

Energy & Environmental Engineering

Dr Smaranika Panda, MS (IIT Madras), PhD (IIT Madras)
Assistant Professor
Environmental Engineering Division
Department of Civil Engineer
S.V. National Institute of Technology

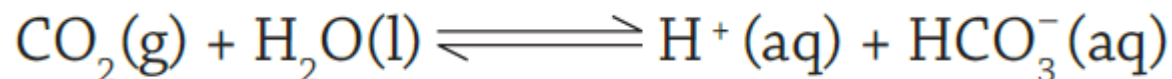
Module 3

- **GLOBAL ENVIRONMENTAL ISSUES AND ITS MANAGEMENT (8 hours)**
- Engineering aspects of climate change. Acid rain, depletion of ozone layer. Concept of carbon credit. Concepts of Environmental impact assessment and Environmental audit. Environmental life cycle assessment



Acid Rain

- Unpolluted rain water is slightly acidic owing to the presence of carbon dioxide in the air. Its pH could be up to 5.7.



- Acid rain” includes both wet and dry acidic deposits
Precipitation with a pH **lower than 5.6** is considered acidic
- Acid rain originates from sulfur dioxide and nitrogen oxide particles
- Once these particles are emitted into the air they form sulfate and nitrate particles
- These particles can travel long distances on wind currents
- By combining with water vapor, these particles form acids which fall to the earth as acid rain.

Acid Rain

- The formation of sulphur compounds and Nitrogen compounds causing acid rain is influenced by the prevailing atmospheric conditions such as the following:
 - Sunlight
 - Temperature
 - Humidity
 - Presence of hydrocarbons
 - Particulates

Effects of Acid Rain

- Poor forest health due to acidification of soil: acid rain can kill nutrient-producing microorganisms
- Acidification of lakes and streams can lead to the death of aquatic life, such as trout and bass
- Acidity can leach mercury out of the soil, causing toxic levels to build up in the fish we eat
- Acid rain can erode buildings and monuments and destroy paint finishes

Vegetation: Acid rain can wash away essential plant nutrients from the soil. In addition, it makes the soil acidic and aids the release of aluminium and copper ions which are harmful to plants.

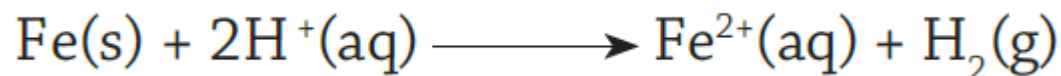
Aquatic life: When pH is less than 4.5, calcium metabolism in fresh water fish will be affected, leading to poor health. As a result, diversity and population of some fish species will be reduced.

Effects of Acid Rain

- **Building Material:** Acid rain will cause damage to common building materials (such as limestone and marble), in addition to damaging statues and monuments.



- Many metals become oxidized. Iron corrodes with the presence of acid rain to form rust. The cost of maintenance of iron structures is high in highly polluted areas.



Ozone Layer Formation

- Ozone (O₃) occurs naturally in the atmosphere. The earth's atmosphere is composed of several layers.
- Ozone forms a layer in the stratosphere, thinnest in the tropics (around the equator) and denser towards the poles.
- Ozone is formed in the atmosphere when ultraviolet radiation from the sun strikes the stratosphere, splitting oxygen molecules (O₂) into atomic oxygen (O).
- The atomic oxygen quickly combines with further oxygen molecules to form ozone.



Need of Ozone Layer

- In the stratosphere we need ozone to absorb some of the potentially harmful ultraviolet (UV) radiation from the sun (at wavelengths between 240 and 320 nm) which can cause skin cancer and damage vegetation
- At ground level, ozone is a health hazard and is a major constituent of photochemical smog.

Ozone layer depletion

- CFCs (Chlorofluorocarbons) & halons (bromine containing gases) are identified as the major culprit in ozone destruction.
- CFCs escape into the atmosphere, they reach the stratosphere intact as they are inert compounds.
- In the stratosphere, the CFCs are broken down by the sunlight releasing chlorine atoms.
- These chlorine atoms act as catalysts in the destruction of O₃.
- Chlorofluorocarbons or CFCs (also known as Freon) are non-toxic, non-flammable and non-carcinogenic. They contain fluorine atoms.
- The following is a list of major uses of CFCs:
 - as coolants in refrigerators and air conditioners
 - as solvents in cleaners, particularly for electronic circuit boards
 - as a blowing agent in the production of foam (for example fire extinguishers)
 - as propellants in aerosols
- CFCs have a lifetime in the atmosphere of about 20 to 100 years, and as a result one free chlorine atom from a CFC molecule can do a lot of damage, destroying ozone molecules for a long time.

Ozone layer depletion- Measurement

- The most common stratospheric ozone measurement unit is the Dobson Unit (DU).
- The average amount of ozone in the stratosphere across the globe is about 300 DU.
- When stratospheric ozone **falls below 200 DU**, this is considered low enough to represent the beginnings of an ozone hole.
- Ozone holes commonly form during springtime above Antarctica, and to a lesser extent in the Arctic.
- The ozone is being destroyed because of the release of chlorofluorocarbons (CFCs), mostly in the **northern hemisphere**.
- These spread throughout the world and diffuse into the stratosphere, where they are broken down to release chlorine.
- The main long-lived inorganic carriers (reservoirs) of chlorine are hydrochloric acid (HCl) and chlorine nitrate (ClONO₂). These form from the breakdown products of the CFCs.

Ozone Layer Depletion- Impact

- UV radiation from the Sun can cause a variety of health problems in humans, including skin cancers, eye cataracts and a reduction in our natural immunity towards many diseases.
- Furthermore, UV radiation can be damaging to microscopic life in the oceans which forms the basis of the world's food chain, certain varieties of vegetation including rice and soya crops, and polymers used in paints, clothing and other materials.
- Health disorders, damage to plant and aquatic life, and degradation of materials will probably increase
- Ozone depletion may even affect the global climate.

Ozone Layer Depletion- Protection

- The fundamental principle behind the actions to protect the ozone layer is to eliminate the usage of ozone depleting substances by replacing them with feasible substitutes or better technology.
- There are a number of steps that we can all take both as individuals and as groups to protect the Earth's ozone layer.
- Following **the Montreal Protocol**, most ozone depleting chemicals (ODCs) have been
- or are being phased out of use in most target applications such as aerosols, refrigeration and air conditioning.
- Avoid any fire extinguishers that contain halons, which have bromine in them. Instead use carbon dioxide, water, or dry chemical extinguisher.
- Although foam packaging is CFC-free, some products contain HCFCs (hydrochlorofluorocarbons), which, while far less damaging to the ozone layer, could contribute substantially to global warming. Hence avoid them
- As per the 2015 research reports from MIT, the antarctic ozone hole is shrinking and healing. This shows that the Montreal Protocol is effective.

EIA

BASIC CONCEPTS OF EIA :

- EIA is an activity designed to identify and predict the impact of a project on **bio-geo-physico-chemical** environment and on **human health** so as to recommend **appropriate** legislative measures, programs, and operational procedures to **minimize** the impact.
- It can be defined more simply as ' **an assessment of the impacts of a planned activity on the environment** '
- EIA is an exercise to be carried out before any project or major activity is undertaken to ensure that it will not in any way harm the environment on a short-term or long-term basis.
- Any developmental activity requires EIA to be done before executed to know the effect of a proposed development on the environment.

EIA

- **Environment may be defined differently depending upon the perspective of the definer. In the case of EIA, environment is usually considered to constitute three main subsystems:**
 1. **Physical Environment (geology, topology, climate, water, air).**
 2. **Biological Environment (terrestrial and aquatic communities, rare and endangered species, sensitive habitats, significant natural sites).**
 3. **Socio-cultural Environment (population, land use, development activities, goods and services, public health, recreation, cultural properties, customs, aspirations).**

EIA

- The EIA identifies the positive and negative impacts to the environment.
- The EIA provides a plan to reduce or offset negative impacts and utilize positive impacts for enhancement measures.
- The EIA provides a monitoring program.

EIA- Objective

The aims and objectives of EIA

- **The immediate aim of EIA is to inform the process of decision-making by identifying the potentially significant environmental effects and risks of development proposals.**
- **The ultimate (long term) aim of EIA is to promote sustainable development by ensuring that development proposals do not undermine critical resource and ecological functions or the well being, lifestyle and livelihood of the communities and peoples who depend on them.**

Evolution of EIA

Major trends in EIA		
Phase	Time	Key Events
Introduction and early development	1970-1975	Mandate and foundations of EIA established in the USA; then adopted by a few other countries (e.g. Australia, Canada, New Zealand); basic concept, procedure and methodology still apply.
Increasing scope and sophistication	mid '70s to early '80s	More advanced techniques (e.g. risk assessment); guidance on process implementation (e.g. screening and scoping); social impacts considered; public inquiries and reviews drive innovations in leading countries; take up of EIA still limited but includes developing countries (e.g. China, Thailand and the Philippines).
Process strengthening and integration	early '80's to early '90s	Review of EIA practice and experience; scientific and institutional frameworks of EIA updated; coordination of EIA with other processes, (e.g. project appraisal, land use planning); ecosystem-level changes and cumulative effects begin to be addressed; attention given to monitoring and other follow-up mechanisms. Many more countries adopt EIA; the European Community and the World Bank respectively establish supra-national and international lending requirements.
Strategic and sustainability orientation	early '90s to date	EIA aspects enshrined in international agreements (see Section 2 – Law, policy and institutional arrangements); marked increase in international training, capacity & building and networking activities; development of strategic environmental assessment (SEA) of policies and plans; inclusion of sustainability concepts and criteria in EIA and SEA practice; EIA applied in all OECD countries and large number of developing and transitional countries.
Source: updated and amended from Sadler, 1996		

Category of projects EIA

Categorization of projects and activities:-

- (i) All projects and activities are broadly categorized in to two categories - Category A and Category B, based on the spatial extent of potential impacts and potential impacts on human health and natural and man made resources.
- (ii) All projects or activities included as Category 'A', including expansion and modernization of existing projects or activities and change in product mix, shall **require prior environmental clearance from the Central Government in the Ministry of Environment and Forests (MoEF)** on the recommendations of an **Expert Appraisal Committee (EAC)** to be constituted by the **Central Government** for the purposes of this notification;

Category of projects EIA

Categorization of projects and activities:-

- (iii) All projects or activities included as Category 'B' including expansion and modernization of existing projects or activities but excluding those which fulfill the General Conditions (GC) stipulated in the Schedule, ***will require prior environmental clearance from the State/Union territory Environment Impact Assessment Authority (SEIAA)***. The SEIAA shall base its decision on the recommendations of a State or Union territory level **Expert Appraisal Committee (SEAC)** as to be constituted for in this notification.
- The **projects requiring an Environmental Impact Assessment report shall be termed Category 'B1'** and remaining projects shall be termed Category 'B2' and **will not require an Environment Impact Assessment report**.
- For categorization the **Ministry of Environment and Forests shall issue appropriate guidelines from time to time**.

Project category

LIST OF PROJECTS OR ACTIVITIES REQUIRING PRIOR ENVIRONMENTAL CLEARANCE

Project or Activity		Category with threshold limit		Conditions if any
		A	B	
1		Mining, extraction of natural resources and power generation (for a specified production capacity)		
(1)	(2)	(3)	(4)	(5)
1(a)	Mining of minerals	≥ 50 ha. of mining lease area Asbestos mining irrespective of mining area	<50 ha ≥ 5 ha .of mining lease area.	General Condition shall apply <u>Note</u> Mineral prospecting (not involving drilling) are exempted provided the concession areas have got previous clearance for physical survey

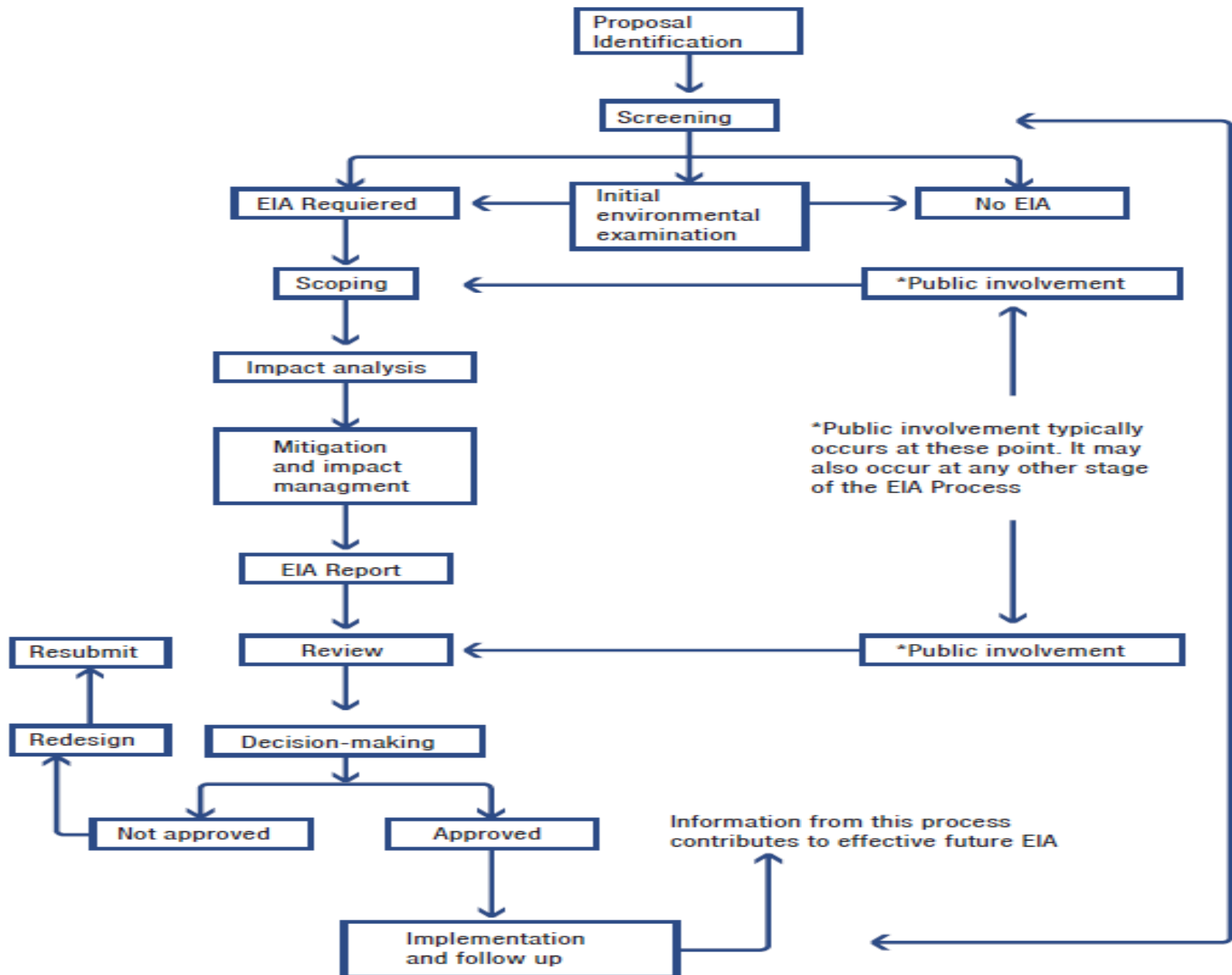
Project category

(1)	(2)	(3)	(4)	(5)
1(e)	Nuclear power projects and processing of nuclear fuel	All projects	-	
2		Primary Processing		
2(a)	Coal washeries	≥ 1 million ton/annum throughput of coal	<1million ton/annum throughput of coal	General Condition shall apply (If located within mining area the proposal shall be appraised together with the mining proposal)
2 (b)	Mineral beneficiation	≥ 0.1million ton/annum mineral throughput	< 0.1million ton/annum mineral throughput	General Condition shall apply (Mining proposal with Mineral beneficiation shall be appraised together for grant of clearance)
3(b)	Cement plants	≥ 1.0 million tonnes/annum production capacity	<1.0 million tonnes/annum production capacity. All Stand alone grinding units	General Condition shall apply

Project category

4		Materials Processing		
(1)	(2)	(3)	(4)	(5)
4(a)	Petroleum refining industry	All projects	-	-
4(b)	Coke oven plants	≥2,50,000 tonnes/annum -	<2,50,000 & ≥25,000 tonnes/annum	-
4(c)	Asbestos milling and asbestos based products	All projects	-	-
4(d)	Chlor-alkali industry	≥300 TPD production capacity or a unit located out side the notified industrial area/ estate	<300 TPD production capacity and located within a notified industrial area/ estate	Specific Condition shall apply No new Mercury Cell based plants will be permitted and existing units converting to membrane cell technology are exempted from this Notification
4(e)	Soda ash Industry	All projects	-	-
4(f)	Leather/skin/hide processing industry	New projects outside the industrial area or expansion of existing units out side the industrial area	All new or expansion of projects located within a notified industrial area/ estate	Specific condition shall apply

EIA Process



EIA Process

Screening:

- Whether or not the project or activity requires further environmental studies for preparation of an Environmental Impact Assessment (EIA) for its appraisal prior to the grant of environmental clearance depending up on the nature and location specificity of the project.
- The projects requiring an Environmental Impact Assessment report shall be termed Category 'B1' and remaining projects shall be termed Category 'B2' and will not require an Environment Impact Assessment report

EIA Process

Scoping: Identify important issues and prepare terms of reference.

- Expert Appraisal Committee determine detailed and comprehensive Terms Of Reference (TOR) addressing all relevant environmental concerns for the preparation of an Environment Impact Assessment (EIA) Report in respect of the project or activity for which prior environmental clearance is sought.
- TOR document sets out what the EIA is to cover, the type of information to be submitted and the depth of analysis that is required.
- It provides guidance to the applicant on how the study should be conducted managed.

EIA Process

Public Involvement:

- Best EIA practice involves and engages the public at numerous points throughout the process with a two-way exchange of information and views.
- Public participation may consist of informational meetings, public hearings, and opportunities to provide written comments about a proposed project.

EIA PROCESS

Impact analysis

Identification of key impacts:

This brings together the previous steps with a view to ensuring that all potentially significant environmental impacts (adverse and beneficial) are identified and taken into account in the process.

The prediction of impacts:

This step aims to identify the likely magnitude of the change (i.e. impact) in the environment when the project is implemented in comparison with the situation when the project is not carried out.

EIA PROCESS

Mitigation: This involves the introduction of measures to avoid, reduce, remedy or compensate for any significant adverse impacts.

Preparing Draft EIA report:

- A draft EIA is prepared in accordance with the Terms of Reference and/or the range of issues identified during the scoping process.
- The draft EIA must also meet the content requirements of the overarching EIA law or regulations.

Preparing Final EIA:

- This step produces a final impact assessment report that addresses the viewpoints and comments of the parties that reviewed the draft EIA. These comments may prompt revisions or additions to the text of the draft EIA.

Decision:

- A decision to approve or reject a mining project is generally based on the final EIA,

Carbon Credit

- Continuous accumulation of carbon dioxide in the atmosphere has contributed to what is known today as Global Warming.
- The several other causes besides burning of fossil fuel which has increased the level of carbon dioxide in the atmosphere are the systematic clearing of forests to make way for more factories and various other human structures.
- The growing awareness about harmful levels of Greenhouse Gases (GHG) and the resulting Worldwide Warming phenomena, has forced the government authorities and private organizations to implement systems that would help in reducing the amount of carbon dioxide in the atmosphere.

Kyoto Protocol

- The Kyoto Protocol was initiated by the United Nations Framework Convention on Climate Change and ratified by 181 countries and the European Union as a whole, individual entity in 1997, and was put into effect in 2005.
- This protocol was proposed by the international community to address and reduce greenhouse gas emissions that have led to global climate change.
- The Protocol makes it mandatory for commercial entities emitting above the permitted limit of carbon dioxide to cut down their emissions to prescribed levels, or they should **buy carbon credits certificates** which can be transacted in the market, or alternatively **pay a charge for the emissions, which is referred to as carbon tax.**

Kyoto Protocol

- One carbon credit allows one tonne of carbon dioxide or a corresponding amount of other greenhouse gases to be discharged in the air.
- Businesses that are **over their quotas** must **buy carbon credits** for excess emissions, while those below can **sell their remaining credits**.
- This exchange of credits between businesses has encouraged carbon trading globally.
- These credits can be exchanged between businesses or bought and sold in **international markets** at prevailing market price at two exchanges, namely the **Chicago Climate Exchange and the European Climate Exchange**.
- The **Multi-Commodity Exchange of India (MCX)** may soon become the third exchange in the world to trade in carbon credits.
- The amount of global emissions can be controlled through the buying and selling of carbon credits in the carbon trading method.

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Carbon Credit

- As a result, the worldwide carbon emissions stay within permissible levels, and the companies come up with ecologically sustainable ways of conducting business .
- The system also motivates the organisations to be more eco friendly so that they can increase their earnings by selling carbon credits.
- As carbon credits are freely traded in the market, they make it very easy for businesses to follow the system.

Carbon Credit

- Carbon credits can also be purchased even if you are not a part of any organisation in order to lower your own carbon footprint.
- The money that you put in this manner is routed to fund ecological projects in any region on the planet so that the emissions made as a result of your activities can be neutralized.
- This sale and purchase in carbon credits helps limit the unchecked emissions of greenhouse gases throughout the world.
- Organizations responsible for atmospheric pollution are made to pay for their acts while ones taking positive steps are rewarded.
- This has caused firms to actively seek ways to decrease their emissions and adopt cleaner ways of doing business.
- Thus, the whole system motivates companies and governments to promote environment friendly processes that reduce greenhouse gas emission.

Carbon Credit: India Status

Exhibit 1: A Few Carbon Trading Companies in India

Name of the Companies/Centres	Special Features
Jindal Vijaynagar Steel	Expected sale in next ten years is \$225 million worth of saved carbon.
Powerguda in Andhra Pradesh	Currently selling 147 tonnes equivalent of saved carbon dioxide credits.
Handia Forest in Madhya Pradesh	Earn at least US\$300,000 every year from carbon payments by restoring 10,000 hectares of degraded community forests.
Torrent Power AEC	Estimated amount receivable from 'Energy Efficiency Project' is Rs. 199.9 crore.
Indian Aluminium	Estimated amount receivable from 'Gas Capture Project' is Rs. 42.9 crore.
Kalpataru Power Transmission	Estimated amount receivable from 'Renewable Project' is Rs. 5.3 crore.
Grasim Industries	Estimated amount from 'Energy Efficiency Project' is Rs. 4.1 crore.
Balrampur Chini	Estimated amount receivable from 'Renewable Project' is Rs. 15.7 crore.

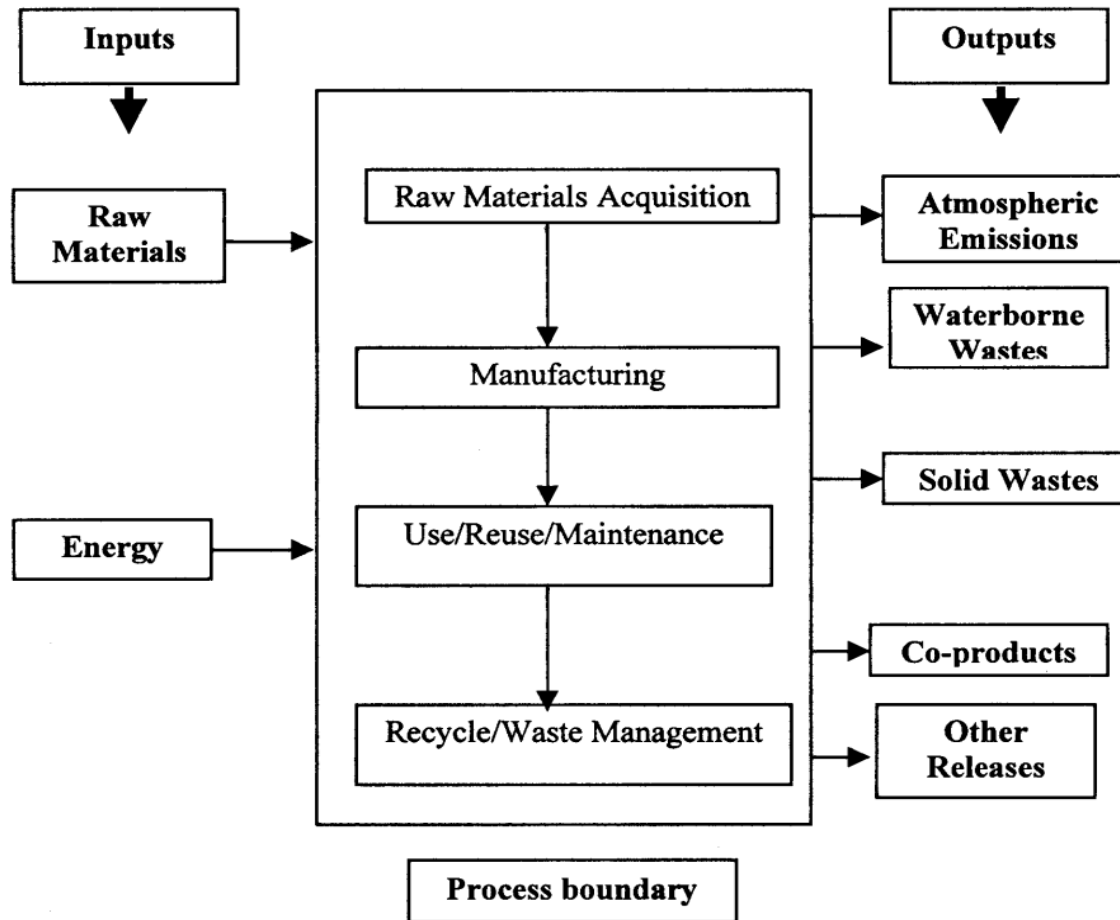
Carbon Credit: India Status

- India's GHG emission is below the target and so, it is entitled to sell surplus credits to developed countries.
- India is considered to claim about 31% of the total world carbon trade, which can give \$25bn in 2010.
- This is what makes trading in carbon credits such a great business opportunity.
- The 800 million farming community in India has also a unique opportunity where they can sell Carbon Credits to developed nations.
- The India's Delhi Metro Rail Corporation (DMRC) has become the first rail project in the world to earn carbon credits

Life cycle assessment

- **Life Cycle:** Consecutive and interlinked stages of a product or service system, from the extraction of natural resources to the final disposal.
- It considers all the environmental impact right from the extraction of raw material to its final disposal.
- It considers both qualitative and quantitative aspects.
- **Life cycle assessment** is a tool for systematic evaluation of the environmental impact of a product throughout each stage of its life cycle.
- **Life-cycle assessment (LCA, also known as life-cycle analysis, ecobalance, and cradle-to-grave analysis)**
- It is a technique to assess environmental impacts associated with all the stages of a product's life from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling.

Life cycle assessment



Life cycle assessment- NEED

- To study the impact of our goods ,services and technology on our environment
- To identify and implement ways of improving environment from the adverse effect.
- To identify the environmental consequence of a decision or a proposed change in the system under study
- It can help us during design stage and manufacturing stage of new product

What is LCA used for

- Manufacturers typically **use LCA's to reduce the environmental impact** of their products by examining the inputs and outputs of their products, with the aim of producing a more environmentally friendly product.
- They might achieve this by implementing a more efficient production process or simply by sourcing raw materials from locations closer to the production facility.

EVOLUTION OF LIFE CYCLE ASSESSMENT

- As a part of ISO 14000 series of standards ISO in 2000 has come out with the following standards:
 1. ISO 14040: Environnemental Management – LCA – Principles and Framework.
 2. ISO 14041: Environmental Management – LCA – Inventory Analysis.
 3. ISO 14042: Environmental Management – LCA – Impact Assessment.
 4. ISO 14043: Environnemental Management – LCA – Interpretation

Components of LCA / Stages of LCA Methodology

An LCA consists of 4 basic stages:

- 1. Goal and scope definition** – define and describe the product, process or activity in question. Define the boundaries and environmental effects to be assessed and the purpose of the study.
- 2. Inventory analysis** – identify and quantify energy and materials inputs and outputs e.g. raw materials required, energy required for production processes, waste and by-products, emissions, materials that can be recycled etc.
- 3. Impact assessment** – assess the potential impacts on the environment and population of energy, materials, emissions etc. based on the inventory analysis.
- 4. Improvement analyses** – with a clear picture of the items involved (inventory analysis) and impact assessment, evaluate the results obtained to identify areas where improvements can be made. Once tested with a positive outcome implement these changes to improve sustainability.