms. This act includes the pollutants such as hazardous substances, by reason of its chemical or physico-chemical properties. Several set of Rules pertaining to management of hazardous wastes, chemicals, micro-organisms etc., have been notified under this act).

According to Section 2 of EPA, definition of important terms used in this act is:

a) **"Environment"** Includes water, air and land and the inter relationship which exists among them and property.

b) **"Environment pollutant"** Includes any solid, liquid or gaseous substances present in such concentration as may be injurious to environment.

c) **"Environmental Pollution"** Means the presence of any environmental pollutant in the environment.

d) **"Hazardous substance"** Means any substance which is liable to cause harm to human beings, other living creatures and property or environment by reason of its chemical or physico-chemical properties or handling.

Some ~important features of this Act are:

- The Central Government shall have power to take all such measures
- As it deems necessary or expedient for the purpose of protecting and improving the quality of the environment pollution.
- Planning and execution of a nationwide programme for the prevention, control and abatement of environmental pollution.
- Laying down standards for emission or discharge or environmental pollutions from various sources whatsoever; So far 61 categories of industries effluent standards have been evolved.

- Restriction of areas in which any industries, operations or processes or class of industries, operations or process shall not be carried out or shall be carried out subject to certain safeguards.
- Laying down procedures and safeguards for the handling of hazardous substances.

In this Act the Central Government has the powers for the Prevention, Control and Abatement of Environmental pollution, entry and inspection any place, to take samples, to establish laboratories, to put penalties for violating the provision in this Act.

Those industries who requires consent under the Water Act, Air Act or both or authorization to handle hazardous waste under Hazardous waste (Management and Handling) Rules, 1989, are required to submit an environmental audit report before 30th September of every year to the concerned SPCB/PCC.

THE WILDLIFE (PROTECTION) ACT 1972

The objectives of this Act are, to maintain essential ecological processes and life-supporting systems, to preserve the biodiversity and to ensure a continuous use of species i.e., protection and conservation of wild life. The definitions of the important terms are:

a) **"Wild life"** has been defined to include any animal, bees, butterflies, crustaceans, fish, moths and aquatic and land vegetation, which forms part of any habitat.
b) **Habitat** includes land, water or vegetation which is the natural home of any wild animal.
c) **Hunting means** to capture, kill, poison, share and trap any wild animal or trying to do so. Injure, destroy or take away any part of the body of such animal and damaging or disturbing the eggs or nests of wild birds and reptiles.
d) Animal articles include any article made from any part of a captive or wild animal (Antler, feather, tooth musk, horn hair, specimens of animals mounted in whole or part by taxidermy, skins, rugs etc.)

The Wildlife (Protection) Act 1972, emphasizes protection of wild and other animals within a broad ecological perspective. It provides for constitution of wild life advisory board, prohibition of hunting and dealing in animal articles without license, protection of specified plants, declaration of sanctuary and restriction on entry in sanctuary, declaration of national parks and closed area, constitution and functions of central zoo authority and penalties for violation of the provisions of this Act.

THE FOREST (CONSERVATION) ACT 1980

The Forest (conservation) Act, was enacted in 1980, and came into force with effect from 25th October 1980. The Act extends to whole of India except the state of Jammu and Kashmir. The Act was subsequently amended in 1988, has the five sections; Extent and commencement, Restriction on the degeneration of forests or use of forest land for non-forest-purpose, constitution of advisory committee, power to make rules and repeal and saving. This Act was further strengthened by adding through 1988 amendments, which deal with penalty for contravention of the provisions of the Act and offences by authorities and Government Department. Under this Act, the prior approval of the central government is essential for diversion of forestland for the non-forestry purpose. The basic objective of this Act is to regulate the indiscriminate diversion of forestlands for non-forestry uses and to maintain balance between the developmental needs of the country and the conservation of natural resource.

Prior to 1980, around 1.43 Lakhs hectare of forestland was diverted for non forestry purposes and this came down to 15000 hectare per annum due to this Act. The diversion of forest land is allowed for purpose other than reforestation, but does not include any work relating or ancillary to conservation, development and management of forests and wild life, namely; the establishment of check posts, fire lines, wireless communication and construction of fencing, dams, pipelines, roads, railways, or other like purpose. Compensatory Afforestation Management and Planning Authority (CAMPA) is being constituted at the national level to monitor the effective implementation of the compensatory afforestation in the country.

INTERNATIONAL AGREEMENTS ON ENVIRONMENTAL ISSUES

Among the United Nation, India is a signatory to a number of Multilateral Environment Agreements (MEA) and Conventions. The major ones are;

- Convention on International Trade in Endangered species of wild Fauna and Flora (CITES), 1973.
- Montreal Protocol on substances that deplete the Ozone layer, 1987.
- Basel Convention on Tran boundary Movement of Hazardous Wastes, 1989.
- UN Convention Frame work on Climate Change (UNFCCC), 1992.
- International Tropical Timber Agreement and the International tropical Timber Organization (ITTO), 1983 and 1994.
- UN Convention on Desertification, 1994.

Introduction to GIS & Remote sensing

GIS: It stands for Geographic Information System. It is defined as a framework that works on the principles of data collection, management, and evaluation. It is a vast field of science related to geography that combines complex data structures. It evaluates the spatial position and assembles layers of informative data into images. For example, 3D scenes and maps are created by using GIS technology.

Applications of GIS in Environmental engineering practices

The GIS technology can be employed in various subjects of environmental sciences that include urban planning, wastewater management, environmental impact assessment, impact prediction, disaster management, monitor marine pollution and air pollution, hazard identification, forest fire management, etc.

Advantages of GIS

The advantages of GIS are listed below.

- **Quick Access to Data:** GIS technology gives quick access to information or data that is getting stored by various components of GIS.
- **Cost-Effective Method:** The use of GIS technology is considered a cost-effective and modern method for predicting complex phenomena.
- **Better Decision Making:** It helps in better decision-making regarding many projects and also it has improved communication among concerned parties.
- **Visual Data Representation:** The geographic data gets represented through visual imageries that can be easily understood.
- **Keep Track of Complex Data:** It keeps the track of complex data and records ongoing changes in spatial locations.

Remote Sensing: It is defined as a process that detects and monitors the physical attributes of a location by remotely computing emitted and reflected waves. It is a process of acquiring a set of information about the Earth from a remote location.

Applications of Remote Sensing in Environmental engineering practices

Remote sensing has various applications in the field of Environmental Sciences that include a wide variety of subjects. Remote Sensing has its remarkable uses in hydrology, meteorology, urban planning and management, forestry/forest cover, droughts and soil conditions, etc.

Advantages of Remote Sensing

The advantages of remote sensing are listed below.

- **Date Representation through Satellite Images:** The acquired data is represented through satellite images that keep permanent records.
- **Monitors Ecological Factors:** Remote sensing helps in monitoring ecological factors of the Earth such as air and water quality, agricultural fields, etc.
- **Requires Less Fieldwork:** One advantage of using remote sensing is large data can be managed through computers while less fieldwork is required.
- **Quick Access to Satellite Images:** Satellite images that identify various landscape features can be easily accessed through remote sensing.
- **Multipurpose Use of Satellite Images:** Satellite images obtained through remote sensing can have various uses and interpretations.

The technology of GIS and Remote Sensing has vast applications in the field of environmental sciences. Within minutes the complex spatial data can be analyzed and presented through visual images. A quick comparison of ongoing environmental crisis can now be monitored and preventive measures could be suggested and adopted in no time. The use of GIS and RS technology provides quick access to stored data, efficiency in work performances, and enables decision-making based on the availability of GIS data. GIS is finding its deep roots in emergency operations that can allow the real-time representation of information.

Problem 1: Calculate the annual rain water potential for a gated community from the following data:

Total no. of houses = 90

Roof area of each house = 111.50 m^2

Average annual rainfall = 75 cm

Coefficient of runoff of roof surface (I) = 0.80

Solution:-

Quantity of rain water that can be harvested from each unit per year

$$= 111.5 \times 0.8 \times {}^{75}/_{100} = 66.9\,m^3/year = 66{,}900\ L/house/year$$

Therefore, for 90 houses $= 66{,}900 \times 90 = \mathbf{6{,}021{,}000\ L/year}$

(This water can be used without any further treatment for Vehicle washing, lawn watering and Street washing)

Problem 2: In a city of two Lakhs population, 5% population are having cars, on an average each car travels 90 km/day and consumes 7.5 liters of fossil fuel per 100 km. Calculate the carbon footprint. Assume 2.7 kg of CO_2 is emitted /liters of fuel.

Solution:-

Population of the city $= 200{,}000$

Number of vehicles in the city $= 200{,}000 \times 5/100 = 10{,}000$

Each car travels 90 km/day

Total distance travelled by all cars in the city per day $= 90 \times 10{,}000$

Given, consumption of fuel per each km = 7.5 ltr / 100km

Total fuel consumed by the cars in the city per day $= 90 \times 10{,}000 \times 7.5/100$

$$= 67{,}500\ L/day$$

CO_2 emitted $= 2.7 \times 67{,}500 = \mathbf{182{,}250\ kg/day}$

[Note: (In this problem, it is symbolically worked out just for cars in the city. Similarly, for other vehicles, industries, based on standards, quantity of CO_2 that emit from every activity can be worked and finally summed up and level pollution can be ascertained).

In this problem, further it is given that 1 liter of fuel emits 2.7 kgs of CO_2 How?

Using molecular weight of carbon = 12 and oxygen = 16

When 1 liter of fuel is burnt = 2.7 x 12/44 = 0.736 kg of carbon is released.

The released carbon reacts with O_2 in atmosphere and gives 2.7 kgs of CO_2].

Problem 3: A city is having a population of 2 Lakhs, 8% of its population having their own cars. Assuming an average each car consumes 7.5 liters of diesel per 100 km and runs 70 km/day, calculate the carbon footprint. Assume 2.8 kg of carbon dioxide is emitted per liters of diesel.

Solution:-

Population of the city $= 200{,}000$

Number of vehicles in the city $= 200{,}000 \times 8/100 = 16{,}000$

Each car travels 70 km/day

Total distance travelled by all cars in the city per day $= 70 \times 16{,}000 = 1{,}120{,}000$ km

Given, consumption of fuel per each km = 7.5 L / 100km

Total fuel consumed by the cars in the city per day $= 70 \times 16{,}000 \times 7.5/100$

$= 84{,}000$ L/day

CO_2 emitted $= 2.8 \times 84{,}000 = \mathbf{235{,}200\ kg/day}$