

SUSTAINABLE DEVELOPMENT

- Our technological development has strong impacts on the natural as well as the social components
- Development does not mean an increase in GNP (Gross National Product) of a few different nations
- They have touched the greatest heights of scientific and technological development but at what cost? The air we breathe, the water we drink, and the food we eat have all badly polluted
- Our natural resources are just dwindling due to over exploitation. If this growth continues in the same way we will be facing a doom's day as suggested by the world's famous report "The limits to growth"
- Development has to be visualized in a holistic manner, where it brings benefits to all, not only for the present generation but also for future generation
- According to G.H.Brundtland (Norwegian Prime minister & Director of WHO) **Sustainable development is defined as "meeting the needs of the present without compromising the ability of future generation to meet their own needs"**.

Principles of Sustainable development

- Improving the quality of human life
- Economic growth for all
- Environmental development

Objectives of sustainable development

- To protect our biodiversity
- To increase forest cover
- To prevent pollution
- To reduce waste
- Design ecofriendly technology
- To control population growth

Key aspects for sustainable development:

1) Inter – generational equity:

We should minimize any adverse impacts on resources and environment for future generations

We should handover a safe, healthy, and resourceful environment to our future generations

This is possible only if we stop over exploitation of resources, reduce waste discharge and emissions and maintain ecological balance.

2) Intra – generational equity:

The development process should seek to minimize the wealth gaps within and between nations

The technology should address to the problems of developing countries, producing drought tolerant varieties for uncertain climates, vaccines for infectious diseases, clean fuel for domestic and industrial use.

This will support the economic growth of poor countries, narrowing the wealth gap and lead to sustainability

MEASURE FOR SUSTAINABLE DEVELOPMENT

Using appropriate technology:-

-It is one which is locally adaptable, eco-friendly and resource efficient and culturally suitable.

-This concept of Nature – often taken as model is called “design with Nature”.

-The technology should use less of resources and should produce minimum waste.

Adoption 3 R's (Reduce, Reuse and Recycle):-

-The 3-R approach advocating minimization of resource use, using them again, recycling the materials goes a long way in achieving the goals of sustainability.

-It reduces pressure on our resources as well as reduces waste generation and pollution.

Promoting Environmental Education & Awareness:-

-Making environmental education the center of all learning process will, greatly help in changing the thinking and attitude of people towards our earth and the environment.

Resource Utilization as per carrying capacity:-

-In order to attain sustainability it is very important that consumption should not exceed regeneration and changes should not allow to occur beyond the tolerance capacity of the system.

Urbanization

Urbanization is the movement of human population from rural areas to urban areas for the want of better education, communication, health, employment, etc.

Causes of urbanization

People move from rural areas to urban areas because cities offer more favorable conditions for the resolution of environmental and social problems than rural areas. A few specific reasons for urbanization are summarized below:

- (i) People move into cities to seek jobs and income.
- (ii) With good governance, cities can deliver education, health care and other services more efficiently than rural areas.
- (iii) Cities provide opportunities for women's empowerment and social mobilization.
- (iv) Density of urban life relieves pressure on areas of biodiversity and natural habitats.
- (v) It is through cities that foreign money flows into a country (whether the source is tourism or trade).
- (vi) Restaurants, movie theaters, theme parks and other varieties of entertainment are available in cities.

Drawbacks of Urbanization

Often people who leave rural areas to find better jobs in the city have no choice but to settle in slums, where they lack access to decent housing, drinking water, sanitation, health care and education.

- **Crimes:** Chances of robbery, murder, assault, etc., increases with unplanned urbanization.
- **Poverty:** Poverty is growing faster in urban than in rural areas. One billion people live in urban slums, which are typically overcrowded polluted and dangerous. Urban areas are not self-sustaining. They survive only by importing food, water, energy, etc. However, they also produce large quantities of waste.
- **Urban Heat Island:** As urban and industrial areas are developed, the majority of the sun's energy is absorbed by urban structures and asphalt. Thus, during warm daylight hours, less evaporative cooling in cities allows surface temperatures to rise higher than in rural areas. Additional

city heat is given off by vehicles and factories as well as by domestic and industrial cooling and heating units. This effect causes the city to become 1 to 6°C warmer than surrounding landscapes. Impacts also include intensification of carbon dioxide emissions and reducing soil moisture. The *urban heat island* has become a growing concern and is increasing over the years.

Urbanization is also responsible for pollution (air, water, noise, etc.) and traffic congestion.

Urban Problems Related to Energy

Urban center use enormous quantities of energy. In the past, urban housing required relatively smaller amounts of energy than we use at present. Traditional housing in India required very little temperature adjustments as the material used, such as wood and bricks, handled temperature changes better than the current concrete, glass and steel of ultra-modern building.

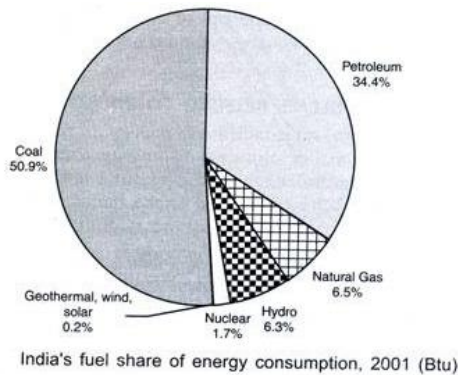
The urban growth is so fast that it is becoming difficult to accommodate all the industrial, commercial and residential facilities within a limited municipal boundary. As a result there is spreading of the cities into the sub-urban or rural areas too, this phenomenon is known as “urban sprawl”.

In developing countries, urban growth is very fast and pollution is uncontrollable and unplanned growth. When compared to rural people, an urban person consumes a lot of energy and materials and generates a lot of waste. This is because urban people have a higher standard of life and their life style demands more energy inputs.

Examples for energy demanding activities

1. Residential and commercial lightings.
2. Transportation means including, motor cycle, car and public transport for moving from residence to work place.
3. Industries using large proportional energy.
4. Modern life-style using a large number of electrical gadgets (fan, fridge, washing machine, A/C, water heater, etc.) in everyday life.
5. Control and prevention of pollution, need more energy dependent technologies.

The two sources of energy are renewable and non-renewable energy sources. Optimal usage shall be the ideal mode for energy conservation. For an integrated management system we should have renewable energy as well as non-renewable energy sources.



At local level, biomass energy tapping, use of solar cooker, solar water heaters and solar photovoltaic cells must be encouraged. This shall be utilised besides the conventional energy from fossil fuels, hydel, thermal and nuclear power resources.

Thus due to high population growth and high energy demanding activities, the urban problems related to energy are much more magnified as compared to the rural population.

WATER CONSERVATION:

Water being one of the most precious and indispensable resources needs to be conserved.

The following strategies can be adopted for conservation for water:

1) Decreasing run off losses: This can be achieved by

- ☐ **Contour cultivation** on small furrows and ridges across the slopes trap rainwater and allow more time for infiltration
- ☐ **Conservation bench terracing** involves construction of a series of benches for catching the runoff water
- ☐ **Water spreading** is done by channeling or lagoon travelling
- ☐ Lagoon travelling means small depressions are dug in the area so that there is temporary storage of water
- ☐ **Chemical wetting agents or conditioners** like Gypsum when applied to soils improves soil permeability and reduce runoff
- ☐ **Surface crop residues** Tillage, mulch, animal residues
- ☐ **Water storage structures** like farm ponds, dug wells

2) Reducing evaporation losses:

- ☐ Horizontal barrier of asphalt placed below the soil surface increases water availability
- ☐ A co-polymer of starch and acrylonitrile called super slurper absorbs water 4000 times its weight

3) Storing water in soil:

- ☐ Soil should be wetted to field capacity
- Leaving the soil fallow for one season water can be made available for the next season for crop growth

4) Reducing irrigation losses:

- ☐ Use of lined canals to reduce seepage
- ☐ Irrigation in early morning or late evening
- ☐ Sprinkling irrigation or drip irrigation

5) Reuse of water:

- ☐ Treated waste water can be used for ferti-irrigation
- ☐ Using grey water from washings, bath tubs for watering gardens washing cars

6) Preventing wastage of water:

- ☐ Closing taps when not in use
- ☐ Repairing any leakage from pipes

7) Increasing block pricing:

- ☐ The consumer has to pay a proportionately higher bill with higher use of water

RAIN WATER HARVESTING:

Objectives

- ☐ To reduce runoff loss
- ☐ To avoid flooding of roads
- ☐ To meet the increasing demands of water
- ☐ To raise the water table by recharging ground water

Rain water harvesting techniques:

Rainwater harvesting means collecting rainwater and storing/conserving it for a later use.

Various Methods of Rainwater Harvesting

There are two main methods of rainwater harvesting:

Storage of Rainwater on the Surface for Future Use: In this method, traditional water-harvesting structures like artificial lakes, ponds, etc., are used as such or after proper revival.

Recharge of Ground Water: The structures used for recharge of ground water are as follows:

(a) *Hand Pumps* The water should pass through a filter bed before percolation in existing hand pumps. They are used for recharging aquifers.

(b) *Pits* They are 1–2 m wide and 3 m deep. They are also back filled with gravel and coarse sand to aid filtration before percolation to the ground. They are used for recharging a shallow aquifer.

(c) *Dug Wells* The rain water, after filtration, is put into existing dug wells for storage.

(d) *Roof-Top and Road-Rop Collection of Rainwater* In urban areas, these methods are very useful to recharge aquifers.

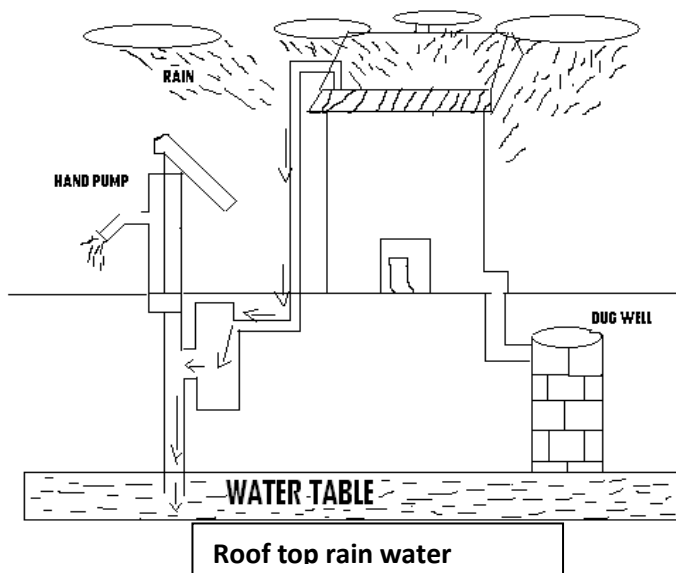
How to Harvest the Rainwater?

Rainwater harvesting systems consists of the following components:

- Catchment- Used to collect and store the captured rainwater.
- Conveyance system – It is used to transport the harvested water from the catchment to the recharge zone.
- Filter – Used for filtering the collected rainwater and removing pollutants.
- Tanks and the recharge structures: Used to store the filtered water which is ready to use.

The process of rainwater harvesting involves the collection and the storage of rainwater with the help of artificially designed systems that run off naturally or man-made catchment areas like- the rooftop, compounds, rock surface, hill slopes, artificially repaired impervious or semi-pervious land surface.

These days, the central ground water board along with the civic authorities is encouraging artificial recharge of ground water through rain water harvesting.



Advantages of Rainwater Harvesting

The benefits of the rainwater harvesting system are listed below.

- Less cost.
- Helps in reducing the water bill.
- Decreases the demand for water.
- Reduces the need for imported water.
- Promotes both water and energy conservation.
- Improves the quality and quantity of groundwater.
- Does not require a filtration system for landscape irrigation.
- This technology is relatively simple, easy to install and operate.
- It reduces soil erosion, storm water runoff, flooding, and pollution of surface water with fertilizers, pesticides, metals and other sediments.
- It is an excellent source of water for landscape irrigation with no chemicals, dissolved salts and free from all minerals.

Disadvantages of Rainwater Harvesting

In addition to the great advantages, the rainwater harvesting system has a few disadvantages like unpredictable rainfall, unavailability of the proper storage system, etc.

Listed below are a few more disadvantages of the rainwater harvesting process.

- Regular maintenance is required.
- Requires some technical skills for installation.
- Limited and no rainfall can limit the supply of rainwater.
- If not installed correctly, it may attract mosquitoes and other waterborne diseases.
- One of the significant drawbacks of the rainwater harvesting system is storage limits.

WASTELAND RECLAMATION

Land is a precious resource because it is used for agriculture, pastures and grazing fields, housing, agroforestry, roads, industrial areas, forestry, etc.

Wasteland is a land which is

- (i) *abandoned,*
- (ii) *degraded* and thus ecologically unstable,
- (iii) *incapable* of producing material or service of value,
- (iv) *eroded,*
- (v) *unfit* for cultivation, unproductive, unfit for grazing as greenery cannot be sustained, and
- (vi) *Saline*, waterlogged, not being utilized to its potentials.

(A) Classification of Wastelands

Wasteland is broadly classified into the following two types:

(i) **Cultivable Wastelands** The lands are cultivable but not cultivated for more than five years due to various reasons such as being declared as notified forest area or state or private occupation.

Examples: Waterlogged marshy lands, saline lands, degraded forests, degraded pastures (or degraded grasslands), shifting cultivation land, gullied land, strip land, etc.

(ii) **Uncultivable or Barren Wastelands**

These wastelands cannot be brought under cultivation or

economic use except at a very high cost.

Examples: Barren rocky lands, areas covered by snow or glaciers, steep sloping areas.

(B) Drawbacks of Wastelands Formation Formation of wastelands result in the deterioration of ecological balance. The various components of the ecosystem directly or indirectly dependent on that particular wasteland are adversely affected.

(C) Wasteland Reclamation

Wasteland reclamation is the process of converting sterile, barren wasteland into something that is fertile and suitable for habitation and cultivation.

(D) Wasteland-Reclamation Practices

Some of the important wasteland-reclamation practices are briefly described below:

a) **Changing Agricultural Practices:** Jhoom or shifting cultivation should be replaced by crop rotation, mixed cropping or developing plantation crops which would improve fertility of land and support a large population.

i) *Mulching:* It means providing protective cover to stop the shifting of sand. A mulch is a protective layer formed by the stubble, i.e., the basal parts of herbaceous plants, especially cereals, attached to the soil after harvest. Dry stems of maize, tobacco, and cotton are used as mulch. For mulching, artificial protective covering can also be used. Mulches act as wind barriers; so soil erosion due to wind is reduced. By addition of organic matter, mulches reduce evaporation and increase soil moisture. Even mulching is useful against water erosion.

ii) *Managing Topography* Water running down the hill erodes soil. The faster it runs, the more soil it carries off the fields. Soil erosion and wasteland formation can be minimized by the following methods:

- *Strip Farming* In alternating strips along the contours, different kinds of crops are planted. When one crop is harvested, the other is still present to protect the soil and keep water from running straight downhill.
- *Contour Ploughing* The ploughing of land is done across the hill, and not in up and down style as in contour ploughing, the ridges created by cultivation make little dams that trap water and allow it to seep into the soil rather

than running off.

- **Tied Ridges** This method involves a series of ridges running at right angles to each other, so that water run-off is blocked in every direction and is encouraged to soak into the soil. Tied ridges are very useful in very heavy rainfall areas.
- **Terracing** means shaping the earth in the form of levelled terraces to hold soil and water. The edges of the terraces are planted with soil-anchoring plant species. This method makes it possible to farm very steep hillsides. However, this method is costly, requires expensive machinery or much hand labour.

b) **Leaching:** By providing adequate drainage to flood-prone and irrigated lands, salinity can be prevented.

By leaching with more water, salt-affected lands can be recovered, especially in the areas where groundwater table is not high.

c) **Afforestation:** It means growing forests over culturable wastelands for the first time. Previously there were no forests there due to lack of seeds or other adverse factors.

Reforestation It means growing the forests over the lands where they were existing earlier; and had destroyed or degraded by forest fires, overgrazing, excessive felling, shifting cultivation, floods, waterlogging, soil erosion, etc.

d) **Protecting the River Banks:** By providing stone, wooden or concrete pitching or by plantation of trees/vegetation along the river banks, it is possible to protect river banks against caving and cutting.

Controlling Formation of Gullies The gullies get widened due to excess run-off water. This can be checked by constructing dams, diversion drains, bounds, etc.

e) **Protecting Soil Erosion by Providing Ground Cover:** After harvesting, the crop residues are left on the ground. They resist wind and water from creating erosion. The ground cover reduces soil temperature and evaporation in the hot season. It thus protects the ground organisms which are helpful in aerating and rebuilding the soil.

f) **Ecological Succession:** This is a natural process of establishment or re-establishment of an ecosystem. In ecological succession, the slow-growing native grasses assist in reclaiming the minerally deficient soils in mining and industrial wastelands.

g) **Drainage:** It is required for waterlogged soil reclamation

where excess water is removed by artificial drainage.

In areas where waterlogging happens after heavy rains, surface drainage is facilitated to remove the excess water.

Subsurface drainage is better because chances of evaporation of water leading to accumulation of salt almost become nil in this method.

RESETTLEMENT AND REHABILITATION ISSUES:

Various development projects often lead to displacement of native or tribal people who are poor and very often not educated. Their rehabilitation is a major socio economic issue.

Problems and concerns:

Displacement problems due to dams:

- The big river valley projects have one of the most serious socio economic impacts due to large scale displacement of local people from their ancestral home and loss of their traditional profession or occupation.
- In India due to big dam construction, more than 20 million people are estimated to have been directly or indirectly affected by these dams
- The Hirakund dam has displaced more than 20,000 people residing about 250 villages.
- The Bhakra Nangal dam was constructed during 1950's and till now it has not been possible to rehabilitate even half of the displaced persons.
- Tehri dam and Sardar sarovar dam also have same issues.

Displacement due to mining:

- Mining is another developmental activity which causes displacement of the native people.
- Several thousands of hectares of land area is covered in mining operation and the native people are displaced.
- Sometimes displacement of local people is due to accidents occurring in mined areas like subsidence of land that often leads to shifting of people.
- Jharia coal fields, Jharkhand have been posing big problems to the residents due to underground fires and they are asked to vacate the area.

□ According to latest estimation, about Rs.18,000 crores will be spent for shifting the population while the cost of extinguishing the fire would be around 8,000 crore.

Displacement due to creation of national parks:

- When some forest area is covered under a national park, it is welcome step for conservation of natural resources.
- However it also has a social aspect associated with it.
- A major portion of the forest is declared as core area where the entry of local people is restricted.
- So they start destruction activities

The major issues related to displacement and rehabilitation is

- Tribals are usually most affected amongst the displaced who are already poor
- Break up of families and women are the worst affected.
- The tribals are not familiar with market policies and trends
- Kinship systems, marriages, social and cultural functions, their folk songs, dances and activities vanish with their displacement
- Loss of identity and loss of intimate link between the people

The objective of the Ministry of Rehabilitation and Resettlement (Government of India) is to transfer the benefits, in lieu of the losses occurred to displaced people due to involuntarily displacement.

This objective may be ensured by implementing the following policies:

- (i) To keep them intact in a *family* or community in which they were settled prior to being displaced.
- (ii) To provide them essential *infrastructure* such as health, schooling and credit in resettlement sites
- (iii) To govern the displacement process by *laws* for avoiding possible problems, to create new rights for them that will enable them to directly share the benefits of the development project and to provide adequate compensation.
- (iv) To relocate them to a *locality* of their preference
- (v) To provide them increasing *incomes* through opportunities of employment and livelihood, to provide them opportunities for the enhancement of capabilities and to improve their standard of living
- (vi) To give them proper *participation* and choice for their resettlement and rehabilitation

- (vii) To provide them social infrastructure and community services

Environmental Ethics: Issues and Possible Solutions

The work '*ethic*' is derived from the Greek work '*ethos*' which means the character of a person as described by his or her actions.

Ethics deals with moral duty and obligations. It gives rise to a set of values, which are used to judge whether one's behaviour or conduct is right or wrong.

Trust, honesty, justice, trustworthiness, competence and accountability are the basis of ethics.

(A) *Issues* In early 1970s, the world started realizing the dangers of human actions on the environment. The main reasons of such concerns were the following issues whose effects were changing the global environment: "ACNE"

A (i) Reduced purification of *atmosphere* because of increased deforestation

C (ii) Increased CO₂ *concentration* and presence of harmful elements in atmosphere due to *enhanced* burning of fossil fuels

N (iii) Depletion of *natural resources* at a rapid rate due to consumption by increasing population

E (iv) Deteriorating quality of *environment* because of urbanization, industrialization, deforestation, consumerism, etc.

These issues result in the following serious consequences: Greenhouse effect, global warming, acid rain, ozone layer depletion, etc.

(B) *Possible Solutions* Awareness of consequences like global warming, etc., has led the society to adopt environmental ethics. These environmental ethics give equal importance to growth and sustainability.

The Following ethical guidelines are very useful as possible solutions for most environment-related problems:

- (i) Humans must keep themselves *informed* about ecological changes as a result of development.
- (ii) Humans must *understand* that they cannot survive alone on the earth. The earth is the habitat of all living species. Living species depend on each other for survival.
- (iii) All humans must be cooperative, honest, *affectionate* and polite to nature and society.
- (iv) Humans must *respect* nature. They are part of it.
- (v) Humans should *act* locally for protection of environment globally.

- (vi) Humans must *protect* natural resources and energies as resources are depleting fast.
- (vii) Humans must *reserve* scarce resources for the future and the future generations.
- (viii) Humans must *involve* themselves in the care of the earth.
- (ix) Everyone should *try* to bring about a change in the attitudes of other persons. They should collectively work towards conservation, protection and restoration of the environment.
- (x) Each human should *plant* at least one tree on his or her birthday.
- (xi) Humans should *purchase* only that much which is essential because excess turns into wastage.

Climate Change

Weather is the reflection of atmospheric humidity, temperature and rainfall. Climate is the average weather pattern over longer duration in a place. Climate change is reflected from the following facts:

- Since the late 19th century, the earth has warmed by 0.3 to 0.6°C on an average.
- By the year 2100,
 - (a) Temperatures would rise by 1 to 3.5°C
 - (b) Global mean sea levels would rise by 15 to 95 cm

Causes of climate change on a global scale are linked with changes in the amount of heat that is either let into the earth system or let out of the earth system.

Depending on proximity to oceans and altitude and amounts of sunlight received by different regions of the world, climate differs from place to place.

For example, hot climates are due to greater concentrations of greenhouse gases in the atmosphere which reduce the amount of heat that is let out of the atmosphere.

III effects of climate change are linked to

- (i) cyclones,
- (ii) floods,
- (iii) dry or wet spells of rain fall
- (iv) cold and hot spells of temperature.

A) Impacts of Climate Change

- (i) Positive Impacts Reduced deaths from cold and higher

agricultural output in northern regions (at least for a while) are few positive impacts of global warming.

(ii) Negative Impacts

- (a) Submergence of low-lying islands (especially in the Pacific), vast saline inundations in countries like Bangladesh, etc., are linked to rise in sea level. (Global warming is responsible for melting of ice caps and glaciers, which lead to rise in sea level.)
- (b) The tourism industry will suffer in parts of southern Europe because of change of climate towards hotter than ever before (prediction by the European Acacia Project).
- (c) Damaging changes in wildlife behaviour like failure of Scottish seabirds to raise young during the 2004 breeding season.
- (d) The poorest of the poor are most likely to be hit by the impacts of climate change.

B) **Solutions of Climate-change Problems:** Some of the simple solutions are

- (i) Reduce the emission of greenhouse gases
- (ii) Use renewable energy resources
- (iii) Use energy efficient technologies

Example 1 What are the important mitigation technologies and commercially available latest technologies for tackling the climate change as per Fourth Assessment Report of Intergovernmental Panel on Climate Change (IPCC)?

Solution As per the IPCC Fourth Assessment Report, the important mitigation technologies and practices presently commercially available are described below:

(i) *Industry*

- Recovery of heat and power
- Recycling of material
- Green technology
- Efficient equipment, etc.

(ii) *Buildings*

- Passive and active solar design for cooling and heating
- Efficient electrical appliances
- Improved cooking stoves
- Efficient lighting and day lighting, etc.

(iii) *Transport*

- Use of public transport systems
- Cycling, walking, etc., non motorised transport
- Use of best fuel-efficient vehicles
- Biofuels
- Proper transport planning, etc.

(iv) Energy supply

- Renewable energy
- Improved efficiency in supply and distribution, etc.

(v) Agriculture

- Improved nitrogen fertilizer application techniques to reduce N₂O emissions,
- Improved rice-cultivation techniques and livestock-and-manure management to reduce CH₄ emissions,
- Dedicated energy crops to replace fossil-fuel use,
- Improved crop and grazing-land management, etc., to increase soil carbon storage,

(vi) Waste

- Recycling and waste minimization
- Compositing of organic waste
- Waste incineration with energy recovery
- Waste-water treatment, etc.
- Landfill methane recovery

(vii) Forests

- Reduced deforestation
- Forest management
- Afforestation
- Reforestation
- Harvested wood-product management
- Use of forestry products for bio-energy to replace use of fossil fuel, etc.

Case Study

Climate Change, Perspectives from India

Climate change is the biggest development challenge for the planet. There is not much difference between managing a local forest and the global climate—we need a framework which encourages cooperation. Then a country can have both growth and less carbon emissions. To tackle the impact of climate change on food security in India, it has been suggested to practice soil and water conservation. Small-scale industries emit substantial greenhouse gases and have the potential for saving huge amounts of energy.

C) Environment Security and Climate Change

The security of the entire global community is increasingly exposed to risk by humans through air, water and/or land pollution. Economic activities cause environmental changes that lead to conflict.

It is important for all countries to cooperate in order to reduce the effects of environmental degradation. Everyone should contribute by limiting greenhouse gas emission, conserving natural resources, and developing and sharing energy-efficient technologies.

Global Warming: The Greenhouse Effect

Greenhouse Effect Definition

“Greenhouse effect is the process by which radiations from the sun are absorbed by the greenhouse gases and not reflected back into space. This insulates the surface of the earth and prevents it from freezing.”

What is the Greenhouse Effect?

A greenhouse is a house made of glass that can be used to grow plants. The sun's radiations warm the plants and the air inside the greenhouse. The heat trapped inside can't escape out and warms the greenhouse which is essential for the growth of the plants. Same is the case in the earth's atmosphere.

During the day the sun heats up the earth's atmosphere. At night, when the earth cools down the heat is radiated back into the atmosphere. During this process, the heat is absorbed by the greenhouse gases in the earth's atmosphere. This is what makes the surface of the earth warmer that makes the survival of living beings on earth possible.

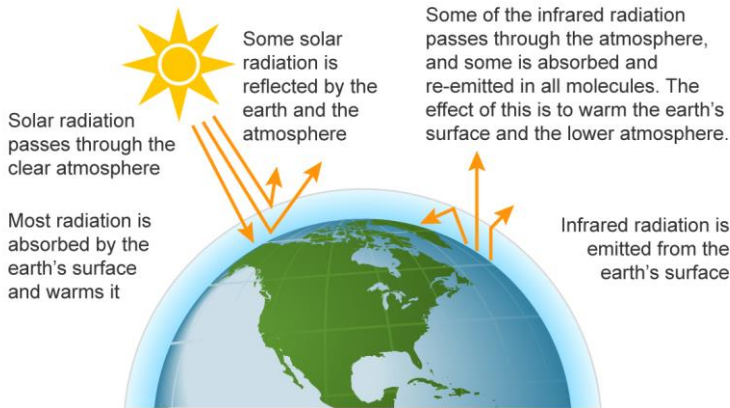
However, due to the increased levels of greenhouse gases, the temperature of the earth has increased considerably. This has led to several drastic effects.

Greenhouse Gases

“Greenhouse gases are the gases that absorb the infrared radiations and create a greenhouse effect. For eg., carbondioxide and chlorofluorocarbons.”

The major contributors to the greenhouse gases are factories, automobiles, deforestation, etc. The increased number of factories and automobiles increases the amount of these gases in the atmosphere. The greenhouse gases never let the radiations escape from the earth and increase the surface temperature of the earth. This then leads to global warming.

The greenhouse effect



Causes of Greenhouse Effect

The major causes of the greenhouse effect are:

Burning of Fossil Fuels

Fossil fuels are an important part of our lives. They are widely used in transportation and to produce electricity. Burning of fossil fuels releases carbon dioxide. With the increase in population, the utilization of fossil fuels has increased. This has led to an increase in the release of greenhouse gases in the atmosphere.

Deforestation

Plants and trees take in carbon dioxide and release oxygen. Due to the cutting of trees, there is a considerable increase in the greenhouse gases which increases the earth's temperature.

Farming

Nitrous oxide used in fertilizers is one of the contributors to the greenhouse effect in the atmosphere.

Industrial Waste and Landfills

The industries and factories produce harmful gases which are released in the atmosphere.

Landfills also release carbon dioxide and methane that adds to the greenhouse gases.

Effects of Greenhouse Effect

The main effects of increased greenhouse gases are:

Global Warming

It is the phenomenon of a gradual increase in the average temperature of the Earth's atmosphere. The main cause for this environmental issue is the increased volumes of greenhouse gases such as carbon dioxide and methane released by the burning of fossil fuels, emissions from the vehicles, industries and other human activities.

Impact of global warming and greenhouse effect

(i)Consequences of Global Warming

- (a) Melting of polar ice caps, and increase of sea/ocean levels
- (b) Flooding of low-lying land
- (c) Less water vapour in the atmosphere leading to more drought
- (d) Causes extremes of weather hurricanes, flooding and droughts, difficulties in growing crops and survival problems

More industrialized countries are responsible for causing high levels of CO₂ in the atmosphere and less industrialized countries are also contributing by destruction of the rainforest.

(ii)Remedial Measures

- (a) Enhance energy efficiency during use by adding insulation to your walls, and by using CFL bulbs, etc.
- (b) Reduce transport sector emissions by less and smart driving.
- (c) Promote renewable energy (like solar energy) usage.
- (d) Remove subsidies on fossil fuels.
- (e) Favour sustainable agriculture.
- (f) Recover methane emissions through waste management.
- (g) Promote afforestation and reforestations—a single tree will absorb approximately one ton of CO₂ during its lifetime.
- (h) Reduce energy consumption by using energy-efficient home appliances.
- (i) Avoid methane production from biomass decay through controlled combustion.
- (j) Enhance energy efficiency during generation, transmission and distribution.
- (k) Reduce waste, prefer reusable products, recycle paper, plastic, metals, etc.
- (l) Eat locally grown fruits and vegetables and not the imported ones. The latter requires the burning of fossil fuels for transport.

Depletion of Ozone Layer

Ozone Layer protects the earth from harmful ultraviolet rays from the sun. It is found in the upper regions of the stratosphere. The depletion of the ozone layer results in the entry of the harmful UV rays to the earth's surface that might lead to skin cancer and can also change the climate drastically.

The major cause of this phenomenon is the accumulation of natural greenhouse gases including chlorofluorocarbons, carbon dioxide, methane, etc.

Ozone-Layer Depletion (Ozone Hole)

(A) **Ozone:** Ozone (O_3) is an allotropic form of oxygen (O_2). It is a pale blue gas. It helps in sustaining life on earth by filtering out the sun's harmful ultraviolet radiation.

(B) **Ozone Layer:** The total amount of ozone in an overhead column of the atmosphere is measured in dobson unit (after the atmospheric ozone pioneer GMB Dobson). One Dobson Unit (DU) indicates that a 0.01 mm thick ozone layer would be formed if ozone is compressed into one layer at 0°C and 1 atm pressure. Across the globe, in the stratosphere, the average thickness of the ozone layer is about 3 mm at 0°C and 1 atm pressure (or about 300 DU). The stratospheric pool of ozone is known as the *ozonosphere*.

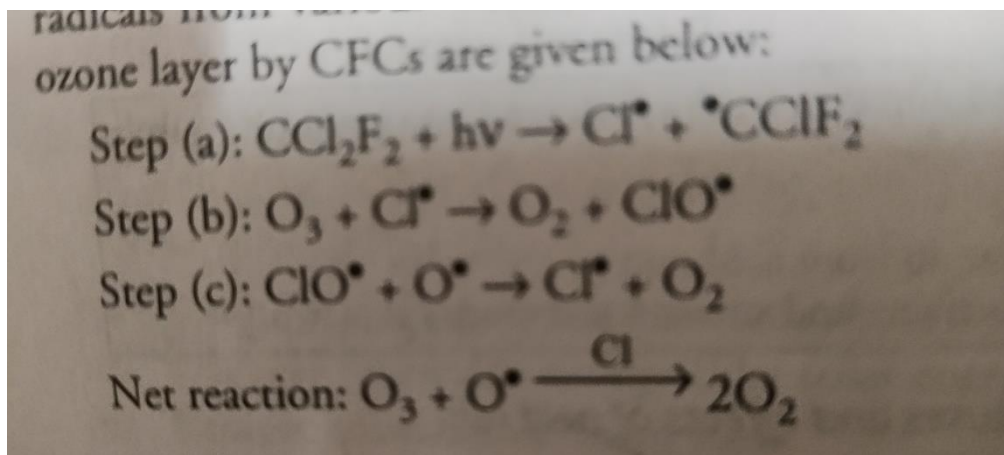
(C) **Ozone Hole:** When the level of ozone in the stratosphere falls below 200 DU, it is considered to represent the beginnings of an ozone hole.

(D) **Causes of Ozone-Hole Formation:** The gradual thinning of the ozone layer and ozone-hole formation occurs by the destruction of ozone due to its reactions with nitric oxide, chlorine, hydroxyl radicals, etc., in the stratosphere.

Flying of supersonic aircrafts, nuclear explosions and various chemical/ photochemical reactions in the atmosphere generate nitric oxide. Burning of biomass generates hydroxyl radicals. Volcanic activity releases chlorine in the atmosphere. Chlorofluorocarbons (CFCs), fluorochloro methane (freons), difluorodichloro methane (CF_2Cl_2) and fluorochloroform (CFCl_3) release chlorine by ultraviolet radiation induced homolytic cleavage in the atmosphere.

It is estimated that about 6.5% of the total ozone-layer depletion is due to chlorine radicals from various CFCs.

The chemical reactions leading to the destruction of ozone layer by CFCs are given below:



As Cl atoms are regenerated in step (c), a long-chain process is followed which keeps on consuming ozone. It is estimated that each atom of chlorine can destroy one lakh ozone molecules when they diffuse to the stratospheric level.

(E) Problems Associated with Ozone-Layer Depletion: The ozone layer absorbs most of the harmful ultraviolet radiations coming from the sun in the region (220–330) nm.

In the absence of an ozone layer, these ultraviolet radiations could cause the following problems:

- (i) Swelling of *skin* and skin cancer; skin aging, burning sensation
- (ii) Death of *phytoplanktons* in marine environment (the sole producers) leading the entire ecosystem to collapse
- (iii) Reduction in the body's ability to fight off disease, as UV suppresses the *immune system*; premature aging.
- (iv) Inhibition and alteration of DNA replication and formation of DNA adduct; leukemia, breast *cancer*
- (v) Visual impairment, dizziness, cataracts of eyes
- (vi) Damage to plants; reduction in crop yields; faster deterioration of *paints, fabrics, plastics*

(F) Remedial Measures to Control the Depletion of Ozone Layer

- (i) Avoid any fire extinguisher that contains bromine-based halons. Preferably use water, carbon dioxide or dry chemical fire extinguishers.
- (ii) Spread awareness about the restricted use of CFCs for the healthy survival of mankind.

- (iii) Avoid purchasing and using refrigerators, air conditioners, etc., which use CFCs, freons, etc., as coolants.
- (iv) Avoid purchasing and using pressurised aerosol cans which use CFCs, freons, etc., as propellants.
- (v) Ban atmospheric nuclear explosions, as they emit NO and deplete the ozone layer.
- (vi) Reduce the air traffic of supersonic aircrafts that fly at the ozonosphere altitude, as they release large amounts of NO and deplete the ozone layer.
- (vii) Facilitate advanced research to plug the ozone holes that have already been formed.

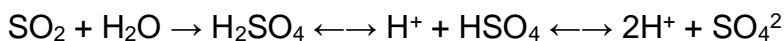
ACID RAIN

Acid rain, also called **acid precipitation** or **acid deposition**, precipitation possessing a pH of about 5.2 or below primarily produced from the emission of sulfur dioxide (SO₂) and nitrogen oxides (NO_x; the combination of NO and NO₂) from human activities, mostly the combustion of fossil fuels. Acid rain contributes to the corrosion of surfaces exposed to air pollution and is responsible for the deterioration of limestone and marble buildings and monuments.

Chemistry of acid deposition

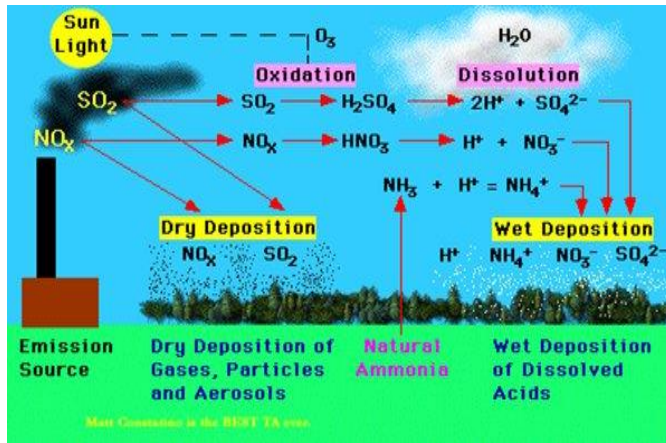
Normal rainwater is weakly acidic because of the absorption of carbon dioxide (CO₂) from the atmosphere—a process that produces carbonic acid—and from organic acids generated from biological activity. In addition, volcanic activity can produce sulfuric acid (H₂SO₄), nitric acid (HNO₃), and hydrochloric acid (HCl) depending on the emissions associated with specific volcanoes. Other natural sources of acidification include the production of nitrogen oxides from the conversion of atmospheric molecular nitrogen (N₂) by lightning and the conversion of organic nitrogen by wildfires. However, the geographic extent of any given natural source of acidification is small, and in most cases it lowers the pH of precipitation to no more than about 5.2.

Anthropogenic activities, particularly the burning of fossil fuels (coal, oil, natural gas) and the smelting of metal ores, are the major causes of acid deposition. In the atmosphere, sulfuric and nitric acids are generated when SO₂ and NO_x, respectively, react with water. The simplest reactions are:





These reactions in the aqueous phase (for example, in cloud water) create wet deposition products.



Causes of Acid Rain

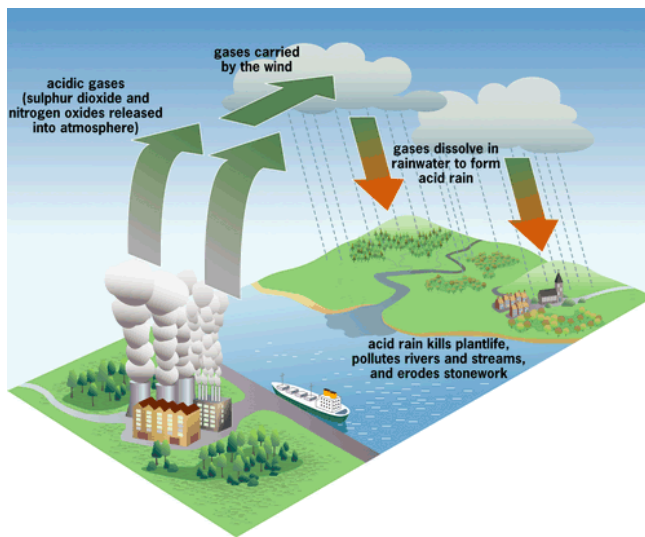
The causes of acid rain are ***Sulphur and Nitrogen particles which get mixed with the wet components of rain.*** Sulphur and Nitrogen particles which get mixed with water are found in two ways either man-made i.e as the emissions that are given out from industries or by natural causes like lightning strike in the atmosphere releasing nitrogen oxides and volcanic eruptions releasing sulphur oxide.

pH 4.2-4.4= Acid rain

pH 5.6= Clean rain

As the pH is $\log [\text{H}^+]$, so each pH unit represents a tenfold change:

- A pH of 5 is ten times more acidic than a pH of 6.
- A pH of 4 is hundred times more acidic than a pH of 6.



1. Acidic gases (sulphur dioxide and nitrogen oxides) released into atmosphere from industries, vehicle's exhaust etc.
2. Acidic gases carried by the wind.
3. Acidic gases dissolve in rainwater to form acid rain.
4. Acid rain kills plant life, pollutes rivers and streams and erodes stone work.

Effects of Acid Rain

- Acid rain is very harmful to agriculture, plants, and animals. It washes away all nutrients which are required for the growth and survival of plants. Acid rain affects agriculture by the way it alters the composition of the soil.
- It causes respiratory issues in animals and humans.
- When acid rain falls down and flows into the rivers and ponds it affects the aquatic ecosystem. It alters the chemical composition of the water, to a form which is actually harmful to the aquatic ecosystem to survive and causes water pollution.
- Acid rain also causes the corrosion of water pipes, which further results in leaching of heavy metals such as iron, lead and copper into drinking water.
- It damages the buildings and monuments made up of stones and metals.

Acid Rain and Taj Mahal

Tourist traffic is not allowed near the Taj Mahal in an effort to control the deleterious effects of pollution. The degradation of the Taj Mahal's marble facades has still not slowed down.

This is due to acid rain generated from local foundries and an oil refinery. The once brilliant white Taj Mahal has been losing its luster, dulling into a sickly pale shade. Two common air pollutants, SO₂ and NO_x, cause acid rain.

Nuclear Accidents and Holocaust

A) Nuclear Accidents

Nuclear accidents can occur at any stage of the nuclear fuel cycle. They may also result from the failure of nuclear devices.

Types of nuclear accidents are discussed below:

1. **Nuclear test:** Nuclear explosions, carried out in underground, because settling down the radioactive materials on the earth's surface and radioactive particles, radioactive rays into the atmosphere.
2. **Nuclear power plant accidents:** The release of radiation occurs during the accidents. The nuclear power plant located in the seismic vulnerable area may cause nuclear accidents.
3. **Improper disposal of radioactive waste:** It is another source of accident. Drums stored underground can rust and leak radioactive materials into water, land and air.
4. **Accident during transport:** Trucks carrying radioactive wastes or fuels are involved in frequent accidents.
5. **Core melt down:** The major accident at a nuclear power plant is a core melt down.

Effect of Nuclear Radiation

1. Radiations may break chemical bonds such as DNA in cells. This effect may be instantaneous, prolonged or delayed types. It may be even carried to future generations.
2. Exposure at low dose of radiation (100-250 rads), people do not die, but begin to suffer from fatigue, vomiting and loss of hair.
3. Exposure at higher dose of radiation (400-500 rads) affects bone marrow, blood cells, natural resistance and blood to fail clot.
4. Exposure at very high dose of radiation (10,000 rads) kills the organisms by damaging the tissues of heart, brain.

World major nuclear accidents

- (i) **Three Mile Island Accident:** On March 28, 1979, a nuclear accident occurred in US at the Three Mile Island nuclear power plant. One of two reactors lost its coolant, which caused overheating and partial meltdown of its uranium core. This resulted

in release of intense radiation as well as radioisotopes. Fortunately, the plume emitted into the atmosphere was quite low for causing toxic effect.

(ii) **Chernobyl Nuclear Accident:** On April 26, 1986, a nuclear accident occurred in Chernobyl, near Kiev, Ukraine. Explosion and fire in the graphite core of one of four reactors released radioactive material that spread over part of the Soviet Union, eastern Europe, western Europe and Scandinavia. This is one of the world's worst nuclear accidents involving 237 confirmed cases of chronic radiation illness and 37 deaths. Hundreds of thousands of Ukrainians, Russians and Belorussians had to abandon entire cities within a 30 km zone of extreme contamination. About 3 million people, more than 2 million in Belarus alone are still living in contaminated areas. Figures from the Ukraine Radiological Institute suggest that over 2500 deaths were caused by the Chernobyl nuclear disaster.

(iii) **Tokaimura Nuclear Accident:** On September 30, 1999, a nuclear accident occurred in a nuclear plant in Tokaimura, Japan. In a uranium-processing nuclear fuel plant, a chain reaction went uncontrolled, resulting in emission of high levels of radioactive gas into the air. Because of this accident, two workers were seriously injured and one worker got killed.

Populations living in contaminated areas and persons who helped with the clean-up of the accident were found to have thyroid or other cancers. Among Ukrainian young children (up to 15 years of age), the average thyroid cancer rate was 4–6 incidents per million before the accident. After the incident, the cancer rate rose to 45 incidents per million.

People were not told the truth until several years after the accident. The lack of public information available after the accident, the stress and trauma of evacuation and concerns of the people affected and concerns about their children's health resulted in significant increases in psychological health disorders such as depression, anxiety, helplessness, social withdrawal, mental stress and lack of hope for the future.

Nuclear Holocaust

Holocaust means large-scale destruction of human lives by intense heat and fire.

It means destruction of biodiversity by nuclear equipments and nuclear bombs. In a holocaust, a large number of living beings are totally

destroyed. Usually, these kinds of destructions are happened in a nuclear war.

Holocaust: Great Destruction Resulting in the Extensive Loss of Life:

Hiroshima–Nagasaki disaster is a nuclear holocaust. America was involved in the development of an atom bomb while World War II was at its peak. The bomb was made and was test fired on 16 July, 1945 in a desert in Mexico. The 30 m tower on which the bomb was placed completely melted. The blinding light that spread for a few minutes turned the sun into a pale ball. Frightened to the core by the resulting blast, scientists vehemently opposed using it on Japan or anywhere in the world. US President Harry Truman was determined to win the war against Japan. He ordered dropping of the bomb on Japan. The *uranium bomb* named the *Little Boy* was dropped on *Hiroshima* on *August 6, 1945*. Within minutes, one lakh persons were burnt to death like moths near a lamp. Just three days later, a *plutonium bomb* named *Fatman* was dropped over *Nagasaki*. The whole area was burnt and looked like a desert. Devastating shock waves, deadly gamma radiations and enormous amount of heat created conditions where any life cannot survive.

It is estimated that by December 1945, as many as 1,40,000 had died in Hiroshima by the uranium bomb and its associated effects. In Nagasaki, roughly 74,000 people died of the plutonium bomb and its after effects. In both cities, around 2,14,000 people in total, most of them were civilians, were killed. In Nagasaki alone, up to 60,000 people were injured. The radius of total destruction was about 1.6 km, followed by fire across the northern portion of the city to 3.2 km south of the bomb.

Radiation poisoning and necrosis caused illness and death after the bombing in about 1% of Hiroshima residents who survived the initial explosion. In the years between 1950 and 1990, It is estimated that hundreds of deaths are attributable to radiation exposure among atomic-bomb survivors from both Hiroshima and Nagasaki.

Effect of Nuclear Holocaust

1. Nuclear winter

Nuclear bombardment will cause combustion of wood, plastics, petroleum, forest etc. Large quantity of black soot will be carried to the stratosphere. Black soot will absorb all radiations and will not allow the radiation to reach the earth. Therefore, cooling will result. Due to this

cooling effect, water evaporation will also reduce. In stratosphere there won't be significant moisture to rain-out the thick soot. Thus, due to nuclear explosions, a process known as opposite to global warming will occur. This is called nuclear winter.

Effect of nuclear winter

(a) Lowers the global temperature, even in summer the temperature will be at around freezing temperature.

(b) Crop productivity will be reduced causing famines and human sufferings.

2. It ignites all combustible material; destroy all the living beings, material crushing and destruction of homes.

Control measures

1. Suitable precautions are to be taken and training must be given to people for handling these materials to avoid accident.

2. Constant monitoring of the radiation level has to be carried out, limit exposure to the workers.

3. Regular checks and control measures are done by Atomic Energy Regulatory Board under the Department of Atomic Energy.

Consumerism and Waste Products

Consumerism is a process and habit of the chronic purchasing of new goods and services, with less attention to their true need, durability, origin of the product or the environmental impacts during manufacture and disposal.

Model of Paul Ehrlich and John Hodlren (1972) :

Population X Consumerism X Waste generation = Environmental degradation

(No. of persons) x per capita use of resources x waste generated per unit of resource use = Overall environmental degradation

In More Developed Countries (MDCs), population is less and resources are in abundance. Lifestyle is luxurious and per capita consumption of resources is very high. More consumption of resources results in more waste generation and greater environmental degradation.

In Less Developed Countries (LDCs), population is large. Adequate resources are not available for all, so per capita consumption is less. However, overall consumption is high. Thus, environmental impact is same or slightly less in comparison to MDCs.

For example, the population of India is 3.4 times more than that of USA but its overall resource use and waste generation is less than 1/8th that of USA.

A) Creators of Consumerist Culture

(i) **Artificial Beauty:** Millions of people use soaps, detergents, hair dyes, skin-care creams and other cosmetic items to enhance their beauty artificially. Manufacturers have been able to create demands for these cosmetic items and the public is busy spending their money for this temporary beauty enhancement.

Fashion Manufacturers of clothes, textiles, shoes and apparel keep changing fashions to accelerate the speed of consumerism through advertisements.

(ii) **Greed of Industry:** To make more profits, industry and large businesses want to sell more products. Generally, products are made for a one-time use. Through regular advertising a “throwaway society” has been created. This society prefers disposable items discarding notions of inherent value, longevity and the environmental consequences of manufacture and disposal of the product. In the developed world, 200 billion paper cups, bottles, cans and plastic cartons are thrown away each year.

(iii) **More Money, Less Time:** Family ties, friendship, everything becomes mediated through the spending of money on goods and gifts and services. A generation is growing up without knowing what quality goods are. Relations are promoted only as a vehicle of giving and taking gifts.

(iv) **Mega Shows:** Manufacturers of items of consumerism (like automobiles, televisions, radios, refrigerators, air conditioners, dishwashers, cosmetics) sponsor megashows. They kindle passion and unquenchable desire for latest items through prizes and other incentives.

(v) **Advertising:** Advertising is designed to create both a desire to follow fashions, and the resultant personal self-reward system based on acquisition. Thus, a consumerist culture is not based on natural demand, but on a created demand.

(vi) **Politics Consumerism** is encouraged politically so that population remains satisfied by material needs and politicians can do whatever they wish for.

B) Drawbacks of Consumerism

Consumerism

- i. causes more *pollution*, creates more waste products, causes wasteful use of material and energy,
- ii. helps lowest-wage, environ- mentally unregulated *over- seas* manufacturers,
- iii. promotes social *unrest*,
- iv. *promotes riots*, and other criminalities, and
- v. Leads to *societal suicide*.

C) Measures to Prevent Excess Consumerism

Some of the measures to prevent excess consumerism include the following:

- i. **Pigouvian Taxes** For encouraging industrial ecology and waste reduction, manufacturers are taxed for some or all the cost of recycling or waste disposal.
- ii. **Ecolabelling** It involves the marking of products to indicate that they are environmentally friendly. Ecolabelling assesses environmental impact and communicates this to the consumer. It also encourages manufacturers to reduce the impacts of their products. *Ecomark is used in India for ecolabelling.*
- iii. **Green Marketing** It involves communicating green image of the better, environmental friendly products to the consumer. It helps in conserving the environment and achieving better marketing niche. People also happily buy green products like refrigerators that do not leak ozone-layer-depleting chlorofluoro carbons (CFC's) and consumes less electricity.
- iv. **Self-awareness and Self-control**

Having fewer things means enjoying what you have more and actually getting to use it. It also helps in fewer distractions from the essentialssuch as food, family, nature, study, and friends.