

# Sustainable Engineering

## Module 1

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## Need for Sustainability

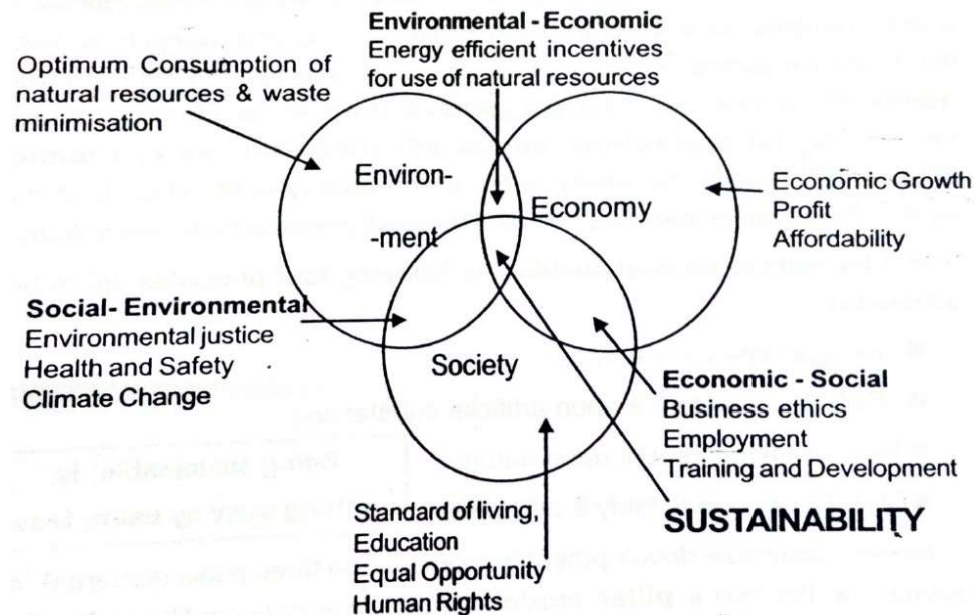
- ❖ Sustainable – Capacity to endure (continue to exist in the same state).
- ❖ Environment – Derived from French term “Environ”, means “surround”.
- ❖ Earth is 4.5 billion (4500 million) years old, but advent of man is only 6 million years old.
- ❖ Evolution of concept of sustainability
  - ❖ 8000-10000 years ago agrarian communities depended on land and water. But never led to environmental degrade, since they maintained the “food chain”.
  - ❖ 17<sup>th</sup>-19<sup>th</sup> century : Fossil fuels (coal, petroleum, natural gas) are introduced, which is non-renewable. Population explosion begins.
  - ❖ Mid 20<sup>th</sup> century : Environment began to pollute due to industrial development.
  - ❖ Late 20<sup>th</sup> century : Population explosion and uncontrolled urbanisation.
  - ❖ Global warming : Gradual increase in the average temperature of the Earth's atmosphere and oceans, caused by increasing concentrations of carbon oxides, Nitrous oxides, sulphur oxides, Fluorocarbons etc.

- ❖ De-forestation affected water recycling which led to reduced rain. Also, it reduced the water holding capacity of soil resulting in soil erosion and flood.
- ❖ 21<sup>st</sup> century : Climate change, increase in sea level, air pollution, water pollution, soil pollution, noise pollution and related health issues crossed the threshold limits and led to the need for sustainability.
- ❖ United Nations document refer to “**key sustainability concepts**” as **inter-generational equity and intra-generational equity**.
- ❖ Four principles to attain sustainability :
  - ❖ Reduce dependence upon fossil fuels
  - ❖ Reduce dependence upon artificial substances
  - ❖ Reduce encroachment on nature
  - ❖ Meet human needs fairly and efficiently
- ❖ The engineers/scientists should use his/her knowledge and creativity, by considering the above 4 principles, to arrive at sustainable solutions for saving society and environment

# Three Pillar Model or Three Circles Model

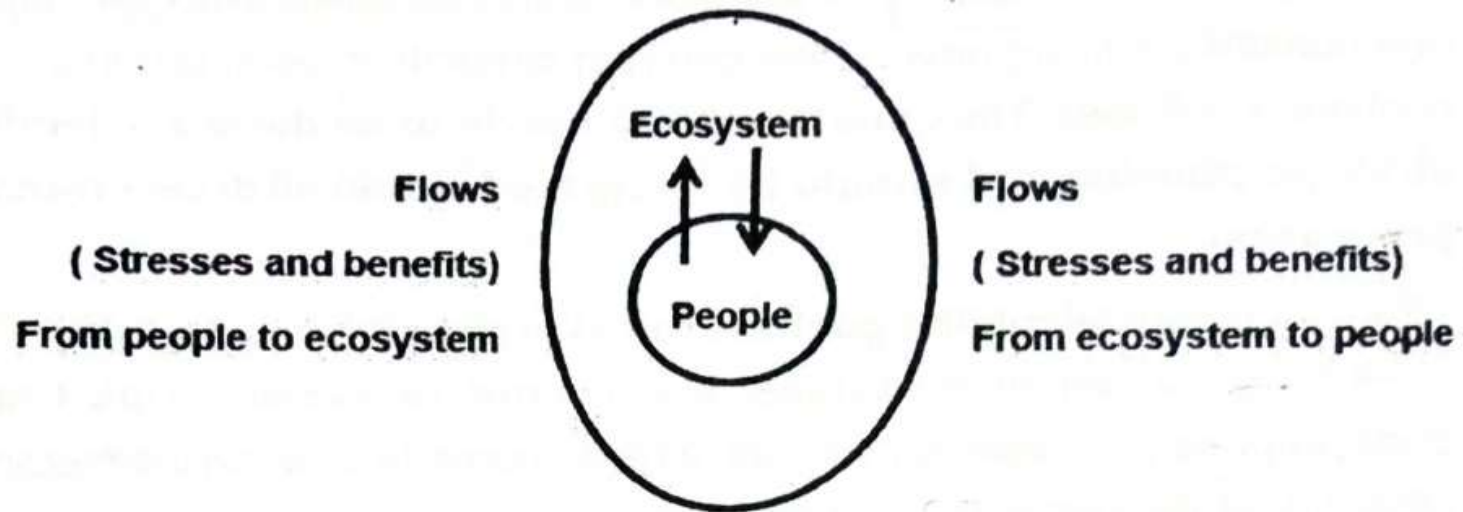
Three basic spheres of sustainability

- ❖ For a sustainable community,
  - ❖ **Economic, Social and Environmental** systems should be in harmony
  - ❖ Provide a healthy, productive, meaningful life (i.e; quality of life) to all community residents of the present and future generation.



## EGG Model of Sustainability

- ❖ Model designed by International Union of the Conservation of Nature (ICUN) in 1994.
- ❖ Basic principle “An egg is good only if both the white and yoke are good”.
- ❖ Outside ellipse represents ecosystem and circular yoke represents people with in the ecosystem.
- ❖ Society is well and sustained only if both people and ecosystem are well.



## Concept of Social Sustainability

- ❖ Rich, poor and other diverse groups of a society should have equal access to basic resources.
- ❖ 3 values that form social sustainability
  - ❖ Quality of life
  - ❖ Growth/Development
  - ❖ Equality
- ❖ But since there is a disagreement between nations, religions, culture, political parties etc. regarding quality of life, the social sustainability is weakly defined.
- ❖ Strategies to attain social sustainability
  - ❖ Alleviate poverty in society
  - ❖ Provide basic needs (food, shelter and clothing) to all
  - ❖ Provide basic education to all
  - ❖ Protection of human rights (social justice) for all
  - ❖ Provide policies and programmes to improve social status
  - ❖ Participation in natural disaster management to minimise damage (cyclone, earthquake, flood etc.)

## Concept of Environmental Sustainability

- ❖ For ensuring Environmental Sustainability,
  - ❖ Optimum consumption of natural resources, at a rate at which they can be replenished naturally
  - ❖ Usage of renewable resources such as, solar, wind, tidal power etc.
  - ❖ Minimize waste and pollution of water, soil, noise etc. (PPP (Polluter Pays Principle) should be strictly enforced)
  - ❖ Popularising public transport system to reduce air pollution
  - ❖ Maintain environmental quality and ecological balance

<b>Consumption of Resources</b>	<b>State of Environment</b>	<b>Sustainability</b>
Less than nature's ability to replenish	Environmental Renewal	Environmental sustainable
Equal to nature's ability to replenish	Environmental Equilibrium	Steady State Economy
More than nature's ability to replenish	Environmental Degradation	Not Sustainable

# ആശങ്കയിൽ മുടി ഉത്തരേന്ത്യ

യൂറോപ്യൻ ബഹിരാകാശ ഏജൻസിയുടെ ഭൗമനിരീക്ഷണ ഉപഗ്രഹമായ സെന്റിനൽ 5ൽ നിന്നുള്ള വിവരങ്ങൾ ഉപയോഗിച്ച് തയ്യാറാക്കിയ ഭൂപടം ഇന്ത്യയിൽ ഈ മാസം 1 മുതൽ 21 വരെയുള്ള കാലയളവിൽ അന്തരീക്ഷത്തിലെ നൈട്രജൻ ഡയോക്സൈഡ് സാന്നിധ്യം കാണിക്കുന്നു.

നൈട്രജൻ ഡയോക്സൈഡ് തീവ്രത

കുറവ് കൂടുതൽ



അവലംബം: നോയിട്ട്രേഴ്സ്

വിവരം: മനോരമ



## Concept of Economic Sustainability

- ❖ Industry/Business is making profit without creating much environmental harm
  
- ❖ In developing countries
  - ❖ Consumption of resources – Sustainable
  - ❖ Population growth – Unsustainable
  
- ❖ In developed countries
  - ❖ Consumption of resources – Unsustainable
  - ❖ Population growth – Sustainable
  
- ❖ The aim is to increase the standard of living of developed world, at the same time to reduce western style of consumption

- ❖ Strategies adopted for economic sustainability:
  - ❖ Optimum use of raw materials
  - ❖ Maintain steady flow of income to workers.
  - ❖ Promote “green business projects” (business which has minimal negative impact to environment and society) (**Eg: Electricity from Solar and Wind, Biogas plant, Waste recycling, used book store, plastic based clothing, eco-friendly toys, jute/cotton/paper shopping bags, rain water harvesting, organic store, recycled products business etc.**)
  - ❖ Innovative methods to be attained through research to gain eco-friendly and cost-effective production techniques in industry
  - ❖ Incentive to workers to improve work efficiency
  - ❖ Value added products should be made along with original products from industry (**Raw agricultural products that have been modified to get a higher market value or a longer shelf life. Eg. Fruits made into jams, pickles, sauces etc.**)

## Economic, Social & Environmental Matrix of Quality of life

Quality of Life Concerns	Economic Issue		Social Issue		Environmental Issue	
	Unsustainable	Sustainable	Unsustainable	Sustainable	Unsustainable	Sustainable
<b>Water</b>	High cost of drinking water	Drinking water availability at low cost	Access to drinking water denied to weaker section	Adequate water supply to all sections	High-level of pollution in lakes and rivers	Conservation of existing fresh water bodies
<b>Food</b>	High cost of food and use of fertilizers and pesticides in farming	Good food available at low cost	Access to good food denied to weaker section	Adequate access to good food to all sections	Overuse of fertilizers and pesticides pollute the environment. Deforestation - conversion of forestland to farms	Food is of nutritious quality and related diseases are lowered.
<b>Energy</b>	High cost and intermittent power supply	Electricity available at low cost	Overuse of energy by the rich society and inadequate energy distribution	Adequate energy available to all sections	Use of fossil fuels and pollution	Use of renewable resources.(solar, wind, biomass)

# Sustainable Development

## ❖ History of sustainable development

- ❖ The concept is developed through a series of discussions carried through books as well as, various conferences held towards the initiative to environmental protection
- ❖ In 1713, Carlowitz, through his book on forest science argued that **“timber would be as important as our daily bread”**.
- ❖ In 1798, Thomas Malthus in his book “An essay on the Principle of Population” stated that **“population multiplies geometrically and food production multiplies arithmetically”**.
- ❖ In 1972, group of scientists known as “Club of Rome” submitted the report “ Limits to growth”, **“with current trend of population increase , humanity will reach the natural limit and crash in next 100 years”**

- ❖ The recommendations about sustainable development from 1972 UN Stockholm Conference were later discussed in the World Conservation Strategy (WCS) meeting held in the year 1980.
- ❖ In 1983, the UN convened the World Commission on Environment and Development (WCED)
- ❖ 1992 – Earth Summit held in Rio-de-Janeiro, Brazil came up an global action plan for sustainable development called “**Agenda21**”
- ❖ 1997 – **Kyoto Protocol**, held in Kyoto, japan, debated on the issue of “**reducing greenhouse gas emission**”.
- ❖ 2000 – Millennium Development goals (MDGs)
- ❖ 2002 – Johannesburg World Summit on Sustainable Development

❖ **Pillars of sustainable development**

- ❖ **Social Pillar** – provides food, shelter, clothing, education and health for human beings.
  - ❖ **Environment Pillar** – provides pollution free air, water and soil.
  - ❖ **Economic Pillar** – provides provision of job, industrial development without creating environmental harm.
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- ❖ In addition to this the government policies can be considered as **fourth pillar** (institutional pillar).

## ❖ Measures for achieving sustainable development

- ❖ **Promote environmental education and awareness** – by introducing environment as a subject in education.
- ❖ **Three “R” approach** – first Reduce, then Reuse and thereafter Recycle
- ❖ **Use of appropriate technology** – technology should be eco-friendly, culturally suitable and should produce minimum waste.
- ❖ **Utilize natural resources as per carrying capacity of environment**
- ❖ **Improving quality of life** – Development should focus on sharing benefits between the rich and poor
- ❖ In addition to this the three “E”s namely **Economy, Ecology and Equality** are to be incorporated in national policy

## Nexus Between Technology and Sustainable Development

- ❖ Science and technology has supported us by increasing the efficiency in consuming our resources and minimizing waste.
- ❖ Technology – “**double edged sword**” – because it eliminates disease and improve standard of living and at the same time causes environmental pollution and climate change.
- ❖ Some of the “**nexus**” (**relationship**) between technology and sustainable development are given below:
  - ❖ **Agricultural technology and sustainable development**
    - ❖ Goal: Improve productivity, soil and water conservation, improving human nutrition, food quality and safety.
    - ❖ Good Agricultural Practices(GAPs) like organic farming which uses bio-fertilizers and bio-pesticides.
    - ❖ Drones can be used to detect crop disease at early stage, taking wild animal count, detecting forest fires, finding illegal activities like ganja cultivation etc.
    - ❖ Terrace farming using “wick irrigation” (Thiri-Nana in Malayalam) technology to save water.





- ❖ Mobile applications for farmers for getting farming information (eg. Plantix).
- ❖ Biotechnology and Genetic Engineering helps to generate disease resistant species and enhance crop yields.
- ❖ Mechanical traction improves productivity and reduces labor cost.
- ❖ **Energy technology and sustainable development**
  - ❖ Switch from non-renewable fossil fuels to renewable energy sources like solar, wind, ocean etc.
  - ❖ High efficient solar panels.
  - ❖ German Air-flow technology can be used to improve efficiency of blades of wind turbines.
  - ❖ Bio fuel produces from garbage can be used which can reduce global carbon emission by around 80%, Also, problems due to dumping of garbage can be avoided.
  - ❖ Transition from incandescent bulbs to CFL (Compact Fluorescent Lamp) and finally to LED (Light Emitting Diode) bulbs to save energy.

## ❖ **Environmental technology and sustainable development**

- ❖ Wastewater treatment methods such as “waste water ponds” and “constructed wetlands” (waste water treatment using natural processes involving sunlight, water, nutrients, algae, atmospheric oxygen and bacterial action).
- ❖ “Catalytic converters” and “diesel particulate filters” installed in vehicles to reduce air pollution.
- ❖ “Bacterial consortium” (group of distinct bacteria) introduced by Japanese researchers to carry out degradation of plastics
- ❖ “CO<sub>2</sub> Capture and Storage” (CCS) technology to reduce atmospheric pollution due to CO<sub>2</sub>

## ❖ **Disease related bio-medical technology and sustainable development**

- ❖ In spite of the technological advancement in bio-medical field, nearly 1000 children are dying daily around the world due to lack of access to drinking water and sanitation. “Ensure water and sanitation for all”, is one of the major sustainable development goals.

## ❖ Communication and Information Technology and sustainable development

- ❖ Educational programmes at all levels are needed to create an awareness and concern for environmental degradation, poverty, population growth, resource consumption and sustainable development.
- ❖ Videoconferencing is an effective tool to reduce the need for travel, travel time, cost and greenhouse gas emissions. Communication devices such as, radio, television, telephones, cellphones, computer networks, satellite systems etc. are being used to share these principles.

## ❖ Space technology and sustainable development

- ❖ Satellite data can be used for locating potential fishing zones.
- ❖ Prediction and early warning of extreme weather conditions.
- ❖ Reusable rockets are used (earlier rockets are allowed to fall on oceans)
- ❖ Conventionally used “Hydrazine rocket fuel” is highly toxic. Indian Space Research Organization (ISRO) has developed an environment friendly propellant (Hydroxylammonium) to power the space craft.

## **Challenges for Sustainable Development**

- ❖ **Misconception about sustainable development** :- Due to unawareness of its importance.
- ❖ **Population explosion** :- World demand more space, food, and energy.
- ❖ **Poverty, hunger and malnutrition.**
- ❖ **Unemployment** :- Leads youth to organize protest movements and violence.
- ❖ **Absence of adequate “political will”, towards attaining sustainability.**
- ❖ **Over exploitation of natural resources** :- eg., fossil fuel
- ❖ **Corruption and misuse of funds issued to sustainable development.**
- ❖ **Poor solid waste management** :- (2100 crores allotted to Kerala - Ref. News 06-09-2020)
- ❖ **Lack of coordination between 3 pillars of sustainable development.**
- ❖ **Fresh water scarcity** :- Need to depend on bottled mineral water.
- ❖ **Deforestation and loss in biodiversity** :- Many species are at the edge of extinction.
- ❖ **Over dependence of fossil fuels.**
- ❖ **Absence of strict environmental laws and legislation.**
- ❖ **Emergence of terrorism and civil conflicts** :- Results in massive displacement of people.

## Multilateral Environmental Agreements (MEA) and Protocols

- ❖ Global initiatives are carried out to study the environmental issues
- ❖ Stockholm Summit in 1972 - Led to Multilateral Environmental Agreement (MEA) and International Environment Protocols.
- ❖ **MEA** is a legally binding agreement, between three or more nations, mostly initiated by United Nations (UN), on how to address environmental problems, which are global in nature.
- ❖ **Environmental Protocol** is a legally binding agreement for solving an environmental problem, widely discussed in a convention with achievable targets. Some of the well known protocols are Kyoto Protocol (1997) and Montreal Protocol (1987).
  
- ❖ **Kyoto Protocol**
  - ❖ To tackle the challenges posed by global warming and climate change all over the world, due to greenhouse gas emissions, by the use of fossil fuels, United Nations Framework Convention on Climate Change (UNFCCC) initiated the framing of **Kyoto Protocol** in the meeting held at Kyoto, Japan, in 1997. Adopted on 11<sup>th</sup> December 1997 and came into force on 16<sup>th</sup> February 2005.

## Clean Development Mechanism

### ❖ **Kyoto Protocol classification**

- ❖ Annex I countries – highly industrialized and developed countries
- ❖ Non-Annex I countries – Developing countries (eg: India)
- ❖ Non-Annex I countries has legally no greenhouse gas reduction targets, but expected to reduce emissions.
- ❖ Annex I countries emitted greater quantity of greenhouse gas. Hence it is their responsibility to reduce overall greenhouse gas (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, Hydrofluro Carbons, Perfluro Carbons and Sulphur Hexafluoride) emissions by 5.2% as compared to 1990 level, during the period 2008-2012. This period is called “**First Commitment Period**”.

❖ **3 flexible mechanisms issued by Kyoto Protocol :**

1. International Emission Trading (IET) – defined in Article 17
2. Clean Development Mechanism (CDM) – defined in Article 12
  - a) Annex I countries are allowed to invest in emission reduction projects in developing countries.
  - b) CDM projects like afforestation, renewable energy, sustainable agriculture and sustainable transport generates **Certified Emission Reduction (CER)** unit or Carbon Credit (One CER is the unit related to the reduction of one tonne of CO<sub>2</sub>)  
**[Penalty on failure :- Pay an amount equivalent to the difference between the target emission and the actual emission, plus 30%, in the “second commitment period”, ie; from 2013-2020]**
3. Joint Implementation (JI) – defined in Article 6
  - a) Annex I countries are allowed to invest in emission reduction projects in developing countries and the Annex I countries in return can meet their own emission reduction targets by earning credits from these projects.



## Environmental Legislations in India

- ❖ Environmental laws refers to the rules and regulations to regulate human activities that affect or likely to affect the environment.
- ❖ Main objectives are :-
  - ❖ To regulate indiscriminate use of natural resources
  - ❖ To protect our environment and biodiversity
  - ❖ To enable authority concerned, for taking legal action against those who violate environmental rules and give punishment, if necessary.
- ❖ In 1976, the 42<sup>nd</sup> amendment was incorporated into Indian Constitution by means of two articles :-
  - i. **Article 48A** :- Responsibility of states to safeguard forests and wild life of country.
  - ii. **Article 51 A (g)** :- Duty of citizen to protect forests, lakes, rivers and wild life.

- ❖ Other articles provided which links to sustainable development :-
  - Article 21 :- “Right to life” extended for all living species (After “Jellikkettu Verdict” in May 2014)
  - Article 47 :- Raising the level of nutrition and public health.
  - Forest Rights Act (2006) or Community Forest Rights (CFR) :- Right of tribal communities (Adivasi Communities) to govern and conserve forests, that they have traditionally managed, which permits to clean any development projects inside such areas.
  - Shore Nuisance Bombay and Colaba Act (1853), The North Indian Canal and Drainage Act (1873), River Boats Act (1956) etc. :- To control water pollution.
  - Air (Prevention and Control of Pollution) Act (1981) :- To prevent air pollution
  - Bhopal gas tragedy (1984) was one of the worst tragedy in the history of mankind, led to the development of Ministry of Environment, Forest and Climate change (MoEFCC)

## ❖ **Water (Prevention and Control of Pollution) Act (1974)**

- ❖ For prevention and control of water pollution
- ❖ Water pollution is the contamination of water or alteration of the physical, chemical or biological properties of water due to the discharge of any wastewater, disposal of poisonous material or obstructing the proper flow, directly or indirectly, which is likely to render injury to public health and other living beings.

### ❖ **Salient features :-**

- ❖ Establishment of Central and state Pollution Control Board (PCB).
- ❖ Prior sanction from PCB is required before installation of industrial activities leading to discharge of industrial effluents.
- ❖ Empower PCB to inspect industrial plants and factories and to take samples for analysis and provides for criminal liabilities.
- ❖ Empowers PCB to shut down the water polluting industry, if necessary and can cut the supply of electricity and water.

❖ **Air (Prevention and Control of Pollution) Act (1981)**

- ❖ For prevention and control of air pollution
- ❖ Air pollution is the presence of any solid, liquid or gaseous substances in the atmosphere in such concentrations which may be injurious to public health and other living beings.
- ❖ **“Noise pollution”** was also included under this act.

❖ **Salient features :-**

- ❖ Establishment of Central and state Pollution Control Board (PCB).
- ❖ Prior sanction from PCB is required before installation of industrial activities leading to discharge of emissions and air pollutants to atmosphere.
- ❖ Empower PCB to inspect industrial plants and factories and to take samples of ambient air, chimney emissions for analysis and provides for criminal liabilities.
- ❖ Empowers PCB to shut down the air polluting industry, if necessary and can cut the supply of electricity and water.

## **Environmental Protection Act (EPA)**

- ❖ EPA was enacted in 1953 under Article 253 of Constitution of India. Also called “**Umbrella Act**”
- ❖ **Salient Features:-**
  - ❖ Protection and improvement of environment.
  - ❖ Prevention of all hazards to all living creatures
  - ❖ Maintaining harmony between human and environment.
  - ❖ Empowers PCB to conduct inspection and if the rules are violated and can take legal action.
- ❖ **Rules and regulations under EPA.**
  - Hazardous waste (Management and Handling) Act – 1989
  - Coastal Regulation Zone Notification – 1991
  - Labelling of environment friendly products – 1991
  - Environmental Impact Assessment Notification – 1994 & 2006
  - National Environment Tribunal Act – 1995
  - National Environment Appellate Authority Act – 1997
  - Municipal Solid Waste (Management and Handling) Act – 2000

- Ozone Depleting Substances (Regulation & Control) Act – 2000
- Noise Pollution (Regulation & Control) Act – 2000
- Batteries (Management & Handling) Act – 2001
- The Biological Diversity Act – 2002
- Energy Conservation Act – 2003
- National Green Tribunal Act – 2010
- Biomedical Waste Management Rules – 2016
- Municipal Solid Waste Management Rules – 2016
- Public Waste Management Rules – 2016
- E-Waste Management Rules – 2016
- Construction & Demolition Waste Management Rules – 2016
- Wetlands (Conservation & Management) Rules – 2017

❖ **Policy Statements for abatement of pollution adopted by government of India**

**1. Precautionary Principle (PP)**

- ❖ Anticipation of harmful environmental impacts and taking appropriate measure to avoid it or choosing the least environmental harmful activity.

**2. Polluter Pays Principle (PPP)**

- ❖ The polluter should bear the cost of pollution caused Hazardous waste (Management and Handling) Act – 1989

❖ **Some of the “Green Laws” under scrutiny/review by High Level Committee (HLC) set by government of India**

- Indian Forest Act – 1927
- Wild Life (Protection) Act – 1972
- Water (Prevention and Control of Pollution) Act – 1974
- Forest (Conservation) Act – 1980
- Air (Prevention and Control of Pollution) Act – 1981
- Environmental (Protection) Act – 1986

- ❖ HLC submitted the report to government of India in November 2015
- ❖ HLC has proposed a “New Umbrella Act” known as “Environment Laws management Act (ELMA). Under this proposal, full time expert bodies are to be constituted both at central and state level to evaluate project clearance in a time bound manner.

