# TWO-YEAR POST-GRADUATE DEGREE PROGRAMME(CBCS) IN **GEOGRAPHY**

Semester-IV

Self-Learning Material

**Paper Code: GEO/DSE/EG/T-421**

**Paper: Environmental Geography- IV: ENVIRONMENTAL MANAGEMENT (Special Paper)**

**DIRECTORATEOFOPENANDDISTANCELEARNING (DODL)**

**UNIVERSITY OFKALYANI**

**Kalyani,NadiaWestBe ngal,India**

| GEO/DSE/EG/T-421 | Environmental Geography- IV: Environmental Management (Special Paper) |
|---|---|
| **Units** | **Compiled by** |
| Unit-1:Environmental Management Planning: purpose and framework | Dr.Kalosona Paul |
| Unit-2: Natural and quasi-natural hazards- case studies from littoral West Bengal: causes, consequences and management | Dr.Kalosona Paul |
| Unit-3: Concept of urban forestry | Dr.Kalosona Paul |
| Unit-4: Concept of sustainable transport | Dr.Kalosona Paul |
| Unit-5: Concept of sustainable development and sustainable development goals | Dr.Kalosona Paul |
| Unit-6: Eco-tourism: case studies from the Himalayan and coastal belts of West Bengal | Dr.Kalosona Paul |
| Unit-7: Green technology | Dr.Kalosona Paul |
| Unit-8: Green economy | Dr.Kalosona Paul |
| Unit-9: Industrial pollution management with special reference to thermal power and sponge iron plants of West Bengal | Dr.Kalosona Paul |
| Unit-10: Recycling of wastes | Dr.Kalosona Paul |
| Unit-11: Renewable energy and green energy | Dr.Kalosona Paul |
| Unit-12: Environmental ethics, policies and laws in India with special reference to air, water and forest | Dr.Kalosona Paul |

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# Director's Message

Satisfying the varied needs of distance learners, overcoming the obstacle of distance and reaching the unreached students are the threefold functions catered by Open and Distance Learning (ODL) systems. The onus lies on writers, editors, production professionals and other personnel involved in the process to overcome the challenges inherent to curriculum design and production of relevant Self Learning Materials (SLMs). At the University of Kalyani a dedicated team under the able guidance of the Hon'ble Vice-Chancellor has invested its best efforts, professionally and in keeping with the demands of Post Graduate CBCS Programmes in Distance Mode to devise a self-sufficient curriculum for each course offered by the Directorate of Open and Distance Learning (DODL), University of Kalyani.

Development of printed SLMs for students admitted to the DODL within a limited time to cater to the academic requirements of the Course as per standards set by Distance Education Bureau of the University Grants Commission, New Delhi, India under Open and Distance Mode UGC Regulations, 2020 had been our endeavour. We are happy to have achieved our goal.

Utmost care and precision have been ensured in the development of the SLMs, making them useful to the learners, besides avoiding errors as far as practicable. Further suggestions from the stakeholders in this would be welcome.

During the production-process of the SLMs, the team continuously received positive stimulations and feedback from Professor (Dr.) Amalendu Bhunia, Hon'ble Vice- Chancellor, University of Kalyani, who kindly accorded directions, encouragements and suggestions, offered constructive criticism to develop it within proper requirements. We gracefully, acknowledge his inspiration and guidance.

Sincere gratitude is due to the respective chairpersons as well as each and every member of PGBOS (DODL), University of Kalyani. Heartfelt thanks is also due to the Course Writers-faculty members at the DODL, subject-experts serving at University Post Graduate departments and also to the authors and academicians whose academic contributions have enriched the SLMs. We humbly acknowledge their valuable academic contributions. I would especially like to convey gratitude to all other University dignitaries and personnel involved either at the conceptual or operational level of the DODL of University of Kalyani.

Their persistent and co-ordinated efforts have resulted in the compilation of comprehensive, learner-friendly, flexible texts that meet the curriculum requirements of the Post Graduate Programme through Distance Mode.



All the Self Learning Materials are self writing and collected from e-book, journals and websites.

Director
Directorate of Open and Distance Learning
University of Kalyani

# Syllabus

| SEMESTER-IV | | | | | | |
|---|---|---|---|---|---|---|
| **Paper Code** | **Paper** | **Theory/ Practical** | **Internal Assessment / Evaluation** | **Examination / Report/ Viva-Voce** | **Credit** | **Marks** |
| **GEO/DSE/EG/ T-421** | **Environmental Geography- IV: Environmental Management (Special Paper)** | Theory | 10 | 40 (Semester-end Examination) | 4 | 50 |

**Unit-1:**Environmental Management Planning: purpose and framework

**Unit-2:**Natural and quasi-natural hazards- case studies from littoral West Bengal: causes, consequences and management

**Unit-3:**Concept of urban forestry

**Unit-4:**Concept of sustainable transport

**Unit-5:**Concept of sustainable development and sustainable development goals

**Unit-6:**Eco-tourism: case studies from the Himalayan and coastal belts of West Bengal

**Unit-7:**Green technology

**Unit-8:**Green economy

**Unit-9:**Industrial pollution management with special reference to thermal power and sponge iron plants of West Bengal

**Unit-10:**Recycling of wastes

**Unit-11:**Renewable energy and green energy

**Unit-12:**Environmental ethics, policies and laws in India with special reference to air, water and forest

**Mode of Internal Evaluation:** Class test

# Contents

### 1.1. Introduction:

This paper aims to introduce environmental geography, environmental management to the students of geography of the third semester. Environmental geography examines the dynamic relationship between human societies and their natural surroundings. This course provides a comprehensive understanding of the intricate connections between human activities, environmental processes, and the sustainable management of Earth's resources. Through interdisciplinary approaches, students will explore key concepts, theories, and case studies to analyze environmental challenges and opportunities on local, regional, and global scales.

### 1.2. Learning Objectives:

- Environmental Management Planning: purpose and framework
- Natural and quasi-natural hazards- case studies from littoral West Bengal: causes, consequences and management
- Concept of urban forestry
- Concept of sustainable transport
- Concept of sustainable development and sustainable development goals
- Eco-tourism: case studies from the Himalayan and coastal belts of West Bengal
- Green technology
- Green economy
- Industrial pollution management with special reference to thermal power and sponge iron plants of West Bengal
- Recycling of wastes
- Renewable energy and green energy
- Environmental ethics, policies and laws in India with special reference to air, water and forest

### 1.3. Assessment of Prior Knowledge:

Student should have prior knowledge when they may ask;

- What is mean by environmental geography?
- What is concept of sustainable development?
- What is importance to study environmental geography?

**1.4. Learning activities:**

This module will offer to build knowledge, individual, group discussion, debates and interaction with teacher-students. Classroom seminars/ discussions regarding various topics covered under this paper may be done. During the personal contact programmers, learners may be assigned to prepare assignment in various on environmental issues, sustainable development, green economy and recycling of wastes etc.

Classroom seminars/ discussions regarding various topics covered under this paper may be done

**1.5. Feedback of learning activities:**

Once the learning process has been completed and internal assessment will be done. On the basis of evaluation reports of the internal assessment some areas of the syllabus will be refocused depending upon student's requirement.

## UNIT-1
## Environmental Management Planning: purpose and framework

**Introduction: -**

The Environment Management Plan (EMP) is required to ensure sustainable development in the area surrounding the proposed project. Hence, it needs to be an all encompasses plan for which the industry, Government, regulating agencies; like Pollution Control Board working in the region and the local residents of the area need to extend their co-operation and contribution. It has been evaluated that the proposed project will have minor impacts on the surrounding areas. Mitigation measures at the source level and an overall Management Plan at the site level are elicited so as to preserve the surrounding environment. The mitigation measures are recommended in order to synchronize the economic development of the project area with the environmental protection of the region. The construction phase impacts are mostly short term, restricted to the plot area and not envisaged on the larger scale. In the operational phase, the environmental impacts are due to continuous operation of the project; hence, the emphasis in the Environment Management Plan (EMP) is to minimize such impacts.

**Concept of the environment and EMP: -**For the promotion of EMP it is necessary to clarify our basic concepts concerning the environment (Takeuchi Kei 1987; Weichhart 1979). The environment viewed from a landscape-ecological aspect means the external conditions related to living things. Human beings exist not only through controlling the natural environment but also by forming a social environment through culture and technology. As such, understanding the environmental structure through the comprehension of the processes required for its constituent elements to exist is more important than a discussion about why the environment is in a particular condition. On the other hand, human beings are at the centre of EMP thinking: the environment to be dealt with is a human environment. This human environment can be divided into a social environment that is close to human life and production and a natural environment that supports human society and economic activities

**Purpose and Objective of Environment Management Plan: -**The objective of Environment Management Plan is given below:

- Mitigation measures for each of the activities causing the environmental impacts.

- Sustainable use of resources used for manufacturing activities which includes optimization of resource consumption.
- Monitoring plans for checking activities and environmental parameters and monitoring responsibilities
- Role responsibilities and resource allocation for monitoring.
- To treat all the pollutants, i.e. effluent, air emission, noise pollution & hazardous waste, that contributes to the degradation of environment, with appropriate technology.
- To comply with all the regulations stipulated by central/state pollution control boards related to air emission control and liquid effluents discharge as per Air & water pollution control laws.
- To handle and management hazardous waste storage and disposal as per Hazardous & Other Wastes (Management and Transboundary Movement) Rules, 2016.
- To encourage, support and conduct development work for achieving environment standards and to improve methods of environment management.
- To promote further forestation in the surrounding areas of the plant.
- To create good environment (devoid of air & noise pollution) for employees.
- To reduce fire and accidental hazards.
- Perspective budgeting and allocation of funds for environment management expenditure.
- Continuous development and search for innovative technologies for better environment.
- To adopt cleaner production technology.

**Scope of the EMP: -**The initial focus of the EMP is the protection of aquatic habitat and traffic management due to increase in visiting people as well as those activities under the direct control of PGPL management where activities may give rise to significant environmental impacts, the EMP includes a number of priority strategies and actions relating to these locations. The EMP also supports collaboration and joint actions with affiliated

organizations, tenants and contractors within the PGPL's sphere of influence. In line with the Environment Policy, the following criteria will be used to determine priorities for attention:

Impact on the physical and biological environment;

Contribution to innovation and definition of best environmental practice;

Compliance with statutory requirements and other environmental commitments;

Availability of resources.

The EMP acknowledges the social and cultural dimensions of responsible environmental management alongside the biological and physical, reflecting a holistic view of the PGPL as a "human ecosystem". The scope of the EMP includes the following functional areas:

**Management systems:** Those systems employed in the management of the PGPL's operational activities. It will include financial systems; engagement and supervision of contractors; purchasing policies, etc.

**Knowledge systems:** Those processes which build knowledge and capacity on environmental issues, principles and sustainable behaviors. It will include training; communications; campaigns; links with operational departments, etc.

**Energy management:** The energy-related aspects of the planning, design, construction, operation and maintenance of the PGPL's facilities.

**Water management:** Aspects of supply, usage and disposal of water pertinent to the planning, design, construction, operation and maintenance of the PGPL's facilities.

**Materials management:** Those services and activities which support the avoidance, resource recovery (e.g., reuse and recycling) and environmentally responsible disposal of solid and liquid waste materials.

**Planning, design and development:** The planning, design and development of the PGPL's built form and associated infrastructure.

**Pollution prevention:** Those aspects of planning and management which support minimisation of air and water pollution and contamination of land resulting from daily routine activities.

**Transport:** Programs, projects, systems and procedures which promote and support walking, cycling and public transport for trip-to-work, accommodation and other related travel.

**Biodiversity and open space:** Those aspects of management and maintenance which support conservation and enhancement of biodiversity and environmentally sustainable use of open space across PGPL and other properties

Environmental management plan (EMP) consists of the set of mitigation, monitoring, and institutional measures to be taken during implementation and operation to eliminate adverse environmental and social impacts, offset them, or reduce them to acceptable levels. The plan also includes the actions needed to implement these measures.Management plans are essential elements of EA reports for Category A projects; for many Category B projects, the EA may result in a management plan only. To prepare a management plan, the borrower and its EA design team (a) identify the set of responses to potentially adverse impacts; (b) determine requirements for ensuring that those responses are made effectively and in a timely manner; and (c) describe the means for meeting those requirements.More specifically, the EMP includes the following components (The World bank Operational Mannual, January, 1999): -

**Mitigation: -**The EMP identifies feasible and cost-effective measures that may reduce potentially significant adverse environmental impacts to acceptable levels. The plan includes compensatory measures if mitigation measures are not feasible, cost-effective, or sufficient. Specifically, the EMP

(a) identifies and summarizes all anticipated significant adverse environmental impacts (including those involving indigenous people or involuntary resettlement);

(b) describes-with technical details-each mitigation measure, including the type of impact to which it relates and the conditions under which it is required (e.g., continuously or in the event of contingencies), together with designs, equipment descriptions, and operating procedures, as appropriate;

(c) estimates any potential environmental impacts of these measures; and

(d) provides linkage with any other mitigation plans (e.g., for involuntary resettlement, indigenous peoples, or cultural property) required for the project.

**Monitoring: -**Environmental monitoring during project implementation provides information about key environmental aspects of the project, particularly the environmental impacts of the project and the effectiveness of mitigation measures. Such information enables the borrower and the Bank to evaluate the success of mitigation as part of project supervision, and allows corrective action to be taken when needed. Therefore, the EMP identifies monitoring objectives and specifies the type of monitoring, with linkages to the impacts assessed in the EA report and the mitigation measures described in the EMP. Specifically, the monitoring section of the EMP provides

(a) a specific description, and technical details, of monitoring measures, including the parameters to be measured, methods to be used, sampling locations, frequency of measurements, detection limits (where appropriate), and definition of thresholds that will signal the need for corrective actions; and

(b) monitoring and reporting procedures to (i) ensure early detection of conditions that necessitate particular mitigation measures, and (ii) furnish information on the progress and results of mitigation.

**Capacity Development and Training: -** To support timely and effective implementation of environmental project components and mitigation measures, the EMP draws on the EA's assessment of the existence, role, and capability of environmental units on site or at the agency and ministry level.If necessary, the EMP recommends the establishment or expansion of such units, and the training of staff, to allow implementation of EA recommendations. Specifically, the EMP provides a specific description of institutional arrangements-who is responsible for carrying out the mitigatory and monitoring measures (e.g., for operation, supervision, enforcement, monitoring of implementation, remedial action, financing, reporting, and staff training). To strengthen environmental management capability in the agencies responsible for implementation, most EMPs cover one or more of the following additional topics:

(a) technical assistance programs,

(b) procurement of equipment and supplies, and

(c) organizational changes.

**Implementation Schedule and Cost Estimates:** -For all three aspects (mitigation, monitoring, and capacity development), the EMP provides

(a) an implementation schedule for measures that must be carried out as part of the project, showing phasing and coordination with overall project implementation plans; and

(b) the capital and recurrent cost estimates and sources of funds for implementing the EMP. These figures are also integrated into the total project cost tables.

**Integration of EMP with Project:** -The borrower's decision to proceed with a project, and the Bank's decision to support it, are predicated in part on the expectation that the EMP will be executed effectively. Consequently, the Bank expects the plan to be specific in its description of the individual mitigation and monitoring measures and its assignment of institutional responsibilities, and it must be integrated into the project's overall planning, design, budget, and implementation. Such integration is achieved by establishing the EMP within the project so that the plan will receive funding and supervision along with the other components.

Environment Management Plans: - The Environment Management Plans detail out the mitigation measures to be implemented both by OIL and Contractors during various stages of the exploratory activity within the Deomali PEL Block. The following environmental management plans have been formulated in line with the proposed project activities viz. site preparation, drilling, well testing and decommissioning (Durning& Broderick, 2017).

1. Pollution Prevention and Abatement Plan

2. Waste Management Plan

3. Flare and illumination Management Plan

4. Storm Water Management Plan

5. Spill Management Plan

6. Wildlife Management Plan

7.Road Safety and Traffic Management Plan

8. Occupational Health & Safety Management Plan

9. Management of Social Issues and Concerns

10. Site Closure Plan

OIL will ensure communication and implementation of the aforesaid management plans prior to the commencement of site preparation and drilling operations in the field. In addition, the mitigation measures for social issues and concerns are also separately presented in this report. An Emergency Response Plan to address technological emergency situations viz. blow outs, fires, oil spill etc. etc. that may arise out of drilling operations has already been discussed in previous chapter. In cases, where there are possible overlaps, the plans have been cross-referenced to avoid repetition.

**1. Pollution Prevention and Abatement Plan (PPAP):**

**Scope: -**The Pollution Prevention and Abatement Plan (PPAP) is applicable for and encompasses both construction and operational phase activities for the proposed project which has the potential to adversely impact ambient air &noise quality, water quality and soil quality of the Deomali PEL Block.

**Purpose: -**The PPAP establishes specific measures and guidelines aimed at effectively addressing and mitigating the air, noise, water and soil quality impacts that may arise as result of well site preparation and access road construction/strengthening, drilling operations, well testing and decommissioning/site closure. The plan also details out roles and responsibilities of OIL and the contractors to ensure effective implementation of the plan.

**Mitigation Measures & Strategies: -** The following mitigation measures need to be adopted and implemented by OIL and its contractors during various phases of the proposed project to prevent and control air emissions (both point and fugitive), high noise generation, soil contamination and fertility loss, contamination and depletion of ground water resources and storm water discharge.

**2. Waste Management Plan:**

**Scope: -** The Waste Management Plan (WMP) is applicable for all process and non-process waste streams which are generated during various hydrocarbons in Deomali PEL Block. The major waste streams covered under this plan includes drill cuttings, waste drilling mud, drilling wash water, kitchen waste and sewage. In addition, waste oil and lead acid batteries generated from the proposed project operations have also been dealt in this plan.

**Purpose: -** The WMP establishes specific measures to ensure proper collection, storage, treatment and disposal of the identified process and non-process waste streams in accordance with the applicable national regulations and guidelines.

**Mitigation Measures: -** The following mitigation measures need to be adopted and implemented by OIL and its contractors for the major waste streams identified in the plan.In addition to the management measures specified for the major waste stream, OIL will prepare and update periodically a waste management inventory of all waste streams identified for the proposed project. Necessary measure will also be taken by OIL to incorporate appropriate waste management and handling procedures in the contractor work document and conduct periodic training of personnel involved in waste handling onsite to ensure proper implementation of the WMP. In this regard, necessary inspection, record keeping, training program and monitoring procedures will be established by OIL and made operational to achieve proper management of all wastes generated on site.

**3. Flare & Illumination Management Plan:**

The glare from the flare and illumination not only cause visual impacts but also causes ecological impacts. These best practices can be adopted for reducing ecological impacts to animals especially when operating in the migratory birds habitat.

**Enclosed Ground Flaring: -** The elevated flare can be replaced by an enclosed ground flare, such as the enclosed ground flare. This type of flare eliminates much of the visual impacts of burning produced gas in a processing facility. Also, the enclosed ground flare will decrease the amount of smoke and noise compared to the elevated flare.

**Work Zone Illumination: -** An oil exploration facility in Maryland has adopted low height (less than 8 m), low-pressure sodium lamp that are most energy efficient to reduce the ecological impacts (Fure, 2006). Further, illumination has been provided only in required locations and has placed UV filters on lamps. Such UV filtered lights have been found to less distractive to migrating birds.

**4. Storm Water Management Plan:**

**Scope: -** The Storm Water Management Plan (SWMP) refers to the proper management of surface run-off generated during monsoons for various phases of activities involved in the project.

**Purpose: -** The purpose of Storm Water Management Plan (SWMP) is to ensure prevent and control any adverse impact of discharge of storm water from the well site and road widening/strengthening areas to nearby natural drainage channels and community water bodies. Proper management of storm water runoff will minimize damage to public and private property, reduce effects of development on land, control stream channel erosion, pollution and sediment deposition and also reduce local flooding.

**Mitigation Measures: -**

• Pipe drainages will be provided for diversion roads constructed for the construction of new bridges and culverts.

• Storm water from all longitudinal and cross drainage works will be connected to the natural drainage courses.

• Necessary measures will be undertaken during construction phase to prevent earth and stone material from blocking cross drainage structures.

• Periodic cleaning will be undertaken to cross drainage structures and road drainage system to maintain uninterrupted storm water flow.

• Obstructions that may cause temporary flooding of local drainage channels, during construction phase will be removed.

• Oil traps and oil water separator will be used to separate oil from runoff water .

• Sediment control measures in the form of silt traps and sedimentation tank will be provided to treat surface run-off before disposal.

5. Spill Management:

A number of chemicals and oil (high speed diesel) will be stored on site, improper handling or accidents are likely to result in spills which have a potential for contaminating the environment. OIL would develop and educate the Contractors/personnel working to prevent such spills and also develop a proper spill response and management plan.

As best practices to avoid/contain any spill OIL would ensure:

• All chemicals are stored within the designated area. To an extent possible all such areas would away from drainage channels

• The flooring of the area should be impervious (paved or HDPE lining) and bunding to be provide on all sides of the chemical storage areas

• The chemical storage area to be covered to ensure it has the minimum runoff.

• All transfers of chemicals to be done with proper care and under the supervision of the Store supervisor

• No oil transfers will occur, unless adequate protection is in place

OIL's spill management plan would aim to con mitigative actions. The following additional measures will be implemented for spill management:

• Once a spill incident has occurred, identify the chemical involved and check hazardous property of the chemical from the Material Safety Datasheet (MSDS);

• Person wearing required PPE will apply necessary absorbent like saw dust for a liquid spill to ensure that the spill does not spread over a wide area or reach any surface water body or drainage channels;

• Thereafter, the substance will be properly collected and stored in a separate labeled container marked–do"hazardousnotandburn";disposeinaccordancewastewith Hazardous Waste (Management, Handling & Transboundary Movement) Rules, 2008.

**6. Wildlife Management Plan:**

**Scope: -** The proposed drilling and testing of hydrocarbons in Deomali PEL Block may impart potential impact on threatened plant and animal species close to the drill sites or access roads. The likely impacts of the project activities on the ecological habitat have been addressed in a Wildlife Management Plan prepared to safeguard forest areas and their characteristic floral and faunal component.

**Purpose: -** The purpose of Wildlife Management Plan is to minimize the impact on natural habitat (forest and river ecosystem) and control any adverse impact due to air and noise pollution from drilling and well testing activities, discharge of untreated waste water from drilling operation, storm water runoff from the well site and road widening/strengthening activities. The Management Plan details out the mitigation measures and strategies to be adopted by OIL and the Contractors during each phase of the project, at the same time

establishing a monitoring network to investigate the effective implementation of the Management Plan.

Mitigation measures:

• Permission from the Standing Committee of National Board of Wildlife (NBWL) to be taken for Loc A &Loc C site as it is located at a distance of 2 km of DehingPatkai Wildlife Sanctuary.

• The drill site will be properly fenced (chain-linked) to avoid straying of any outsider as well as wildlife;

• No temporary electric supply connection line from the grid will be laid for the proposed project activity. All electric requirements will be supplied from the internal DG sets.

• Noise Levels at the drill site will be controlled through selection of low noise generating equipment and installation of sufficient engineering controls viz. mufflers, silencers etc.

• Movement of heavy vehicles will be restricted at night time, especially in access road within the forest area as most of the mammal's movement occurred during night;

• Care would be taken while disposal drill cutting & other drilling waste and discharge of waste water from the drilling site.

The following measures and strategies needs to be adopted to safeguard the natural habitat from the possible impacts resulting from the project and its related activities. An Environment Management Cell (EMC) will be developed for implementation of environmental mitigation & management plan. Forest personnel and veterinary doctor will be taken into the management cell for implementing the wildlife management plan. The environment cell would look after the following measures:

• Any wild animal species if trapped during site development or operation of drilling would be released into suitable habitat;

• If elephant migrates into the drill site, then with the help of Forest Department personnel, the animal will be driven back into its suitable habitat;

• Proper monitoring of indicator species will be carried out and compared to baseline to understand any negative impacts;

• All sightings of sensitive species in and around the project site will be reported and adequate steps will be taken with the help of forest personnel to reduce conflict between such animals and project activities or people working at site.

• The Environment Compliance Officer will hold training program for all the OIL employees and sub-contractor on the applicable practice and mitigation measures contained within the Wildlife Management Plan.

• Signage will be provided for the significant wildlife habitat, migration route and corridor within the block area and on the material transport route.

**7. Road Safety & Traffic Management Plan:**

**Scope: -** The Road Safety & Traffic Management Plan is applicable to all operation pertaining to OIL and contractor vehicular movement viz. vehicle involved in the transportation of raw materials, project and contractor personnel, drilling rig and heavy equipment transportation to well site and decommissioning.

**Purpose: -** The Road Safety & Traffic Management Plan outlines specific measures to be adopted and implemented by OIL to mitigate any potential impact on community health and safety that may arise out of movement of vehicles and transportation of drilling rig and heavy equipment's during site preparation, drilling and decommissioning activities.

**Mitigation Measures: -**

• Proper signage will be displayed at important traffic junctions along the predefined access routes to be used by construction and operational phase traffic. The signage will serve to prevent any diversion from designated routes and ensure proper speed limits are maintained near village residential areas.

• The condition of roads and bridges identified for movement of vehicles and drilling rig will be assessed by OIL to ensure their safe movement.

• Precautions will be taken to avoid damage to the public access routes including highways during vehicular movement.

• Safe and convenient passage for vehicles, pedestrians and livestock to and from side roads and property accesses connecting the project road will be provided. Work that affects the use

of side roads and existing accesses will not be undertaken without providing adequate provisions.

• Parking of project vehicles along village access roads prohibited. Signposted parking facilities will be utilized for such purpose.

• Any road diversions and closure will be informed in advance to the villagers who are accessing the defined routes

• Traffic flows will be scheduled wherever practicable during period of increased commuter movement.

• Clear signs, flagmen & signal will be set up at major traffic junctions and near sensitive receptors viz. primary schools in consultation with Gram Panchayat and local villagers.

• Movement of vehicles during night time will be restricted. Speed limits will be maintained by vehicles involved in transportation of raw material and drilling rig.

• Regular supervision will be done by contractor to control vehicular traffic movement along defined traffic routes particularly near identified sensitive receptors

• A Journey Management Plan will be formulated and implemented by the contractor to control construction and operational phase traffic.

• Routine maintenance of project vehicles will be ensured to prevent any abnormal emissions and high noise generation.

• Adequate training on traffic and road safety operations will be imparted to the drivers of project vehicles. Road safety awareness programs will be organized in coordination with concerned authorities to sensitize target groups viz. school children, commuters on traffic safety rules and signage.

**8. Occupational Health & Safety Management Plan:**

Purpose: - The Occupation Health & Safety Management Plan (OHSMP) has been formulated to address the occupational health and safety related impacts that may arise from proposed project activities viz. drilling and testing operation of construction machinery/equipments, storage and handling of fuel and chemicals, operation of drilling rig and associated equipment, during drilling and decommissioning/site closure.

**Mitigation Measures: -**

• All machines to be used in the construction will conform to the relevant Indian Standards (IS) codes, will be kept in good working order, will be regularly inspected and properly maintained as per IS provisions and to the satisfaction of the site Engineer.

• Contractor workers involved in the handling of construction materials viz. borrow material, cement etc. will be provided with proper PPEs viz. safety boots, nose masks etc.

• No employee will be exposed to a noise level greater than 85 dB(A) for a duration of more than 8 hours per day. Provision of ear plugs, ear muffs etc. and rotation of workers operating near high noise generating areas.

• Hazardous and risky areas, installations, materials, safety measures, emergency exits, etc. shall be appropriately marked.

• All chemicals and hazardous materials storage container will be properly labeled and marked according to national and internationally recognized requirements and standards. Materials Safety Data Sheets (MSDS) or equivalent data/information in an easily understood language must be readily available to exposed workers and first-aid personnel.

• The workplace must be equipped with fire detectors, alarm systems and fire-fighting equipments. Equipments shall be periodically inspected and maintained to keep good working condition.

• Health problems of the workers will be taken care of by providing basic health care facilities through health centres temporarily set up for drilling base camp.

• The sewage system for the camp must be properly designed, built and operated so that no health hazard occurs.

• Adequate sanitation facilities will be provided onsite for the operational workforce both during construction and operational phase of the project.

• Garbage bins will be provided in the camp and regularly emptied and the garbage disposed off in a hygienic manner.

• Training programs will be organized for the operational workforce regarding proper usage of PPEs, handling and storage of fuels and chemicals etc.

## 9. Management of Social Issues and Concerns:

Mitigation measure have been outlined to address project related social issues and concerns in order for OIL to take proactive steps and adopt best practices, which are sensitive to the socio-cultural setting of the region. The plans will include people residing in proximity to the proposed well sites and access routes.

**Providing Job Opportunities: -** During site construction non-technical jobs will be generated. Most of the people employed during this stage would be semi-skilled or unskilled. People from adjoining areas especially given preference through local contractors according to the skill sets possessed.

**Ensuring: -** Public Safety Since the project involves the movement of heavy vehicles and machinery in the area, the issue of public safety of the villagers, especially children, tea garden workers is an important concern. During the drilling phase and for the rest of the project activities proper safety measures will be undertaken both for transportation as well as the other operations. The drill site would be fenced and gates would be constructed so that the local people are refrained from straying into the site. The movement of traffic is also likely to disrupt access conditions of the inhabitants residing close to the access road. The increase in traffic will have implications on their safety too, as well as create congestion, potential delays and inconvenience for pedestrians.

## 10. Site Closure Plan:

The site closure plan for will identify all the activities which would be performed during the restoration of a well site in case the well is not economically viable and no further use of that particular well bore is envisaged. Along with the well site the approach road connecting the well will be restored accordingly. As OIL would obtain Forest Clearance for the site from the State Forest Department, the conditions and recommendations mentioned thereof at the Forest Clearance document would be complied and consultations with the Forest Department officials to be made at the time of site closure and reinstatement.

Chronological inventory of activities which would be performed during the closure of the site are detailed in this section The following activities have been considered in the closure plan:

• Plugging & Abandonment of well: Close the well head properly to prevent any further leakage

• Decommissioning Phase: Removal of the materials form the site

• Waste/mud pit closure and reclamation

• Reinstatement Phase: regeneration of the land

• Handover Phase: Returning the land to the original owner

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## UNIT-2
## Natural and quasi-natural hazards - case studies from littoral West Bengal: causes, consequences and management.

**Introduction: -**

Natural hazards are naturally occurring geophysical phenomena that in their extreme forms threaten life or property. They occur in the lithosphere (e.g., earthquakes), atmosphere, (e.g., storms), hydrosphere (e.g., floods) or biosphere (e.g., locust infestations). Many of them can be considered resources in their less extreme forms, but hazards when they exceed certain thresholds defined with respect to their impacts upon human or environmental systems. Thus, water is a life-sustaining commodity, but in abundance it can result in floods, while in unanticipated shortage it can cause droughts. Many parts of the world have meteorological and hydrological regimes that are subject to extremes which allow scarcity and excess to alternate: in the tropics, for example, floods and droughts may follow each other, as happens periodically in countries like Bangladesh and Ethiopia.Global climate change has not yet led incontrovertibly to an increase in the physical strength or frequency of natural hazards, but eventually it will probably result in more powerful storms, more abundant surface runoff of water, and longer periods of drought- -i.e., more extreme meteorological hazards. This is worrying, because the casualties and damage caused by storms and floods are non-linearly related to nature's kinetic energy expenditure, such that very large events cause disproportionately greater losses. On the other hand, global change in human systems has already resulted in a considerableincrease in vulnerability to natural disaster. Factors resulting in the growth of vulnerability include high rates of population growth, rapid urbanization of hazardous areas (such as coasts that suffer storm surges and steep slopes that undergo mass movements) and the mushrooming expansion into hazardous terrain of the world's largest cities (Burton &Kates, 1964).

Mainly hazards are classified into two main categories. First is natural hazard, most of the time referred as act of God. Second is a man-made hazard, caused by the carelessness of mankind. This division is based on two main parameters. They are the total number of people killed and the periodicity of the event. After realizing the long-term impact of environmental pollution on human health and wellbeing two other hazards came into picture. They are social hazards and quasi-natural hazards. Finally, hazards are classified into Natural, Quasi-Natural, Social and Man-Made, according to public perception of the degree of disruption and their ability to control the event. The figure below shows different hazards according to the ways

in which people perceived the degree of disruption and the severity of the threat in terms of their ability to control the event (Whittow, 1980).

**Characteristics of Hazard: -**Hazard contains four important elements:

1) Hazard is expressed as a probability, the likelihood that something may happen in the future. When, where and how much is not sure, but it is possible to identify areas where a hazard is more likely to occur than in other areas.

2) The hazard probability is restricted to a specified period of time; usually a year. The annual probability is the likelihood that an event will happen in the next year. Without this restriction, theprobability expression would be useless. The likelihood that a floodplain will be flooded is 100%, but it could take 1000 years before it actually happens. It is more relevant to know what the probability is that it is flooded in the coming year, or the year after.

3) It is valid for a specified area; Earthquakes happen near fault zones, floods on floodplains, landslides on slopes. The site-specific characteristics co-define the hazard conditions.

4) The intensity – or magnitude – of the event. To be capable of causing loss of life or damage, the event must be of a certain intensity or magnitude. The intensity may be expressed as the energy released by an earthquake or volcanic eruption, the volume of water during a flood or the size and speed of a landslide. It is clear that the more energy or momentum released by the event, the more damaging potential it has. A mass movement of a few kilograms may cause no problems (unless it is a rock falling on someone's head), but a mud flow of several thousand cubic meters can be quite devastating.

**What are the causes of natural hazards? -**The causes of natural hazards depend on the type of natural hazard(https://www.studysmarter.co.uk/explanations/geography/dynamic-landscapes/natural-hazards/).

**a. Geophysical hazards:** Tectonic processes cause geophysical hazards.

**b. Hydrological hazards:** Hydrological hazards result from heavy rainfall, melting of ice and snow, and storm surges. Deforestation and the breaching of dams and channels with steep banks exacerbate these hazards.

**c. Meteorological hazards:** Extreme weather conditions, such as rain, wind, hail and snow, cause meteorological hazards. Climate change has exacerbated meteorological hazards.

**d. Climatological hazards:**Long periods of heat or cold cause climatological hazards. Climate change exacerbates them as global surface temperatures rise.

**e. Biological hazards:** Bacteria, viruses, parasites, moulds, or fungi that can affect human health through disease are biological hazards. Many arise from new pathogens transmitted from animals to humans. An obvious example is the current Covid-19 pandemic.

**Consequences of Natural Hazards: -**Hazards can have social, economic and environmental impacts on society. These include loss of life, injuries, and damage to infrastructure, businesses, and ecosystems. As you can imagine, these components are inevitably interlinked. For instance, the social issues resulting from the Black Saturday bushfires in Australia in 2009 have resulted in economic consequences. The projected lifelong costs of mental health issues have totaled $1,068bn, and the costs of chronic disease to $321m. The environmental damage has been projected to result in a total loss of $411m. The major impacts are (https://www.studysmarter.co.uk/explanations/geography/dynamic-landscapes/impacts-of-hazards/):

**1. What are the economic impacts of hazards?** - The economic impacts are caused by direct and indirect results of the hazards. Examples of economic impacts from direct results are the loss of property and infrastructure caused by an earthquake. Economic impacts from indirect results are negative consequences of gross domestic product growth, trade and opportunities.The economic impacts of tectonic hazards are heavily influenced by the time, geographic location and land area exposed to the hazard. Because of this, earthquakes tend to have a significantly larger economic impact in comparison to volcanoes, as volcanoes tend to be located close together in a smaller area of land, and fewer people live in these areas. Other important components which influence the economic impact of hazards are the level of development of the affected area and country, the level of insured and non-insured losses, the population affected and urbanization.

**2. What are the social impacts of hazards? -**Some of the social impacts of hazards are loss of life, injuries, and physical and psychological health issues. It often considers the aspects of the individuals within the affected community. For instance, New Orleans lost 20% of its population due to Hurricane Katrina. This was not due to deaths but because people migrated as a result of losing their homes.

**3. What are the environmental impacts of hazards?** The impacts of hazards on the environment include damage to or destruction of physical systems, particularly ecosystems. Several of the direct environmental damages caused by the 2011 tsunami in Japan include contamination of groundwater, desilting of coastal waterways and destruction of coastal ecosystems. Further indirect impacts include the environmental toll of reconstruction.

**4. Inequality and impacts of hazard: -** The Risk-Poverty Nexus Model and the Pressure and Release Model (PAR) demonstrate that inequality influences the amount of impact from hazards.

**a. The Risk-Poverty Nexus Model:** The Risk-Poverty Nexus Model shows the strong link between poverty and the impacts of a hazard. Those in poverty are the most impacted by disasters and remain in poverty because of the disaster. Low-income households and communities are the most affected by the consequences of natural hazards in terms of income, housing, health and education and also receive the least aid in recovery. They also tend to have less access to insurance and social protection. All of this contributes to a reduction in their resilience.

**b. The Pressure and Release Model (PAR):** The Pressure and Release Model (PAR) demonstrates the intersection of the socioeconomic context and the impact of a hazard. The model suggests that elements in the progression of vulnerability are divided into root causes, dynamic pressures and unsafe conditions. In addition to the natural hazard itself, these components apply pressure on people. Therefore, societies which are ineffectively governed, in poverty and have low coping capacity are more likely to be affected by the natural hazard. The model demonstrates that reducing vulnerability releases the amount of pressure to reduce the disaster.

**5. Influence of governance on impacts of hazards**: - Well-organized and strong governance has a significant influence in reducing the impacts of hazards. Governance does not just mean a single authority but a system of public, private and voluntary sectors that collectively make decisions associated with complex issues. As you've already understood, reducing poverty has a significant impact on reducing vulnerability. The different important aspects of governance comprise economic, political and administrative components, all of which are interlinked and need to be functioning for strong governance. All of these are required to reduce disaster risk.

**Naturalhazards - case studies from littoral West Bengal: -** The State of West Bengal ("the State") is vulnerable to natural calamities like flood, cyclone, hail storm, thunder squall, drought, landslide, erosion and sometimes earthquakes because of its geo-morphological, climatic and seismic conditions. Floods and cyclonic storms occur almost every year in different parts of the State and inflict huge loss of life and property causing untold hardships and trauma in the lives of the people. These natural disasters strike at the very root of the economic growth of the State. The Govt. of West Bengal ("GoWB") recognizes the need to have a Disaster Management Policy with proactive, comprehensive, and sustained approach to disaster management to reduce the detrimental effects of disasters on overall socio-economic development of the state. GoWB believes that Disaster Management is a holistic approach which is inclusive of all the activities before, during and after disaster.

There are many coastal issues which have already created conflicts between various resource users and interest groups, between developers and ecologists, engineers and geoscientists, landowners and economists in west Bengal. Over the last few decades, the people of the low lying coastal plain have experience with so many extreme events like cyclones, coastal flooding, saline water instruction, embankment breaching, norwester, sea level rise due to global warming and its impact. The landless people are now the most vulnerable communities to hazards and disasters. The coastal plain of West Bengal with extensive lowlands, wetlands, channels, estuaries and funnel shaped Bay estuary along with wide and shallow offshore provide favorable conditions for the occurrences of many hazards like tropical cyclones, coastal flooding, tidal waves etc. Failure of protective embankment from sea flooding at the storms, severe coastal erosion and degradation of sand dunes in the present coastal belt hazards loss of fertile agricultural lands and wetlands are the result of such major coastal hazards. The Sagar Island is located at the mouth of the Hugli Estuary and is facing to the Bay of Bengal. The region is one of the most remote areas of West Bengal. The deltaic island is separated by rivers on both the side. From one island to another island the local people have to spend a long time for going their destination. In terms of transport and communication it is the most backward regions of South 24 Parganas. Road communications are not well developed. Only one main road exists in the block. in my study. So, accessibility is very low in terms of transport and communication (https://www.jetir.org/view?paper=JETIR1903B21).

The coastal landscape is always the outcome of different morpho dynamics as well as hydrodynamics processes like erosion, sediment transport, and deposition which affect the

associated shorelines to a large extent. Changing global climate associated with sea level rise is responsible for the intensification of coastal land erosion which in turn, makes the coastal livelihood hopeless (Duriyapong and Nakhapakorn, 2011). The impact of global mean sea level (GMSL) rise appears in the alteration of coastal swamps, amplified shore flooding, increased coastal erosion, and saltwater intrusion into deltaic freshwater sources as well as the destruction of groundwater (IPCC, 2014). On the other hand, the enormous growth of human habitation within the deltaic zones, barrier islands, or along the estuarine system had converted the coastal setting to cultivated land, fishing ponds and industrial uses (Snoussi et al., 2008) in the developing world. In India, 7500 km coastline comprising two island chains (Andaman Nicobar Islands and Lakshadweep) is inhabited by 25% of its total population within 50 km from the coastline. The West Bengal coast consists of two distinct featureless plains; (1) Lower Sundarban Region and (2) Midnapore coastal tract.

The Sundarban deltaic coast is composed of unconsolidated sand, silt, and clays, deposited in an intermediate coastal setting characterized by high energy fluvial and low energy tidal conditions (Sahana and Sajjad, 2019). It is characterized by a wide-ranging fluvio-marine tract with numerous islands and tidal creeks and channels. The deltaic Sundarban is densely vegetated by halophytic plants and grasses and sharply divided into two distinct land use segments. The South-western part (Hugli–Matla inter-fluvial zone) reclaimed for agriculture and settlement since 1770 is characterized by the continuous earthen embankment along the channels and islands to combat tidal flooding. The south-eastern part (Malta–Hariabhanga inter-fluvial zone), is uninhabited and protected as Sundarban Biosphere Reserve (SBR). The south western part is geomorphologically more active, while the eastern part is in decaying condition, resulting in the dominance of marine processes (Paul& Das, 2021).

The Midnapur coastal plain, covering 27% of the West Bengal coastal tract (Chakraborty, 2010), exhibits the successive rows of ancient dunes (Digha dunes, Ramnagar dunes, Contai dunes representing beach front, older and ancient dunes respectively) with intervening clayey tidal flats along the previous shorelines (Chakrabarti, 1995). Active dunes, the important geomorphological features of the coast, are situated in the south-western part of the Digha–Mandarmani coast where the height of the dunes varies in between 3 and 25 metres, tending to shift landward to adjust their position in changing sea level (Das and Dandapath, 2014). Along the western side of Midnapur coast, rip currents and waves hit the coast at close to a right angle, as waves are converging in character, resulting in erosion of foreshore sands which in turn leads to a retreat of the shore, elevation loss of beach and loss of coastal

vegetation. In the eastern part, on the other hand, waves beat the land at 30°- 40° angle due to the strong divergence. As a result, some riverine depositions are observed (Kuehl et al., 1997). The beach front dunes of this area are retreating in parallel by more or less one kilometre at a rate of 11m/ year from 1877 to 1965 due to frequent marine transgression (Bhandari and Das, 1998). An acceleration of erosion was also noticed since 1994 (Chakraborty, 2010) resulting in discontinuous conduits by several tidal inlets such as Jatra Nala, Ramnagar Inlet, Pichaboni inlet, Jaldha inlet from west to east. These made the area more vulnerable. According to Mukherjee and Chatterjee (1997), four important factors are identified like a durable littoral drift on a smooth gradient beach, loss of loose sand by wind force, a collaboration of the high wave with tides during storm condition, possibility of faulting as evidenced in recent past, and bathymetric condition of the continental shelf.

Comprehensive information about the vulnerability in different aspects helps planners and policymakers to undertake a proper management strategy to reduce the destructions (Hinkel and Klein, 2009). Therefore, the vulnerability level in terms of sea level rise, flooding, and the impact of storm surges has apparently been highlighted in some previous works along the West Bengal coast; however, no comprehensive work has been undertaken at the micro level to illustrate the most damaging vulnerabilities in the changing climate. Coastal Hazard Wheel can be a better solution for this purpose. Coastal Hazard Wheel method has already been applied for other coasts of India and abroad. The Coastal Hazard Wheel (CHW) is developed as a universal coastal classification framework which acts as a multi-hazard assessment and decision support tool from local to the national level to assist coastal researchers and policymakers in determining the hazard profile of a particular coastal stretch, to identify probable management options, and make an integrated communication and information network to assist the aims of the Integrated Coastal Zone Management (ICZM) in changing climate. By this modern technological input, the authors, tried to explore the vulnerability of West Bengal coast at the micro-level in terms of ecosystem disruption, gradual inundation, saltwater intrusion, erosion, and flooding and to recommend the probable methods of hazard mitigation.

**Principles of West Bengal State Disaster Management Policy (WBSDMP): -** Disaster management is not a separate sector or discipline but an approach for solving problems relating to disasters impacting upon any sector-agricultural, industrial, environmental, social, etc. Ultimately, disaster management is the responsibility of all sectors, all organizations and all agencies that may be potentially affected by a disaster. Utilising existing resources ensures

efficiency in resource utilization and lower costs. With this background in mind, GoWB has outlined a set of key principles that will guide the development and implementation of the Disaster Management policy in West Bengal. These principles are designed to provide guidance during all phases of disaster management and are consistent with internationally accepted best practices.

**1. Integrating disaster management into development planning: -** Disaster prevention and preparedness should be an integral part of every development t policy. Therefore, the State's development strategy shall explicitly address disaster management as an integral part of medium and long-term planning, especially for disaster prone districts in the state.

**2. Multi-hazard approach to disasters: -** The GoWB recognizes that disasters can either be man-made, natural or even arising out of technological causes. A robust Disaster Management policy must therefore provide, plan and prepare for all types of hazards and disasters that may be reasonably expected to occur in a region.

**3. Sustainable and continuous approach: -** One of the objectives of sustainable development is to increase the inherent strength of all agencies, including the community to deal with disaster situations. Achieving this objective requires sustained initiatives encompassing social, economic and infrastructure issues. Further, once capacity is built up, it must be sustained and this would be an ongoing and continuous activity. The Government of West Bengal aims to improve on a continuous and sustainable basis, the infrastructure and processes for relief, rehabilitation and reconstruction and institutionalize capacity building at all levels within the State in order to be able to mitigate the impact of disasters.

**4. Leverage for existing Government machinery: -** The GoWB shall strive to ensure that the long-term approach to disaster management utilizes the existing administrative machinery of the State Government of West Bengal at all levels within the State in order to undertake communication, capacity creation, relief, rehabilitation and reconstruction, information collection and dissemination and sharing of disaster management best practices. All Government Departments, local self-governments and agencies are encouraged to utilize all available resources within their respective areas for disaster management before seeking assistance from entities in other areas or higher authorities.

**5. Effective inter-agency co-operation and co-ordination: -** Successful disaster response requires a quick and organized response. The active participation of affected communities,

NGOs, private sector and various Government Departments like Fire and Emergency Services, Home(Police), Health & family Welfare, etc. is thus critical to any response activity. Therefore, the DM policy in West Bengal shall focus on establishing response mechanisms that are quick, coordinated and participative.

**6. Capacity building:** -Managing disasters using only a handful of stakeholders would be inefficient. The Government of West Bengal, therefore, recognizes that the Disaster Management policy will need to strengthen the resilience and capacity of NGOs, private sector and the local community to cope with disasters while simultaneously building the capacity of the Government machinery to manage disasters. Effective disaster management requires that the especially vulnerable groups of the community like women, old people, landless labour, etc. be fully aware of the extent of their vulnerability to disasters for reducing its impact, prior to its actual occurrence. Further, NGOs, private sector and the community must understand and be familiar with Disaster Management principles and practices, what their own responsibilities are, how they can help prevent disasters, how they must react during a disaster and what they can do to support themselves and relief workers, when necessary. Training is an integral component of capacity building. Development of Disaster Management as a distinct managerial discipline will be taken up to create a systematic and streamlined disaster management cadre. Gender issues in disaster management will be addressed and the empowerment of women towards long term disaster mitigation will be focused upon.

**7. Autonomy and equity: -** Disasters are catastrophic events whose impact is felt across socio-economic boundaries. Consequently, any Disaster Management effort should be neutral and non-discriminatory. To that extent, it is necessary that the Disaster Management institutions possess the autonomy to make decisions in a fair, scientific and systematic manner. Disaster assistance and relief must also be provided in an equitable and consistent manner without regard to economic or social status of beneficiaries. Relief assistance must be provided without any discrimination of caste, creed, religion, community or sex.

**8. Accommodating aspirations of people: -**The objective of any effort relating to disaster management is to benefit the community. People are central to the decision-making process for disaster management and their priorities should be reflected in the programmes undertaken.

**9. Accommodating local conditions: -** Disaster Management efforts should be sensitive to local customs, beliefs, and practices and be adapted to local conditions. In addition, changes in the community and evolving social and economic relationships must be borne in mind to avoid confrontation and bottlenecks. This will ensure participation of the local community and foster a culture of joint responsibility for disaster management at all levels.

**10. Financial sustainability: -**GoWB is committed to allocating funds in the long term to ensure the sustainability of disaster management effort. One of the key elements in ensuring the long-term sustenance and permanency of the organization is the manner in which funds would be generated and deployed on an ongoing basis. This is necessary in view of GoWB's focus on disaster mitigation.

**11. Cost sharing and cost recovery: -** The GoWB encourages citizens and Government agencies to proactively enhance their capacity to deal with disasters. It is not possible for the GoWB to bear all the costs of disasters on a sustainable basis, or provide rehabilitation on a long-term basis. The long-term approach is to move towards spreading the risks through various risk transfer mechanisms and incentivizing individuals and other entities to protect their interests through insurance. However, in doing so, GoWB would seek to protect the interests of poorer sections of the society through appropriate mechanisms.

**12. Develop, share and disseminate knowledge: -** No single organization can claim to possess all the capabilities required to provide effective disaster management. The disaster management entities within West Bengal will typically network with a number of other entities to augment their capabilities. Basic concepts related to disaster management and the role of the community therein shall be included in the curriculum of schools. This shall serve to sensitise people to the participative approach needed for effective disaster management information and knowledge embracing all facets of disaster-from mitigation to amelioration-shall be infused in schools, colleges and teacher's training syllabi.

**Quasi-natural hazard: -** Quasi-natural hazard refers to those hazard that occurs due to the interaction between the activities done by the humans and the various types of natural processes that takes places on the surface of the earth. For example, smog, desertification. On the other hand, man-made hazard refers to those hazards that occurs due to the activities done by the humans. For example, mining accident, collapsing of man-made structures, polluting groundwater.Quasi-natural hazards such as smog or desertification arise through the interaction of natural processes and human activities. (iii)Manmade hazards such as the

toxicity of pesticides to fauna, accidental release of chemicals or radiation from a nuclear plant. These arise directly as a result of human activities.Quasi-natural hazard refers to those hazards that occur due to the interaction between the activities done by the humans and the various types of natural processes that take places on the surface of the earth. These are some important quasi-natural hazards:

**A. Dam Failure:** -Dam failures can occur as a result of structural failures, such as progressive erosion of an embankment or overtopping and breaching by a severe flood. Disastrous floods caused by dam failures, although not in the category of natural hazards, have caused great loss of life and property damage, primarily due to their unexpected nature and high velocity floodwater. Due to construction of large dams in mountain areas, which insert pressure on land and intensifying the intensity of earthquake.

**B. Desertification: -** Desertification is the process by which natural or human causes reduce the biological productivity of dry lands (arid and semiarid lands). Declines in productivity may be the result of climate change, deforestation, overgrazing, poverty, political instability, unsustainable irrigation practices, or combinations of these factors. The concept does not refer to the physical expansion of existing deserts but rather to the various processes that threaten all dry land ecosystems, including deserts as well as grasslands and scrublands.

**C. Smog: -** Smog is a type of intense air pollution. The word "smog" was coined in the early 20th century, and is a contraction (portmanteau) of the words smoke and fog to refer to smoky fog; its opacity, and odor. Man-made smog is derived from coal combustion emissions, vehicular emissions, industrial emissions, forest and agricultural fires and photochemical reactions of these emissions.

**Natural hazards mitigation aspects in West Bengal:** -The State of West Bengal ("the State") is vulnerable to natural calamities like flood, cyclone, hail storm, thunder squall, drought, landslide, erosion and sometimes to earthquakes because of its geo-morphological, climatic and seismic conditions. Floods and Cyclonic storms occur almost every year in different parts of the State and inflict huge loss of life and property causing untold hardships and trauma in the lives of the people. These natural disasters strike at the very root of the economic growth of the state. The Govt. of West Bengal ("GoWB") recognizes the need to have a Disaster Management Policy with proactive, comprehensive, and sustained approach to disaster management to reduce the detrimental effects of disasters on overall socio-economic development of the state. GoWB believes that Disaster Management is a holistic

approach which is inclusive of all the activities before, during and after disaster. The aim of the West Bengal State Disaster Management Policy is to establish necessary systems, structures, programs, resources, capabilities and guiding principles for reducing disaster risks and preparing for and responding to disasters and threats of disasters in the State of West Bengal in order to save lives and property, avoid disruption of economic activity and damage to environment and to ensure the continuity and sustainability of development.

Statistical probability of the occurrence of an event with a certain destructive capability in an area within a specific duration can often be estimated. In some cases, likelihood of occurrence can be established for several hours or days in advance. If a hazard is unlikely to cause any damage to the environment or lead to any loss of life, intervention to minimize the hazard is not required. Because of uneven distribution of industrial centers, lifeline facilities and population densities, estimated risk is not expected to have a perfect correlation with the corresponding hazard estimate across the region. It may not be appropriate to directly adopt the risk estimates, considered admissible in developed countries, in the Indian context by policy makers because of the differences in psychological perceptions of the stakeholders, and also because the cost involved in directly adopting the risk perceptions of a more affluent society may be prohibitively expensive. More often, rare and low probability events with long return times do not warrant investment on prevention or moderation mainly from social and economic standpoint. High-density population and expansive infrastructure in cities and large towns implicate high risk. On the other hand, in small towns and villages, alternative mitigation measures such as organizing the local community to cope with hazards may be more suitable because of the unorganized nature of the construction industry. Implementation of these measures would require participation of all stakeholders, particularly the local population and government as well as non-governmental organizations. Specific short-term action plan towards risk management with regards to major natural hazards includes quantification of hazard associated with a natural event, estimation of the potential impacts, and thereafter implementation of measures to reduce vulnerability. Measures such as building bylaws, zoning ordinances, insurance and tax incentives are also used to manage the risk associated with several types of natural hazards in developed countries.

Immediate response is anticipated as and when a natural disaster strikes. On the other hand, the post-disaster steps account for rehabilitation, reconstruction and gathering of information. Strategic approach necessitates identification and quantification of hazard and subsequent risk assessment. The hazard assessment involves gathering of information, precise to an

acceptable extent, on the probable site, the associated severity and likelihood of occurrence within a specific time-period. The analysis incorporates geological and geomorphological scientific data as well as statistical records of past occurrences. The local specific hazard information developed through synthesis of the available and processed data can be produced in the form of a hazard map/atlas. In holistic approach, a vulnerability map reflecting a multi-hazard scenario can be developed and integrated on priority and weightage basis towards risk assessment. Risk assessment involves quantification of anticipated loss or damage from the projected hazard. The analysis of risk is achieved through integration of results from hazard analysis and vulnerability assessment. Vulnerability is mostly accounted for by land use accompanied by various combinations of factors like, rapid urbanization, improper construction practices, inadequately enforced building bylaws, socio-economic attributes, lack of awareness, environmental degradation and lack of preparedness. An approximate first-order attempt towards estimating composite vulnerability in a multi-hazard scenario for West Bengal is illustrated in Figure 2. Based on delivered risk assessment, further motivational activities can be formulated covering every administrative level, from rural to urban set-ups. Capacity-building programs may beforced following recognition of the needs and the hazard priority.

**Policy towards Reduction of Vulnerability in West Bengal: -**One cannot stop occurrences of natural disasters, but can mitigate its impacts through reduction of vulnerabilities. A recent study on reduction of vulnerabilities to natural disaster has suggested that public policy should focus on the need to reduce the population concentration in vulnerable areas, and to minimize the concentration of utilities and other infrastructure in disaster-prone locations. Otherwise, more ex-post assistance would be needed to affected communities, which in turn generates a "Samaritan's dilemma", i.e., an increase in risk-taking and a reluctance to ex-ante protective measures for the disaster. By disaster management we generally specify only ex-post rescue operations, medical and financial aids, reconstruction, etc. But today disaster management has another dimension, and it is ex-ante protective measures. Ex-ante protective measures include self-insurance, market insurance, self-protection, etc. One major problem with ex-ante measures is that it costs resources, which are scarce in a developing region like West Bengal. Therefore, careful evaluation of the likely ex-post impacts and the probability of occurrences of disasters are highly needed before taking any ex-ante protective measure. One of the ex-ante protective measures is market insurance, i.e., purchasing coverage from an insurer to reduce the financial consequences following a loss by disaster. However, for a

number of reasons, market insurances for disaster have not been sufficiently developed in developing countries. It may be due to lack of markets or inadequate institutional framework or some other factors. There is also the problem of underinsurance. Even in heavily insured countries like the United States, only a relatively small portion of actual damages are insured. After Hurricane Katrina the total insurance claims was less than forty percent of the estimated total damage of the storm in that country.

Most of the residents of disaster-prone areas in West Bengal are unprepared for a catastrophic event. Only few of them consider self-protection due to the absence of disaster insurance market. Under such circumstances there is no other way than to undertake ex-post assistance. Here governments are typically held accountable for their response to disasters, sothey have strong incentives to invest in ex-post assistance. On the other hand, ex-ante disaster insurance has little incentives to politicians and policy makers, since it involves costs today and a possible payoff in the undetermined future, when no one knows who will be in power.Governments, especially in developing countries, have to pay a higher price due to limited resources, opportunity costs of deploying development funds for relief and reconstruction, weaker institutional and governance frameworks, and institutional options depending on size of country, type of disasters and other factors. So, there cannot be unique approach to disaster management. Various institutional models for disaster management exist in the world.

Sea level rise due to global warming leading to changing coastal environmental scenarios is a very recent phenomenon. As a result, coastal climate like relative humidity, river flow rates and run off, fertility of coastal soils, distribution of coastal biomes, characters of tidal flow regime and wave actions, pattern of sedimentation and sedimentary environment, nutrient upwelling and downwelling, chemical parameters of coastal waters, frequency of cyclonic storms, storm surges and coastal inundation thereon have been changing with time. Monitoring integrated coastal zone management including proper steps of coastal protection applying useful and befitted coastal engineering structures, and the proper implementation of the roles of exclusive economic zone along with the coastal zone regulations may mitigate such problems (Das, 2022).

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## UNIT-3
## Concept of urban forestry.

**Introduction: -**

Urban forests go far beyond just improving the aesthetics in urban landscapes. They help improve living conditions by countering environmental pollution. They help create quieter cities by acting as sound barriers between homes and roads (& railway lines). They help conserve biodiversity while providing niches for a wide variety animals, birds, insects and other creatures. One very important role (if recognized and worked upon) that urban forests play is to provide the children an opportunity to connect with and learn about natural phenomenon even while growing up in an urbanized setting where most of the things are put together artificially. This exposure can help them take better decisions in the wide when they move on to acquire important positions in the society (Satya, 2014).

Urban forestry is an integrated concept, defined asthe art, science, and technology of managing treesand forest resources in and around communityecosystems for the psychological, sociological, aesthetic economic, and environmental benefits treesprovide society. It emerged as a discipline in NorthAmerica in response to better ways to deal with thegrowing importance of tree-dominated urban green-space, as well as growing pressures on green areas.During recent decades an international urbanforestry research community has developed, as hasan increasing body of knowledge as well as newapproaches and techniques. Urban forestry has closelinks to forestry, but tends to be more multi-disciplinary (Konijnendijk& Randrup, 2004).

The global population is trending towards urban areas. The United Nations Report states more than half the world's population lives in urban spaces which will rise in upcoming years. On the global level the highest urbanization rate from 1995 to 2015 was recorded from Africa whereas urban areas of Asia hold highest proportion of population. The rapid urbanization is inducing the ecological, social and economic changes in all the sectors. There is hardly any doubt on the fact that the well-planned urban spaces can be great places to live. In the present age of speedy development, the urban developments are leading to the environmental challenges. Other than the pressure of the demand of fulfilling the basic infrastructural needs of the ever-growing urban population, the pressure on the natural resources is growing to the great extent. Due to increasing density of human population, in the human modified landscapes, the forest blocks are fragmented or disappeared.

The conversion of the green and blue spaces into concrete-cement is posing the future threat on the urban environment. The land use changes resulting into the habitat alteration which is accelerating the extinction of the species at the local level. The conditions are further deteriorating with the ever-increasing climatic extremities like storm water flooding and droughts at the extreme sides of the water crises. Thus, due to the anthropogenic causes the urban sites are often harsh, under tremendous pressures and threats limiting a space for trees, creating adverse climatic conditions and pollution. The professionals engaged in the planning and management of the urban sites in the present day are working in the highly complex environments with the added challenges of multiple and rapidly changing urban demands. The efforts for retaining the sites holding green component of nature (such plant species or tree) amid urban development is a challenge. The professionals as the urban planners and managers often struggle to keep greenspace issues on the political agenda resulting into the emergence of the comprehensive andintegrated land use concepts and approaches, build on the expertise and skills of various professions.

Therefore, it is necessary that the greenspaces are being looked with an integrative perspective through certain professional field. Every element of the greenspace is considered to be part of the whole ecosystem in integrity. The urban Forestry came out as one of the professional sectors to overcome the challenges of urban development with retention of the greenspaces. This multidisciplinary sector does not only depend on the forest officials. The international agreement bound the urban forestry to deals with forests or forest-like systems in urban areas. To consider the needs of the ever-growing urban population and to maintain the urban environment, the best option is to maintain the urban ecosystem through the urban forestry which offers variety of benefits. Whereas the direct monetary benefits include the forestry products, the quality environment and mitigation towards ecological impacts are the indirect monetary benefits. The sector is still under considerable scientific debate on its contents of the concepts and related terms. Which greenspace parts are undertaken in purview of the urban forestry domain? What needs to be considered as ‘urban’? How the urban forestry interrelates with the other similar concepts and what are the strengths?

Urban forests (and trees) constitute the second forest resource considered in this report. We specifically emphasize the fact that agricultural and urban forests exist on a continuum defined by their relationship (and interrelationship) with a given landscape. These two forest types generally serve different purposes, however. Whereas agricultural forests are considered primarily in terms of their contribution to biodiversity conservation or, as in the

case of agroforestry, to agricultural production, urban forests are assessed primarily in terms of the range of environmental services and values they provide to urban and suburban residents. The potential list of services is extensive and will vary according to different individuals, organizations, and locations, with many services being difficult to precisely quantify. Trees affect numerous environmental processes, such as water cycling; sound propagation; and pollution formation, dispersion, and removal. Trees also directly affect human populations by altering the social, economic, health, and aesthetic aspects of urban environments.

These effects exist in all treed landscapes but are more prominent in urban areas because of the higher concentration of people.As in the previous chapter, this chapter begins with a general description of the resource, including formal definitions. This first section also includes a brief listing of environmental services associated with urban forests and the specific threats they face. The second section presents currently available data for understanding urban forests at the national scale. These data rely heavily on satellite imagery and are focused on describing the extent of forest cover in urban areas. The chapter concludes with a discussion of the adequacy of the current information base and strategies for improving it (Nowak, 2010).

Urban forestry is an integrated concept, defined as the art, science, and technology of managing trees and forest resources in and around community ecosystems for the psychological, sociological, aesthetic economic, and environmental benefits trees provide society. It emerged as a discipline in North America in response to better ways to deal with the growing importance of tree-dominated urban greenspace, as well as growing pressures on green areas. During recent decades an international urban forestry research community has developed, as has an increasing body of knowledge as well as new approaches and techniques. Urban forestry has close links to forestry, but tends to be more multidisciplinary.

**What Is an Urban Forest? -** The very idea of an urban forest at first seemed strange, even contradictory, when this term was invented. But it has become accepted and even commonplace. Community forest and city green are related terms with similar meanings. All three refer to the trees, lower vegetation, open green spaces, and associated wildlife within a municipality or adjacent to it. The term “urban forestry” was coined in 1965 by Prof. Erik Jorgensen at the University of Toronto. This unusual juxtaposition of “urban” and “forestry” arose in searching for an appropriate title of a graduate student’s thesis. Jorgensen gave this

scholarly definition of urban forestry: “a specialized branch of forestry (that) has as its objective the cultivation and management of trees for their present and potential contributions to the physiological, sociological, and economic well-being of urban society.” Furthermore, he believed urban forestry does not deal only “with the city trees or with single tree management, but rather with the tree management in the entire area influenced by the urban population.” It was in the United States that urban forestry first took root and developed into a national movement. In traditional forestry, trees are managed for timber harvests and to provide other goods and services.

But in urban forestry trees are cultivated mainly for their aesthetic and environmental qualities, to be “harvested” only when they die or become hazardous. A traditional type of forest set aside for the good of a community sometimes is referred to as a “community forest” and may be considered a part of the larger urban forest that also includes trees within the town. A community forest at Zurich, Switzerland, has provided timber, firewood, recreation, and watershed protection since 853 AD; the oldest community forest in America was established in 1640 at Newington, New Hampshire. “Community forestry” sometimes is used as a synonym for urban forestry. That is because residents of towns and hamlets usually consider themselves rural, not urban. They think that urban forestry does not apply to them even though it is meant to be inclusive of all municipalities, regardless of size.

**Definition of Urban Forestry:** -In 1970, the definition of urban forestry was introduced by the work of Jorgensen (1986) He defined - “Urban forestry is a specialized branch of forestry and has as its objectives the cultivation and management of trees for their present and potential contribution to the physiological, sociological and economic well-being of urban society. These contributions include the overall ameliorating effect of trees on their environment, as well as their recreational and general amenity value.”

Miller (1997) describes the urban forest as “the sum of all woody and associated vegetation in and around dense human settlements, ranging from small communities in rural settings to metropolitan areas”.

Helms (1998) defined urban forestry as, “The art, science, and technology of managing trees and forest resources in and around urban community ecosystems for the physiological, sociological, economic, and aesthetic benefits tree provide society”.

Ball et al. (1999) described in broader perspective, "Urban forestry is a multi-disciplinary activity that encompasses the design, planning, establishment and management of trees, woodlands and associated flora and open space, which is usually physically linked to form a mosaic of vegetation in or near built-up areas. It serves a range of multi-purpose functions, but it is primarily for amenity and the promotion of human wellbeing".

Harris et al. (2004) state that "Urban forestry is the management of planted and naturally occurring trees in urban and urban-interface areas".

FAO defined urban forestry (including urban peri-urban forestry) as an integrated, interdisciplinary, participatory and strategic approach for the urban and peri-urban areas to plan and manage the tree resources for the holistic benefits in the economic, environment and socio-culture sectors.

FAO does not restrict the Urban Forest as a system of woodlands, group of trees, individual trees amidst urban and peri-urban space but extended to all type of the green spaces flourished with woody trees which include fragmented forests patches or pockets, parks and garden trees, relict space trees, any public or private land or institutional or religious space flourished with trees amidst the grey space (concrete-cemented urban, rurban and periurban area). In case of agricultural land, the dedicated field is 'agroforestry',similarly, as a scientific and technical discipline dedicated to the TOF in urban land is 'urban forestry'.

FAO (2010) uses internationally accepted definition of the 'forest' and developed 'Other Wooded Land' (OWL) for forest-like category. Recognizing the gap, the Global Forest Resource Assessment 2000, FAO - FRA coined the expression "Trees Outside Forests" (TOF) which includes the uncategorized forest or fragmented or patches of uncategorized forest or group of trees or other thickets and groves in the urban areas (See Appendix I for FAO/FRA definitions with explanatory notes from).

Keeping aside all the ambiguities in defining 'urban' land use, the FAO developed "Other Land with TOF" category to be identified as predominantly 'urban' in the context of 'urban forestry'

**Features and the factors affecting the urban forests:**

**Ecological and other Geographic Factors: -**The natural vegetation of the undisturbed environment is a function of climatic factors such as temperature and precipitation; and the

geographic factors such as ecoregion or altitude. At any site, the micro-climatic features due to variations in topography, soils, and sunlight exposure influence tree growth and canopy cover. Further, the urban canopy cover in forested ecoregions is highest, followed by grasslands and deserts, thus confirming ecoregion as a main contributor to urban canopy variation at a continental scale. These facts also point out that the human modification of urban vegetation through activities like irrigation has not superseded the effects of ecoregion characteristics. The relation of the geographic factors with the urban development and canopy cover are well understood. The areas with greater topography (like steep slopes) or higher densities of riparian corridors are second priority for the construction of buildings due to several reasons, therefore, resulting into preservation of the areas. There are ample of examples where regulations limit the urban development to the floodplains, thus giving space for the forest growth amid urban sprawls.

**Urban Morphology or Form: -** The urban vegetation is greatly affected by the urban morphology or form, other factors such as local land use especially historic development patterns and age of development. The urban places with greater total land area are more likely to have more open space that may be occupied by trees. The mix of land uses within urban places and their environments may affect urban forest structure or urban green infrastructure. Urban trees tend to grow most abundantly on residential and vacant land, including open space in parks. These lands therefore account for the greatest proportion of the urban forest.

Though the densely populated places have fewer open spaces or less area available for vegetation, therefore, lacks forest growth. The local land use and patterns of urbanization also affect the urban forest growth. The trees are more likely to grow on lands for the public gardens or public parks, thus, availability of the land area for such use will give chance for the urban forest growth.

**Socioeconomic Factors: -** The socio-economic status like income, education, etc. together with the natural or ecological conditions affects the status of the urban green infrastructure or urban forest. Hedonic price analyses, for example, show clearly that trees add to the value of residential properties. This means that trees are a normal economic good and that people are willing to pay more for housing with trees. Because willingness to pay relates directly to household income and income is correlated with education, a plausible hypothesis is that urban canopy cover is correlated positively with household income and education.

**Policy Factors: -** Among the human factors (which also include urban form and socioeconomic factors), the local regulations equally influence the urban forest structure. The local regulations and the strategies of the officials for execution in urban development play important role in green infrastructural development. The urban development statutes and the policy direct the town planners for the comprehensive plans, regulation of the location, density, and nature of development through zoning ordinances and subdivision regulations define the urban forest growth. Strategies and approaches to urban forest management range from the sharing of responsibilities between municipal departments such as public works, parks and recreation, and planning, to hiring urban foresters to take primary responsibility for management, to participation in programs such as 'Plant a Tree Campaign'.

**Components of Urban Forest: -**The major components are (Satya, 2014):

**1. Parks and greenbelts: -** Urban parks are traditionally one of the most obvious forms of urban forest. Parks are threatened by buildings, spontaneous settlements, vandalism, environmental stress and restricted government funds. It is more and more acknowledged that many parks can only be preserved and managed through the commitment of residents and innovative management approaches. Greenbelts can have multiple uses and functions, such as improving environmental quality, providing recreation, and serving as an alternative transportation route (bicycle and foot paths).

**2. Street trees: -** Due to inadequate planting space and the high cost of protecting individual trees, collision and vandalism have destroyed many street trees. On the other hand, sufficient innovative techniques are available that increases the survival rate and longevity of street trees.

**3. Trees in urban farming: -** Trees in urban farming have only recently received more attention under the umbrella of urban agricultural initiatives. Agroforestry gardens are probably the most significant urban green space in tropical developing countries. Some tree species require little space and can be manipulated into shape by training or coppicing.

**4. Protected areas: -** Protected areas are natural or reconstructed habitats that receive some level of ecological protection in order to preserve their ecological or biological functions. Although urban forests may contain less biological diversity than rural woodlands, they still play a significant role in conservation of biodiversity. For instance, Delhi ridge houses rich biodiversity and hence is being protected.

**Urban Forest: Security Against Catastrophes and Livelihood:**

**Urban Heat Island: -** The urban areas are considered to be the 'heat islands' due to exposed non-reflective water-resistant impervious surfaces which absorb high proportion of the solar irradiance and increase the temperature of the area. The intensity of the heat island over space and time is determined by the interactions between patterns of surface heating and regional meteorology. Further, the anthropogenic activities are contributing by adding the heat and pollutants from the industrial and vehicular emissions. The anthropogenic heat increases the near-surface air temperatures whereas pollutants increase radiation absorption in the lower atmosphere and creates an inversion layer. This inversion layer prevents rising of the air for normal cooling and affects the dispersion of the air pollutants. The urban trees or forests provide the reflective surface to the solar radiations and through the cooling shade effect maintain the temperature of the surface. Thus, planting the trees is an effective strategy for urban heat island mitigation.

**Urban Floods: -** The rain water is the only source to replenish the fresh water stock on the earth. The hydrological cycle maintains the ecological flows so that the underground water gets recharged, surface reservoirs get filled and streams maintain their flows pattern. The green cover plays important role in the water retention and percolation of the rainwater. Tree crowns intercept rain and reduce the intensity of the rainfall, thus decide the fate of rainwater as per the nature of the surface – pervious or impervious. Alike, green infrastructure, the grey infrastructures of the urban areas are impervious to the surface water. In absence of the seepage, the stormwater drains as runoff without being channelized to urban waterways. The underground water remains unchanged. Further, due to the impervious features of grey cover, the spillovers are quite common in urban environment. The water-logged conditions and the floods result from the disturbances in the ecological flows.The urban forest plays important role in stormwater runoff reduction. The urban forest reduces the intensity of the rainfall and prolongs retention time for the rainwater to enter the urban waterways. Thus, urban forest keeps a check to the flooding of areas.

**Urban Pollution: -** The urban or peri-urban or rurban environment (air, water and soil) frequently experience pollution due to different anthropogenic interventions which affect the natural characteristics of the atmosphere, hydrosphere and lithosphere. The pollution load causes the catastrophe in one or the several ways by enhancing the toxicity of the spheres. The nutrient enrichment of the urban lakes or water reservoirs, presence of the chemicals and

heavy metals in soil and water, the smog in the urban atmosphere, etc. are some of the examples of the catastrophes commonly observed in urban environment. The urban forest maintains the quality of the spheres through its role in reducing the negative impact of the anthropogenic activities in terms of pollution. The urban forest forms a natural treatment system and reduces the nutrient loads in water through phytoremediation. The presence of the urban forest can develop relatively high carbon to nitrogen ratios that can improve nutrient buffering capacity in the areas that receive high inorganic nutrient fertilizers. The role of trees in maintaining air quality is known to the great extent. Thus, the urban forest has the capacity to buffer the pollution loads.

**Urban Forests: -** Livelihood The sustainability of any action requires the community involvement which requires certain level of the economic importance of the said asset. This is provided by the urban forest in following manner:

• Recreation and well-being;

• Aesthetics;

• Nature and landscape conservation;

• Biodiversity preservation;

• Climate and hygiene;

• Wood production; and

• Food production.

Kenney et al. (2011) provided such a list of criteria and indicators for the sustainability of the urban forests. His work considered engagement of the community in managing the resources:

**The Vegetation Resource**: - The management of the vegetation resource in the urban context require following criteria, viz.

• Canopy cover

• Age distribution of trees in the community

•Species mix

• Native vegetation

• The condition of publicly owned trees

• Publicly owned natural areas

• Native vegetation

**The Community Framework: -** The tree resource management required shared responsibility of the community as per the following criteria, viz.

• Public agency cooperation

• Involvement of large private and institutional landholders

• Green industry cooperation

• Neighborhood action

• Citizen-municipality business interaction

• General awareness of trees as a community resource

• Regional cooperation

The Resource Management Approach: - The approach includes physical resource management as well as public and administrative perceptions under the following criteria, viz.

• Tree inventory

• Canopy cover inventory

• Citywide management plan

• Citywide funding

• City staffing

• Tree establishment planning and implementation

• Tree habitat suitability

• Maintenance of publicly owned, intensively managed trees

• Tree risk management

• Tree protection policy development and enforcement

• Publicly owned natural areas management planning and implementation

Several studies showed that with respect to above functions and the criteria, the perception and acceptance of urban forestry in the form of trees is good as per the public opinion, still the large section of the population are not conversant with the knowledge of the maintenance of the urban trees. The modern development practices are already posing challenges to the traditional approach of maintenance. In such conditions the urban forestry practitioners or the experts are required.

**Major Threats and Influences Affecting the Urban Forest: -**Numerous potential threats can significantly alter urban forests and their associated benefits. These threats (Nowak et al. 2010) include the following:

**1. Insects and diseases: -**Urban forests can be, and are, severely affected by numerous insects and diseases, many of them introduced from other geographic regions into urban centers. Some insects and diseases—such as the gypsy moth, Asian longhorned beetle, emerald ash borer, and Dutch elm disease—have caused significant tree mortality that has virtually eliminated dominant tree species in some places (e.g., Dozier 2012, Liebhold et al. 1995).

**2. Wildfire: -** Uncontrolled fires can cause significant damage to trees and forests and dramatically alter the urban landscape, especially in urban areas adjacent to wildlands (Nowak 1993, Spyratos et al. 2007). High population growth and urban expansion in California, for example, have led to a substantial increase in fire ignitions in wildland-urban interface areas (Syphard et al. 2007). In addition, the intermingling of trees with manufactured structures in these areas significantly complicates and limits the options available for fire suppression activities and vegetation management practices used to reduce fire risk.

**3. Storms: -** Urban forests can be altered and have been significantly damaged by wind, ice, and snow storms that result in broken branches and toppled trees (e.g., Greenberg and McNab 1998, Irland 2000, Proulx and Greene 2001, Valinger and Fridman1997). As in the case of fire, the proximity of trees to buildings, roads, and power lines complicates forest management in this regard, while elevating the potential damage that can result.

**4. Invasive plants: -** Invasive plants such as kudzu (Pueraria lobata), English ivy (Hederal helix), European buckthorn (Rhamnus cathartica), and Norway maple (Acer plantanoides) can degrade or alter urban forests by removing and replacing native plants and altering ecosystem structure. English ivy and kudzu have been known to cover acres of canopy trees (Dozier 2012, Webb et al. 2001). The introduction of nonnative species in gardens and parks enhances this risk.

**5. Development: -** Land development significantly alters the urban landscape, affecting plant and wildlife populations and forest biodiversity and health (Nowak et al. 2005). Development can lead to rapid reductions in tree populations (clearing of forest stands), can alter species composition (e.g., tree planting after development), can increase tree populations (e.g., tree planting in formerly cleared areas), and can alter the urban environment (e.g., increase or decrease in air temperatures). Development associated with urban expansion into rural areas can also significantly alter the regional landscape, particularly in forested regions where forest area is reduced, fragmented, or parcelized (i.e., forest stands remain intact but have multiple landowners). In timber-producing regions, when development alters the rural forest landscape, it will likewise affect the available timber supply and forest management practices (Zhang et al. 2005).

**6. Pollution: -** Air and water pollution can affect tree health in urban areas if pollutant concentrations reach damaging levels. Forests have been shown to be affected by air pollution, especially from regional deposition of ozone, nitrogen, sulfur, and hydrogen (Stolte 1996). Ozone has been documented to reduce tree growth (Pye 1988), reduce resistance to bark beetle, and increase susceptibility to drought (Stolte 1996). Air pollution can also enhance tree growth through increased levels of carbon dioxide or by providing essential plant nutrients such as sulfur and nitrogen (e.g., NAPAP 1991).

**7. Climate change: -** Climate change is expected to produce warmer air temperatures, altered precipitation patterns, and more extreme temperature and precipitation events (EPA 2009, IPCC 2007). These climate changes can cause changes in urban forest composition (Iverson and Prasad 2001, Johnston 2004) and have the potential to exacerbate other urban forest threats (e.g., invasive species and pests). Climate change has the potential to alter urban forests, not only through species changes, but also through direct effects from storms, floods, etc., that may kill large portions of the forest in relative short time periods. Urban forest managers will need to understand and adapt to potential species shifts and changes to the

environment to produce sustainable and healthy urban forests under future climatic conditions.

**8. Improper management: -** Because numerous people directly manage most of the urban forest, the decisions and actions of the managers significantly affect urban forest composition and health. Improper decisions related to species selection, tree locations, and maintenance can lead to conflicts with the urban population and infrastructure, tree damage, and poor tree health that can lead to premature tree mortality. Actions or inactions taken by the multitude of urban landowners can pose a threat to urban forests, but they can also help bolster urban forest health and sustainability if proper tree care and management are conducted.

**Urban Forest Effects - Benefits and Costs: -** Along with the numerous potential benefits of urban forests, there are a wide range of potential costs and, as with all ecosystems, numerous important interactions that must be understood to optimize the net benefits from urban vegetation. Through proper planning, design, and management, urban trees can mitigate many of the environmental impacts of urban development by moderating climate, reducing building energy use and atmospheric carbon dioxide (CO2), improving air quality, lowering rainfall runoff and flooding, and reducing noise levels. However, improper landscape designs, tree selection, and tree maintenance can increase environmental costs such as pollen production, emissions of volatile organic compounds from trees and maintenance activities, as well as increased building energy use, additional needs for waste disposal, increases in infrastructure repair costs, and water consumption. The urban forest can also generate costs associated with natural disasters, such as those associated with storms, and insect or disease outbreaks (Dwyer et al.).

Urban forests can also be used to facilitate carbon sequestering efforts. As discussed in Chapters 4 and 6, carbon sequestration occurs when trees accumulate carbon and release oxygen (O2) essential for life. The conversion of forests to land uses such as roads, homes, office buildings, factories, shopping centers, sports stadiums, and airports releases carbon dioxide into the atmosphere, which contributes to climate change. Urban tree planting efforts, whether through green belts, parks, windbreaks, or shade trees around residential houses, can play an important role in the sequestration of carbon. One example is the nearly 55,000 tons of carbon that is expected to be sequestered through an urban tree program in Pretoria (Tshwane) South Africa (Stoffberg et al. 2010). The development and maintenance of urban forests, coupled with sustainable living concepts such as recycling and wind, solar, and other

renewable energy technologies, can be used to address the growing concern of global climate change. Interestingly, in one analysis a park-like design of an urban forest seemed to be less effective for carbon sequestration purposes than a forest-like design due to emissions from construction and maintenance activities (Strohbach et al. 2012). A final engineering use of urban forests can involve their ability to filter or block glare and reflected light (Beatty and Heckman 1981, Smardon 1988). Materials such as light-colored concretes, glass, water, snow, and metals can reflect light in ways that cause difficulties involving increased heat and concentrated light energy. The strategic placement of trees can mitigate some of these problems. In addition to reducing glare imposed on homes, urban trees can reduce glare imposed on automobile drivers and pedestrians, which increases human health and safety conditions.

Urban foresters are responsible for the development, implementation, and management of an urban forestry program for a state, city, county, or other municipality. Typical job responsibilities of urban foresters include analyzing and preparing elements of a tree management plan and implementing and enforcing city ordinances. Duties of urban foresters may also include tree planting, streetscape design, tree protection, tree survey and mapping activities, and the development of standards and protocols for tree placement. Communication skills are important, as urban foresters are typically called upon to present issues, problems, and changes related to urban forestry practices to various audiences such as city councils and community groups. Urban foresters may also be involved in supervising volunteers or groups involved in urban forestry projects, may serve as an information resource for the general public, and, therefore, may be involved in education and training programs. Further, urban foresters may be assigned the task of developing or managing databases related to urban trees or tree health, which requires knowledge and training in dendrology, entomology, GIS, and GPS, among other areas.

rban forests can have a positive impact on cities and, especially, their population. They can contribute to the physical and mental health of people by creating spaces for physical activity and buffering stress. In addition, they can improve air quality, by removing harmful pollutants, as well as reduce noise. From a social point of view, urban forests can support local livelihoods, enhance community cohesion, increase food security for marginalized communities, promote urban residents' connection to nature, and enhance equity. For example, small land areas repurposed in pocket parks with trees and seating can become space for social interaction. On the other side, urban forests can also be beneficial for the

urban ecosystem. In particular, they can mitigate the heat island effect, improve the water infrastructure, intercept rainfall and surface runoff to reduce erosion and sedimentation, enhance agricultural production in urban and peri-urban areas, and increase property values. Urban forests can even improve traffic and reduce driver speeds if properly incorporated along streets. In this regard, trees can have an important role in a "complete streets" policy. "Complete streets" are a transportation policy and design approach that requires streets to be planned and designed to enable safe, convenient and comfortable travel. Urban forests can help the achievement of these objectives by reducing air temperature, providing shade, and in some cases protecting commuters form environmental and safety hazards, such as pollution. Some cities have already started to implement the use of trees in a strategic way. For example, the city of Medellin in Colombia has obtained positive results with the adoption of such policies. They were able to achieve a decrease in the temperature of the corridors by 2-3°C, improving the every-day travel of 1 million people.

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## UNIT-4
## Concept of sustainable transport

**Introduction: -**

A sustainable transport system must provide mobility and accessibility to all urban residents in a safe and environment friendly mode of transport. This is a complex and difficult task when the needs and demands of people belonging to different income groups are not only different but also often conflicting. For example, if a large proportion of the population cannot afford to use motorized transport - private vehicles or public buses - then they have to either walk or ride bicycles to work. Provision of safe infrastructure for bicyclists and pedestrians may need segregation of road space for bicyclists and pedestrians from motorized traffic or reduction in speeds of vehicles. Both measures could result in restricting mobility of car users. Similarly, measures to reduce pollution may at times conflict with those needed for reduction in road accidents. For example, increases in average vehicle speeds may reduce emissions but they can result in an increase in accident rates.

But most public discussions and government policy documents dealing with transportation and health focus only on-air pollution as the main concern. This is because air pollution is generally visible and its deleterious effects are palpable. It is easy for most people to connect the associations between quality of motor vehicles, exhaust fumes and increased morbidity due to pollution. But most individuals are not able to understand the complex interaction of factors associated with road accidents. Health problems due to pollution are seen as worthy of public action whereas those due to injury and death in accidents as due to individual mistakes. Therefore, policy documents dealing with sustainable development for cities always include options for pollution reduction but rarely for accident control.

It is a fact that, unless the needs of non-motorized modes of traffic are met it will be almost impossible to design any sustainable transportation system for urban areas. We show that pedestrians, bicyclists and nonmotorized rickshas are the most critical elements in mixed traffic. If the infrastructure design does not meet the requirements of these elements all modes of transport operate in sub-optimal conditions. However, it is possible to redesign the existing roads to provide a safer and more convenient environment for non-motorized modes. This also results in improved efficiency of public transport vehicles and enhanced capacity of the corridor when measured in number of passengers transported per hour per lane (Mohan & Tiwari, 1999).

Transportation is a concept which drives the social development, connects people and local communities to the world, creates vehicle markets, and facilitates commercial/ logistics operations (Goldman &Gorham, 2006). Besides, transportation is a system closely associated with the concept of mobility and accessibility, created in order to satisfy the mobility needs of nations, to offer a quality living space for people, and involves the transportation of people, goods and services. Mobility is a concept accounting for the transportation of people, livestock, goods and services from one place to another, which often has an influence on smaller groups and which is not limited to the current infrastructure and behavior patterns of the market. Approaches which define the transportation performance from the perspective of mobility consider the basis of transportation in terms of mobility of human beings (people/km) and mobility of goods (ton/km). The transportation performance is measured as the amount of travel per unit, and the main goal is to increase this ratio. Accessibility, on the other hand, is defined as the ease of access to goods, facilities and activities people and businesses need. The main purpose of accessibility is to make better decisions on the land usage at a national and individual level; to improve transportation modes and their quality; to shorten the travel time between two locations; to support non-motorized ways of transportation; to improve public transportation options; and to integrate and enable transportation modes. When it comes to transportation modes, safe alternatives which offer slow transportation on short distances are more commonly preferred over the alternatives offering fast transportation on long distances (Özuysal et al., 2003).

The Concept of Sustainable Transportation: -The concept of sustainable transportation can be defined as making transportation investments which aim to offer accessibility with effective, safe, equal, healthy, environmentally-friendly, integrated, participative and economical approaches (Kaçıral, 2007). The main purpose of sustainable transportation is to increase the efficiency of transportation investments without compromising on the quality and ease of access. The success of transportation systems depends on the balanced relationship between mobility, accessibility and interconnectedness of the roads. For example, in a city where the roads are designed to have multiple lanes considering only the mobility of the vehicles, the mobility of the vehicles will be improved. However, such roads will be dangerous for pedestrians and bicycle drivers. Therefore, mobility of pedestrian/bicycles will be limited. The fact that transportation infrastructure is shaped with respect to private cars does not provide the same mobility for all parties and even may eliminate the mobility of individuals

who do not drive. In such a system, even the drivers have the mobility as long as they are driving (Vn, 2009).

Integration of transportation modes, development of transportation plans offering mobility with increased accessibility while placing importance on principles such as environmental, social and economic sustainability and development of suitable policies are the goals of sustainable transportation. The following list of priorities must be considered for the traffic if these goals are to be achieved (Kaya, 2013).

The transport sector plays an important role in society at large. On the one hand, its development has enabled social and economic benefits, while on the other, it causes negative social, economic and environmental impacts. Additionally, it is those negative impacts, such as congestion, air and water pollution, climate change, the depletion of non-renewable resources and many others that need to be reduced in the long term. To reduce these impacts, the concept of sustainable transport must be developed. Many studies have been carried out on this aspect but, to date, only a few attempts at their comprehensive review have been made (Roman, 2022).

Safe, efficient, low carbon, and affordable mobility for all is essential to sustainable human development and must be enabled in all sustainable development policies. Transport is central to powering lives and livelihoods. It is the engine of the global economy and helps spur human development. Every day, people all over the world depend on a variety of transport modes to make a living, go to school, access essential goods and services, and ultimately, enhance equal opportunities to participation in society. With growing transport demand and impacts, the sustainability of the transport sector must improve to meet sustainable development and climate change action targets. As economies grow, especially in the Global South, transport greenhouse gas (GHG) emissions continue to rise, impacting the successful implementation of the 2030 Agenda for Sustainable Development and Sustainable Development Goals (SDGs). Business-as-usual growth implies a three-fold rise in transport emissions, more dependence on private motorisation, and more congestion in rapidly urbanising regions around the world. Nevertheless, a more sustainable pathway for mobility is possible with strengthened policy measures, increased mitigation investments, accelerated technological innovation, and widespread behaviour change (Yiu et al., 2019).

**Sustainable Transport Definition: -**The concept of sustainable transport has its roots in the definition of sustainability (Hall, 2002). According to a widely accepted definition,

sustainability is “development that meets the present needs without compromising the ability of the future generations to meet their needs”. It, therefore, involves prioritizing specific needs while respecting the constraints of the environment to meet current and future societal needs (Brundtland, 1987; OECD, 1998). From the perspective of economic practice, it makes sense to consider sustainability as an integrated order. This means combining environmental, spatial, economic, social and institutional order into a single entity (Burchard-Dziubi et al., 2014).

Sustainable transport, or sustainable transportation, which is also often referred to as green transport due to its emphasis on environmental aspects, is stemmed from sustainable development. According to the Transportation Research Board, “sustainability is not about threat analysis; sustainability is about systems analysis. Specifically, it is about how environmental, economic, and social systems interact to their mutual advantage or disadvantage at various space-based scales of operation”. Richardson emphasizes that in a sustainable transport system, fuel consumption, vehicle emissions, congestion, safety and social and economic access should be maintained at a level that does not cause extensive or irreversible damage to future generations. The OECD, on the other hand, defines sustainable transport as transport that does not endanger public health or ecosystems. In addition, the reasonable use of renewable and non-renewable resources should be adhered to.

Sustainable transport is defined both in a narrow and broad sense. In the narrow sense, the authors focus only on the problems of resource depletion or air pollution. Additionally, even though this problem represents the most significant long-term environmental threat, it is incorrect to equate sustainable transport with environmental aspects alone. When sustainable transport is defined in a broad sense, social and economic well-being are additionally analyzed. Therefore, a broader definition is favored in research, as also highlighted by Litman and Burwell (Litman, 2006), which also encourages the search for integrated solutions in sustainable transport (Zhou, 2000).

It is worth mentioning that sustainable transport should involve integrating environmental aspects with social and economic concerns, but also building an appropriate institutional setting for this. Meanwhile, related activities should be undertaken to ensure that the current, but also future needs of the population are met (Roman, 2022).

**The Historical Development of Sustainable Transportation Policy:** -The concept of sustainability was first defined in the “Brundtland Report” published in 1987. The first report

in which transportation was addressed with regards to sustainability was the European Union Report on "The Future Development of the Common Transport Policy" published in 1992. This report involved subjects such as minimization of private car usage, promoting the use of clean fuel, and development of public projects in order to encourage people to walk and drive bicycles.Increasing traffic congestion, air pollution and rapid decrease in green spaces were discussed in the Transportation Session conducted in "Habitat II United Nations Conference on Human Settlements" in 1996. The issues discussed were directly related to sustainable transportation. With the "Kyoto Protocol" signed in 1997, it was aimed to reduce six types of greenhouse gases (GHG), namely, the carbon dioxide (CO2), methane (CH4), dinitrogen monoxide (N2O), hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and sulfur hexafluoride, emitted in industrialized countries. The level of usage of the current airway and highway transportation modes, their environmental impact and climate change, and sustainable transportation modes were defined in the "Sustainable Mobility Report of The Common Transport Policy— Sustainable Mobility Perspectives for the Future" published in 1998. It was aimed to improve the quality of public transportation vehicles, to ensure transportation safety, to develop intermodal transportation and to design environmentally-friendly transportation alternative.

"The White Paper European Transport Policy for 2010: Time to Decide" was published in 2001 discussing the period of time between 2001 and 2010. This report aimed at traffic congestions reduction, intermodal transportation, preservation of freedom of movement, adaptation of the regulations, reduction of the oil dependency by 98%, using alternative fuels, improving energy efficiency, minimizing the expected increase in mortality associated with transportation and traffic congestions by the end of the 10 years period. The "World Bank Cities on the Move Report" published in 2002 suggested a strategy which included four basic items. These items were structural development/ operational efficiency of advanced transportation modes, better focus and interventionsto help the poor and policy/organizational reform. Moreover, the report aimed to develop non-motorized transportation modes, to improve the traffic management capacity, to limit the demand, and to increase the reach of BRT (Bus Rapid Transit) systems and to increase the fuel efficiency for those vehicles. "EU Green Paper: Towards A New Culture for Urban Mobility" was published in 2007.

The report discusses several subjects such as reducing the tendency to use private cars, encouraging walking and bicycle use, optimizing the private car use with carpool method, reducing vehicle use with virtual mobility (teleworking, teleshopping, etc.), developing

parking policies, promoting public transportation, limiting the entry of vehicles into the city centerimplementing parking rate policies, more efficient transportation planning with Intelligent Transportation Systems (ITS), better integration of freight distribution in urban areas, and encouraging eco-driving with minimized energy consumption. “The EU White Paper” published in 2011 aims at a reduction in the GHG emission share of transportation sector by 60% until 2050, having the GHG emission levels decreased by 80–95%. Additional goals were defined as decreasing the use of vehicles running on traditional fuels by 50% until 2030 and their complete disappearance from the cities by 2050. The International Maritime Organization (IMO) Marine Environment Protection Committee (MEPC) announced their decision in 2012 stating that the sulfur content of the fuels used in sea vessels shall not exceed 0.50% m/m globally as of January 10, 2020. This measure aims to ensure sustainability in maritime transportation in order to reduce the pollution exposure of the inhabitants of coastal cities.

CEDBIK (Turkish Green Building Council) launched the Green Buildings Summit held in Turkey in 2013, and included an article on transportation as part of its Building Certification Guidelines as a criterion. This measure suggested housing projects to be designed close to public transportation network and to minimize the use of private cars having optimized the use of parking spaces with a sustainable transportation approach. In this context, the goal was to promote modes of transportation with no or minimum energy consumption such as walking or driving a bicycle for short distances and the use of public transportation for longer distances in order to reduce the carbon emissions. The guidelines emphasize that the distance between the entrance of a building and a public transportation hub (bus station, metro station, train station, etc.) must be less than 500 m and that regular transportation services must be provided at least once in an hour. Thus, it was aimed to make it possible for the users to be able to transport using methods such as public transportation, bicycle, shuttle, carpool, etc. instead of private cars.

“The National Report for Habitat III Conference” prepared by the Ministry of Environment and Urbanization of Turkey published in 2016 includes a transportation section, which notes that there have been several investments made into railway, maritime (port) and air transportation in Turkey in the recent years as part of accessibility of sustainable transportation modes. National Transportation Master Plan and Logistics Master Plan were developed and new high-speed railways are commissioned. Nevertheless, it was emphasized that construction of metro and light rail transit systems have gained momentum; that two

sides of Istanbul is connected with an underwater railway tunnel as part of the Marmaray Project; and that this project is a solution developed in order to preserve the natural and historical characteristics of the city, which is running at high-capacity, environmentally-friendly, reduces air pollution, noise pollution and the dependency on private transportation and highway. On the other hand, the regulations on the reduction of private car use in support of sustainable transportation policies, development of "park and ride" practices, popularizing public transportation, and the use of environmentally-friendly fuel types were underlined. The Report states that there are basic transportation issues in Turkey such as unplanned urbanization especially in terms of city transportation, insufficient infrastructure investments in the face of increasing number of private cars, preference of private cars instead of public transportation, insufficiency of urban railway systems, pedestrian and bicycle paths. Due to such issues, it was reported that the authorities are aware of the fact that the transportation network is unsustainable, high cost, unsafe, and not environmentally-friendly (Doğan et al., 2018).

Environmentally Sustainable Transport: - Consistent with the broad definition of sustainable development (WCED, 1987), the specification for a sustainable transport system requires that the movement of people and goods is provided in an environmentally, socially, and economically viable way; mobility for any purpose is to be considered as a means rather than an end. Environmentally sustainable mobility implies changes in behavior and new innovative approaches at all levels of society and sectors of the economy. Important prerequisite for realizing an EST system in the long term are conformity with ecological limits (critical levels and loads) and the prevention of pollution.

A sustainable transport system is one that (Wiederkehr et al., 2004):

- provides for safe, economically viable, and socially acceptable access to people, places, goods, and services;
- meets generally accepted objectives for health and environmental quality (e.g., those concerning air pollutants and noise put forward by the World Health Organization);
- protects ecosystems by avoiding exceedances of critical loads and levels for ecosystem integrity, e.g., those adopted by the UNECE for acidification, eutrophication, and ground level ozone; and

- does not aggravate adverse global phenomena such as climate change, stratospheric ozone depletion, and the spread of persistent organic pollutants.

**Principles of Sustainable Transportation:**

**A. Principles of Sustainable Transportation with Respect to Environment: -**

Environmental sustainability principles of transportation are commonly divided into four categories, as follows:

**a. Reducing Noise and Environmental Pollution: -** In order to be able to prevent environmental and noise pollution, alternative solutions to motorized vehicle use must be developed. Freight transportation must focus on railway and maritime transportation and freight villages must be built. Measures which favor public transportation, pedestrians and bicycle drivers must be taken and the number of vehicles in the city center must be limited (Kaçıral, 2007).

**b. Reducing the Consumption of Non-renewable Resources: -** It is of utmost importance to ensure an efficient demand management in transportation in order for the efficient use of resources. In this context, non-renewable resources must be consumed at lower levels when compared to renewable resources. However, the rate of consumption of renewable resources should not exceed the regeneration capacity of such resources (Daly, 1990).

**c. Biodiversity and Protection of Natural Habitats: -** Agricultural and recreational areas and forest lands must be planned as part of transportation investments in order to support biodiversity without interfering natural life. Infrastructure decisions on the course of transportation applications must be planned with these principles in mind (Kaçıral, 2007).

**d. Prevention of Water Pollution: -** One of the most important environmental impacts of the transportation sector, water pollution and its prevention are critical for the protection of water resources and aquatic creatures. In this context, necessary limitations must be in effect as part of the regulations on tankers and ships involved in freight transportation by sea.

**B. Principles of Sustainable Transportation with Respect to Economy: -** Economic sustainability principles of transportation are commonly divided into seven categories, as follows (Doğan et al., 2018):

**a. Improved Accessibility: -** Ensuring easy access to social and economic needs with shortened distances is essential in terms of increased accessibility. Systems which support the use of non-motorized vehicles, and public transportation must be developed while ensuring accessibility.

**b. Integration: -** Vertical integration between government departments and horizontal integration between regions and sectors are critical for sustainable transportation. In this context, all transportation modes must be integrated in a way to promote balanced development in accordance with the sustainable transportation process.

**c. Infrastructure Funding: -**Transportation systems must be able to provide for the needs of the people in the long-term in the most efficient, effective and economical manner, having the necessary risk analyses performed. In this context, increasing the participation with strategic promotion of the competition in the market is important for financial sustainability. Innovative approaches such as land value capture programs resulting from the sustainable transportation systems, green bond investments, and Transit Oriented Development (TOD) must be explored as funding models for transportation investment. It must be ensured that financial management of high budget transportation investments, especially in case of a public-private sector engagement, are not abandoning sustainable transportation principles in the name of profitability. International development funds and environment funds must be improved for sustainable transportation. Moreover, governments must try to improve the credibility of cities with collaborations on both national and local levels.

**d. Calculation of Consumer Costs: -** In order to fund sustainable investments with regards to pricing of transportation systems, users must be asked to pay for carbon tax, Sustainable Transportation 239 congestion tax and others in proportion to their contribution to the pollution. Accurate calculation of investment costs is important for correct and equal allocation of the expenses to users. In this context, hidden and other subsidies must be estimated with respect to transportation investments, and social, economic, and environmental costs must be accurately calculated in order to assess the long-term costs of each transportation model.

**e. Financial Prosperity: -** Financial policies must enable and support sustainable transportation. Financial tools (tax, etc.) must be developed in accordance with sustainable transportation.

**f. Prevention of Accidents: -** Moving away from highway-weighted infrastructure investment policies is important for transportation safety. Prevention of traffic accidents will minimize their burden on the national economy.

**g. Technologic Advances: -** Result-oriented government and investment policies and incentivizing and supporting the private sector with a number of incentives are important in terms of the development of sustainable transportation technologies. Nevertheless, performance standards which aim at the development of clean and efficient systems and technologies for transportation sector must take effect and must be applied. Recent support in technologic advancements has led to the construction of environmentally-friendly roads in developed countries. For example, the Georgia Interstate Highway located in Troup County, USA, was extended 16 miles about halfway between Atlanta and Montgomery, Alabama, and was the world's first sustainable highway project. With the highways redesigned in the Netherlands, all the street lights were replaced in Studio Roosegaarde, recharging lanes for electric vehicles were added and traffic paintings were placed in order to warn the drivers. In France, a stretch of one kilometer of highway is now producing power using solar energy with the photovoltaic panels.

**C. Principles of Sustainable Transportation with Respect to Society: -** Social sustainability principles of transportation are commonly divided into six categories, as follows:

**a. Equality: -** Sustainable transportation policies are considered one of the strongest indicators of a strong economy and quality of life in the world. In this context, transportation must focus on equal opportunity to use services, minimization of the differences in available transportation possibilities across groups and reducing regional/social differences while providing for the transportation needs of the people.

**b. Education: -** Governance and Participation of the People: Due to their often-high budget needs, transportation investments are generally made by central governments and the locals and local administrations are commonly left outside of the decisionmaking process. However, the benefits of the transportation investments stretch into the nation as a whole, their environmental damages are limited to the local scale. In this case, demands of the locals must be considered in transportation investments with respect to equality in sustainability and it must be ensured that the benefits are equallydistributed if it is aimed to minimize the damages in question. Transportation plans must be discussed for their long-term impacts as

part of a holistic approach with transparency, asking for the opinion of the people as opposed to an approach based on the income.

**c. Information Sharing: -** It is important to create a technical information network in order to allow the planning and building parties operating in developing countries to be able to access information about the transportation sector and training opportunities available for them. Such a network can be built with the collaboration of multinational banks, international institutions and government authorities at all levels.

**d. Safety and Health: -** Safer and healthy transportation alternatives must be developed and implemented in order to achieve sustainable transportation, having reduced the use of motorized vehicles which are the reason behind the death of approx. 500,000 people due to traffic accidents annually and which contribute to the air pollution by 70% on an average.

**e. Personal Responsibility: -** In order to ensure sustainable transportation in the long term, new generations must be raised with the awareness of sustainability responsibility towards the nature and transportation policies.

**f. Aesthetics: -** Transportation projects must be developed in a way not to disturb the historic and aesthetic texture of the city.

**Types of Sustainable Transport: -** Here is a quick look at the different types of sustainable transport that can be effectively used to alleviate the negative impact on the environment.

**i. Electric vehicles:** The healthy growth rate of e-vehicles across the globe solidifies the urgency to transition to green energy. E-vehicles are one of the foremost types of sustainable transport that help in minimizing carbon emissions without sacrificing comfort or performance.

**ii. Bicycles:** One of the most economical alternatives, using bicycles over short distances can help not only the environment but also an individual's health. Cycling is considered a healthy activity that can help individuals stay fit while keeping pollution at bay.

**iii. Natural gas transport:** A reliable type of sustainable transport, natural gas has a significantly lower carbon footprint and is cheaper when compared to petrol and diesel. Moreover, CNG has become the primary fuel for public transport across various countries.

**Benefits of Sustainable Transport: -** Leveraging fossil fuels in the transportation sector is fairly common because it is the most commonly used fuel to power engines. But this perception is now undergoing a change. The urgency of climate change and the proliferation of sustainable transportation have put forth many advantages to the environment and the end consumer.

i. Regardless of the type of sustainable transport being used, it is an established fact that they emit less pollution. This is highly beneficial for the environment as carbon emissions from conventional petrol and diesel-powered vehicles harm the environment.

ii. Since sustainable transport emits less pollution, it promotes the physical well-being of the population. The air pollution levels are at a constant high, especially in metropolitan cities. This results in multiple health ailments in the lungs, heart, as well as other respiratory issues.

iii. Sustainable transport helps in relieving congestion. The nominal cost of using sustainable public transit helps in keeping personal vehicles off the streets and promotes optimal energy efficiency.

Sustainable mobility can bring major environmental, economic, urban and health-related benefits. Most importantly of all, it reduces air pollution and noise. In addition, the replacement of combustion engine vehicles with more environment-friendly electric technology can have a major impact on people's health, as they involve less environmental and noise pollution and, in some cases, promote physical exercise. Besides, the use of electric transport can generate savings for the user, given that, although the initial investment is higher, it's cheaper to maintain and it also entails tax benefits. Vehicles with green technology have fewer components and therefore have fewer replacement procedures and requirements.

Another economic benefit of green mobility is the development of a new industry, leading to an increase in the supply of new jobs. The electric vehicle industry is undergoing exponential growth worldwide, with sales expected to increase by 35% by 2023, according to the assessments made in the Electric Vehicle Outlook report. The commitment to sustainable mobility and the promotion of other means of transport also contribute to the transformation of cities. The central areas have to cope with slightly fewer combustion vehicles, giving way to green and pedestrian areas, with a major emphasis on bicycles and sustainable public transport.

**Sustainable freight transport: -** It's also necessary to look for sustainable alternatives in the field of freight transport, such as prioritizing rail. However, in many cases this isn't possible due to the complexity of the logistics. Therefore, in order to reduce fuel costs, transport companies may choose to purchase existing vehicles. In addition, the driving mode is a decisive factor when it comes to fuel economy, as it can lead to more efficient fuel consumption and considerably lower $CO_2$ emissions. In terms of urban delivery transport, also known as "last mile", electric motor vehicles and bicycles are becoming more and more common.

**Smart roads: -** Smart roads are another example of technology's contribution to sustainable transport. These roads incorporate advanced technology in terms of safety, vehicle charging and connectivity. The technologies that make smart roads a reality include photovoltaic pavements with charging systems, elements interconnected via 5G such as traffic signals, smart zebra crossings with LEDs and projectors, and the use of Big Data to manage urban mobility flows, among many others.

**Problems in Transport Sector:** -In comparison to the past decade, the logistics & transportation sector is rapidly growing. Being the backbone of the country's economy, transportation plays a critical role in promoting trade across states and securing smooth operations. However, after all these years of being introduced to new cutting-edge technology, there are many challenges that are still faced by the transportation industry and striving hard to tackle-them with the best ways to avoid any demand losses. Here we have discussed the major problems faced by the transportation industry and how we at WheelsEye solve these problems and provide more efficiency.

**Top Problems Faced by Transportation Sectors & Their Solution: -**From agriculture & manufacturing to residential moving, you cannot perform any operation without the transportation industry. That's why it plays an essential part to manage the flow of goods from point A to point B. Whether you are looking for top-notch Delhi transportation services or from anywhere, you are rest assured that qualified and professional drivers will arrive at your doorstep. Here we have enlisted some top challenges encountered by transportation and how WheelsEye resolves them.

**1. High Bulk Order Ratio: -** Majorly transportation companies face issues in managing huge bulk order intensity ratios. When the company receives various orders, it gets difficult for the

transport companies to priorities and juggle the bulk orders to deliver them on the expected time. It happens during the time of the festival when mass delays are observed.

**Solution: -** Wheels Eye manages thousands of orders in a year with this largest fleet and experienced team. With the help of a skilled operational and demand team, we made it easier for us to maintain the required stock while limiting the excess supply. We strive to provide innovative solutions that not only help to optimise the inventories, but also focus on achieving the utmost value.

**2 Sky Reaching Fuel Prices: -** Another major issue that transport firms deal with in the Indian logistics industry is the climbing fuel cost. In past decades, Fuel prices have hit the roof, and this inflation is directly causing a huge rise in transportation expenses for transporters. Due to this, companies try to improve their margin by cutting back on the expenses and earnings of truckers.

**Solution: -** Wheels Eye understands how expensive Full truckload services can be. However, we strive to provide the most affordable rates in the industry. Instead of increasing operational costs, we try to meet the demands of the consignee's business requirements and budget.

**3. Unforeseen Delays: -** From bad weather conditions and accidents to bad road conditions, there are plenty of reasons why transport delivery might get delayed. Due to these unforeseen conditions, transportation industries owing to a high probability of late deliveries, and sometimes they have to pay a heavy loss. In India, we know how terrible road conditions are in remote areas, the traffic congestions, multiple checkpoints, and toll stations, all these things can make a logistics company lose a lot of time and money.

**Solution: -** To reduce the risk management factor and improve the efficiency of deliveries, Wheels Eye has provided a 24/7 Live tracking feature. Our entire fleet is GPS-enabled, through which we continually monitor the activity of our vehicles. However, whenever we notice unnecessary delays or suspicious activity, we take action right away. Moreover, we also provide insurance coverage on request, which can safeguard your material shipment in case of unforeseen conditions.

**4.Shortage of Skilled Drivers: -** The dearth of skilled drivers and staff is at an alarming stage in the transportation industry in India. You may find a lot of labourers that are under-skilled, overworked and do not meet the desired skill set, due to which trucks are lying idle.

However, to improve the efficiency of the process, it is crucial to have skilled drivers and experienced staff in the company.

**Solution: -** With the help of our skilled operators and teams of professionals, we not only ease down the supply management chain process but also improve the efficiency of the operations without any hassle. That's why to avoid any inconvenience we work with verified drivers and skilled professionals only.

**5. Adopting New Technology: -** In this digital era, logistics companies are also switching to advance cutting-edge technology. However, many companies are still finding it challenging to adapt to new and innovative technology. This technology barrier is stopping them to reach out to more consumers and blocking the expansion of their logistics services.

**Solution: -** Wheels Eye adopted this technology a way back. We have provided cutting-edge technology to our users to book trucks online and keep track of their trips live without any hassle. We specially designed an online truck booking to make it convenient for business owners to look for vehicles according to their freight requirements and budget without wasting their precious time.

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## UNIT- 5
## Concept of sustainable development and sustainable development goals

**Introduction: -**

Overall development of humanity over the last decades has led to the increasingly unfavorable climate changes and natural disasters, but also wars and political and socio-economic instability. Through their action, humans have negatively impacted on the environment, endangering the survival of the Earth and the future generations. These conditions have indicated changes in the behavior aiming towards more rational and efficient management of all resources that will allow less pressure and environmental impact. Such responsible behavior that will ensure the long-term exploitation of resources, without jeopardizing future generations is considered withinthe concept of sustainable development evolving in the 70s and especially in the 80s of the last centuries. The concept of sustainable development is based on the concept of development (socio-economic development in line with ecological constraints), the concept of needs (redistribution of resources to ensure the quality of life for all) and the concept of future generations (the possibility of long-term usage of resources to ensure the necessary quality of life for future generations).

The essence of the concept of sustainable development derives from the Triple bottom line concept, which implies the balance between three pillars of sustainability – environmental sustainability focused on maintaining the quality of the environment which is necessary for conducting the economic activities and quality of life of people, social sustainability which strives to ensure human rights and equality, preservation of cultural identity, respect for cultural diversity, race and religion, and economic sustainability necessary to maintain the natural, social and human capital required for income and living standards. Complete sustainable development is achieved through a balance between all these pillars, however, the required condition is not easy to achieve, because in the process of achieving its goals each pillar of sustainability must respect the interests of other pillars not to bring them into imbalance. So, while a certain pillar of sustainable development becomes sustainable, others can become unsustainable, especially when it comes to ecological sustainability, on which the overall capacity of development depends (Tomislav, 2018).

Sustainable development basically merges economics and environmental science both in theoretical and practical perspectives. Several other articulations consider sustainable development as a process of development by which various environmental, economic and

social benefits can be simultaneously and concurrently maximized. These articulations suggest that sustainable development, in short, is a blend of economic, social and ecological approaches, each of these being indispensable and complimentary to each other. Sustainable development (SD) is, in fact, a pattern of resource use that aims to meet human needs while preserving the environment so that these needs can be met not only for the present generation, but also for generations to come.

Sustainable development is a socio-ecological process characterized by the fulfillment of human needs while maintaining the quality of the natural environment indefinitely. The linkage between environment and development was globally recognized in 1980, when the International Union for the Conservation of Nature published the World Conservation Strategy and used the term "sustainable development". This term has been used as a unifying theme in presenting environmental and social concerns about worrisome trends toward accelerated environmental degradation and social polarization in the 1970s and 1980s. The concept came into general usage after the Brundtland Commission Report (1987), formally called the Report of World Commission on Environment and Development (WCED). WCED was set up by the United Nations General Assembly. Thus, the term 'sustainable development' was widely adopted by mainstream development agencies following the publication in 1987 of "Our Common Future " by the World Commission on Environment and Development (WCED), chaired by the then prime minister of Norway, Gro Harlem Brundtland. It stated that "sustainable development is development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. It is now considered to be one of the most widely recognised definitions. As we can notice, it contains within it two key concepts:

- the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and
- the idea of limitations imposed by the state-of-art technology and social organization on the environment's ability to meet present and future needs."

The United Nations 2005 World Summit outcome document refers to economic development, social development and environmental protection as the "interdependent and mutually reinforcing pillars " of sustainable development. Many definitions and images (visualizing sustainability) of sustainable development may coexist. Broadly defined, the sustainable development mantra enjoins current generations to take a systems-approach to growth and

development and to manage natural, produced and social capital for the welfare of their own and future generations

**Development and Sustainability: -**Two fundamental elements of the concept of sustainable development, i.e. development and sustainability, preceded the creation of the concept itself. According to Sharpley (2000), development and sustainability could be in the juxtaposition, where both could have possible counterproductive effects, while neoclassical economists emphasize that there is no contradiction between sustainability and development (Lele, 1991). Sachs (2010: 28) also suggests how there is no development without sustainability or sustainability without development. The notion of development is related to the past western concept of imperialism and colonialism, and in that period it implied infrastructure development, political power, and economic policy, serving imperialists as an excellent tool for marginalization and diminishing the power of certain countries (Tangi, 2005). Certain authors link the meaning of development to economic development and the term "underdeveloped areas" (later called "Third World Countries"), which US President Harry Truman introduced in the mid-20th century, signifying areas with the significantly lower standard of living than developed areas (Estevo, 2010: 2).

Classical theories of development consider development within the framework of economic growth and development. According to these theories, development is a synonym for the economic growth that every state in a particular stage has to undergo, driven by the transformation of traditional agriculture into modern industrialized production of various products and services, i.e., shifting from the traditional society to the stage of maturity and high consumption. These theories consider developing countries as countries limited by the poor allocation of the resources emerging as a result of the firm hand of government and corruption, inefficient and insufficient economic initiatives, but also political, institutional and economic austerity, whereby being captured in dependence and domination of developed wealthy states (Todaro and Smith, 2003). According to several neoliberal and modern development theories established over the past 60 years (Willis, 2005: 27) and the contemporary understanding, development is a process whose output aims to improve the quality of life and increase the self-sufficient capacity of economies that are technically more complex and depend on global integration (Remeny, 2004: 22).

Fundamental purpose of this process is a creation of stimulating environment in which people will enjoy and have long, healthy and creative life (Tangi, 2005). Romer's new or

endogenous growth theory suggests that economic growth is a result of the internal state or corporate system, and the crucial role in economic growth is knowledge and ideas (Romer, 1986; Todaro and Smith, 2003). The endogenous growth theory model consists of four basic factors: 1) capital measured in units of consumer goods, 2) labor involving the individual skills, 3) human capital comprising education, learning, development and individual training, and 4) technological development. In accordance with this model, if countries want to stimulate economic growth, they have to encourage investment in research and development and the accumulation of human capital, considering that appropriate level of the state capital stock is the key of economic growth.

**History of the Concept of Sustainable Development:** -In the 18th century economic theoreticians such as Adam Smith pointed out issues of development, in the 19th century Karl Marx and classical economists Malthus, Ricardo and Mill also argued about certain elements of sustainable development, while later neoclassical economic theory emphasized the importance of pure air and water and renewable resources (fossil fuels, ores) as well as the need for government intervention in the case of externalities and public goods (Willis, 2005: 147; Bâc, 2008: 576; Črnjar&Črnjar, 2009: 79). Previous periods, and even the following century, saw the dominance of the economic doctrine with focus on human as a ruler of natural resources (Črnjar&Črnjar, 2009: 61). The term sustainable development was originally introduced in the field of forestry, and it included measures of afforestation and harvesting of interconnected forests which should not undermine the biological renewal of forests. This term was firstly mentioned in the Nature Conservation and Natural Resources Strategy of the International Union for Conservation of Nature published in 1980 (IUCN, 1980). Although initially sustainable development primarily viewed an ecological perspective, soon it spread to social and economic aspects of study.

Development based on economic growth remained until the 1970s when it was obvious that consumerism and economic growth put pressure on environment with the consequences of polluted and inadequate living space, poverty and illness (Šimleša, 2003: 404). At the same time, the exploitation of natural resources, in particular the stock of raw materials and fossil fuels, has led to deliberation of the needs of future generations and created a prerequisite for defining the attitude of long-term and rational use of limited natural resources. The imbalance between human development and ecological limits has pointed to the growing environmental problems and possible consequences with disastrous proportions. Črnjar&Črnjar (2009) summed up the basic causes of environmental pollution: 1) anthropogenic causes of

environmental pollution (economic growth, technical and technological development, industrial development, development of traffic and transport infrastructure, population growth and urbanization and mass tourism), 2) natural causes of environmental pollution (soil erosion, floods, earthquakes, volcano eruptions, fires, droughts and winds) and 3) other causes of environmental pollution (wars, insufficient ecological consciousness, imbalance between development and natural ecosystems and limited scientific, material, organizational and technological opportunities of society). The consequences of these factors − seen in various ecological problems, ecosystem disturbances, global climate change, natural catastrophes, hunger and poverty, and many other negative consequences − have been warning about the sustainability of the planet.

Aspiration of developed countries to improve the socio-economic and ecological situation of developing and undeveloped countries gathered scientists, economists and humanists from ten countries in Rome in 1968 to discuss the current problems and future challenges of humankind (limited natural resources, population growth, economic development, ecological problems, etc.). Grouped as an independent global organization called the Roman Club, these scientists have published two significant editions – Limits of Growth in 1972 and Mankind at the Turning Point in 1974, containing the results of their research and appealing the world to change the behavior toward the planet, while in the first edition the term sustainability was clarified in the framework of the contemporary concept of sustainable development (Drljača, 2012: 20; Meadows et al., 1972). The Roman club warned that excessive industrialization and economic development would soon cross the ecological boundaries. In 1971 Nicholas Georgescu-Roegen published The Entropy Law and the Economic Process, similarly warning about the dangers of economic development and marking the beginning of the ecological economics and environmental economics (Levallois, 2010).

Among the various activities, three key events set the fundaments and principles of sustainable development. According to them, the history of the concept of sustainable development is divided into three periods.

**The first period** covers the period from economic theories, where certain theorists (Smith, Marx, Malthus, Ricardo and Mill mentioned above) recognized the boundaries of development and environmental requirements, through the activities of the Roman Club, which warned on the negative consequences of economic development, to the First United Nations Conference on the Human Environment held in Stockholm in 1972 (Mebratu, 1998;

Drexhage& Murphy, 2010). This conference marked the introduction of the concept of sustainable development, and although it did not fully associate environmental problems with development, it stressed the need for changes in economic development policy (UN, 1972; Mebratu, 1998; Drexhage& Murphy, 2010). In the report published after the conference, the necessity of balance between economic development and environment was proclaimed and 28 principles were set aimed to preserve environment and reduce poverty. Within the action plan, 109 recommendations (socioeconomic, political and educational) were given for quality environmental management, and finally, after the conference, resolution on institutional and financial agreements was signed between the states (UN, 1972).

Years after the Stockholm conference represent the **second period** of the concept of sustainable development. The terms such as development and environment, development without destruction and development in accordance with the environment were increasingly used in publications, while the term eco-development was first described in edition of the United Nations Environment Program (UNEP) published in 1978 (Mebratu, 1998). In 1980, International Union for Conservation of Nature (IUCN) set an idea of linking economics and the environment through the concept of sustainable development (IUCN, 1980). A few years later, more precisely in 1983, the United Nations World Commission on Environment and Development(WCED) was established to develop a global change program. This program was aimed to raise awareness and concern about the negative impact of socio-economic development on the environment and natural resources as well as provision of perspectives of a long-term and sustainable development in accordance with the environmental protection and conservation (Drexhage& Murphy, 2010: 7). After several years of work, in 1987 the Commission of 19 delegates from 18 countries, led by Gro Harlem Brundtland (the then Norwegian Prime Minister), published a report Our Common Future, better known as the Brundtland Report, where the concept of sustainable development was introduced in its true sense (Drexhage& Murphy, 2010). In its twelve chapters this report analyzed and provided a clear overview of the conditions in the world (socio-economic development and order, environmental degradation, population growth, poverty, politics, wars, etc.) and elaborated the concept of sustainable development. As a new approach, this concept should be able to respond to future challenges, such as achieving balance between socio-economic development and the environment, reducing pollution and environmental degradation, exploiting natural resources, reducing harmful gas emissions and climate impacts, reducing poverty and hunger, achieving world peace and other serious challenges and threats faced by

humanity. In the second chapter, the concept of sustainable development is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987: 43), which contains the core of the concept and soon became a generally accepted and probably the most cited definition in the literature, no matter where the context of sustainable development is being discussed.

This event was followed by **the third, so-called After Brundtland period**, which lasts until today and included several significant events. Marking the twentieth anniversary of the conference in Stockholm, UN conference on environment and development called the Earth Summit or the Rio Conference was held in Rio de Janeiro in 1992. Theconference saw the participation of numerous governmental and non-governmental organizations from 178 countries. Its focus was to define a global framework for solving issues of environmental degradation through the concept of sustainable development, considering that in the 20-year period the integration of environmental concerns and economic decision-making was ignored and the state of the environment was worse (UNCED, 1992ab; Mebratu, 1998; Drexhage& Murphy, 2010). More than 10,000 international journalists transmitted the conference to millions of people around the world, witnessing the importance of the conference. The preparation of the conference began in 1989 and as a result the following documents were adopted: 1) Rio Declaration on Environment and Development, 2) Agenda 21, 3) non-legally binding authoritative statement of principles for a global consensus on the management, conservation and sustainable development of all types of forests, 4) Climate Change Convention and 5) Convention on Biological Diversity. The first two documents are key for the concept of sustainable development.

**Why is sustainable development important? -** "Economic inequality, social instability and environmental degradation are common features of unsustainable development. Poor people bear the brunt of these problems because their livelihoods are precariously balanced on volatile economic opportunities and environments vulnerable to change. They lack opportunities for meaningful participation in the decisions that affect their livelihoods. Systems of governance and institutional arrangements can add to this dilemma by reinforcing the influence of certain sectors on decision-making processes. There can be no lasting development if governments, donors and civil society choose the short-term view. To effectively eliminate poverty all aspects of sustainable development should be taken seriously. This means not only focusing on vigorous economic growth, but encouraging economic growth that benefits the poor and is based on sound management of the

environment. More specifically, this means creating sustainable livelihoods for poor people. Only governments can create the right political and economic framework for sustainable development. One part of the framework is effective co-ordination with other stakeholders. Ministries, civil society organizations, industry and donors can often work within their own spheres, without reference or responsibility to each other, inevitably leading to unsustainable policies and programs. There is a need to build capacity for participatory planning for sustainable development between these organizations. National strategies for sustainable development (NSSDS) are a tool to assist countries in overcoming these sorts of problems and start to strengthen their capacity for sustainable development (DFID, 1999).

**Dimensions of Sustainable Development: -**Basically, sustainable development has four main pillars (dimensions) - social, economic, environmental and institutional. However, in recognition of the growing importance of information and communication technologies and the role they play in development, a fifth dimension i.e., ICT is added. This integration of social, economic, environmental, institutional, and ICT is an imperative widely recognized by the community. Following are brief definitions of these dimensions.

**1. Social Dimension: -** The imperative of the twenty-first century is sustainability: to raise the living standards of the world's poor and to achieve and maintain high levels of social health among the affluent nations while simultaneously reducing and reversing the environmental damage wrought by human activity. Sustainability issues are generally expressed in scientific and environmental terms, but implementing change is a social challenge that entails, among other things, internationaland national law, urban planning and transport, local and individual lifestyles and ethicalconsumerism. Development is considered to be socially sustainable when it achieves social justice via equitable resource allocation, eradicates poverty and provides social services such as education, health, etc., to all members of the society, especially the neediest ones. The social dimension of sustainable development is, thus, based on I he notion that man constitutes an important means of development and its prime target should be to strive to achieve this notion for both present and the future generations. Social sustainability is one aspect of sustainable development. Social sustainability encompasses human rights, labor rights and corporate governance. In common with environmental stainability, social sustainability is the idea that future generations should have the same or greater access to social resources as the current generation. Social resources include ideas as broad as basic human rights and all other cultures.

**2. Economic Dimension: -** Economically, sustainability means providing economic welfare to people at present and in the future, while paying more attention to the "natural capital". It means and includes the natural resources of economic value, considered as the bases for the economic system, such as plants, soil, animals, fish; and bio-environmental system such as air and water purification. Sustainability, thus, interfaces with economics through the social and ecological consequences of economic activity. Sustainability economics represents a broad interpretation of ecological economics where environmental and ecological variables and issues are basic but part of a multidimensional perspective. Social, cultural, healthrelated and monetary / financial aspects have to be integrated into the analysis. However, the concept of sustainability is much broader than the concepts of sustained yield of welfare, resources or profit margins. At present, the average per capita consumption of people in the developing world is sustainable but population numbers are increasing and individuals are aspiring to high consumption -Western lifestyles. The developed world population is increasing only slightly but consumption levels are unsustainable. The challenge for sustainability is to curb and manage Western consumption while raising the standard of living of the developing world without increasing its resource depletion and environmental impact. This must be done by using strategies and technology that break the link between economic growth on the one hand, and on the other, environmental damage and resource depletion.

**3. Environmental Dimension: -** An ecologically sustainable system maintains a solid base of natural resources and avoids excessive use of such resources. This involves the conservation of biodiversity, attaining atmospheric balance, productivity of soil as well as other systems of natural environment which are usually classified as non-economic resources. In tackling sustainable development problems, environmentalists tend to focus on what is known as "environment borders". As a concept it means that each natural environment system has certain limits that should not be exceeded by excessive consumption, or else a deterioration in natural system is irrevocable and inevitable. Therefore, from an environmental point of view, sustainability means setting limits for consumption, population growth, pollution and the faulty ways of production including wasting waters, cutting the forests or erosion of the soil. Healthy ecosystems provide vital goods and services to humans and other organisms. There are two major ways of reducing negative human impact and enhancing ecosystem services.

**a. Environmental management:** This direct approach is based largely oninformation gained Erom earth science, environmental science and conservation biology. However, this is

ultimately the management of a long series of indirect causal factors that are initiated by human consumption; so, a second approach is through demand-management of human resource-use.

**b. Management of human consumption of resources:** It is an indirect approach based largely on information gained from economics. Herman Daly (1973) has suggested three broad criteria for ecological sustainability:

- renewable resources should provide a sustainable yield (the rate of harvest should not exceed the rate of regeneration);
- for non-renewable resources there should be equivalent development of renewable substitutes; and
- waste-generation should not exceed the assimilative capacity of the environment.

**4.Institutional Dimension: -** The institutional dimension of sustainable development is concerned with the participation of all community members in the decision-making process and the acquisition of the information that affects their lives transparently and accurately. It is also concerned with the organizations, such as councils and committees charged with the implementation of various aspects of Millennium Development Goals (MDGs).

**5. Digital (ICT) Dimension: -** Information and communication technologies (ICTs) are closely related to the abovementioned four dimensions of sustainable development. The millennium development goals and the recommendations of the international summit for information and communication technology held in Geneva in November, 2003 provided a suitable methodological framework on how to make use of ICT in achieving sustainable development. Therefore, the digital dimension has been added as a fifth dimension of sustainable development.

**Principles/Premises of Sustainable Development: -** Some of the principles/premises underlying the concept of sustainable development include the following:

1) Sustainable development is an alternative design for development, which, by definition should be environmentally benign and eco-friendly.

2) That the present generation should meet its needs without compromising the ability of future generations to meet their needs, i.e., to ensure that the productive assets available to future generations are not unfairly diminished.

3) That those who enjoy the fruits of economic development today must not make future generations worse-off by excessively degrading the Earth's exhaustible resources and polluting its ecology and environment.

4) That there is a symbiotic relationship between consumerist human race and producer natural systems.

5) That environment and development are not mutually exclusive - healthy environment is essential to sustainable development and healthy economy as well.

6 That economic development which erodes natural capital is often not successful.

7) That environmental mistakes of the past need not be repeated, as the past-patterns of environmental degradation are not inevitable.

8) That development is not growth only, it should stand for broader goals of social

9) That sustainable development in the long run has to do with ecology, resources and people, along with their service agencies, institutions and other aspects of their social organization.

10) That sustainable development has two major aspects - internally sustainable development and externally sustainable development - without both, no real sustainable development would exist.

11) That sustainable development is largely accountable to the poor, and hence, it should ensure that the poor have adequate access to sustainable and secure livelihoods.

**Sustainable Development Goals: -**At the historic UN General Assembly Summit in September 2015, the 2030 Agenda for Sustainable Development was adopted by the UN's 193 member states. The 17 Sustainable Development Goals (SDGs) and their 169 targets are part of this agenda. The Sustainable Development Goals are a bold, universal agreement to end poverty and all its dimensions and craft an equal, just and secure world – for people, planet and prosperity (https://sdgs.un.org/goals).

**1. End poverty in all its forms everywhere:**

i. By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day

ii. By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions

iii. Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable

iv. By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance

v. By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters

**2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture:**

i. By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.

ii. By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons.

iii. By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.

iv. By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.

v. By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed.

**3.Ensure healthy lives and promote well-being for all at all age:**

i. By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births.

ii. By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births.

iii. By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases.

iv. By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being.

v. Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol.

vi. By 2020, halve the number of global deaths and injuries from road traffic accidents.

vii. By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programs.

viii. Achieve universal health coverage, including financial risk protection, access to quality essential health-careservices and access to safe, effective, quality and affordable essential medicines and vaccines for all.

ix. By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.

**4.Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all:**

i. By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes.

ii. By 2030, ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education.

iii. By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university.

iv. By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship.

v. By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations.

vi. By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy.

vii. By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non- violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development.

**5. Achieve gender equality and empower all women and girls:**

i. End all forms of discrimination against all women and girls everywhere.

ii. Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation.

iii. Eliminate all harmful practices, such as child, early and forced marriage and female genital mutilation.

iv. Recognize and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate.

v. Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life.

vi. Ensure universal access to sexual and reproductive health and reproductive rights as agreed in accordance with the Program of Action of the International Conference on Population and Development and the Beijing Platform for Action and the outcome documents of their review conferences.

**6. Ensure availability and sustainable management of water and sanitation for all:**

i. By 2030, achieve universal and equitable access to safe and affordable drinking water for all.

ii. By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.

iii. By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.

iv. By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.

v. By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate.

vi. By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.

**7. Ensure access to affordable, reliable, sustainable and modern energy for all:**

i. By 2030, ensure universal access to affordable, reliable and modern energy services.

ii. By 2030, increase substantially the share of renewable energy in the global energy mix.

iii. By 2030, double the global rate of improvement in energy efficiency.

a. By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology. b. By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States and landlocked developing countries, in accordance with their respective programmes of support.

**8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all:**

i. Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries.

ii. Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high- value added and labour-intensive sectors.

iii. Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services.

iv. Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead.

v. By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value.

vi. By 2020, substantially reduce the proportion of youth not in employment, education or training.

vii. Take immediate and effective measures to eradicate forced labour, end modern slavery and human trafficking and secure the prohibition and elimination of the worst forms of child

labour, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms.

viii. Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment.

ix. By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products.

x. Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all.

**9.** Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation:

i. Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all

ii. Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries

iii. Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets

iv. By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.

v. Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research anddevelopment workers per 1 million people and public and private research and development spending.

**10. Reduce inequality within and among countries:**

i. By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average.

ii. By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status.

iii. Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and action in this regard.

iv. Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality.

v. Improve the regulation and monitoring of global financial markets and institutions and strengthen the implementation of such regulations.

vi. Ensure enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions in order to deliver more effective, credible, accountable and legitimate institutions.

vii. Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies.

**11. Make cities and human settlements inclusive, safe, resilient and sustainable:**

i. By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums.

ii. By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.

iii. By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.

iv. Strengthen efforts to protect and safeguard the world's cultural and natural heritage.

v. By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product

caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations.

vi. By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.

vii. By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities.

**12. Ensure sustainable consumption and production patterns:**

i. Implement the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries.

ii. By 2030, achieve the sustainable management and efficient use of natural resources.

iii. By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.

iv. By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment.

v. By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse.

vi. Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle.

vii. Promote public procurement practices that are sustainable, in accordance with national policies and priorities.

viii. By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature.

**13. Take urgent action to combat climate change and its impacts:**

i. Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries.

ii. Integrate climate change measures into national policies, strategies and planning.

iii. Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning.

- Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible.
- Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities.

**14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development:**

i. By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.

ii. By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans.

iii. Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels.

iv. By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics.

v. By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information.

vi. By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation.

vii. By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism.

**15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss:**

i. By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements.

ii. By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally.

iii. By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.

iv. By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development.

v. Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species.

vi Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed.

vii. Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products

viii. By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species

ix. By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts

**16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels:**

i. Significantly reduce all forms of violence and related death rates everywhere.

ii. End abuse, exploitation, trafficking and all forms of violence against and torture of children.

iii. Promote the rule of law at the national and international levels and ensure equal access to justice for all.

iv. By 2030, significantly reduce illicit financial and arms flows, strengthen the recovery and return of stolen assets and combat all forms of organized crime.

v. Substantially reduce corruption and bribery in all their forms.

vi. Develop effective, accountable and transparent institutions at all levels.

vii. Ensure responsive, inclusive, participatory and representative decision-making at all levels.

viii. Broaden and strengthen the participation of developing countries in the institutions of global governance.

ix. By 2030, provide legal identity for all, including birth registration.

x. Ensure public access to information and protect fundamental freedoms, in accordance with national legislation and international agreements.

**17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development:**

i. Strengthen domestic resource mobilization, including through international support to developing countries, to improve domestic capacity for tax and other revenue collection.

ii. Developed countries to implement fully their official development assistance commitments, including the commitment by many developed countries to achieve the target of 0.7 per cent of gross national income for official development assistance (ODA/ GNI) to developing countries and 0.15 to 0.20 per cent of ODA/GNI to least developed countries; ODA providers are encouraged to consider setting a target to provide at least 0.20 per cent of ODA/GNI to least developed countries.

iii. Mobilize additional financial resources for developing countries from multiple sources.

iv. Assist developing countries in attaining long-term debt sustainability through coordinated policies aimed at fostering debt financing, debt relief and debt restructuring, as appropriate, and address the external debt of highly indebted poor countries to reduce debt distress.

v. Adopt and implement investment promotion regimes for least developed countries.

vi. Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism.

vii. Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed.

viii. Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology.

ix. Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the Sustainable Development Goals, including through North-South, South-South and triangular cooperation.

x. Promote a universal, rules-based, open, non-discriminatory and equitable multilateral trading system under the World Trade Organization, including through the conclusion of negotiations under its Doha Development Agenda.

xi. Significantly increase the exports of developing countries, in particular with a view to doubling the least developed countries' share of global exports by 2020.

xii. Realize timely implementation of duty-free and quota-free market access on a lasting basis for all least developed countries, consistent with World Trade Organization decisions, including by ensuring that preferential rules of origin applicable to imports from least developed countries are transparent and simple, and contribute to facilitating market access.

xiii. Enhance global macroeconomic stability, including through policy coordination and policy coherence.

xiv. Enhance policy coherence for sustainable development.

xv. Respect each country's policy space and leadership to establish and implement policies for poverty eradication and sustainable development.

xvi. Enhance the Global Partnership for Sustainable Development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the Sustainable Development Goals in all countries, in particular developing countries.

xvii. Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships.

xviii. By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts.

xix. By 2030, build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic product, and support statistical capacity-building in developing countries.

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## UNIT- 6
## Eco-tourism: case studies from the Himalayan and coastal belts of West Bengal.

**Introduction: -**

Ecotourism is a sub-component of the field of sustainable tourism. Ecotourism's perceived potential as an effective tool for sustainable development is the main reason why developing countries are now embracing it and including it in their economic development and conservation strategies. Ecotourism, as an alternative tourism, involves visiting natural areas in order to learn, to study, or to carry out activities environmentally friendly, that is, a tourism based on the nature experience, which enables the economic and social development of local communities. It focuses primarily on experiencing and learning about nature, its landscape, flora, fauna and their habitats, as well as cultural artifacts from the locality. A symbiotic and complex relationship between the environment and tourist activities is possible when this philosophy can be translated into appropriate policy, careful planning and tactful practicum.

Carefully planned and operated ecotourism sites, especially if it is village-based and includes local participation, is able to provide direct benefits that might offset pressure from other less sustainable activities that make use of natural and cultural resources. Eco tourism, natural resources, cultural heritage, rural lifestyle and an integrated tourism is a type of local economic activities. Therefore, ecotourism in naturel and cultural areas was carried out with a number of elements in their natural landscape and cultural landscape (water, vista, topography, vegetation, clean air), as well as in the variety of recreational activities suitable for all kinds of environments. Therefore, ecotourism and its natural assets and raw materials to create, as well as directing people to travel is an attractive force (Kiper, 2013).

Ecotourism helps in community development by providing the alternate source of livelihood to local community which is more sustainable. Its aim is to conserve resources, especially biological diversity, and maintain sustainable use of resources, which can bring ecological experience to travelers, conserve the ecological environment and gain economic benefit. However, achieving the aims in ecotourism depends on whether they are environmentally and ecologically sustainable and economically applicable. Ecotourismhelps in involving local community for the conservation of the ecology and biodiversity of the area that biodiversity in return provides the economic incentives to the local community. Eco-tourism contributes to conservation of biodiversity; sustains the well-being of local people; involves responsible

action on the part of tourist and the tourism industry; promotes small and medium tourism enterprises; requires lowest possible consumption of natural resources; stresses local participation, ownership, and business opportunities, particularly for rural people; and above all includes the learning experiences.

**Scope and Definitional Perspective of Ecotourism: -**Global estimates revealed that in Australia and New Zealand, 32% of visitors search for the scenery, wild plants, and wildlife, as part of their trip. In Africa, 80% of tourists who visited countries in this continent named wildlife as a primary motivational attribute. In North America, 69–88% of the European and Japanese travelers considered wildlife and bird-watching to be the most important attributes of their visits. In Latin America, 50–79% of visitors advocatedthat visit to protected areas represented an important factor in choosing such destinations. In America, it was claimed that over 100 million people participated in wildlife activities, of which 76.5million were related to viewing wildlife, and 24.7 million were interested in bird-watching. This has generated over $20 billion in economic activity with an estimated growth of 30% per year. In all the cases, it was estimated that tourism in the natural and wildlife settings accounted for a total 20–40% of international tourism receipts, with an estimate that it will increase by 20–50% per year (Filion et al., 1994).

However, despite the fact that these statistical estimates have not been matched by any commonly acceptable data, there is a growing concern that this segment accounts for a significant proportion of world travel. Herein lies the first major concern about ecotourism that ofmeasuring the number of visitors participating in ecotourism holidays, as there is a breadth of definitions and large scope of activities. Certain limitations also arise from the spectrum within which ecotourism operates. A variety of terms have been introduced to describe the same phenomenon which may be referred to as nature travel, nature-orientated tourism, nature tourism, nature–based tourism, sustainable tourism, alternative tourism and special interest tourism (Laarman & Durst, 1987).

On this point, it has been noted that it is more feasible to treat ecotourism as a spectrum with a variety of products ratherthan attempting to define ecotourism from a specific stance or product. More specifically, it was claimed that the spectrum includes:

- supply factors (nature and resilience of resources; cultural or local community preferences; types of accommodation); and

- demand factors (types of activities and experiences; degree of interest in natural or cultural resources; degree of physical effort).

In this event, however, there is evidence to illustrate that ecotourism is not meeting existing demand, but is driven by a demand which evolved through the marketing practices of this form of travel by the supply side. Despite such recognition, this concept has still not got a common definition, making it the most important tourism buzzword of this decade. However, there are a number of conceptual attempts that define the concept of ecotourism. In particular, it was claimed that the definitional structure of ecotourism is based on two approaches (Steward &Sekartjakrarini, 1994):

- the activity-based perspective of ecotourism; and
- the definition regarding ecotourism as an industry.

Orams (1995a) argues that the majority of ecotourism definitions lie between the passive position and the active position towards the high responsibility pole on the continuum. He further suggested that he desired state is to move from the minimum passive position towards a higher or active pole ofthe continuum. The active pole mainly emphasizes the actions of protecting the environment and the behavioral intentions of ecotourists, whereas the passive position concentrates solely on ecotourism development, not enhancing the antagonistic impacts or the ecotourists' need to be satisfied. Ecotourism has also been defined based on three criteria (Wall, 1994: 5): the characteristics of the destinations; the motivations of its participants; and the organizational characteristics of the ecotourism trip.

**Definition of Ecotourism:** -The activities of persons traveling to and staying in places outside their usual place of residence for not more than one consecutive year for leisure, business and other purposes constitute "Tourism". Such visits for being close to nature to enjoy its enormous creations, both biotic and abiotic, in a most environment friendly manner, without any adverse impact on the ecosystem, is particularly known as 'Eco-Tourism'.

According to the WTO, "tourism that involves traveling to relatively undisturbed natural areas within the specialized object of studying, admiring and enjoying the scenery and its wild plants and animals, as well as any existing cultural aspects (both of the past or the present) found in these areas" is defined as eco-tourism. It is distinguished from mass tourism or resort by having a lower impact on the environment and by requiring less infrastructure development.

Most common definition of Eco-Tourism is nature-based tourism (visitors are mainly interested in observing and appreciating nature and traditional cultures in natural areas) that has following attributes:

- Contributes to Biodiversity Conservation;
- Supports the well-being of local people;
- Involves responsible action by both tourists and local people to minimize negative environmental and socio-cultural impacts;
- Requires the lowest possible consumption of non-renewable resources;
- Stresses local ownership, as well as business opportunities for local (especially rural) people.

Eco-tourism tends to be modest in scale (e.g., tour groups of not more than 25 people, hotels with fewer than 100 beds). It is also likely to be operated by small or medium sized compar1ies that specialize in leading and providing accommodation for small groups in natural areas. These companies may furnish guides from the local population. Visitors may be given extensive information concerning ecosystems, local cultures and their relationship to the environment and sustainability issues. The key elements of eco-tourism include a natural element as a prime attraction, an optimumnumber of environment-friendly visitors, activities, which do not harm any ecosystem and the positive involvement of the local community in maintaining the ecological balance. Eco-tourism can take many forms and magnitudes. For example, 'losing' oneself in a beautiful natural forest or landscape - watching animals, birds and trees in-a forests, corals and marine life in sea, engaging in trekking, boating or rafting, wandering amongst sand dunes-. -these are some of the common forms of eco-tourism. Though the concept has gained importance only recently, India has been experiencing various forms of eco-tourism all through the ages.

‘Ecotourism is a form of tourism inspired primarily by the natural history of an area, including its indigenous cultures. The ecotourist visits relatively undeveloped areas in the spirit of appreciation, participation and sensitivity. The ecotourist practices a non-consumptive use of wildlife and natural resources and contributes to the visited area through labor or financial means aimed at directly benefiting the conservation of the site and the economic well-being of the local residents...’ (Ziffer, 1989: 6)

‘Ecotourism is a nature tourism that contributes to conservation, through generating funds for protected areas, creating employment opportunities for local communities, and offering environmental education.’ (Boo, 1991b: 4).

‘Nature-based tourism that is focused on provision of learning opportunities while providing local and regional benefits, while demonstrating environmental, social, cultural, and economic sustainability’ (Forestry Tasmania, 1994: ii).

‘Nature-based tourism that involves education and interpretation of the natural environment and is managed to be ecologically sustainable. This definition recognizes that natural environment includes cultural components, and that ecologically sustainable involves an appropriate return to the local community and long-term conservation of the resource.’ (Australia Department of Tourism, 1994: 17).

‘Low impact nature tourism which contributes to the maintenance of species and habitats either directly through a contribution to conservation and/or indirectly by providing revenue to the local community sufficient for local people, and therefore protect, their wildlife heritage area as a source of income.’ (Goodwin, 1996: 288).

‘A responsible nature travel experience, that contributes to the conservation of the ecosystem while respecting the integrity of host communities and, where possible, ensuring that activities are complementary, or at least compatible, with existing re- source-based uses present at the ecosystem.’ (Boyd & Butler, 1993: 13)

**Principles of Ecotourism: -** Ecotourism comprises number of interrelated components all of which should be present for authentic ecotourism to occur. Ross K. Dowling pointed out that there are five key principles that are fundamental to ecotourism. They are: 1. ecotourism is nature-based, 2. ecologically sustainable, 3. environmentally educative, 4. locally beneficial and 5. generates tourist satisfaction. The first three characteristics are considered to be essential for a product to be considered 'ecotourism' while the last two characteristics are viewed as being desirable for all forms of tourism.

**1. Nature Based: -** Ecotourism is based on the natural environment with a focus on its biological, physical and cultural features. Ecotourism occurs in, and depends on natural settingand may include cultural elements where they occur in a natural setting. The conservation of the natural resource is essential to the planning, development and management of ecotourism.

**2. Ecologically sustainable: -** All tourism should be sustainable - ecologically, socially and environmentally. Ecotourism is ecologically sustainable tourism undertaken in a natural setting. The challenge to ecotourism in any country or region is to develop its tourism capacity and the quality of its products without adversely affecting the environment that maintains and nurtures it. This involves ensuring that the type, location and level of ecotourism use does not cause harm to natural areas.

**3. Environmentally Educative: -** The educative characteristic of ecotourism is a key element, which distinguishes it from other forms of nature-based tourism. Environmental education and interpretation are important tools in creating an enjoyable and meaningful ecotourism experience. Ecotourism attracts people who wish to interact with the environment in order to develop their knowledge, awareness and appreciation of it. By extension, ecotourism should ideally lead to positive action for the environment by fostering enhanced conservation awareness.Ecotourism education can influence tourist, community and industry behaviour ·and assist in the longer-term sustainability of tourist activity in natural areas. Education can also be useful as a management tool for natural areas. Interpretation helps tourists see the big picture regarding the environment. It acknowledges the natural and cultural values of the areas visited as well as other issues such as resource management.

**4. Locally Beneficial: -** The involvement of local communities not only benefits the community and the environment but also improves the quality of the tourist experience. Local communities can become involved in ecotourism operations, and in the provision of knowledge, services, facilities and products. These benefits should outweigh the cost of ecotourism to the host community and environment. Ecotourism can also. generate income for resource conservation management in addition to social and cultural benefits. The contribution may be financial with a part of the cost of the tour helping to subsidies a conservation project. Alternatively, it could consist of practical help in the field with the tourists being involves in envirmm1ental data collection and/ or analysis.

**5. Tourist satisfaction: -** Satisfaction of visitors with the ecotourism experience is essential to long-term viability of the ecotourism industry. Included in this concept is the importance of visitors' safety in regard to political stability. Information provided about ecotourism opportunities should accurately represent the opportunities offered at particular ecotourism destinations. The ecotourism experience should match or exceed the realistic expectations of

the visitor. Client services and satisfaction should be second only to the conservation and protection of what they visit.

**Ecotourism and its emerging forms: -** In planning and management of ecotourism it is also important to be aware of a number of different styles of ecotourism. They may vary considerably in regard to a range of factors including:

- The types of natural settings they require,
- The extent of direct contact and involvement with the natural environment,
- The group sizes involved,
- The use and extent of personal interaction with tour guides,
- The reliance on mechanized means of transport and supporting infrastructure, and
- The type of visitor satisfaction and experience realized.

Tourism experts have so far identified three broad styles of ecotourism. (McCotter, 1995). They include a. Frontier Ecotourism, b. Small Group Ecotourism and c. Popular Ecotourism.

**a. Frontier Ecotourism: -**Frontier ecotourism involves individuals or small groups of generally ten or less people who utilize non-motorized forms of transport (e.g., walking or canoeing) to visit relatively remote and lightly used natural areas. Visitors are generally very self-reliant and have few demands for supporting services and infrastructure. There is a very special and unusual 'first-hand' experience that often requires a high degree of challenge and some knowledge of outdoor survival skills. Examples include trekking, rafting and kayaking.

**b. Small Group Ecotourism: -**This type of ecotourism involves individuals or relatively with small groups (approximately 15 or less) who utilize motorized forms of transport such as buses or large boats. There are low requirements for self-reliance and the degree of challenge is generally 'off the beaten track'. This type of ecotourism operation may involve moderately high levels of challenge and self-reliance but is generally suitable for participants from a wide variety of age groups who do not necessarily require any special outdoor skills.

**c. Popular Ecotourism: -**This type of ecotourism involves the transport of large numbers of visitors to, through or across a country's best and most popular natural attractions. It relies on high-capacity mechanized form of transport such as buses or large boats. There are low requirements for self-reliance .and the degree of challenge is generally low. There may be

sustained requirements for supporting. infrastructure and services (e.g., visitor centers, food and drink outlets, boardwalks and toilets). This style of ecotourism is available to all visitors irrespective of age or physical capability. There are also other tourist activities, which are closely related to the ecotourism but are not within the strict definition of ecotourism. Examples of such activities include · aquaria, botanical gardens, zoos which displays native fauna, and visitor centers and displays of native flora and fauna in locations which, are remote from their natural setting. While all of these examples can have substantial educational and interpretive components and similar objectives to ecotourism, they do not occur in and depend on a natural setting and are therefore not exclusively the subject of ecotourism.

**Impacts of Ecotourism:**

**A. Environmental Impacts:** -The most proclaimed positive issue is ecotourism's contribution to sustainable resource management through conservation of the natural resources on a direct or indirect basis (Cater, 1993). Although this represents a shift from the tendency of protecting the environment towards the enhancement of the quality of resources, it is generally achieved through the enhancement of biodiversity. The term biodiversity or biological diversity was defined as 'the variety of all life forms, the different plants, and micro-organisms,the genes they containand the ecosystems of which they form a part. In this case, biodiversity conservation is taking place at three different levels, that of genetic diversity, species diversity and ecosystem diversity.Certain cases around the globe illustrate attempts to benefit from certain aspects of biodiversity conservation. For example, in Australia, the protection of the ecosystem diversity assisted in the provision of a water supply, nutrient cycling, and waste assimilation. In Costa Rica the conservation of the ecosystem offered positive incentives to deforestation programs, as well as assistedin thepreservation ofmarine resources in the Caribbean.In Central America, benefits included the stimulationof national pride, historical value through cultural and natural sites, and ecological benefitsthrough watershed protection, and medicinal contributions from pharmaceutical products from tropical forests.

In general terms, the impacts from ecotourism on nature are diverse, as these also reflect visitors' activities and behavior. Certain research showed that the response of wildlife appears to be dependent upon the particular behavior of visitors who have contact with wildlife. Cases have demonstrated differential impacts to plant and animal species with some

species exhibiting high sensitivity and others showing low sensitivity to visitor disturbance. Antagonistic impacts were also noted in cases where certain animals or species that are more sensitive altered their behavior and activities to completely avoid contact with visitors, resulting in potential long-term existence.

Wildlife feeding as a common feature within ecotourism also creates certain issues of concern. One is the welfare of the animal as tourists feed the animals unsuitable foods hence leading to nutritional problems. The second issue concerns the degree of interaction with these species, as certain contact with animals will give visitors an impression that animals are there for instant human gratification, to be handled and 'consumed'. This situation will then lead to the demands that other species also be made available, and that the respect for wildlife's rights irrespective of their utility value for humans will not be developed. Meanwhile, the capacity of a setting to absorb visitor impacts influences the characteristics of the tour product and its environmental sustainability.In addition, constraints with carrying capacity issues and their effects on the site modifications and development exist as certain ecotourism destinations are moving from the exploration to development stage of their product-life cycle (Weaver, 1998: 24–25). In general terms, ecotourism is facing the problems of classification, observation, monitoring and interpretation of its environmental impacts (Dimanche & Smith, 1996).

**B. Economic Impacts: -**The direct and indirect benefits which are derived from biodiversity conservation, represent the fundamental goal of ecotourism, by attracting visitors to the natural settings and using the revenues to fund conservation and fuel economic development (Cater, 1993, 1994). Regularly, one of the strategies to integrate conservation and development is through the so-called Integrated Conservation and Development Projects (Weaver, 1998). These types of projects aim to finance conservation by intensifying and developing commercial activities that encourage the preservation of the natural habitats. Although the effectiveness of such projects has been argued on the basis of their cross-purpose impact through the exploitation of the ecosystem, others have raised such projects and introduced new terms in order to narrow down their limitation, that of commercial Integrated Conservation and Development Projects. In short, these types of projects aim to (Simpson, 1995):

- improve the economic welfare of the destination;
- provide valuable tools for publicizing conservation;

- lay the mechanism by which consumers can contribute to conservation;
- increase contribution in the form of donations.

Further, another critical issue in such efforts at a local level highlights the financial source for conservation through fees. Although this issue is more applicable to protected areas, it was claimed that destinations which are dependent on high visitation patterns at local(specifically national parks) and national levels, could rejuvenate economic revenue to support its entire park system. This has been demonstrated by ecotourists stating a willingness to pay more to support the conservation of the destination areas. The principle of willingness-to-pay represents a measure of the economic value of the natural area (often protected areas) to ecotourists, which has been used in a number of cases to increase public support and funding for such areas. In turn however, the ability to increase revenues depends on the visitors' willingness to pay for an ecotourism experience. Nevertheless, there arefive main mechanisms to capture the revenue from these sites.

Another alternative is indirect collection where park entrance fees are paid by tourism operators who include the fees in their tour package price, or other sectors of the tourism industry. The financial income, which these mechanisms generate, has been suggested as representing a source of conservation in only a few countries, as in most of the cases the funds are not handed to the agencies which manage the parks but to the central treasury of the destination areas. There are numerous case-studies which revealed this failure of maintaining the financialresources in the parks, all of which suggest that a fee structuremodification is necessary through the establishment of funds in special accounts for protected areas, or earmarking a certain percentage of parks fees for individual parks (Dominguez & Bustillo, 1995: 36).

In short, among the economic benefits of ecotourism there is a fear that the presence of an economic imperative suggests that growth is possible in the direction of mass tourism. In avoiding this scenario, efforts should be placed to measure the capital stocks of the destinations through an appropriate accounting framework such as environmental balance sheets, and measurement techniques of the capital flows such as the travel cost methods and the maximum sustainable yield method (Fyall & Garrod, 1997).

**C. Social and Cultural Impacts: -**The sustainable component of ecotourism often attests certain direct and indirect sociocultural benefits and costs at the sites and/or at the destination

level (see Table 2). Generally speaking, it was proposed that the assessment of the cultural impacts of ecotourism could be based on four criteria: commodification element; culture affecting social change; cultural knowledge; and cultural patrimony elements. Alternatively, Weaver(1998: 27)refers to Sherman's and Dixon's (1991) classification of the option and experience benefits of ecotourism from the clientele perspective. The option benefits refer to the individual's satisfaction of having just one option of visiting natural attractions, while the experience benefits refer to the individual's satisfaction of knowing that certain conservation efforts are occurring in the natural attractions. In general terms, the involvement of local people could generate a sense of pride and a form of ownership, and simultaneously act as a buffer against certain sources of investment outside the local area. It further creates opportunities for diversification through new forms of ecological enterprises, or the so-called 'farming of exotic plants and animals. Hence, the provision of local and regional benefits was claimed to involve a commitment from providers of ecotourism experiences, to distribute equitably benefits to the local community, even though in certain cases ecotourism enterprises maybe based in other communities orinvolve national or multinational ownership.

Ecotourism can also raise awareness of the value of traditional crafts and cultural interchange in twodifferent perspectives (Healy, 1994; Harvey& Hoare, 1995):

- Firstly, ecotourists' post-trip attitudes may be different as a result of a better understanding enhanced by the destination conservation and cultural issues. These tourists may become active or volunteer in some conservation or cultural events in their own community.
- Secondly that can benefit especially from the sale of tourism merchandise, as it can be involved with the ecotourism activities through cultural/sustainable product development, use of local materials, which in turn can be used as a tool for educating ecotourists about the resources and the local culture.

In addition to these pros of ecotourism, Wallace (1992) suggests the role that ecotourism has as a model of sustainable community development, based on the claim that the link between conservation of resources and the sustainable development needs of local people is inseparable. In turn, certain case-studies have highlighted that a limited number of economic benefits remain at the local level (Dimanche & Smith, 1996), and others raised the significance of these incentives and high community involvement levels. Further, the impacts of tourists on the society and culture of a host country are related to the type of tourism, the

nature of the tourism activity and the economic and social structures of the host country.In this context, the development of ecotourism sites has led to local populations being removed from their land. Once ecotourism was established, the local community were unable to return to theirterritory, and as such were engaged in other activities such as agriculture.Others have also claimed that ecotourism is often found in areas where practices by the indigenous population have more often than not been sustainable and relatively environmentally benign.

**Challenges for Ecotourism**: -

**1. Finding the right balance between industrial growth and conservation:** Investing in natural capital is important to stimulate ecotourism. However, governments should set restrictions and regulations to prevent the overexploitation of the natural resources.

**2. Distinguishing credible ecotourism providers:** To avoid "greenwashing", it is important to establish common standards and certification mechanisms for eco-resorts (or ecolodges) and ecotourism products.14 The certification process should be managed and supervised by a single, independent regulatory body.

**3. Accepting changes in conventional tourism patterns:** Environmentally and socially responsible tourism can bring about higher costs and less comfort and convenience for tourists; for example, by incorporating carbon offset payment schemes for long-distance travel by aircraft to ecolodge destinations; limiting access to sensitive ecosystems to specific areas or seasons; or reducing the availability of imported goods that accumulate a huge carbon footprint to reach remote tourist areas.

**Ecotourism in Himalaya: -**The great Himalaya, one of the longest orographic ranges in the world with the highest mountains on the planet, is home to more than half a billion people in Nepal, Bhutan, Pakistan, China (Tibet), India, Afghanistan, Bangladesh, and Myanmar. The Himalaya provide a life-support base for an additional 1.9 billion people who live in downstream basins, and three billion people rely on food produced in these basins, making the Himalaya an important resource for half of the world's population. The Himalaya are a critical global asset for economic, sociocultural, and environmental reasons. The diversity of their physiographic landscapes, climates, and biotic systems makes the Himalaya an extremely attractive region for tourism. In addition, the region is very rich in cultural diversity, with multitudes of cultural mosaics, ancient civilizations, archeological assets, and other historical sites.

Tourism in a broader sense has existed for a long time in the Himalayas: in the form of pilgrimage to Hindu sanctuaries that are located high up in the mountains. With the arrival of the British in the 19th century, summer resorts, the so-called Hill Stations, were established. Examples for these foundations are Darjeeling, Nainital, Mussoorie or Shimla. Nowadays, these Hill Stations are most frequented by members of the Indian and Pakistani middle-class. "Modern" tourism in the Himalayan region – activities such as trekking, mountain climbing, sightseeing and winter sports – has been introduced only in the last few decades. These forms of western mass tourism have a huge impact on the environment and on the local social structure. This paper will explain the history of tourism in the Himalaya and discuss the effects of modern mass tourism on the local society and environment and possible enhancements towards a sustainable tourism in this region.

The Himalayan temperate forest zone extends 3,000 km from southern Afghanistan to southwest China (Olson et al. 2001). It contains 2 of Earth's biodiversity hotspots (Myers et al. 2000), an extraordinary array of ecological niches in a relatively small area, and globally the highest fractions of endemic and threatened species in the world (Grenyer et al. 2006). Himalayan temperate forests have been used for thousands of years by to support subsistence-based livelihoods. Forests are the primary source of fuel for cooking, heating, and construction, are intensively used for livestock grazing, hunting, food gathering, and traditional medicines, and provide raw materials for economic development. These sameforests contain highly threatened, endemic biodiversity and provide essential ecosystem services, including climate and water-cycle regulation. Since the 1980s, demand for timber and fuelwood increased, resulting in forest loss and degradation (Pandit et al. 2014). Even though forest protection is a primary conservation target across Himalayan countries, forest loss has continued (Brandt et al. 2017).

The Himalayan region provides opportunity for a natural experiment to investigate ecotourism impacts because it contains countries in very different stages of economic and tourism development. Tourism has proliferated across the Himalaya as a way to balance economic development and forest conservation (Pandit et al. 2014).We analyzed 4 Himalayan countries with active ecotourism industries: India, Nepal, Bhutan, and China. Nepal and Bhutan are relatively small and located primarily in the Himalaya and its foothills. India and China are mostly outside the Himalayas and have regional administrative units with distinct policies and contexts. Because of their large size, we focused on single administrative

units located primarily in the Himalaya: Himachal Pradesh State, India, and Yunnan Province, China.

**Site identification and characterization of ecotourism strategies:** -To identify ecotourism sites and characterize ecotourism strategies and contexts, including the number, origin, and purpose of tourists and economic wealth, we reviewed the peer-reviewed and gray literature on ecotourism for each country (Supporting Information). We compiled statistics, when possible, but comparable and consistent statistics across sites were typically not available; thus, we relied on province-, state- or country-level data. We obtained information about the overarching forest governance strategy and forest change in each country (Brandt et al. 2017).Tourism areas, unlike protected areas or administrative units, do not have delineated boundaries. However, tourism tends to be concentrated, and tourists typically visit an ecotourism hub (i.e., a population center where tourists concentrate for accommodation, food, guides, and other amenities). To identify our ecotourism hubs we compiled a list of the most popular general tourism hubs based on official tourism statistics and other literature reviewed for each country; searched Google (search terms such as ecotourism in Bhutan and ecotourism in Yunnan) to identify hubs that advertised ecotourism; narrowed the list by asking regional experts to identify ecotourism hubs they considered the most popular; and overlaid our map of potential hubs on an ecoregion map (Olson et al. 2001) to identify sites that included forest in the Himalayan temperate zone.

**Ecotourism strategies:** -The four countries we analyzed differed considerably in terms of the types of ecotourism they implemented (Supporting Information). India is one of the most populous and rapidly developing countries in the world. Himachal Pradesh, the focus of our analysis, had the second-lowest GDP/capita of any unit in our analysis (US$2,200), and the lowestoverall forest-loss rate from 2000-2017 (0.40%). Himachal Pradesh has a unique forest governance system of traditional, community-based forestry that is officially recognized by the federal government. Tourism in Himachal Pradesh started in the colonial era in the form of seasonal vacation centers (i.e., Hill Stations), created by the British during the 19th century (Ahluwalia & Little 1998). Since the 1970s, the state government has implemented policies to encourage the development of both corporate and leisure tourism (Pandey & Wells 1997), and the number of tourist visitors grew from 8 million in 2006 to 15 million in 2011 (KPMG 2012), the vast majority of which were domestic. Nature-based, adventure, and religious tourism dominated.Nepal is among the poorest countries in the world with primarily community-based sustainable forest management (Brandt et al. 2017).

Nepal had the lowest GDP/capita (US$835) and the second-highest rate of temperate forest loss (1.0%) of our study units. Nepal has been a popular international ecotourism destination since the 1970s, and tourism has been important for economic development (Schroeder & Sproule-Jones 2012). Nepal's tourism policy is designed to maximize the number of tourists and offers relatively inexpensive visas and few restrictions on travel and the length of time tourists may stay in the country (Schroeder & Sproule-Jones 2012). In 2014 Nepal hosted over 790,000 tourists, a 58% increase from approximately 500,000 in 2000 (MoCTCA 2015; Nepal 2015), and has a national goal of 2 million tourists per year by 2020 (Nepal & Karst 2017). The majority of tourists in Nepal are international and come to visit national parks and to trek (Nepal 2015).

Bhutan is a small Buddhist kingdom, known for its gross domestic happiness (GDH) policy, where environmental protection and economic growth are equally prioritized, a sustainable development approach that is unique among developing nations (Brooks 2010, 2013). Bhutan had the second highest GDP/capita of any unit in our study (US$3,110) and the second lowest forest-loss rate (0.9%). Bhutan's national forest policy emphasizes forest conservation (Brandt et al. 2017), and tourism in Bhutan is a relatively recent phenomenon compared with India and Nepal. Tourism was introduced as a means of attaining foreign currency to help achieve economic development and autonomy from donor aid (Nepal & Karst 2017), but, in contrast to Nepal, Bhutan has pursued a controlled approach. In 1974 Bhutan implemented a policy known as „„high value, low volume““ (Schroeder &SprouleJones 2012). Tourist visas are expensive and short, and travel permissions are tightly controlled, which limits both tourism numbers and the activities tourists can engage in. Although there is great potential for adventure-based tourism, such as climbing and trekking,it is limited due to the tight control (Gurung & Seeland 2008), and the primary activity of most tourists is "cultural sight-seeing" on designated tours to specific sites (Bhutan 2014; TCB 2015). In 2014 Bhutan hosted 133,480 tourists, about one-fifth as many as Nepal. We found no empirical studies about ecotourism and forests in Bhutan.

China has had the fastest growing economy in the world in recent decades. Strong economic development policies for western China have stimulated high rates of economic growth in Yunnan (Xu et al. 2006). Yunnan's forest governance policy emphasizes for-profit use of forests (Brandt et al. 2017). Yunnan had the highest GDP/capita (US$5,117) and thehighest forest-loss rate (2.9%) of all of our study units. The most common economic development strategies include extractive-based activities, including cash crops, mining, and hydropower,

except for specific areas where ecotourism has been implemented (Donaldson 2007; Li & Han 2000; Wang & Buckley 2010). The Himalayan region of Yunnan is designated as the premiere ecotourism destination in China and aggressively marketed to the growing middle class in eastern China. Ecotourism has grown exponentially since 1990 and the vast majority of tourists are domestic (Brandt et al. 2012; HKTDC 2017; Jenkins 2009). For example, tourist visitors in Diqing Prefecture grew from 40,000 tourists in 1995 to 5.3 million visitors in 2009. We found 2 empirical studies from theChinese Himalaya about the impacts of tourism on forests, both of which reported that ecotourism led to accelerated deforestation due to rapid economic development and population growth.

**Eco-tourism of Coastal Belts of West Bengal: -**Tourism over the years cropped up to be a revolutionizing phenomenon and it is emerging as a catalyst of the development process due to economic and employment generation as well as generates a number of socio-economic benefits, particularly in remote and backward area at the regional, national as well as global levels. So, tourism is now recognized as an emerging and fast developing industry everywhere in the world as well as India and West Bengal also. But indiscriminate expansion of the tourism industry has resulted in some ecological and cultural damages to the host country. For this reason, after 1980s the concept of the eco-tourism has been popularized rapidly by the HECTOR CEBALLOS LASCURAIN in 1983 initially the term used as eco-tourism. The coastal stretch of West Bengal with a length of about 350km comprises the two districts- Purba Medinipur(East Midnapur) and Dakshin Chabbisparagana (South 24 Paraganas). This region (Like- Digha, sankarpur,Tajpur, Mandermony, Sagar Island, Bakkhalietc) is a transitional zone in-between sea and land where the Casuarinas and mangrove forest are whispering, sea are roaring, the flora and fauna are blooming and where visitors can rejuvenate yourself in the company of sand, sea and sun in the pristine open air which has kept her doors wide open to established the eco-tourism destination.

Basic Features of The Coastal West Bengal: - West Bengal has golden opportunities for the establishment of eco-tourism due to characterized by the Royal Bengal Tiger, Mangrove Forest (Sundarban-world largest Zoogeographical region), wide and hard beaches ( Bay of Bengal coastal tract in West Bengal like Digha, Sankarpur, Mandarmoni, Sagar Island, Bakkhalietc) where the sightseer play and enjoy romance with sun, sand and sea in the sea beaches and different types of aquatic life, flora- fauna, rolling seas, sand dunes, casuarinas forest, red crabs, eye catching beautiful scenario, which has kept her doors wide open to established the eco-tourist destination. This region is a transitional zone in-between sea and

land where the mangrove forest is whispering, sea is roaring, the flora and fauna are blooming and where visitors can rejuvenate yourself in the company of sand, sea and sun in the pristine open air. Each part of the coastal region of West Bengal is nothing short of spectacular view wearing a green blanket the coastal area seems like an emerald of West Bengal. Among these rich flora and fauna are the major eco-tourism resources, which help to increase the glamour of the eco-tourism industry in West Bengal coastal region. In coastal region of West Bengal, there are varieties of trees, shrubs, climbers, herbs, and medicinal plants etc. which are creating acolorful spectrum of bio-diversity. Except these, many endangered flora and faunas are also the chief source of tourist attraction, and, although, eco-tourism is the nature-based tourism so it can be said that rich flora and fauna also make a way to ripen eco-tourism industry in West Bengal coastal region. But all the West Bengal coastal zone environments provide a unique combination of resources and constrains (like beaches, sand dunes, wetlands, barrier island, reefs etc. and storms/cyclone, sea level rise, more vulnerable erosion by fluvio-marine processes and anthropogenic activities etc.) which may be considered to explore the opportunities for development of eco-tourism which is one of the assuring effective managements of the coast.

Prospects of Eco-tourism Development in The West BengalCoastal Tract:

**1. Presents romance with sun, sand and sea: -** The coastal tracts (Specially sea-beach) of W.B. presents gorgeous source of scenic beauty where the sightseer plays and enjoy romance with sun, sand and sea in the sea beaches (well-liked places are – Digha,Sankarpur, Tajpur,Mandarmoni,Juneput Sagar Island, Bakhkhali, Henry's Island etc.). The mentioned places of coastal tracts of W.B. are offers their individuals characteristics as wide,hard and flat beaches where have presents rolling seas, sand dunes, casuarinas forest, red crabs, eye catching beautiful scenario, remarkable variety of aquatic and forest life(different types of fishes, crocodile, varieties of birds, royal Bengal Tiger etc.) Which are ultimately attracts tourist in the coastal area of W.B.

**2. Maintained high degree of Bio-diversity: -** Coastal region of WB is a land of hope, a hope to care for the green and save nature. This region is a transitional zone in-between sea and land where the mangrove forest is whispering, sea is roaring, the flora and fauna are blooming and where visitors can rejuvenate yourself in the company of sand, sea and sun in the pristine open air. Eachpart of the coastal region of WB is nothing short of spectacular view wearing a green blanket the coastal area seems like an emerald of WB. Among these

rich flora and fauna are the major eco-tourism resources, which help to increase the glamour of the eco-tourism industry in WB coastal region. In coastal region of WB, there are varieties of trees, shrubs, climbers, herbs, medicinal plants etc. Which are create a colorful spectrum of bio-diversity. Except these, many endangered flora and faunas are also the chief source of tourist attraction, and, although, eco-tourism is the nature-based tourism so it can be said that rich flora and fauna also make a way to ripen eco-tourism industry in West Bengal coastal region.

**3. Employment opportunities: -** Sustainable development of eco-tourism are of immense significant in generating the employment opportunities of many semi-skilled and unskilled people, particularly in remote and underdeveloped areas. A large number of women and young people are engaged in hotel, transport services, travel agencies, making and selling, hand crafts, cultural activities and other tourism-related tasks.According to 2001 census, there are so many poor families settled in WB coastal areas and the coastal districts of WB accounts for 11324066 people who are approximately 14.13 0/0 of the total population (80176197) of the state spread across 2139759 households in two coastal districts (South 24 Pgs. and East Midnapore). The distribution of population across districts shows that, the total share of working population is 34.57 0/0 of the total population of which 89.440/0 are male workers and 10.56 0/0 are female workers. About 65.43 0/0 of total population are unemployed who are totally dependent on 34.57 0/0 of total workers (Marginal + Main workers).

**4. Pleasant weather condition: -** Pleasant warm weather condition like tropical monsoon climate with an average annual rainfall of 1500 mm and maximum air temperature is around 35 0C and the minimum is 13 0C, which affected by land breeze and sea breeze, are attract the tourist round the year. (The beaches of Digha, Shankarpur, Bakkhali etc. attract a large number of tourists each year. Digha beach alone attracts 1.5 lakh tourists per year. The annual pilgrimage of Ganga Sagar brings more than one lakh pilgrims every year).

**Problems for Promoting Eco-tourism: -** Many small sandy islands and mudflats mark the river channels and most the of tourist places in WB coastal area get completely inundated during high tide. Much of the western part of the coast is now inhabited and cultivated. Industry and tourism have established a strong presence in the area between the Subarnarekha River on the west and the Hugli in the east. The eastern sector is almost an unpopulated area except for Sagar, Mahisani, Namkhana, Frazergung areas, including the inter tidal reclaimed

part of about 500 sq.km from the north of existing mangrove forests. Agriculture is a predominant activity in the western sector. In the eastern sector, the reclaimed lands are now supporting single-crop agriculture with low productivity. The impacts of human activities come through (a) diesel driven fishing boats through release of hydrocarbon due to lack of maintenance), (b) fishing harbor activities, (c) aquaculture farms and (d) agriculture, none of which has been properly assessed. Other economic activities, besides fishing and agriculture, include honey collection, wood cutting, Salt pan activity in Dadanpatrabar area and Brickfields are also mushrooming along the river and backwater courses. Tourism is a major contribution to the economy of the coastal zone. Tourism activity invariably leads to accelerated road transport (diesel driven), hotel industry and illegal encroachment by small traders. Each of these components has a direct impact on environment quality of land, air and water. So, now days the coastal plain of west bengal suffers by many problematic issues which have created conflicts between various resource users and interest groups, between developers and ecologists/environmentalist, engineersand geoscientists and land owners and economists in West Bengal.The risk has been increased considerably in the interactive zone of human activities and coastal hazards.

**Progress of Tourism in the Two Coastal District (like East Midnapore and South 24 PGS.) of West Bengal: -**Tourism is a major contribution to the economy of the coastal zone. The beaches of Digha, Shankarpur, Bakkhali etc. attract a large number of tourists each year. Digha beach alone attracts 1.5 lakh tourists per year. The annual pilgrimage of Ganga Sagar brings more than one lakh pilgrims every year. The Lothian Island Sanctuary (Bhagatpur Crocodile farm) attracts 30,000 tourists while Sundarban Tiger Reserve gets about 50,000 tourists per year. Tourism in the Sundarbans can also lead to a profitable activity for local population. Tourist statistics indicate that at present 1, 80,000 tourists annually visit Sundarban area. An opinion poll about tourism attraction indicates that most of the participants (100%) are interested in inter island boat trips, besides showing interest in bird watching (50%), turtle nesting (33%) and recreational fishing (17%). The tourism activity can further be augmented by interdicting underwater Plexiglas capsule for watching the marine life. As many as 83% of the tourists have shown interest in this regard. The local people could therefore be engaged in inter island boat trips, as guides for bird-watching, turtle nesting sites and recreational fishing. The employment of the local people in all other promotional activities should form an important component of management strategy. The coastal town of Digha has changed from a small village to a tourist resort over a period of

four decades. Initially, lack of communication and transport had kept the influx of the tourists at a low order. During the last four decades road connections have improved and a fleet of transport operations led to significant influx of tourists, which in turn necessitated development of hotels, holiday houses, private lodges, etc (Mandal et al., 2013).

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## UNIT-7
## Green Technology

**Introduction:-**

Green technology is a broad word that refers to the application of science and technology to generate environmentally sustainable products and services. It is connected to cleantech, which refers to goods or services that increase operational performance while lowering costs, reduce energy usage and waste, or decrease negative environmental effects.

Green technologies cover a wide range of technologies that assist in reducing human influence on the environment and fostering long-term growth. The fundamental parameters for green technology are social equitability, economic feasibility, and sustainability. India's current push for renewable energies and green technology, such as solar, wind, and nuclear power, can go a long way in aiding the country's success story.

For example, renewable energy sources like solar and wind power play a pivotal role in decreasing reliance on fossil fuels, thereby mitigating greenhouse gas emissions and addressing the climate change aspect of the triple planetary crisis. Similarly, advancements in sustainable agriculture, such as vertical farming and the adoption of biochar, aid in conserving land and water resources while bolstering food production. Biochar, a charcoal-like substance derived from pyrolyzing agricultural and forestry residues, not only mitigates pollution but also securely sequesters carbon, making a significant contribution to climate change mitigation. The diverse array of green technology illustrations underscores the versatility and potential of these eco-friendly solutions in tackling the multifaceted challenges confronting our planet.

**Aims and scope**

Green and sustainable technologies, which are environmentally friendly and low-carbon, are rapidly growing and are positioned to dominate world's future. Unfortunately, as the negative environmental, health and economic impacts of non-sustainable choices become

ever more abominable, there is a clear need to accelerate the penetration of green technologies to create a resilient global society.

To do this, renewable energy sources including solar, wind, hydro, tidal, geothermal, and storage concepts must be scaled up, green materials processing technologies must be expanded including recycling, industrial symbiosis and industrial ecology. Society's transportation system must be decarbonized. The world's unsustainable systems must be converted to green resilient systems end masse and new green technologies that remediate environmental desecration but be scaled up. We must anticipate challenges and global catastrophic risks and prepare for them to make a resilient society. Free and open-source technological development has been proven to be one of the most potent sources of innovation and rapid technology distribution. Thus, open-source green technologies are of particular interest as it couples open-source rapid innovation with the much-needed acceleration of green technology deployment.

Green Technology, Resilience and Sustainability is an open access international, multi-disciplinary journal in green technology engineering and research focused on solutions for sustainability and global resilience. The journal aims to be a leading peer-reviewed platform and an authoritative source of original research and reviews related to Green Technology, Resilience and Sustainability.

**The Evolution of Green Technology**

The history of green technology has roots deeper than one might initially suspect, stretching back to the era of the Great Depression. The Soil Conservation Act of 1935, established in the United States on April 27, 1935, formed the Soil Conservation Service. This was a response to the devastating Dust Bowl of the 1930s, when intense dust storms resulted from poor farming practices and heavy equipment use. This service was designed to control floods, prevent impairment of reservoirs, maintain the navigability of rivers and harbours, protect public health, public lands, and relieve unemployment.

While the concept of environmental protection was nascent, it became more formalized with the establishment of the Environmental Protection Agency (EPA) in 1970, following a surge in public concern for the environment after World War II. Green technology evolution was initiated when scientists began recognizing the environmental impacts of coal-burning factories in the early 1990s. Since then, the sector has continuously evolved, fueled by social

movements, organizations, and government policies advocating for sustainable development. This journey highlights the adaptive and reactive nature of green technology in response to the environmental crises we face.

Modern green technology encompasses a wide range of innovative solutions, from renewable energy sources like solar and wind power to waste management and recycling systems. As public awareness of environmental issues continues to grow, the demand for green tech is also increasing. These advancements have the potential to reshape industries, create new job opportunities, and contribute to a more sustainable and eco-friendlier world.

**Goal of the Green Technology**

Green technology (GreenTech) has a number of ambitious goals aimed at creating a more sustainable future for our planet. Here are some of the key objectives:

- **Reduced Reliance on Fossil Fuels:** Burning fossil fuels is a major contributor to greenhouse gas emissions and climate change. GreenTech strives to replace fossil fuels with renewable energy sources like solar, wind, and geothermal power.
- **Combating Climate Change:** By mitigating greenhouse gas emissions, GreenTech aims to slow down global warming and its associated environmental consequences.
- **Pollution Reduction:** Green technologies address various types of pollution. For instance, electric vehicles and cleaner manufacturing processes reduce air pollution, while advancements in waste management minimize water and soil contamination.
- **Resource Conservation:**GreenTech promotes the efficient use of natural resources. This includes sustainable practices in agriculture, water management, and material science to minimize resource depletion.
- **Environmental Restoration:** In some cases, GreenTech goes beyond reducing harm and aims to actively restore environmental damage. This can involve techniques for land reclamation, reforestation, and pollution remediation.
- **Economic Benefits:** The GreenTech sector itself is a driver of economic growth, creating new jobs in research, development, manufacturing, and installation of these technologies. Additionally, GreenTech can lead to long-term cost savings through reduced reliance on imported fossil fuels and improved resource efficiency.

**Advantages of Green Technology**

- Energy Sector- Power generation is the field where green technology has the potential to make a difference. Green energy, such as solar PV, biogas generation, and wind power, can provide additional job possibilities and be successfully implemented to provide energy solutions to communities in remote places.

- Helps in reducing the input cost- One of the primary objectives of any company is to cut costs on the input side. Green technologies such as green buildings, energy efficiency measures, and green manufacturing, among others, have been identified as energy and resource savers. This not only assists firms in lowering their input costs, but it also allows them to fulfil their social duties.
- Manufacturing sector-Green manufacturing can provide considerable benefits to manufacturing companies. Green technology in the manufacturing field can help reduce waste and pollution by modifying production and consumption habits. This not only decreases a product's environmental footprint, but it also makes production a more environmentally friendly and cost-effective activity because inputs from the source are decreased by design.
- Trickles Effect- The fact is that all green technologies take into account the demands of both people and the environment, so it's no surprise that success in one area leads to success in others. In India, for example, people have employed alternative green power production methods to not only meet their personal energy demands, but also to sell their energy to the grid, resulting in a large profit.
- Approach of Green Farming-Green farming methods have been shown to be both healthier for humans and productive for the soil. In contrast to inorganic farming approaches, which resulted in a decline in production after a given amount of time, green farming leads to increased productivity over longer periods of time.
- Helps in creating avenues-Green technology has the potential to create new industries that were previously unimagined, especially at a time when the economy is slowing. Previously, waste management was restricted to garbage dumping. In South Asia alone, waste management is already a $25 billion business. As a result, the environment will be cleaned up, jobs will be created, toxic and greenhouse gas emissions will be reduced, and there will be numerous benefits.
- Benefits in rural sector-Green technology have the potential to have a significant impact on local communities. The provision of bio-gas plants to rural families has the potential to empower communities and boost production. It was seen during the distribution of solar lanterns as part of several programmes, such as the TERI's Lighting a Billion Lives Campaign. It is obvious that people have benefited from it by not just using but also trading the outputs.

**Green Tech vs. Clean Tech vs. Environmental Technology**

- While the terms green tech, clean tech, and environmental tech are often used interchangeably, they have distinct focuses. Green tech encompasses any technology that is environmentally friendly or sustainable, aiming to reduce our overall impact on the environment. On the other hand, clean tech focuses on improving environmental performance, often by making production processes more efficient and eco-friendlier.
- Environmental tech, sometimes referred to as climate tech, is specifically geared towards addressing issues caused by human-induced climate change. This can include technologies for reducing greenhouse gas emissions or adapting to the consequences of a changing climate, such as sea-level rise and extreme weather events.
- By understanding the nuances between these terms, we can better appreciate the diverse range of solutions that green, clean, and environmental technologies offer in addressing our planet's most pressing challenges.

**Examples of Green Technology**

**LED Lighting**-There is a significant increase in efficiency by avoiding incandescent lighting. Traditionalincandescent light bulbs use more energy than LED light bulbs. LED lights are used outside of pure visual assistance. Moreover, they are used in vertical farming and even in the fight against malaria.

**Wind Energy**- Wind turbines are often named along with solar panels as the gold standard of green technology. Wind turbines can be installed in areas where solar panels aren't effective, due to low levels of solar radiation. They may run day and night. The land underneath can still be used for farming and ranching. There are downsides to wind turbines. They have a limited operational life, and wind turbine blades are rarely recyclable. Wind turbines don't generate power when wind speeds are too high or too low.

**Solar Panels**-Solar panels are one of the most popular types of green technology. They may be small solar panels on an RV to provide power when dry camping or solar panels on top of one's home to reduce your energy bill. Solar panels are more common than solar concentrators because they are passive devices, and solar concentrators have the nasty side effect of frying migratory birds. Solar concentrators also require a lot of space and cost more money than solar panels. Their only upside is that the super-heated column of salt inside many designs provides heat that generates steam, driving turbines through the night. With solar panels, you don't have power when the sun goes down unless you managed to charge up the batteries during the day.

**Programmable thermostats**-A low-cost green technology solution is a programmed thermostat. With a programmable thermostat, you can set a schedule and have the temperature automatically adjust to your comings and goings, consequently saving both energy and money. The ability to monitor and modify temperature remotely is an additional benefit of a smart thermostat.

**Vertical Farming-** Vertical Farming is an innovative agricultural practice that has the potential of solving the impending food crisis. Instead of growing our crops horizontally, produce is grown in stacked vertical layers. By doing so, crops require less or even no soil at all, and water efficiency is increased at the same time. Vertical farming can guarantee regular output of produce and boost crop yields based on its controlled environment including temperature, light, humidity, as well as artificial intelligence.

**Electric Vehicle**-The electrification of transport is now one of the most popular uses of green technology in the world. It's so widely accepted that most developed countries have included electric vehicles as part of their decarbonization plans. As the name suggests, electric vehicles are cars powered entirely by electricity instead of fossil fuels, which massively reduces greenhouse gas emissions.

Lithium-ion batteries, which are how electric vehicles are powered, have the great benefits of being rechargeable and have high energy intensity to power cars at long distances. However, it's important to note that these batteries require extracting raw materials, mainly lithium and cobalt, using up large quantities of energy and water to do so. Furthermore, mine workers, which include children as young as seven, often face unsafe working conditions.

**Green Buildings**

A green building is designed to be self-sufficient, from its electric power grid, energy generation, down to its water system. While solar panels are already widely used as an energy source for households and businesses, green buildings utilize solar panel designs that can generate both electricity and heat. The front of these panels is designed to produce photovoltaic energy while the rear produces hot water by means of a heat exchanger, allowing households to enjoy free hot water. Highly efficient and insulated windows also help reduce heat loss, some to the point that can bring energy bills down to zero.

**Waste-Electricity Generator**

Reusing waste and wastewater to generate electricity can help alleviate both the global trash issue and reliance on other non-renewable sources for electricity supply. One method to do so is to simply burn the waste, allow the heat to produce steam that will power an electric

turbine, generate electricity. However, this method has a high chance of producing high emissions and very likely, toxic gases from the waste.

**Carbon Capture**

Carbon capture and storage technologies have recently made headlines following the opening of the world's largest direct air capture plant in Iceland in early September. This particular plant, named Orca, is estimated to capture about 4,000 tonnes of carbon dioxide from the atmosphere every year, which will then be stored underground and turned into stone.

Carbon capture and storage also has the seal of approval from the UN-backed IPCC Report. In both its 2018 and 2021 climate change report, it states that "all pathways to limit global warming to below a 1.5℃ rise in median global temperatures forecast the use of Carbon Dioxide Removal (CDR) of about 100–1000 gigatons of CO2" this century.

**Plastic Roads**

On the subject of waste, a green technology that has lately gained more attention is the use of plastic roads. First appeared in India around two decades ago, plastic roads are made entirely of or mixed with used plastics – bags, bottles and any plastic waste you can think of – and can be paved into roadways that can comfortably support vehicle transportation.

India has since installed over 60,000 miles of plastic roads while this green tech has been gaining traction in countries like Britain, the Netherlands – a start-up built two 30-metre stretches of cycle track in the Dutch towns of Zwolle and Giethoorn, which claims to be the world's first recycled plastic bike path – and Vietnam.

**Recycling**

Recycling involves reusing the material in some way, so that you don't have to rely on new sources of the material to meet demand. The most commonly recycled materials include aluminium, steel, plastic and paper. In the case of aluminium, you use less than a tenth of the energy recycling the metal as is required to remove it from bauxite. We're increasingly seeing rare earth minerals recycled. These are used in cell phones and other high-end electronics. China is the major source of these minerals, and trade wars and their own restrictive manufacturing rules limit access to this critical material for the rest of the world. The most successful such recycling program is found in Japan. They pioneered the recycling of rare earth metals used in fluorescent lights, too. Recycling can include incineration. Burning waste wood, paper and plastic is not ideal, but it can generate power when the alternative is burning coal or oil; the latter are limited resources.

Green Technology, Resilience and Sustainability covers research in the following areas that focus on solutions to environmental issues:

- *New green technologies that help improve renewable energy supply*
    - Solar Photovoltaic Technology
    - Solar Thermal and Passive Solar Applications
    - Wind Energy Technology
    - Geothermal Technology
    - Wave, Tide and Ocean Energy Technologies
    - Hydro Power and Pumped Storage
    - Renewable Hydrogen Production Technology and Fuel Cells
    - Energy Storage
    - Distributed Generation and Smart Grids
    - Hybrid or Dual Use Concepts (e.g., agrivoltaics, floatovoltaics, BIPV etc.)
- *New green materials processing technologies*
    - Recycling systems
    - Green materials
    - Green buildings and construction processes
    - Efficient and sustainable industrial processes
    - Green products
    - Industrial symbiosis
    - Industrial ecology
    - Life cycle assessment and analysis
    - Sustainable chemistry
- *New green technologies that help improve transportation*
    - Electric vehicles
    - Battery technology
    - Green urban design and walkable cities
    - Public transport
    - Bicycle engineering
- *New green technologies that remediate environmental desecration*
    - Water conservation, purification and treatment
    - Rehabilitation of chemical and nuclear contaminated sites and brown fields
    - Reforestation and methods to prevent illegal logging
    - Green sanitation
    - Pollution reduction and elimination
- *Resilient technologies*

- Sustainable utilization of resources such as land, water, and air
- Biodiversity preservation
- Free and open communication systems
- Education systems
- Agriculture systems and alternative foods
- Preparation for disasters: natural and manmade
- Preparations to reduce global catastrophic risks
- Technologies that reduce existential risk

The Emergence of Green Tech Advancements and Innovation

- Advancements like Artificial Intelligence (AI) and related technologies are having a huge impact on industries and culture at every level. Use of automation is making our working and personal lives more efficient, and this is beginning to carry over into environmental causes.
- Over the past decade, there has been remarkable progress in implementing renewable energy sources like solar, wind, and geothermal power. As they've developed, these technologies have become more efficient and cost-effective.
- They're no longer impractical and out of reach, but have become a viable alternative to fossil fuels. We've also made great strides through breakthroughs in energy storage, smart grid systems, and electric vehicle technology.
- All of these advances have have further expanded the hopes and possibilities for a more sustainable future. However, making such tech solutions the rule rather than the exception takes an investment in time and funding, and many regions of the world are running short of both.
- The good news is that opportunities to develop green tech solutions are becoming more plentiful, and growing knowledge of the benefits makes funding such advances a solid investment in the future of our planet.
- In fact, these are opportunities we can't afford to miss.

**Green Tech Trends and Future Outlook**

The trajectory of technology unmistakably bends towards green initiatives, with transformative trends and exciting advancements continually emerging. The ultimate aim is for green technology to cease being a distinct niche and instead become the cornerstone of all technological progress. Envisioning a world where green technology is the norm represents the pinnacle of our aspirations.

Presently, trends such as low-carbon construction, carbon capture and storage, renewable energy storage, hydrogen fuel, and upcycling spearhead the movement. Renewable energy sources like solar, wind, geothermal, and hydropower are in a constant state of evolution, becoming more efficient and accessible alternatives to traditional energy sources.

The push towards reducing plastic usage is noteworthy, seeking to minimize pollution and waste in products and packaging. Yet, the journey extends beyond the adoption of green technology. The ultimate objective is to move beyond emission reduction towards establishing regenerative enterprises.

Regenerative enterprises aspire not only to achieve net-zero emissions but to surpass this benchmark. Their goal is to operate with carbon negativity, actively removing more carbon from the atmosphere than they release. Furthermore, their ambition extends to actively improving the environment and revitalizing ecosystems.

This progression entails a series of shifts - from emission reduction to achieving net-zero status, then transitioning to carbon negativity, and ultimately, cultivating regenerative enterprises. Each phase signifies a stride towards a future where technology isn't merely mitigating harm but actively fostering the well-being and sustainability of our planet.

As these trends and ambitions continue to shape the technological landscape, green technology will take center stage in tackling global environmental challenges. This transition will not only advance sustainability but also ignite innovation towards a future that is not only cleaner and greener but also thriving and regenerative.

**The Role of Government and Policies in Green Tech Adoption**

Government policies play a vital role in stimulating the growth and adoption of green technology. By implementing tax credits and renewable energy mandates, governments can catalyze innovation and make green technology more accessible. Financial incentives and the promotion of renewable energy sources facilitate the transition to cleaner, more sustainable energy production.

However, the efficacy of government policies in fostering green technology can differ across nations, with some policies sparking more controversy than others. Despite these challenges, government support remains essential in nurturing the development and adoption of green technologies, thus helping to combat climate change and shape a more sustainable future for all.

**Ethical Considerations in Green Tech Implementation**

The application of green technology requires a careful contemplation of various ethical facets, including fairness, inclusion, the minimization of negative impacts on communities

and ecosystems, and a comprehensive approach to sustainability. It is essential to ensure that the benefits of green technology are available to everyone and that no one is excluded from the process, thereby promoting social justice and equity.

Moreover, the potential repercussions of green technology on communities and ecosystems need careful consideration. It's crucial to prevent environmental damage or disrespect for local cultures when implementing these solutions. By adopting a holistic perspective on sustainability, green technology can yield benefits for both people and the planet, taking ethical considerations into account.

**Investing in Green Technology**

There are several investment options available for those interested in supporting the growth of green technology. Investors can purchase stocks in companies dedicated to environmentally-friendly technologies, choose individual stocks within the green tech sector, or invest in a mutual or index fund concentrating on environmental investments.

Investing in a mutual or index fund for green tech provides diversified exposure to the industry, thereby reducing dependence on the success of a single company. By financially supporting green technology, individuals and businesses can contribute to the development and adoption of sustainable solutions, thereby helping to mitigate environmental challenges and foster an eco-friendlier future.

**Investment Opportunities in Green Technology**

Investors who are interested in supporting the future of green technology can explore various avenues that will address our most pressing environmental and social issues.

Here are five of the most promising green technologies to consider adding to your impact investing portfolio.

1. **Renewable Energy:** Investing in solar, wind, hydroelectric, or geothermal energy projects, as well as companies involved in manufacturing renewable energy equipment.
2. **Energy Efficiency:** Supporting companies that develop energy-efficient technologies for buildings, industrial processes, and transportation.
3. **Sustainable Agriculture:** Investing in agricultural technologies that promote efficient resource utilization, reduce chemical inputs, and enhance sustainable farming practices.
4. **Waste Management and Recycling:** Backing companies involved in waste-to-energy projects, recycling technologies, and sustainable waste management solutions.

5. **Water Conservation:** Investing in companies or projects that focus on water conservation and management can play a crucial role in addressing water scarcity challenges. Look for investments in technologies such as efficient irrigation systems, water monitoring and treatment solutions, rainwater harvesting, water-efficient appliances, and smart water management systems.

You could also consider investments in companies involved in sustainable water infrastructure development, wastewater treatment, and desalination technologies to promote responsible water resource management. These will not only address the problems of water scarcity, they will also reduce fallout from pollution during manufacturing process and sustainability in agriculture.

Serious investors want to know the benefits and risks before supporting corporations, and impact investing is no different.

**Benefits and Drawbacks of Investing in Green Technology**

The advantages of investing in green technology are many, and the risks are relatively few. With time and further development, the risks will become more manageable as well.The benefits include:

- **Environmental impact:** Investing in green technology allows individuals and organizations to contribute directly to environmental sustainability. By supporting clean energy projects, sustainable infrastructure, and eco-friendly practices, investors can help reduce carbon emissions, protect natural resources, and mitigate climate change impacts.
- **Financial returns:** Green technology investments offer promising financial returns. As governments worldwide enact policies and regulations to promote sustainability, companies in the green technology sector stand to benefit from increased demand and market opportunities. Renewable energy projects, for instance, have demonstrated strong growth potential, with the sector attracting substantial investment and generating competitive returns.
- **Job creation and economic growth:** The green technology sector has the potential to spur job creation and economic growth. Investing in this sector can stimulate innovation, encourage entrepreneurship, and create employment opportunities in areas such as research and development, manufacturing, installation, and maintenance of green technologies. What's more, transitioning to a low-carbon economy can lead to cost savings in sectors like energy, transportation, and construction.

- **Risk mitigation:** Investing in green technology can help mitigate risks associated with traditional, resource-intensive industries. Fossil fuel dependency, for example, exposes investors to volatility in oil prices and geopolitical tensions. Diversifying investment portfolios to include green technology can reduce exposure to these risks and position investors favourably in a rapidly changing energy landscape.

Besides, these are investments you can feel good about.

**Conclusion**

The realm of green technology offers a promising path towards a more sustainable and environmentally conscious future. By harnessing the power of innovation and technology, we have the opportunity to mitigate the impacts of climate change, reduce greenhouse gas emissions, and create a more resilient society. From renewable energy sources to sustainable agricultural practices, the possibilities for greener living are vast and ever-evolving.

As we continue to embrace green technology and integrate it into our daily lives, we move closer to a world where sustainability is not just a goal but a way of life. By prioritizing ethical considerations and striving for a harmonious balance between people and the planet, green technology has the potential to yield benefits that extend far beyond the present moment. Let us seize the opportunities presented by green tech trends and work towards a future where environmental stewardship is at the forefront of all technological progress.

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# UNIT-8
# Green Economy

**Introduction:**

The term "green economy" refers to an economic system that prioritizes sustainability and environmental responsibility alongside traditional economic goals. It emerged as a response to growing concerns about environmental degradation, climate change, resource depletion, and social inequalities associated with conventional economic practices. The concept gained prominence in the early 21st century, particularly in the context of international discussions on sustainable development and climate change mitigation. The United Nations Environment Programme (UNEP) played a significant role in popularizing the concept through its reports and initiatives.

A green economy is a process of fostering social and environmental sustainability via the encouragement of public and private investment in infrastructure. The green economy is significant because it promotes low-carbon, sustainable economic growth and guarantees that natural resources will continue supporting our well-being by providing resources and environmental services. At their core, economies are made up of laws and standards that reward some behaviours and penalize others. Our economies currently encourage excessive consumerism, weaken social ties, and deplete natural resources. But this is just how our economies have developed to work; it is neither inevitable nor necessary.

Investments in renewable energy, including solar power, onshore and offshore wind power, hydrogen, electric vehicles, and energy-efficient housing, indicate a green economy. Sustainable development is not replaced by the idea of a “green economy,” but rather, a new emphasis is placed on the economy, investment, capital, infrastructure, jobs, skills, and favourable social and environmental results.

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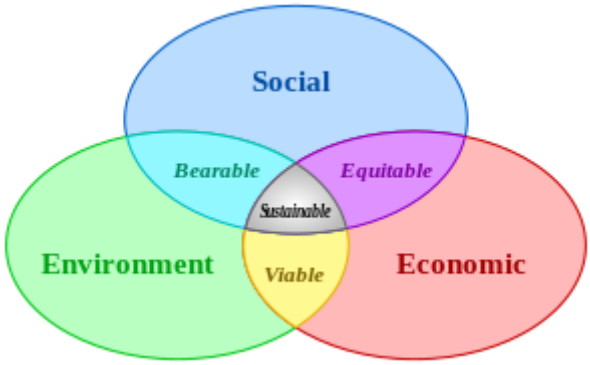


Figure 1: The three pillars of sustainability
Source: Wikipedia

## 1. GUIDING PRINCIPLES OF THE GREEN ECONOMY

The principles of the Green Economy are given as follows including Efficiency, well-being, Planetary Boundary, etc.:

**Efficiency and Sufficiency:** The green economy aims to promote sustainable production and consumption. Low-carbon, resource-conserving, varied, and circular economies are inclusive. It accepts fresh approaches to economic growth that tackle the problem of achieving wealth within the confines of the planet. It acknowledges that if we are to stay within the limits of the earth, there must be a substantial worldwide change to limit the consumption of natural resources to physically sustainable levels.

**Justice:** The green economy encourages equity across generations and within them. The green economy is non-discriminatory and inclusive. In addition to providing enough room for wildlife and wilderness, it promotes the equitable distribution of opportunity and outcome, decreasing gaps between individuals. It adopts a long-term outlook on the economy, generating wealth and resilience that serve the needs of present and future citizens while responding quickly to address the multifaceted poverty and injustice that exist now.

**The well-being:** The green economy is focused on people. Its goal is to produce real, shared wealth. It emphasizes accumulating wealth that will promote well-being. It prioritizes spending on and gaining access to the infrastructure, know-how, and education required for everyone to flourish. It provides chances for ethical and sustainable businesses, jobs, and livelihoods. Although it is based on individual decisions, it is built on collective action for the public good.

**Planetary Boundary:** The green economy protects, restores, and finances the environment. An inclusive green economy respects and promotes nature's many distinct values, including the economic importance of producing goods and services, the social values of culture, and the ecological values that support all life. It applies the precautionary principle to prevent the loss of critical natural capital and the violation of environmental boundaries while acknowledging the limited sustainability of natural capital with other capitals. It invests in preserving, expanding, and restoring the earth's soil, water, air, and natural systems. It is creative in managing natural systems, taking into account their characteristics like circularity and matching with the lives of the local community that depend on biodiversity and natural systems.

**Good Governance:** An inclusive green economy is grounded on evidence; its institutions and norms are cross-disciplinary, utilizing both reliable science and economics and local expertise for adaptive strategy. It is backed by institutions with the necessary resources to fulfil their various duties in an effective, efficient, and accountable manner. These institutions are integrated, collaborative, and cohesive across sectors and governance levels. So that societal demand is added to enlightened leadership, it demands public engagement, prior informed consent, transparency, social dialogue, democratic accountability, and freedom from entrenched interests in all institutions—public, private, and civil society. While upholding robust, uniform, centralized standards, procedures, and compliance systems, it

encourages decentralized decision-making for local economies and the management of natural systems.

## 2. PRIMARY FOCUSES OF THE CURRENT GREEN ECONOMY

- Green Economy ideas will be demonstrated, emphasizing investments, technology, and financial access.
- Assistance with developing and implementing macroeconomic policies to help nations transition to a green economy.
- Employing regional, sub-regional, and national fora to promote the macroeconomic approach to sustainable economic growth.

## 3. GREEN ECONOMY TRANSITION'S BUSINESS OPPORTUNITIES

Companies must switch to a green economy to meet their goals for sustainable development. This beneficial circle fosters sustainable manufacturing, encourages resource and energy efficiency, and allows the adoption of ecologically friendly items, procedures, and technology. Although developing a green economy through initiatives like "no use of carbon" takes time and money, businesses themselves are increasingly seeing these initiatives as offering green economy economic prospects. Since innovation is the primary driver of economic growth across the board, the green economy is no exception. The use of low-carbon technologies and practices, as well as technologies that rely on clean and renewable energy, is encouraged by green economy business opportunities, which emphasize building a healthy environment and promoting the well-being of all.

## 4. GREEN ECONOMY GLOBAL INITIATIVES

There are several Initiatives that are globally working in various countries:

- Germany's Energiewende (Energy Transition)
- China's Ecological Civilization
- South Korea's Green Growth Strategy
- Costa Rica's Carbon Neutrality Initiative
- The European Green Deal

- Singapore’s Sustainable Development Blueprint

## 5. PARTNERSHIP FOR ACTION ON GREEN ECONOMY (PAGE)

The Partnership for Action on Green Economy (PAGE) aims to make economic policymaking centered on sustainability. The Partnership helps countries and regions reorient their economic practices and policies toward sustainability to promote economic growth. As a result, poverty and inequality are decreased, income and jobs are created, and the ecological foundations of their economies are strengthened. PAGE was created directly to the Rio+20 Declaration, The Future We Want, which urged the international community and the UN system to help interested nations make, adopt, and implement green economy policies and strategies. PAGE offers a comprehensive and well-coordinated package of technical support and capacity-building services by combining the expertise of five UN agencies: UNEP, ILO, UNIDO, UNDP, and UNITAR.

## 6. GREEN ENERGY INITIATIVES LAUNCHED BY THE GOVERNMENT

**The Hydrogen Energy Mission**:The Hydrogen Energy Missions an effort that aims to generate hydrogen from renewable energy sources, with the potential to revolutionize the transportation industry. It would also encourage India's adoption of clean fuels. The budget's emphasis on green hydrogen is compatible with technical advances and the long-term objective of reducing reliance on minerals and rare earth element batteries for energy storage.

**Public Transportation**: For the first time, the cabinet has approved private financing of INR 18,000 crores (USD 2.43 billion) for 20,000 buses, as well as creative financing through public-private partnerships, which would transform India's public transportation system. The effort intends to reduce reliance on personal automobiles and, as a result, the carbon impact.

**Deep Ocean Mission:** The mission would conduct deep sea surveying and exploration, as well as programs to safeguard deep marine biodiversity. This initiative will have a budget of about INR 4,000 crore over the next five years.

**Reduction of Corporate Tax:** At the moment, businesses in the renewable energy sector rely primarily on these indirect state incentives because there aren’t any clear rules or policies yet protecting the renewable energy market. Indian businesses will be more competitive in the international market due to the corporation tax rate now being among the lowest in the world. They’ll want to stay and grow their business in India. A 15% personal income tax rate

is an option for new domestic companies that only function in the manufacturing sector and were founded on or after October 1, 2019. Companies that commence manufacturing on or before March 31, 2023, are eligible for this tax benefit. Such businesses pay an effective tax rate of 17.01%. This action would benefit not only India's manufacturing industry but also all commercial activities there and help the industry as a whole to recover.

**Enhance Land Purchase:** Private businesses currently find it highly challenging to purchase land in India. Private companies should now experience a shift in this due to the government's efforts to alter the mechanism used for land acquisition. The so-called "plug and play" concept will replace the current mechanism for awarding renewable energy projects in the future, which should reduce significant risks. According to the "plug and play" plan, the government will essentially buy the land and manage the initial and most crucial permissions later. Following that, the projects and land that have been acquired will be distributed to private enterprises following the recognized bidding process.

**Quintessential Power Purchase Agreements:** The government now considers the national standardization of all power purchase agreements ("PPAs") for solar and wind energy. The new power purchase agreements should include a stiff penalty if the state breaches its responsibilities or defaults, the Ministry of New and Renewable Energy announced. Letters of credit should also be accepted as a form of payment.

The government intends to effectively manage waste from construction and demolition activities, as well as bioremediate all inherited landfills, with a focus on integrated management of manure, sludge, and sewage treatment; waste classification; the reduction of disposable plastics; and the reduction of air pollution.

## 7. STRATEGIES FOR ACHIEVING A GREEN ECONOMY

There are strategies which are taken to achieve a green economy.

**Buildings:** An energy audit may significantly cut your building's carbon footprint and energy expenditures.

**Fisheries:** By promoting sustainable fishing methods, we can prevent overfishing. Select seafood that has been caught responsibly.

**Forestry:** Nearly 20% of the world's greenhouse gas emissions are caused by deforestation.Reduce the need for paper items by using electronic files.A healthy

environment and sustainable livelihoods are supported when you purchase certified sustainable forest products.

**Transportation:** Using public transportation or carpooling has a positive influence on the environment, economy, and community.Short-distance travel by bike or on foot is healthy for you and the environment.It promotes Green Economy in the transportation industry when you choose alternate modes of transportation.

**Water:** Making simple efforts to utilize water responsibly will help protect this priceless resource.Turn off the faucet while not in use. A Green Economy must prioritize resource efficiency, and one of our most valuable resources is water.

**Agriculture:**To ensure that we can feed everyone, it is time to encourage sustainable agriculture.Create your food garden and visit your neighborhood farmers' market.The support of a green economy for agriculture is communicated to farmers when they purchase locally sourced, organic, and sustainable food items.

**Energy:** Encourage the development of clean, renewable energy sources by patronizing companies and buying their goods, or by making their investments.Consider strategies to increase personal energy efficiency while we try to make the switch to renewable energy.

**Waste:** Composting food scraps and recycling relevant items lowers the strain on our natural resources.

**Sustainable Infrastructure:**Economic activity, environmental quality, and resource consumption are all heavily impacted by land use decisions. Planning and zoning control thus gives local governments powerful instruments for shaping the green economy. Local governments may raise citizens' living standards and enhance the business climate by promoting wise, rational land use decisions.

**Utilization and Production Locally:** Local production and consumption boost economic security and communal wealth while reducing the adverse environmental effects of long-distance freight transportation. The benefits of local spending spread throughout entire local economies because of the multiplier effect. Communities may receive better food at a lesser cost when it is locally sourced. Renewable energy produced nearby can lower the cost of living for locals and the cost of doing business for companies and increase supply security.

**Stream Management of Waste:** Local governments are generating employment and lowering corporate expenses by reducing the costs and negative externalities related to trash disposal. Several municipal governments have established aggressive solid waste management initiatives. For instance, Hawaii County wants to create a world with no waste. Innovative technologies will be needed to reduce the waste stream, boost recycling rates, and convert garbage to energy without relying on incineration to achieve this aim.

**Development of the Green Economy:** The traditional goal of economic growth is to increase the output of commodities and services. For creating local money, production, and exportation are essential. As a result, most traditional economic development strategies center on increasing exports. A green economy adapts conventional economic development tactics to create businesses that enhance environmental consequences.

**Green Purchasing and Resource Efficiency:** There are other, frequently more efficient approaches for constructing green local economies in addition to green economic development strategies that enhance production and supply. Utilizing the community's purchasing power and the demand for energy, water, and environmentally friendly products, resource efficiency, and green purchasing are two main ways of tackling the consumption side of the green economy.

Twenty years after the landmark Earth Summit, world leaders will reunite at the United Nations Conference on Sustainable Development in this crucial year for the environment and sustainable development.

## 8. ROLE OF TECHNOLOGY IN GREEN ECONOMY

- Technology and Innovation plays a very important role in Green Economy:
- Advances in solar photovoltaic (PV) panels and wind turbines have drastically reduced the cost of renewable energy, making it competitive with traditional fossil fuels.
- Smart grid technology and the Internet of Things (IoT) enable more efficient energy use and distribution, reducing waste and optimizing consumption.
- The development of EVs and their supporting infrastructure, like charging stations, is key to reducing greenhouse gas emissions from the transportation sector.

- Innovations in recycling processes allow for more materials to be reused, reducing waste and the need for raw materials.
- Technologies like drones, sensors, and AI enable precision agriculture, optimizing resource use and minimizing environmental impact.
- Innovations in CCS are crucial for mitigating the impact of existing carbon emissions, with potential applications in power generation and industrial processes.
- The development of biodegradable materials and green chemistry practices help reduce toxic waste and reliance on non-renewable resources.
- Technological advancements in water treatment, including desalination, are vital for ensuring clean water supplies.

## 9. ADVANTAGES OF GREEN ECONOMY

According to Saraswathi (2022), here are the advantages of Green Economy:

**Decreasing Environmental Pollution**: Green Economy potentially works towards decreasing theenvironmental pollution like, Air, water, soil pollution etc. and also improves the Quality of soil, conservesthe water and purifies the Air. It indicates that green economy protects the environmental wellbeing.

**Saves the Biodiversity:** Global warming, loss of biodiversity, deforestation, desertification, resourcedepletion can gradually be obstructed, by implementing Green Economy which will automatically save theearth and its biodiversity.

**Industrialization:**Creation of more industries means more employment and more employment meansmore stable society as economically which increases the GNI Per capita of India.

**Economic Growth:**Green economy enhances the establishment of new markets which have the potentialto support domestic as well as international business environment. These activities of the countryautomatically concentrate on Growth of an Economy.

**Green Technologies:**Industrial sector and Agriculture industries will be able to achieve a dignified placedue to the emphasis on green technologies. And reduce greenhouse gas emissions and the amountof waste generated during the entire life cycle of a product.

**Innovations:** Green economy takes the initiative to innovate the new skills and inventions, this will inviteestablishment of more educational institutions which will ultimately increase the scopes for the students.

**Sustainable Development:**Green economy promotes the sustainable developmental activities like,Conservation of Energy, increasing the fertility of soil, Protecting the biodiversity and ecological system,Metro rail Project, Promoting the MSMEs Projects etc.

**Economic and Environment Friendly:**Green economy policies are economic and environmentallyfriendly. It means green economy is cost benefit and increases the state of wellbeing.

**Quality of Life:**Green economy increases the quality life by reducing environmental risks and ecologicalscarcity.

**Efficient Use of Resources:** Green economic policy brings economic stability by reducing theconsumption of natural resources and it increases the efficiency in use of resources available

## 10. DIFFICULTIES IN ACHIEVING GREEN ECONOMY

Achieving a green economy presents numerous challenges, like-

**Transition Costs:** Shifting to a green economy requires significant investment in new infrastructure, technologies, and practices. These transition costs can be substantial and may pose challenges, particularly for countries with limited financial resources.

**Policy and Regulatory Barriers:** Inadequate or inconsistent policies and regulations can hinder the adoption of green technologies and practices. Regulatory barriers, such as subsidies for fossil fuels or weak environmental standards, may discourage investment in renewable energy and other sustainable solutions.

**Resistance from Established Industries:** Traditional industries, such as fossil fuels, may resist efforts to transition to a green economy due to vested interests, economic dependence, and fear of disruption to existing business models. This resistance can slow down progress towards sustainability.

**Technological Limitations:** Some green technologies, such as renewable energy storage or carbon capture and storage, are still in the early stages of development and face technological

limitations, including high costs and efficiency issues. Overcoming these challenges requires further research and innovation.

**Behavioural Change:** Achieving a green economy requires changes in consumer behaviour, such as adopting sustainable consumption patterns, reducing waste, and choosing environmentally friendly products. However, changing deeply ingrained behaviours can be difficult and may require education, awareness-raising, and incentives.

**Global Cooperation and Coordination:** Environmental challenges, such as climate change and biodiversity loss, require global cooperation and coordination to be addressed effectively. However, achieving consensus among nations with diverse interests and priorities can be challenging, leading to delays in implementing coordinated solutions.

**Limited Access to Finance:** Access to finance is essential for investment in green infrastructure, technologies, and projects. However, many developing countries face challenges in accessing affordable financing for green initiatives, which can hinder their transition to a green economy.

**Inequality and Social Justice:** Transitioning to a green economy must prioritize social justice and equity to ensure that the benefits of sustainability are shared equitably among all segments of society. Addressing inequality, poverty, and marginalization is crucial for building a more inclusive and sustainable future.

**Lack of Public Awareness and Engagement:** Building public awareness and engagement is essential for garnering support for green initiatives and policies. However, many people may lack awareness of environmental issues or may not fully understand the benefits of transitioning to a green economy, which can impede progress.

**Complex Interdependencies:** The transition to a green economy involves complex interdependencies between environmental, social, and economic factors. Balancing these interconnected dimensions while avoiding unintended consequences requires holistic and integrated approaches to decision-making and policy formulation.

## 11. INDIA'S STATUS AS A GREEN ECONOMY

Despite significant international commitments to the 2030 Global Development Agenda and the Paris Climate Agreement, India is ranked 169th out of 180 nations on the Global Green Economy Index (GGEI). The Green Economy Barometer gives insights into the successes of

the Indian economy across high-impact sectors, making it indispensable in the development of the Government of India's next 15-year plan.Countries throughout the world are evaluated based on variables such as waste management, air quality, biodiversity & habitat, fisheries, ecosystem services, and climate change, according to the 2020 Environmental Performance Index.India ranked 169 out of 180 nations in the top six major economies, indicating that it trails in green growth.Individually, India's rankings for some of the metrics are as follows: AirQuality (179), Sanitation & Drinking Water (139), Waste Management (103), Biodiversity & Habitat (149), Fisheries (36) and Climate Change (36).

With roughly 1.3 billion people experiencing major environmental health concerns, India's dismal performance is grounds for concern.The Indian economy must continue to grow to accomplish its development goals.However, the environmental repercussions of expansion might be massive, as it would deplete natural resources such as minerals, water, and fossil fuels, causing fuel, energy, and raw material costs to skyrocket.The extent to which India embraces green growth will be determined by its capacity to minimize its reliance on the resources required to support economic growth over time, therefore increasing social fairness and creating jobs.Green growth has the potential to play a critical role in balancing these goals.

**CONCLUSION**

The green economy is a global, transformative change to the status quo. It will necessitate a significant shift in government priorities. This change will not be easy, but it is required if we are to meet the Sustainable Development Goals. Moving to a green economy has the potential to achieve sustainable development and poverty eradication on an unprecedented scale, with unprecedented speed and effectiveness. India ranks 68th out of 80 countries on the Global Green Economy Index despite having made significant international commitments to the Paris Climate Agreement and the 2030 Global Development Agenda (GGEI). In light of the numerous crises and rising resource shortages, the economic paradigm of greening the economy has taken center stage in regional and global sustainable development processes. The timely provision of high-quality and pertinent skills is essential to a green economy. Workers need to update their skills or learn new ones and be prepared with sustainability-related capabilities, which Education for Sustainable Development (ESD) may deliver. A fresh approach to the economy is needed to address these issues. Future research should focus more on green innovation in the public sector. Of course, this might concentrate on various

institutional and organizational innovations, such as new and/or updated designs for policy instruments. To do this, we must stimulate the demand for green technologies, products, and services, opening up new markets and employment prospects. The time has come to embrace the green economy.

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## UNIT-9

# Industrial pollution management with special reference to thermal power and sponge iron plants of West Bengal

**Introduction:**

Industrial pollution is an additional term that means a huge amount of waste is discharged from various categories of industrial plants (Red, orange-A, Orange-B). Industrial waste or pollutants is generated from manufacturing or industrial processes. With the rapid production growth, the volume of wastewater discharged into water bodies has increased. Solid and liquid industrial wastes are ascending into watercourses and these are considered the main sources of poisons that disrupt marine biota and degrade water parameters (physical, chemical or biological). Water parameters are a serious problem for humanity, as the straight line is associated with the healthy survival of alive organisms (Sinha et al., 2016). Industrial wastewaters are categorized according to their concentration and pollution (Thomas and Thomas, 2017). Industrial wastewater is categorized as mud and gravel, mess from canteens, concrete, masonry, scrap metal, trash, oil, solvents, chemicals, grass and trees, wood and similar waste. They can be revealed by calculating parameters such as pH, alkalinity, BOD, COD, TDS, TSS, DO, organic and inorganic substances (Moran, 2018).

Various pollution control measures are required to be taken up by industries to ensure that emissions and effluents are as per the standards. This largely consists of ensuring that(i)effluents and emissions are treated before their release into the environment and (ii) these meet the quality standards laid down by CPCB.

**Industrial pollution management with special reference to thermal powerplant west Bengal: Particulate Matter (PM) Control:** Electrostatic precipitators (ESPs) and fabric filters (baghouses) are commonly used to remove particulate matter from flue gases.

**Sulfur Dioxide (SO2) Control:** Flue gas desulfurization (FGD) systems, such as wet scrubbers or dry scrubbers, are employed to reduce SO2 emissions by capturing and neutralizing sulfur compounds.

**Nitrogen Oxides (NOx) Control:** Selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR) systems are used to reduce NOx emissions by converting nitrogen oxides into less harmful compounds. Coal Quality and Combustion Optimization: Using high-quality coal with lower sulfur and ash content can help reduce emissions. Optimizing

combustion processes through better burner design and control systems can improve efficiency and reduce pollution. Efficient Energy Use and Waste Heat Recovery: implementing measures to improve the overall efficiency of the power plant can reduce fuel consumption and emissions per unit of electricity generated. Waste heat recovery systems can capture and utilize excess heat from various processes, improving overall energy efficiency.

**Water Management and Treatment:** Proper management of wastewater and cooling water to prevent contamination of water bodies is crucial. Implementing water treatment technologies such as sedimentation, filtration, and chemical treatment can help minimize the impact of wastewater discharge.

Ash Handling and Disposal: Proper handling and disposal of coal ash, including fly ash and bottom ash, are essential to prevent air and water pollution. Utilizing technologies like ash ponds, ash recycling, or conversion into construction materials can reduce environmental impacts.

**Monitoring and Compliance:** Continuous monitoring of emissions, effluents, and ambient air quality is necessary to ensure compliance with regulatory standards. Regular maintenance, inspections, and audits help identify and address potential pollution sources and issues.

**Environmental Impact Assessment and Mitigation:** Conducting comprehensive environmental impact assessments (EIAs) before plant construction or major upgrades helps identify potential environmental risks and develop mitigation measures. Implementing environmental management plans (EMPs) and incorporating environmental best practices can minimize adverse impacts on ecosystems and communities. Investment in Clean Technologies: Investing in research and development of cleaner technologies such as carbon capture and storage (CCS) or renewable energy integration can help transition towards a more sustainable and low-emission energy sector.

**Stakeholder Engagement and Transparency**:Engaging with local communities, regulatory agencies, environmental NGOs, and other stakeholders fosters transparency, accountability, and collaboration in pollution management efforts. Communicating environmental performance data, mitigation measures, and progress towards sustainability goals enhances public trust and support.

**Control of pollution through the 'Consent to Operate (CTO)' process:**As per the Air and Water Acts61, industrial units, that had started operations after obtaining CTEs issued by the

WBPCB had to apply to State Pollution Control Board for 'Consent To Operate' (CTO). No industry can operate without a valid CTO. This is granted to an industry stipulating (i) the name of the products/ by-products and quantity to be produced per month (ii) parameters with prescribed standards and frequency of effluent and emission sampling (iii) type and quantity of fuel used etc. Thus, through CTO, WBPCB monitors the compliance of environmental laws and standards in terms of raw materials consumed, emissions, effluents and waste discharges. The validity of the CTO of Red industries was increased (June 2016) by WBPCB from three to five years. The renewal of applications should be filed by the industry at least 120 days prior to expiry of the CTO.

**Control of Pollution in Critically Polluted Areas (CPAs) and Severely Polluted Areas (SPAs):**

On the basis of a comprehensive environmental assessment using ComprehensiveEnvironmental Pollution Index (CEPI) criteria, CPCB had identified Haldia,Howrah and Asansol in West Bengal as Critically Polluted Areas (CPA) in August2010 and Durgapur as a Severely Polluted Area (SPA) in September 2013.

**Preparation and implementation of remedial action plan for the CPAs:**

As per the directives (January 2010 and September 2013) of CPCB, WBPCBhad to prepare Remedial Action Plan (Plan) to tackle pollution in the CPAsand SPA. The Plan inter alia had to include various short-term and long-term mitigation measures to be taken up by the concerned industrial units. These were to be incorporated in the State Environmental Policy. Audit, observed that as of July 2017, WBPCB prepared (June 2011) Plans for three CPAs. However,Plan for Durgapur SPA was not prepared as of July 2017. In reply, the department stated (December 2017) that preparation of the Plan for Durgapur SPA would be taken up by the WBPCB.Audit observed that Plans in respect of Asansol and Haldia CPAs were not implemented in the following instances: According to the Plan for Asansol, 23 industries were identified as polluting industries and were taken up for monitoring by WBPCB. However, the Audit observed that only six of these industries were in the regular inspectionschedule of the concerned Asansol Regional Office (RO). No monitoring wasbeing done in the remaining 17 industries. The Action Plan also proposed theconstruction of four Sewage Treatment Plants (STPs), Municipal Solid WasteManagement facilities and also roads and bridges72 for the Asansol area. Audit,however, observed that none of the works

were taken up as of December 2017.In reply, the Department stated (December 2017) that the implementation of Plan.

was being monitored on a regular basis and industries were inspected as and whenrequired. However, the Department could not provide any specific informationor documents regarding regular inspections.The Plan of Haldia proposed to monitor 19 industries. However, accordingto the inspection schedule of Haldia RO, the relevant inspecting authority,WBPCB had monitored (2012-17) only 11 out of the 19 units.

**Impact on the Environmental Quality in the CPAs and SPA:**

Audit observed that due to the failure of WBPCB to take control measureseffectively as per the Remedial Action Plan as well as the CPCB directives, the environmental quality of CPAs and SPAs remained unabated as evidencedby theair/ water quality analysis reports are discussed below:WBPCB had conducted third-party air and water quality monitoring threetimes between February 2015 and March 2017 against the stipulated six times77 inthese CPAs and SPA. Analysis of air quality monitoring reports prepared by thethird party as depicted in Chart No 3.2 showed that Particulate Matter78 (bothPM10 and PM2.5) exceeded permissible limits in all stations in Haldia, Howrah,Asansol, and Durgapur.

to WBPCB about the massive air pollution due to dust emissions. Anotheradjoining village petitioned (June 2016) against coal dust contamination to the nearby ponds. Noise and the flying ash of uncovered dumpers transporting ash through village roads also disrupted village life. During joint inspection, the Audit observed that (i) the coal crusher house was in dilapidated condition, (ii) the coal conveyor belts were not covered and (iii) the emission control devices of the conveyor belt and the unloading yard were not operational. There was no sprinkler in the coal crusher area and coal stockyard to arrest the fugitive emission 66. As such, pollution was continuing unabated.

**Industrial pollution management with special reference to the sponge iron plant of West Bengal:**

India is the second largest producer of sponge iron in the world and had been the largest producer of sponge iron in the world till the year 2016and accounted for about 25 % of world's production. The Indian sponge iron industry sector is highly polluting because most of the units are using coal-based technology and are operating in small modules. Therefore, there is urgent need to understand how the elements of 'best practice' can precisely contribute

to environmental sustainability of the sector. Accordingly, this research study attempts to understand the resource consumption (raw material, energy, water, etc.) and waste generation in terms of air emission and solid waste generation. With the help of Data Envelopment Analysis (DEA), an efficient set of such industries have been identified and using the resource consumption and waste generation data of these industries, an empirical model has been evolved for assessing environmental sustainability of this industrial sector. Sponge iron is produced by processes using coal and natural gas as the raw material. Wrought iron is manufactured using sponge iron as the raw material. In this process iron ore is reduced under extremely high temperatures using coal. Wrought iron is initially prepared by beating the sponge iron from the furnace using heavy hammers and folding process. The wrought iron produced by this method contents three percent impurities as slag and small percentages of impurities. Wrought iron produced is further treated under intense heat conditions to produce the final wrought iron product. Nowadays, reduction process of iron ore is used to manufacture sponge iron. This reduction process is found to be an environmentally friendly and energy saving technology and reduces the amount of waste production.

The Sponge iron industry comes under the red category of industries to the Government of India. Sponge iron plants have different standards for stack emissions. Coal based plants should emit particulate matter of only 100 mg/Nm3. Carbon dioxide levels and carbon monoxide should not be more than 12% and 1% respectively. Sponge iron industries should follow national ambient air quality (NAAQ) standards. The air pollutants dispersed from sponge iron industry should have only Suspended Particulate Matter (SPM) not more than 100 µg/m3. The industry has to follow the CPCB standards for the letting out effluent water. An electrostatic precipitator should be installed in the industrial manufacturing site. Equipment to control air pollution should be provided with continuous power supply. A dust collection system has to be installed in the industrial site. Equipment for fugitive emission measurement should also be installed in the industrial area. Zero discharge plants are to be setup in the site and measures to reuse the water have to be taken. To prevent mixing with effluent drain to dispose rain water should be provided within the plant. CREP does mention solid waste related guidelines. Power generation can be achieved by setting up boilers for energy recovery. Alternate sources of fuel should identify in this boiler. Agricultural fields should not be used for disposing the wastes from the industry. Road construction or landfilling can be used for disposing the wastes from the kilns. Recycling or reusing principle can be used for energy efficiency. Industrial steam recovery boiler for power generation can

be used in sponge iron plants. Sprinkling of water near loading area has to be done. Green belt of 15m width should be provided done. Separate stack for kilns should be given. The following measures have to be taken for environment protection in sponge iron industries

Here are key aspects of industrial pollution management in the sponge iron industry:

**Particulate Matter (PM) Control:** Installation and maintenance of equipment like electrostatic precipitators (ESPs), cyclone separators, and bag filters to capture particulate emissions from the rotary kilns and other processes.

**Sulfur Dioxide (SO2) Control:** Utilization of sulfur absorption materials or flue gas desulfurization (FGD) systems to reduce SO2 emissions, especially if sulfur-rich fuels like coal are used.

**Nitrogen Oxides (NOx) Control:** Implementation of selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR) systems to minimize NOx emissions during combustion.

**Fuel Selection and Optimization:**Choosing cleaner fuels such as natural gas or low-sulfur coal to reduce emissions of sulfur compounds and other pollutants.Implementing combustion optimization techniques to enhance fuel efficiency and reduce emissions during the reduction process.

**Efficient Energy Use and Waste Heat Recovery:**Employing energy-efficient technologies and practices in sponge iron production to minimize energy consumption and greenhouse gas emissions. Installing waste heat recovery systems to capture and utilize excess heat from kiln gases for power generation or other industrial processes.

**Water Management and Treatment:**Implementing water conservation measures and recycling/reusing water within the plant to minimize water consumption and discharge.Treating wastewater from plant operations using appropriate treatment technologies such as sedimentation, filtration, and biological treatment before discharge.

**Dust Suppression and Management:**Implementing dust suppression measures such as water spraying, enclosing conveyor belts, and covering stockpiles to reduce fugitive dust emissions.Proper management of dust generated during handling, processing, and transportation through dust collection systems and containment measures.

**Ash and Solid Waste Management**:Developing effective ash handling and disposal systems for managing waste generated during the production process, including coal ash and iron ore residues.Exploring options for utilizing waste materials, such as recycling steel mill slag or ash in construction applications, to reduce waste generation and environmental impact.

**Regulatory Compliance and Monitoring:**Ensuring compliance with local environmental regulations, emission standards, and pollution control norms applicable to the sponge iron industry.Conducting regular monitoring of air emissions, water quality, noise levels, and other environmental parameters to assess performance and identify areas for improvement.

**Environmental Impact Assessment (EIA) and Risk Mitigation:**Conduct comprehensive EIAs before establishing new sponge iron plants or expanding existing facilities to assess potential environmental impacts and develop mitigation measures. Implementing risk management strategies to prevent accidents, spills, and other environmental incidents, including emergency response plans and training programs for employees.

**Research and Innovation**: Investing in research and development of cleaner technologies, process improvements, and alternative raw materials to reduce environmental pollution and enhance sustainability in the sponge iron industry. Collaborating with research institutions, industry associations, and government agencies to exchange knowledge, share best practices, and promote innovation in pollution management.

By adopting a holistic approach that integrates pollution control technologies, efficient resource management, regulatory compliance, and continuous improvement efforts, the sponge iron industry can minimize its environmental footprint and contribute to sustainable development. Collaboration among stakeholders, transparency in operations, and proactive environmental management are key drivers for achieving long-term environmental sustainability in this sector.

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# UNIT-10
# Recycling of Waste

## A. Introduction

Firstly, we have to know that what is waste? So, the answer is that unwanted or unusable forms of materials are referred to as waste. Thus, waste refers to any substance which is thrown out after its primary use or becomes defective, worthless or does not have any other use. Some of the examples of wastes are household trash, wastewater, hazardous waste, radioactive wastes and so on.

And the recycling of waste is the process by which waste products are converted into useful materials or products through various processes. The process of recycling of wastes includes the reprocessing of organic matter but it does not include the energy recovery and the reprocessing into those substances which are to be used as either fuels or for the backfilling operations. In other words, recycling denotes a method by which there is collection and subsequent breakdown of the waste material in order to create something new out of it, that is, to reuse it. This process has more relevance in today's time because of the increased effects of pollution and global warming.

## B. The Importance of Recycling in Waste Management

Waste management has become a pressing issue globally, with the ever-increasing volume of waste posing significant challenges to environmental sustainability, public health, and resource conservation. In this context, recycling emerges as a pivotal strategy in waste management, offering numerous benefits that contribute to mitigating these challenges. This article explores the importance of recycling in waste management, highlighting its environmental, economic, and social significance, supported by relevant references.

### Environmental Benefits

Recycling plays a crucial role in reducing the environmental impacts of waste disposal. By diverting recyclable materials from landfills and incinerators, recycling helps to conserve natural resources, reduce energy consumption, and mitigate greenhouse gas emissions. For instance, a study by The World Bank highlights that recycling aluminum cans saves up to 95% of the energy required for primary aluminum production, thereby reducing carbon dioxide emissions [1]. Similarly, recycling paper reduces the demand for virgin pulp, thereby

conserving forests and preserving biodiversity [2]. These environmental benefits underscore the importance of recycling as a sustainable alternative to traditional waste disposal methods.

**Economic Advantages**

In addition to its environmental benefits, recycling offers significant economic advantages. The recycling industry generates employment opportunities, stimulates innovation, and contributes to economic growth. According to the U.S. Environmental Protection Agency (EPA), the recycling and reuse activities in the United States supported over 750,000 jobs and contributed $36.6 billion in wages in 2019 [3]. Moreover, recycling reduces waste management costs associated with landfilling and incineration, thereby providing cost savings for municipalities and businesses. These economic benefits highlight the importance of recycling as a driver of sustainable economic development.

**Social Implications**

Recycling also has important social implications, contributing to community engagement, education, and empowerment. Recycling programs provide opportunities for community involvement and participation in waste management initiatives, fostering a sense of environmental responsibility and citizenship. Moreover, education and awareness campaigns promote sustainable behaviors and encourage individuals to reduce, reuse, and recycle waste. Research by Liu et al. emphasizes the importance of public awareness and participation in enhancing the effectiveness of recycling programs [4]. By engaging communities and promoting environmental stewardship, recycling contributes to building resilient and sustainable societies.

**Conservation of Resources:**

Recycling helps conserve valuable natural resources such as timber, water, and minerals. By reusing materials like paper, plastic, glass, and metal, we can reduce the demand for virgin resources, thus preserving ecosystems and biodiversity. For instance, recycling one ton of paper can save up to 17 trees and significant amounts of water and energy required for the production process.

**Energy Savings:**

Recycling often requires less energy compared to the extraction and processing of raw materials. Manufacturing products from recycled materials generally consumes fewer resources and emits fewer greenhouse gases. For instance, producing aluminum from

recycled scrap requires only 5% of the energy needed for primary production, leading to substantial energy savings and reduced carbon emissions.

**Waste Reduction:**

Effective recycling programs divert significant amounts of waste from landfills and incinerators, thereby extending the lifespan of these disposal sites and reducing environmental pollution. By minimizing the volume of waste sent to landfills, recycling helps mitigate issues like leachate contamination, methane emissions, and soil degradation, thus safeguarding public health and environmental integrity.

**C. Types of Recycling of Waste**

Recycling can be classified into three types. They are primary, secondary and tertiary recycling. Tertiary recycling is further sub classified into internal and external recycling. Figure 1 shows the schematic view of the types of recycling.

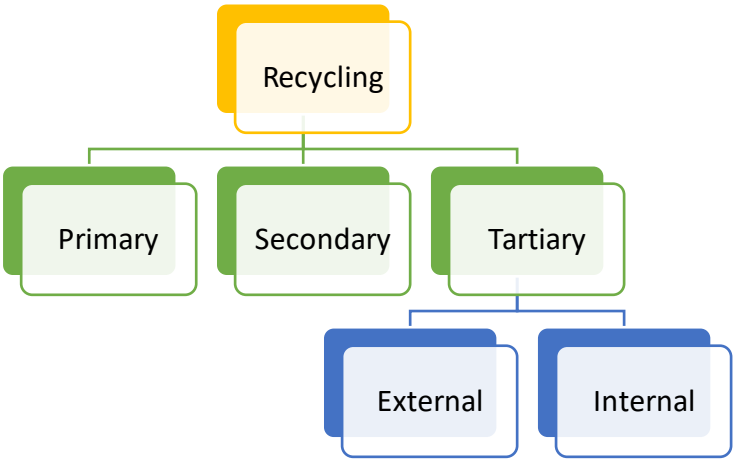


*Figure: Types of recycling of waste*

**1. Primary Recycling:**

Primary recycling refers to the reuse and recovery of materials without altering their original form. It entails utilizing items for a second time without significant modifications, maintaining their intended purpose. Examples of primary recycling include donating items to friends, family, or charitable organizations, as well as selling them for further use.

**2. Secondary Recycling:**

Secondary recycling involves making practical alterations to materials or products without resorting to chemical processes. This form of recycling typically entails transforming items into new forms through physical manipulation. For instance, cutting and reshaping various

products to create art and crafts or repurposing envelopes by cutting them into smaller pieces for use as scrap paper exemplify secondary recycling practices.

**3. Tertiary Recycling:**

Tertiary recycling encompasses the reprocessing of materials or products using chemical processes or heat. This form of recycling often involves more intensive treatments to break down and reform materials into new products. Examples of tertiary recycling include melting metals to create new objects, chemically treating old paper to produce fresh paper products, and crushing plastic bottles to manufacture new items.

**3.1. External Recycling:**

When materials or products undergo tertiary recycling with the involvement of the public, it is termed external recycling. This process typically entails individuals sorting waste and depositing it into designated recycling bins for collection and subsequent transfer to reprocessing facilities.

**3.2. Internal Recycling:**

Internal recycling refers to tertiary recycling processes conducted within factories or manufacturing facilities without direct public participation. Materials or products are recovered and reprocessed within the confines of the production environment, facilitating resource conservation and waste reduction within industrial settings.

**D. Steps involving the Recycling of Waste.**

The recycling process involves several steps, each crucial for efficiently converting waste materials into reusable products. Here is a detailed outline of the typical recycling process:

**1. Collection**

The Recyclable materials from municipal solid waste is collected by the following methods.

1. Collection of segregated or source-separated recyclables. They are collected by the waste collectors with and without subsequent processing.
2. The materials for recycling can also be collected from the transfer stations or any other centralized recovery facility.

If the waste is a mixed municipal solid waste then they have to be segregated and collected in different coloured bins. Green bins or sacks are for green waste e.g. Food and garden waste.

Blue colour bins are for recyclables and black is for non-recyclables. Once segregated, the recyclables are delivered to waste collectors for further processing.

**2. Sorting.**

Once commingled recycles are collected and delivered to a central collection facility, the different types of materials must be sorted. This is done in a series of stages, many of which involve automated processes such that a truckload of material can be fully sorted in less than an hour. Some plants can now sort the materials automatically, known as single-stream recycling. In plants, a variety of materials are sorted such as paper, different types of plastics, glass, metals, food scraps and most types of batteries. A 30 percent increase in recycling rates has been seen in the areas where these plants exist. Sorting can be done by various methods. They are-

*i. By hand*

*ii. By Automated machinery*

*iii. By strong metals*

**3. Rinsing**

Food packaging should no longer contain any organic matter (organic matter, if any, needs to be placed in a biodegradable waste bin or be buried in a garden). To avoid organic matter, the packing material needs to be rinsed before placing in a trash bag.

**4. Processing & Recycling**

Although many government programs are concentrated on recycling at home, a 64% of waste is generated from industry. The focus of many recycling programs done by industry is the cost– effectiveness of recycling. The ubiquitous nature of cardboard packaging makes cardboard a commonly recycled waste product by companies that deal heavily in packaged goods, like retail stores, warehouses and distributors of goods. Other industries deal in niche or specialized products, depending on the nature of the waste materials that are present.

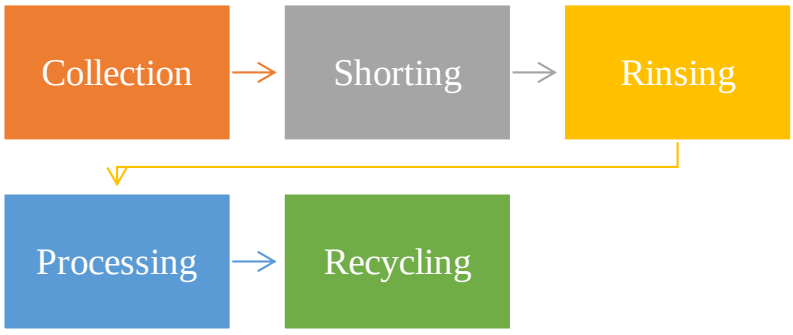


*Figure: Processing steps of recycling of waste.*

**E. Different methods of Recycling of waste.**

The recycling of waste encompasses a variety of methods tailored to the specific types of materials being processed. Each method serves to convert waste into reusable resources, thereby reducing the strain on natural resources and minimizing environmental impacts. Here are some of the key methods of waste recycling, along with their details:

1. Mechanical Recycling:
    - Mechanical recycling, also known as traditional recycling, involves physically processing waste materials into new products without significantly altering their chemical composition.
    - This method is commonly used for materials such as paper, cardboard, plastics, glass, and metals.
    - The process typically includes sorting, cleaning, shredding, and melting or remolding the materials into raw materials for manufacturing new products.
    - Mechanical recycling is widely practiced due to its cost-effectiveness and relatively low environmental impact.
2. Chemical Recycling:
    - Chemical recycling, also referred to as advanced or molecular recycling, involves breaking down waste materials at the molecular level to produce raw materials or fuels.
    - Unlike mechanical recycling, chemical recycling can handle complex and contaminated materials that are challenging to recycle through conventional methods.
    - Processes such as pyrolysis, gasification, depolymerization, and hydrothermal treatment are used to convert waste plastics, rubber, and other polymers into chemical intermediates or energy products.
    - Chemical recycling technologies are still emerging and undergoing development but hold promise for addressing difficult-to-recycle waste streams and reducing reliance on fossil fuels.

3. Biological Recycling (Composting):
    - Biological recycling, also known as composting, involves the decomposition of organic waste materials by microorganisms under controlled conditions to produce compost, a nutrient-rich soil amendment.
    - Composting is commonly used for organic waste such as food scraps, yard trimmings, and agricultural residues.
    - The process requires the right balance of carbon-rich (e.g., leaves, paper) and nitrogen-rich (e.g., food waste, grass clippings) materials, along with moisture and aeration, to facilitate decomposition.
    - Composting can be done on a small scale in backyard compost bins or on a large scale in industrial composting facilities.
    - Compost produced through biological recycling can be used to enrich soil, improve agricultural productivity, and reduce the need for chemical fertilizers.
4. Energy Recovery (Waste-to-Energy):
    - Energy recovery involves converting non-recyclable waste materials into heat, electricity, or fuels through thermal or biological processes.
    - Waste-to-energy (WTE) facilities incinerate municipal solid waste (MSW) at high temperatures to generate steam, which drives turbines to produce electricity.
    - Alternatively, anaerobic digestion processes can break down organic waste in the absence of oxygen to produce biogas, which can be used for heat or electricity generation.
    - Energy recovery from waste helps offset the use of fossil fuels, reduces greenhouse gas emissions, and diverts waste from landfill disposal.
5. Upcycling:
    - Upcycling, also known as creative reuse, involves transforming waste materials into new products of higher value or quality than the original.

- Unlike traditional recycling, which breaks materials down into raw materials, upcycling preserves the integrity of the original items while adding aesthetic or functional enhancements.
- Upcycling can be a creative and innovative way to repurpose materials that would otherwise be discarded, reducing waste and promoting sustainability.
- Examples of upcycled products include furniture made from reclaimed wood, fashion accessories crafted from discarded textiles, and artwork created from salvaged materials.

6. Industrial Recycling:
    - Industrial recycling refers to the reclamation of manufacturing by-products, excess materials, and industrial waste streams within the production process.
    - Industrial recycling often involves closed-loop systems where materials are continuously recycled within a specific industrial sector, reducing the need for virgin resources and minimizing waste generation.
    - Processes such as material recovery, remanufacturing, and by-product synergy help industrial facilities optimize resource efficiency and minimize environmental impacts.
    - Industrial recycling contributes to cost savings, resource conservation, and the development of sustainable manufacturing practices.
7. Source Separation and Municipal Recycling Programs:
    - Source separation involves separating recyclable materials from mixed waste at the point of generation, such as households, businesses, and institutions.
    - Municipal recycling programs provide infrastructure and services for the collection, sorting, and processing of recyclables from residential and commercial sources.
    - Source separation and municipal recycling programs encourage participation in recycling efforts, reduce contamination of recyclable materials, and facilitate the recovery of valuable resources.
8. Construction and Demolition (C&D) Recycling:

- Construction and demolition recycling involves recovering and recycling materials generated from construction, renovation, and demolition activities.
- Commonly recycled materials from C&D projects include concrete, asphalt, wood, metals, and gypsum drywall.
- C&D recycling reduces the environmental impact of construction projects, conserves resources, and diverts bulky waste from landfills.
- Techniques such as onsite sorting, mobile processing equipment, and partnerships with recycling facilities enable efficient recovery and recycling of C&D materials.

**F. Conclusion**

the practice of recycling waste is an essential component of sustainable resource management and environmental stewardship. Through a combination of mechanical, chemical, biological, and industrial recycling methods, as well as source separation programs and innovative upcycling initiatives, we can effectively divert waste from landfills, conserve natural resources, and reduce greenhouse gas emissions. Recycling not only mitigates the environmental impact of waste disposal but also offers economic benefits, including job creation, resource conservation, and energy savings. By incorporating recycling into our daily lives, businesses, and industrial processes, we can transition towards a circular economy model where materials are continually reused, remanufactured, and repurposed, minimizing waste generation and maximizing resource efficiency.

However, achieving widespread adoption of recycling requires concerted efforts from individuals, communities, governments, and industries. Education, outreach, and public awareness campaigns play a crucial role in promoting recycling practices and encouraging responsible consumption habits. Moreover, policy interventions, regulations, and incentives are necessary to support recycling infrastructure development, enhance waste management systems, and foster a culture of sustainability.

As we strive to build a more resilient and sustainable future, investing in recycling and waste reduction initiatives is imperative. By embracing the principles of reduce, reuse, and recycle, we can minimize our environmental footprint, protect natural ecosystems, and create a healthier planet for current and future generations. Together, let us commit to harnessing the power of recycling to create a cleaner, greener, and more prosperous world.

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# UNIT-11
# Renewable Energy and Green Energy

**1. Introduction:**

The World Energy Forum has predicted that fossil-based oil, coal and gas reserves will be exhausted in less than another 10 decades. Fossil fuels account for over 79% of the primary energy consumed in the world, and 57.7% of that amount is used in the transport sector and are diminishing rapidly. The exhaustion of natural resources and the accelerated demand of conventional energy have forced planners and policy makers to look for alternate sources. Renewable energy is energy derived from resources that are regenerative, and do not deplete over time. Renewable energy offers our planet a chance to reduce carbon emissions, clean the air, and put our civilization on a more sustainable footing. It also offers countries around the world the chance to improve their energy security and spur economic development. Modern biomass encompasses a range of products derived from photosynthesis and is essentially chemical solar energy storage. Renewable energy supplies 18% of the world's final energy consumption, counting traditional biomass, large hydropower, and ''new'' renewables (small hydro, modern biomass, wind, solar, geothermal, and biofuels). Traditional biomass, primarily for cooking and heating, represents about 13% and is growing slowly in some regions as biomass is used more efficiently or replaced by more modern energy forms. Large hydropower represents 3% and is growing modestly, primarily in developing countries. New renewables represent 2.4% and are growing very rapidly in developed countries and in some developing countries. Global renewable energy capacity grew at rates of 15–30% annually for many technologies during the five-year period 2002–2006, including wind power, solar hot water, geothermal heating, and off-grid solar PV. Renewable energy markets grew robustly in 2008. Among new renewables (excluding large hydropower), wind power was the largest addition to renewable energy capacity.

**1. Definition:**

Renewable energy sources also called non-conventional energy, are sources that are continuously replenished by natural processes. For example, solar energy, wind energy, bio-energy bio-fuels grown sustain ably), hydropower etc., are some of the examples of renewable energy sources A renewable energy system converts the energy found in sunlight, wind, falling-water, sea waves, geothermal heat, or biomass into a form, we can use such as

heat or electricity. Most of the renewable energy comes either directly or indirectly from sun and wind and can never be exhausted, and therefore they are called renewable.

Renewable energy sources are essentially flows of energy, whereas the fossil and nuclear fuels are, in essence, stocks of energy

**1. Forms of renewable energy:**

**1.1 Solar Energy:**

Solar energy is the most readily available and free source of energy since prehistoric times. It is estimated that solar energy equivalent to over 15,000 times the world's annual commercial energy consumption reaches the earth every year. India receives solar energy in the region of 5 to 7 kWh/m2 for 300 to 330 days in a year. This energy is sufficient to set up 20 MW solar power plant per square kilo meter land area. Solar energy can be utilized through two different routes, as solar thermal route and solar electric (solar photovoltaic) routes. Solar thermal route uses the sun's heat to produce hot water or air, cook food, drying materials etc. Solar photovoltaic uses sun's heat to produce electricity for lighting home and building, running motors, pumps, electric appliances, and lighting.

Fig 1: Solar energy

**Solar Thermal Energy Application**

In solar thermal route, solar energy can be converted into thermal energy with the help of solar collectors and receivers known as solar thermal devices.

The Solar-Thermal devices can be classified into three categories:

Low-Grade Heating Devices - up to the temperature of 100°C.

1. Medium-Grade Heating Devices -up to the temperature of 100°-300°C
2. High-Grade Heating Devices -above temperature of 300°C

Low-grade solar thermal devices are used in solar water heaters, air-heaters, solar cookers and solar dryers for domestic and industrial applications.

**Solar Water Heaters:**

Most solar water heating systems have two main parts: a solar collector and a storage tank. The most common col lector is called a flat-plate collector (see Figure 12.1). It consists of a thin, flat, rectangular box with a transparent cover that faces the sun, mounted on the roof of building or home. Small tubes run through the box and carry the fluid - either water or other fluid, such as an antifreeze solution – to be heated. The tubes are attached to an absorber plate, which is painted with special coatings to absorb the heat. The heat builds up in the collector, which is passed to the fluid passing through the tubes.

Fig 2: Solar Flat Plate Collector

An insulated storage tank holds the hot water. It is similar to water heater, but larger is size. In case of systems that use fluids, heat is passed from hot fluid to the water stored in the tank through a coil of tubes. Solar water heating systems can be either active or passive systems. The active system, which are most common, rely on pumps to move the liquid between the collector and the storage tank. The passive systems rely on gravity and the tendency for water to naturally circulate as it is heated.

A few industrial application of solar water heaters are list ed below:

- Hotels: Bathing, kitchen, washing, laundry applications
- Dairies: Ghee (clarified butter) production, cleaning and sterilizing, pasteurization
- Textiles: Bleaching, boiling, printing, dyeing, curing, ageing and finishing
- Breweries & Distilleries: Bottle washing, wort preparation, boiler feed heating
- Chemical /Bulk drugs units: Fermentation of mixes, boiler feed applications
- Electroplating/galvanizing units: Heating of plating baths, cleaning, degreasing applications.
- Pulp and paper industries: Boiler feed applications, soaking of pulp.

**Solar Cooker:**

Solar cooker is a device, which uses solar energy for cooking, and thus saving fossil fuels, fuel wood and electrical energy to a large extent. However, it can only supplement the

cooking fuel, and not replace it totally. It is a simple cooking unit, ideal for domestic cooking during most of the year except during the monsoon season, cloudy days and winter months.

**Box type solar cookers:**

The box type solar cookers with a single reflecting mirror are the most popular in India. These cookers have proved immensely popular in rural areas where women spend considerable time for collecting firewood. A family size solar cooker is sufficient for 4 to 5 members and saves about 3 to 4 cylinders of LPG every year. The life of this cooker is up to 15 years. This cooker costs around Rs.1000 after allowing for subsidy. Solar cookers are widely available in the market.

Fig 3- Box Type Solar Collector

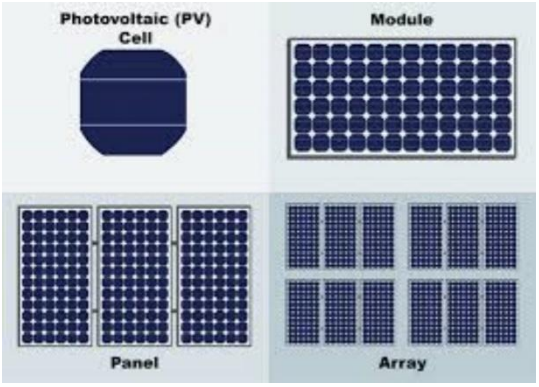


Fig 4- Solar Photovoltaic Array

**Solar Electricity Generation**

**Solar Photovoltaic (PV):**

Photovoltaic is the technical term for solar electric. Photo means "light" and voltaic means "electric". PV cells are usually made of silicon, an element that naturally releases electrons when exposed to light. Number of electrons released from silicon cells depend upon intensity of light incident on it. The silicon cell is covered with a grid of metal that directs the electrons to flow in a path to create an electric current. This current is guided into a wire that is connected to a battery or DC appliance. Typically, one cell produces about 1.5 watts of power. Individual cells are connected together to form a solar panel or module, capable of producing 3 to 110 Watts power. Panels can be connected together in series and parallel to make a solar array, which can produce any amount of Wattage as space will allow. Modules are usually designed to supply electricity at 12 Volts. PV modules are rated by their peak Watt output at solar noon on a clear day. Some applications for PV systems are lighting for commercial buildings, outdoor (street) lighting, rural and village lighting etc. Solar electric power systems can offer independence from the utility grid and offer protection during

extended power failures. Solar PV systems are found to be economical especially in the hilly and far-flung areas where con venational grid power supply will be expensive to reach.

Fig 5- Photovoltaic Streetlights

Fig 7- Wind Energy

**PV tracking systems** is an alternative to the fixed, stationary PV panels. PV tracking systems are mounted and provided with tracking mechanisms to follow the sun as it moves through the sky. These tracking systems run entirely on their own power and can increase output by 40%.

**Back-up systems** are necessary since PV systems only generate electricity when the sun is shining. The two most common methods of backing up solar electric systems are connecting the system to the utility grid or storing excess electricity in batteries for use at night or on cloudy days.

**Solar Water Pumps**

Fig: Photovoltaic Water Pumping

In solar water pumping system, the pump is driven by motor run by solar electricity instead of conventional electricity drawn from utility grid. A SPV water pumping system consists of a photovoltaic array mounted on a stand and a motor-pump set compatible with the photo voltaic array. It converts the solar energy into electricity, which is used for running the motor pump set. The pumping system draws water from the open well, bore well, stream, pond, canal etc.

**3.2 Wind Energy:**

Wind energy is basically harnessing of wind power to produce electricity. The kinetic energy of the wind is converted to electrical energy. When solar radiation enters the earth's atmosphere, different regions of the atmosphere are heated to different degrees because of earth curvature. This heating is higher at the equator and lowest at the poles. Since air tends to flow from warmer to cooler regions, this causes what we call winds, and it is these airflows

that are harnessed in windmills and wind turbines to produce power. Wind power is not a new development as this power, in the form of traditional windmills -for grinding corn, pumping water, sailing ships - have been used for centuries. Now wind power is harnessed to generate electricity in a larger scale with better technology**.**

**Wind Energy in India:**

India has been rated as one of the most promising countries for wind power development, with an estimated potential of 20,000 MW. Total installed capacity of wind electric generators in the world as on Sept. 2001 is 23270 MW. Germany 8100 MW, Spain- 3175 MW, USA 4240 MW, Denmark 2417 MW, and India - 1426 MW top the list of countries. Thus, India ranks fifth in the world in Wind power generation.

There are 39 wind potential stations in Tamil Nadu, 36 in Gujarat, 30 in Andhra Pradesh, 27 in Maharashtra, 26 in Karnataka, 16 in Kerala, 8 in Lakshadweep, 8 Rajasthan, 7 in Madhya Pradesh, 7 in Orissa, 2 in West Bengal, 1 in Andaman Nicobar and 1 in Uttar Pradesh. Out of 208 suitable stations 7 stations have shown wind power density more than 500 Watts/ m2.

**Central Govt. Assistance and Incentives**

The following financial and technical assistance are provided to promote, support and accelerate the development of wind energy in India:

1) Five years tax holiday.
2) 100% depreciation in the first year.
3) Facilities by SEB's for grid connection.
4) Energy banking and wheeling and energy buy back
5) Industry status and capital subsidy
6) Electricity tax exemption
7) Sales tax exemption

**Applications:**

- Utility interconnected wind turbines generate power which is synchronous with the grid and are used to reduce utility bills by displacing the utility power used in the household and by selling the excess power back to the electric company.
- Wind turbines for remote homes (off the grid) generate DC current for battery charging.

- Wind turbines for remote water pumping generate 3 phase AC current suitable for driving an electrical submersible pump directly. Wind turbines suitable for residential or village scale wind power range from 500 Watts to 50 kilowatts.

**3.3 Bio Energy:**

Biomass is a renewable energy resource derived from the car bonaceous waste of various human and natural activities. It is derived from numerous sources, including the by-products from the wood industry, agricultural crops, raw material from the forest, household wastes etc. Biomass does not add carbon dioxide to the atmosphere as it absorbs the same amount of carbon in growing as it releases when consumed as a fuel. Its advantage is that it can be used to generate electricity with the same equipment that is now being used for burning fossil fuels. Biomass is an important source of energy and the most important fuel worldwide after coal, oil and natural gas. Bio-energy, in the form of biogas, which is derived from biomass, is expected to become one of the key energy resources for global sustainable development. Biomass offers higher energy efficiency through form of Biogas than by direct burning.

**Biogas Plants:**

Biogas is a clean and efficient fuel, generated from cow-dung, human waste or any kind of biological materials derived through anaerobic fermentation process. The biogas consists of 60% methane with rest mainly carbon-di-oxide. Biogas is a safe fuel for cooking and lighting. By-product is usable as high-grade manure.

**A typical biogas plant has the following components**:

A digester in which the slurry (dung mixed with water) is fermented, an inlet tank - for mixing the feed and letting it into the digester, gas holder/dome in which the generated gas is collected, outlet tank to remove the spent slurry, distribution pipeline(s) to transport the gas into the kitchen, and a manure pit, where the spent slurry is stored. Biomass fuels account for about one-third of the total fuel used in the country. It is the most important fuel used in over 90% of the rural households and about 15% of the urban households. Using only local resources, namely cattle waste and other organic wastes, energy and manure are derived. Thus, the biogas plants are the cheap sources of energy in rural areas. The types of biogas plant design popular are: floating drum type, fixed dome-type and bag-type portable digester.

Fig 8- Biogas Plant

**Biomass Briquetting:**

The process of densifying loose agro-waste into a solidified biomass of high density, which can be conveniently used as a fuel, is called Biomass Briquetting (see Figure 12.8). Briquette is also termed as "Bio-coal". It is pollution free and ecofriendly. Some of the agricultural and forestry residues can be briquetted after suitable pre-treat mint. A list of commonly used biomass materials that can be briquetted are given below: CornCob, JuteStick, Sawdust, PineNeedle, Bagasse, CoffeeSpent, Tamarind, CoffeeHusk, AlmondShell, Groundnutshells, CoirPith, BagaseePith,Barleystraw, Tobaccodust, RiceHusk, Deoiled Bran.


**Fig 9- Biomass Gasifiers**

**Advantages**

Some of advantages of biomass briquetting are high calorific value with low ash content, absence of polluting gases like sulphur, phosphorus fumes and fly ash- which eliminate the need for pollution control equipment, complete combustion, ease of handling, transportation & storage - because of uniform size and convenient lengths.

**Application**

Biomass briquettes can replace almost all conventional fuels like coal, firewood and lignite in almost all general applications like heating, steam generation etc. It can be used directly as fuel instead of coal in the traditional chulhas and furnaces or in the gasifier. Gasifier converts solid fuel into a more convenient-to-use gaseous form of fuel called producer gas.

**Biomass Gasifiers**

Biomass gasifiers (see Figure 12.9) convert the solid biomass (basically wood waste, agricultural residues etc.) into a combustible gas mixture normally called as producer gas. The con version efficiency of the gasification process is in the range of 60%–70%. The producer gas consists of mainly carbon-monoxide, hydro gen, nitrogen gas and methane, and has a lower calorific value (1000–1200 kcal/Nm3).

Gasification of biomass and using it in place of conventional direct burning devices will result in savings of at least 50% in fuel consumption. The gas has been found suitable for com bastion in the internal combustion engines for the production of power.

**Applications:**

Water pumping and Electricity generation: Using biomass gas, it possible to operate a diesel engine on dual fuel mode-part diesel and part biomass gas. Diesel substitution of the order of 75 to 80% can be obtained at nominal loads. The mechanical energy thus derived can be used either for energizing a water pump set for irrigational purpose or for coupling with an alternator for electrical power generation - 3.5 KW- 10 MW

**Heat generation:**

A few of the devices, to which gasifier could be retrofitted, are dryers- for drying tea, flower, spices, kilns for baking tiles or potteries, furnaces for melting non-ferrous metals, boilers for process steam, etc. Direct combustion of biomass has been recognized as an important route for generation of power by utilization of vast amounts of agricultural residues, agro-industrial residues and forest wastes. Gasifiers can be used for power generation and available up to a capacity 500 kW. The Government of India through MNES and IREDA is implementing power-generating system based on biomass combustion as well as biomass gasification.

**High Efficiency Wood Burning Stoves**

These stoves save more than 50% fuel wood consumption. They reduce drudgery of women saving time in cooking and fuel collection and consequent health hazards. They also help in saving firewood leading to conservation of forests. They also create employment opportunities for people in the rural areas.

**Bio fuels**

Unlike other renewable energy sources, biomass can be converted directly into liquid fuels—biofuels— for our transportation needs (cars, trucks, buses, airplanes, and trains). The two most common types of biofuels are ethanol and biodiesel. Ethanol is an alcohol, similar to that used in beer and wine. It is made by fermenting any biomass high in carbohydrates (starch es, sugars, or celluloses) through a process similar to brewing beer. Ethanol is mostly used as a fuel additive to cut down a vehicle's carbon monoxide and other smog-causing emissions. Flexible-fuel vehicles, which run on mixtures of gasoline and up to 85% ethanol, are now available.


**Fig 10 – Bio-diesel Driven bus**

Biodiesel, produced by plants such as rapeseed (canola), sunflowers and soybeans, can be extracted and refined into fuel, which can be burned in diesel engines and buses. Biodiesel

can also made by combining alcohol with vegetable oil, or recycled cooking greases. It can be used as an additive to reduce vehicle emissions (typically 20%) or in its pure form as a renewable alternative fuel for diesel engines.

**Biopower**

Biopower, or biomass power, is the use of biomass to generate electricity. There are six major types of biopower systems: direct-fired, cofiring, gasification, anaerobic digestion, pyrolysis, and small - modular. Most of the biopower plants in the world use direct-fired systems. They burn bioenergy feedstocks directly in boiler to produce steam. This steam drives the turbo-generator. In some industries, the steam is also used in manufacturing processes or to heat buildings. These are known as combined heat and power facilities. For example, wood waste is often used to produce both electricity and steam at paper mills. Many coal-fired power plants use cofiring systems to significantly reduce emissions, especially sulfur dioxide emissions. Cofiring involves using bio energy feedstock as a supplementary fuel source in high efficiency boilers. Gasification systems use high temperatures and an oxygen-starved environment to convert biomass into a gas (a mixture of hydrogen, carbon monoxide, and methane). The gas fuels a gas turbine, which runs an electric generator for producing power. The decay of biomass produces methane gas, which can be used as an energy source. Methane can be produced from biomass through a process called anaerobic digestion. Anaerobic digestion involves using bacteria to decompose organic matter in the absence of oxy gen. In landfills -scientific waste disposal site - wells can be drilled to release the methane from the decaying organic matter. The pipes from each well carry the gas to a central point where it is filtered and cleaned before burning. Methane can be used as an energy source in many ways. Most facilities burn it in a boiler to produce steam for electricity generation or for industrial processes. Two new ways include the use of microturbines and fuel cells. Microturbines have outputs of 25 to 500 kilowatts. About the size of a refrigerator, they can be used where there are space limitations for power production. Methane can also be used as the "fuel" in a fuel cell. Fuel cells work much like batteries, but never need recharging, producing electricity as long as there is fuel. In addition to gas, liquid fuels can be produced from biomass through a process called pyrolysis. Pyrolysis occurs when biomass is heated in the absence of oxygen. The biomass then turns into liquid called pyrolysis oil, which can be burned like petroleum to generate electricity. A biopower system that uses pyrolysis oil is being commercialized. Several biopower technologies can be used in small, modular systems. A small, modular system generates electricity at a capacity of 5 megawatts or less. This system is designed for use at the small-town level or even at the consumer level.

For example, some farmers use the waste from their livestock to provide their farms with electricity. Not only do these systems provide renewable energy, they also help farmers meet environmental regulations.

**Biomass Cogeneration**

Cogeneration improves viability and profitability of sugar industries. Indian sugar mills are rapidly turning to bagasse, the leftover of cane after it is crushed and its juice extracted, to generate electricity. This is mainly being done to clean up the environment, cut down power costs and earn additional revenue. According to current estimates, about 3500 MW of power can be generated from bagasse in the existing 430 sugar mills in the country. Around 270 MW of power has already been commissioned and more is under construction.

**3.4 Hydro Energy:**

The potential energy of falling water, captured and converted to mechanical energy by water wheels, powered the start of the industrial revolution. Wherever sufficient head, or change in elevation, could be found, rivers and streams were dammed and mills were built. Water under pressure flows through a turbine causing it

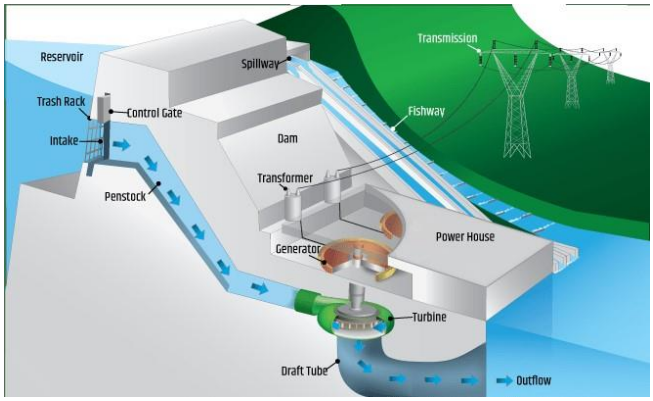


**Fig 11- Hydro Poer Plant**

to spin. The Turbine is connected to a generator, which produces electricity (see Figure 12.11). In order to produce enough electricity, a hydroelectric system requires a location with the following features: Change in elevation or head: 20 feet @ 100 gal/min = 200 Watts. 100 feet head @ 20 gal/min gives the same output.

In India the potential of small hydro power is estimated about 10,000 MW. A total of 183.45 MW small Hydro project have been installed in India by the end of March 1999. Small Hydro Power projects of 3 MW capacity have been also installed individually and 148 MW project is under construction.

**Small Hydro**

Small Hydro Power is a reliable, mature and proven technology. It is non-polluting, and does not involve setting up of large dams or problems of deforestation, submergence and rehabilitation. India has an estimated potential of 10,000 MW

**Micro Hydel**

Hilly regions of India, particularly the Himalayan belts, are endowed with rich hydel resources with tremendous potential. The MNES has launched a promotional scheme for portable micro hydel sets for these areas. These sets are small, compact and light weight. They have almost zero maintenance cost and can provide electricity/power to small cluster of villages. They are ideal substitutes for diesel sets run in those areas at high genera tion cost. Micro (upto 100kW) mini hydro (101-1000 kW) schemes can provide power for farms, hotels, schools and rural communities, and help create local industry.

**3.5 Wave and Tidal Energy:**

**Tidal Energy**

Tidal electricity generation involves the construction of a bar rage across an estuary to block the incoming and outgoing tide. The head of water is then used to drive turbines to generate electricity from the elevated water in the basin as in hydroelectric dams.

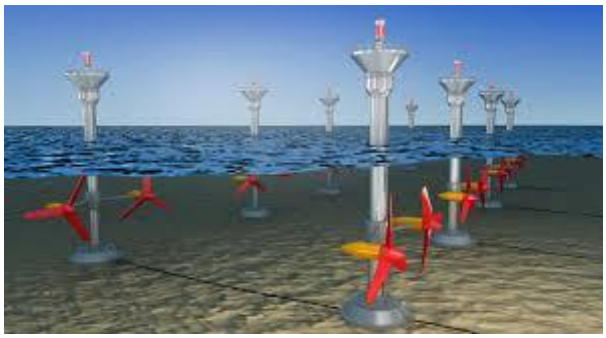

Fig: Tidal Energy

Barrages can be designed to generate electricity on the ebb side, or flood side, or both. Tidal range may vary over a wide range (4.5-12.4 m) from site to site. A tidal range of at least 7 m is required for economical operation and for sufficient head of water for the turbines.

**Ocean Energy**

Oceans cover more than 70% of Earth's surface, making them the world's largest solar collectors. Ocean energy draws on the energy of ocean waves, tides, or on the thermal energy (heat) stored in the ocean. The sun warms the surface water a lot more than the deep ocean water, and this temperature difference stores thermal energy. The ocean contains two types of energy: thermal energy from the sun's heat,

Fig 13- Ocean Energy

and mechanical energy from the tides and waves. Ocean thermal energy is used for many applications, including electricity generation. There are three types of electricity conversion systems: closed-cycle, open cycle, and hybrid. Closed cycle systems use the ocean's warm surface water to vaporize a working fluid, which has a low boiling point, such as ammonia. The vapour expands and turns a turbine. The turbine then activates a generator to produce electricity. Open-cycle systems actually boil the seawater by operating at low pressures. This produces steam that passes through a turbine / generator. The hybrid systems combine both closed-cycle and open-cycle systems. Ocean mechanical energy is quite different from ocean thermal energy. Even though the sun affects all ocean activity, tides are driven primarily by the gravitational pull of the moon, and waves are driven primarily by the winds. A barrage (dam) is typically used to convert tidal energy into electricity by forcing the water through turbines, activating a generator. India has the World's largest programmes for renewable energy. Several renewable energy technologies have been developed and deployed in villages and cities of India. A Ministry of Non-Conventional Energy Sources (MNES) created in 1992 for all matters relating to Non-Conventional / Renewable Energy. Government of India also created Renewable Energy Development Agency Limited (IREDA) to assist and provide financial assistance in the form of subsidy and low interest loan for renewable energy projects. IREDAcovers a wide spectrum of financing activities including those that are connected to energy conservation and energy efficiency. At present, IREDA's lending is mainly in the following areas:

Solar energy technologies, utilization of solar thermal and solar photo voltaic systems

• Wind energy setting up grid connected Wind farm projects

• Small hydro setting up small, mini and micro hydel projects

• Bio-energy technologies, biomass-based co-generation projects, biomass gasification, energy from waste and briquetting projects

• Hybrid systems

• Energy efficiency and conservation

### 3.6 Geothermal Energy:

Geothermal energy systems tap the heat originating from the earth's molten interior and the decay of radioactive materials in the crust. The potential size of the resource is very large although conversion technologies for fully accessing the estimated 100 million quads of available worldwide resource are yet to be proven. Geothermal energy is currently being used in various locations around the world to produce electricity at costs competitive with conventional sources and provide energy directly for space heating, food and industrial processing, refrigeration, and aquaculture.

**Fig 14- Geothermal Energy**

**Geothermal Electric Technologies:**

Hydrothermal resources, consisting of water and/or steam trapped in fractured or porous rocks, are currently the only type of geothermal energy being accessed on a commercial scale. Electricity is produced via one of three major routes: dry steam, flash steam, and binary conversion. Dry steam systems use the geothermal steam directly to drive a turbine-generator while flash steam technologies first convert hot geothermal liquids to steam by quickly reducing its pressure. Finally, binary cycle systems are used for generating power from lower-temperature liquids by using the hot geothermal waters to vaporize a secondary working fluid which then drives a turbine-generator unit. The state of California in the U.S. currently receives 6% of its electricity from geothermal energy, and installed units exist in the Philippines, Mexico, Italy, Japan, New Zealand, and other countries. Advances in methods for locating, drilling, and extracting geothermal energy coupled with improvements in conversion technologies can help geothermal electricity expand its current market share further, effectively competing with fossil powered sources in the baseload power market.

**Geothermal Heating Technologies:**

In some regions of the world, low-temperature geothermal energy is being used directly for space heating, such as in several cities in Iceland where steam/hot water lines carry geothermal fluid through the district heating system. Another promising technology is the geothermal heat pump (GHP). GHPs operate like a conventional heat pump (a refrigerator,

for example, is a one-way heat pump) and use the heat gradient between the earth's surface and groundwater or soil several hundred feet below the surface to power the pump. Because GHPs are reversible, they can provide space heating in the winter and space cooling in the summer as well as supplement domestic hot water needs year-round. More than 100,000 of these systems have been installed in the U.S. to date and sales continue to grow at significant rates.

**The few important steps taken by the Ministry of India for development of renewable Energy sources are recapitulated below:**

- India has among the world's largest programs for renewable energy. India's activities cover all major renewable energy sources of interest to us, such as, biogas, biomass, solar energy, wind energy, small hydro power and the other emerging technologies. In each of these areas, India has programs of resource assessment, R&D, technology development and demonstration. Several renewable energy systems and products are now not only commercially available, but are also economically viable in comparison to fossil fuels, particularly when the environmental costs of fossil fuels are taken into account.

- Realizing the need for concentrated efforts in this sector, The Government of India established a Commission for Additional Sources of Energy (CASE) in the Department of Science and Technology, in 1981. The mandate of CASE is to promote research anddevelopment activities in the field of renewable energy.

CASE was formally incorporated in 1982, in the newly created Department of Nonconventional Energy Sources (DNES). In 1992 DNES became the Ministry for Nonconventional Energy Sources, commonly known as MNES.

- India has a vast supply of renewable energy resources, and it has one of the largest programs in the world for deploying renewable energy products and systems. Indeed, it is the only country in the world to have an exclusive ministry for renewable energy development, the Ministry of Non-Conventional Energy Sources (MNES). MNES was renamed the Ministry of New and Renewable Energy.

- India has pioneered in the world in many administrative actions of renewable energy promotion such as: - 1) Electricity regulatory commission within liberalized market 1991 2)

Mandatory environmental audits for power projects -1992 3) Energy conservation bill -2000 4) Renewable Energy promotion bill- 2005.

- The Ministry is encouraging the setting up of grid-interactive power projects based on renewable energy through private investment route.

- The State Nodal Agencies are responsible for promotion and development of private sector projects by way of providing necessary clearances, allotment of land, allotment of potential sites in case of SHP projects and facilitating power purchase agreements etc.

- State Electricity Regulatory Commissions (SERCs) are determining tariffs by taking into account the submissions of all stakeholders, including consumers.

- A number of leading financial institutions and banks are financing renewable energy-based power

- **Legal Provisions: - Under the ElectricityAct, 2003,** the Central Government, from time to time, is responsible for preparing the national electricity policy and tariff policy, in consultation, among others, with the State Governments for the optimal utilization of all resources, including renewable sources of energy. The Act 2003 has several enabling provisions, with a view to promote accelerated development of non-conventional energy-based power generation, as summarized below:

**Section 86(1) (e),** "The State Commission shall promote co-generation and generation of electricity from renewable sources of energy by providing suitable measures for connectivity with the grid and sale of electricity to any person, and also specify, for purchase of electricity from such sources, a percentage of the total consumption of electricity in the area of a distribution license" Section 3 (1), Government of India (GoI) shall, from time to time, prepare the National Electricity Policy and Tariff Policy, in consultation with the State Governments for developing the power system based on optimal utilization of resources such as coal, natural gas, nuclear, hydro, and renewable sources of energy. Section 4, GoI shall, after consultation with the State Governments, prepare a national policy, permitting stand-alone systems (including those based on renewable sources of energy) for rural areas. **For these reasons, today India is among the leaders in the world in utilization of several renewable Energy Technologies.**

## 4.Green Energy:

### 4.1 Introduction:

Green energy, also known as renewable energy or clean energy, refers to energy derived from naturally replenishing and environmentally sustainable sources. Unlike fossil fuels such as coal, oil, and natural gas, which are finite and contribute to pollution and climate change, green energy sources harness natural processes to generate electricity and heat without depleting natural resources or emitting harmful pollutants.

The introduction of green energy has gained significant attention and momentum in recent years due to growing concerns about climate change, air pollution, and energy security. Green energy technologies are diverse and include solar power, wind power, hydroelectricity, geothermal energy, biomass energy, tidal energy, and wave energy. These technologies offer a range of benefits, including reduced greenhouse gas emissions, improved air quality, energy independence, job creation, and economic growth.

Governments, businesses, and individuals around the world are increasingly investing in and adopting green energy solutions to transition towards a more sustainable and resilient energy system. This shift towards green energy is driven by technological advancements, policy support, public awareness, and the recognition of the urgent need to mitigate the impacts of climate change.

### 4.2 Characteristics of Green Energy:

**Renewable:** Green energy sources are renewable, meaning they are naturally replenished and can be used indefinitely without depleting their resources. Examples include solar energy, wind energy, and hydroelectric power.

**Low or Zero Carbon Emissions:** Green energy production typically results in significantly lower or zero emissions of greenhouse gases and other pollutants compared to fossil fuels. This makes it a more environmentally friendly option.

**Local Generation:** Many green energy systems can be deployed locally, allowing communities and individuals to generate their own energy and reduce reliance on centralized power grids.

**Technological Innovation:** The green energy sector is characterized by continuous technological advancements, leading to improvements in efficiency, cost-effectiveness, and scalability of renewable energy systems.

**Energy Independence:** Using green energy sources can help reduce dependence on imported fossil fuels, contributing to greater energy independence for countries and regions.

**Sustainable Development:** Green energy supports sustainable development by promoting economic growth, creating jobs in the renewable energy sector, and reducing environmental impacts associated with traditional energy sources.

### 4.3 Need of Green Energy:

Green energy is produced from renewable sources and produces very less impact on our environment. So, in order to protect Mother Nature from pollution and to ensure the supply of energy continuously we should start using green energy for industrial as well as domestic purpose.To limiting global warming and protecting ecosystems by reducing CO2 emissions through energy efficiency and renewable Energy, Green Energy Technology is essential. As temperatures rise, agricultural output will fall, damage from floods and storms will increase, (tropical) diseases will become more prevalent and access to water will become more of a problem for more and more people. The cost to our environment is greater and loss is irreversible. The Earth's flora and fauna will suffer both directly from higher temperatures and indirectly through the damage to their habitats. Ecosystems will disappear. Even small temperature increases will cause coral bleaching and threaten some amphibians. Temperature rises of 3° or 4°C and more will lead to major extinctions around the globe.

### 4.4 Uses of Green Energy:

There are many options of using renewable energy at residential or commercial spaces.

- Most common form of renewable energy comes from sunlight or solar energy. One can get solar panels installed in residential and commercial spaces where sunlight is available in plenty.
- Other places where wind is in abundance may raise wind turbines to generate renewable energy. The energy thus gotten can be used for pumping water and or for charging sailboat battery.

- Biomass is another very popular renewable energy source. It is used for producing electricity and also used as a transportation fuel. The use of biomass as a renewable form of energy is commonly known as bio-energy.
- Geothermal energy on the other hand, taps the internal heat of the Earth for a variety of uses, including cooling and heating of buildings and electric power production.
- Marine energy is yet another very important renewable form of energy. It comes from a variety of sources including tidal energy and energy generated from the ocean's waves, driven from both tides and winds.

**4.5 Types of Green Energy:**

1) Solar Energy
2) Hydro Energy
3) Geothermal Energy
4) Wind Energy
5) Biomass Energy.
6) Tidal Energy
7) Wave Energy

**5.Conclusion:**

In conclusion, renewable and green energy sources offer promising solutions to address global energy challenges while mitigating environmental impacts. These sources, including solar, wind, hydroelectric, geothermal, biomass, tidal, and wave energy, provide several key benefits:

**Environmental Sustainability:** Renewable energy sources produce little to no greenhouse gas emissions or pollutants, reducing air pollution and mitigating climate change.

**Resource Availability**: Unlike finite fossil fuels, renewable energy sources are abundant and naturally replenished, ensuring long-term energy security and resilience.

**Diverse Options**: The diversity of renewable energy sources allows for flexibility in energy production, reducing dependence on a single energy source and enhancing energy system stability.

**Community Benefits:** Renewable energy projects often bring benefits to local communities, including infrastructure development, revenue generation, and improved public health.

To fully realize the potential of renewable and green energy, continued investment in research, technology development, policy support, and public engagement is essential. By accelerating the transition towards a clean energy future, we can achieve sustainable development goals, protect the environment, and ensure a prosperous and resilient energy system for generations to come.

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## UNIT-12

## Environmental ethics, policies and laws in India with special reference to air, water and forest

### Environmental ethics

Environmental ethics is a branch of philosophy that looks at the moral rules and values that guide how people should treat the environment.It aims at providing ethical justification and moral motivation for the cause of global environmental protection (Sarkar,2012). It looks into things like how people should interact with nature, what our duties are to the environment and the animals that live in it, and what moral duties we have to protect natural resources and ecosystems. Environmental ethics often addresses issues such as:

**1.Anthropocentrism vs. Ecocentrism**: Anthropocentrism says that moral concerns should be centered on people, while ecocentrism says that we should value the environment for its own sake, without caring about people.

2. **Intrinsic Value of Nature:** This view says that nature has value in and of itself, even if it isn't useful to people. It is different from instrumental value, which says that nature is only important if it helps people.

3. **Sustainability:** Environmental ethics looks at how people can live their lives in a way that meets their needs now without making it harder for future generations to do the same.

**4. Biodiversity and Conservation:** It talks about the moral duty to protect endangered species and keep biodiversity alive, since all living things have worth on their own.

5. **Responsibility for Environmental Harm:**

Environmental ethics looks at who is responsible for damaging the environment and what actions that hurt ecosystems, both locally and nationally, mean from an ethical point of view. Environmental ethics gives us a way to think about how people affect the environment and helps us make moral choices about environmental policy, resource management, and our own lifestyles.

**Environmental policies and laws (air, water and forest):**

India's environmental policy and laws encompasses a wide range of measures aimed at addressing environmental challenges while promoting sustainable development.

**Environmental policies and laws on Air**

India has a variety of environmental policies and laws aimed at addressing air pollution, which is a significant environmental challenge in the country. Some key policies and laws related to air quality in India include:

**1.The Air (Prevention and Control of Pollution) Act, 1981:** This is India's main law that controls air quality. It gives the national and state governments the power to stop and control air pollution by setting up pollution control boards and rules for how much pollution factories and cars can put into the air (Divan at al.,2022. It is a significant piece of environmental legislation in India. It was enacted to combat air pollution and to promote the preservation of the quality of air. The act empowers the central and state pollution control boards to prevent and control air pollution. It provides for the establishment of pollution control boards at the central and state levels, which are responsible for implementing various measures to prevent and control air pollution.

**Key provisions of the Air (Prevention and Control of Pollution) Act, 1981 include:**

1. Setting of standards for emissions from industrial plants and automobiles.
2. Regulation of the location of industries to prevent air pollution.
3. Power to take samples of air and to perform tests to assess air quality.
4. Issuing directions for the closure, prohibition, or regulation of any industry, operation, or process that causes or is likely to cause air pollution.
5. Imposing penalties for contravention of the provisions of the Act.

The act aims to protect and improve the quality of air by controlling and reducing air pollution levels, thereby safeguarding public health and the environment. It has been amended over the years to address emerging challenges and to strengthen its provisions in line with evolving scientific understanding and technological advancements in pollution control.

**2. National Ambient Air Quality Standards (NAAQS):**

The National Ambient Air Quality Standards (NAAQS) are guidelines established by regulatory bodies in various countries to define the acceptable levels of air pollutants in the

atmosphere. These standards serve as benchmarks for assessing air quality and are crucial for protecting public health and the environment.

In India, the Central Pollution Control Board (CPCB) is responsible for setting NAAQS under the Air (Prevention and Control of Pollution) Act, 1981. The NAAQS in India cover various pollutants, including particulate matter (PM10 and PM2.5), sulfur dioxide (SO2), nitrogen dioxide (NO2), carbon monoxide (CO), ozone (O3), ammonia (NH3), and lead (Pb). The NAAQS specify the maximum permissible concentrations of these pollutants in the ambient air over specific time periods (e.g., 24 hours, annual average). These standards are periodically reviewed and revised based on scientific research, health impacts, technological advancements, and international practices.

By adhering to NAAQS, regulatory authorities can monitor and control air pollution levels, enforce regulations on industries and vehicles, and implement measures to improve air quality. Public awareness and participation are also essential for achieving compliance with NAAQS and ensuring the well-being of communities and ecosystems.

**3. The Environment (Protection) Act, 1986:** This law gives the central government the power to protect and improve the quality of the environment, including the quality of the air. It makes sure that industrial operations are regulated and that air pollution is avoided (Divan at al.,2022). The Environment (Protection) Act, 1986 in India lays down several principles for the development and maintenance of air quality. These principles serve as guiding tenets for policymaking, regulation, and enforcement to ensure the protection and improvement of air quality.

key principles of the Environment (Protection) Act, 1986 related to air quality development:

(I) In the context of air quality, precautionary principle underscores the need to proactively address sources of air pollution to avoid adverse impacts on human health and the environment.

(II) Those who pollute the environment should bear the costs of pollution control and remediation. It encourages accountability and responsibility among polluters and provides an economic incentive for adopting cleaner technologies and practices. In the context of air quality, industries and other sources of pollution are held liable for the costs associated with mitigating their emissions and reducing their environmental footprint.

(III) The government is responsible for ensuring that air pollution is kept within acceptable limits and that the public's right to clean air is upheld.

(IV) The act promotes public participation in environmental decision-making and access to information related to environmental matters, including air quality data, monitoring results, and regulatory actions. It recognizes the importance of transparency, accountability, and inclusivity in environmental governance and encourages the involvement of affected communities, stakeholders, and civil society organizations in efforts to improve air quality.

**4. The National Clean Air Programme (NCAP):** This programme, which started in 2019, is a big plan to clean up the air in Indian towns. It sets goals to lower the amounts of PM2.5 and PM10 by 20 to 30 percent by 2024, focusing on 102 towns that have been found to have bad air quality.

**5. Bharat Stage Emission Standards (BSES):** These rules, which are similar to Euro standards, control the pollution that cars and trucks release. India has been adopting stricter BSES to control pollution from vehicles and make the air better.

**6. Different State-Level Initiatives:** To deal with air pollution, many Indian states have taken their own steps, such as making it illegal to burn crop residues, promoting cleaner cooking fuels, putting stricter rules on businesses, and starting programmes to control vehicle emissions.

India still has a big problem with air pollution, especially in the big cities, even with these rules and laws in place. Problems include putting the rules into action and making sure they are followed, as well as dealing with the things that cause pollution, like factory emissions, car traffic, burning biomass, and building work. Both the national and local governments need to keep working to protect public health and improve air pollution.

**Environmental policies and laws on Water:**

India has several environmental policies and laws aimed at protecting and managing water resources. Some key policies and laws related to water management and conservation in India include:

**1.The Water (Prevention and Control of Pollution) Act, 1974:** This law sets up national and state pollution control boards to stop and control water pollution. It says what needs to be done to stop and control water pollution and keep or restore the cleanness of water (Hewameealla, 2006).The Water (Prevention and Control of Pollution) Act, 1974, is an

important piece of legislation enacted by the Government of India to prevent and control water pollution. The primary objective of this Act is to maintain or restore the wholesomeness of water for various uses such as drinking, recreation, and industrial purposes. It empowers the central and state pollution control boards to implement measures for the prevention and control of water pollution.

Key provisions of the Act include:

(I) The Act empowers the central and state pollution control boards to set standards for the prevention and control of water pollution.

(II) It provides for the establishment of monitoring mechanisms to assess water quality and conduct inspections of industries discharging effluents into water bodies.

(III) The Act prohibits the discharge of pollutants into water bodies beyond a certain prescribed limit.

(IV) It stipulates penalties for contravention of its provisions, including fines and imprisonment for offenders.

(V) The Act mandates the adoption of measures for the prevention and control of water pollution, including the treatment of effluents before discharge.

(VI) It establishes central and state pollution control boards with powers to implement the provisions of the Act and take necessary actions to prevent and control water pollution.

**2. The Environment (Protection) Act, 1986:** This law gives the central government the power to protect and improve the quality of the environment, including the quality of the water. Controlling pollution, managing waste, and regulating industrial operations are all part of it. While the Water (Prevention and Control of Pollution) Act, 1974, primarily focuses on water pollution control, the Environment (Protection) Act, 1986, has a broader scope covering various aspects of environmental protection, including water quality enhancement.

The principal provisions of the Environment (Protection) Act, 1986, that contribute to enhancing water quality include:

(I) The Act empowers the central government to take measures for protecting and improving environmental quality. This includes measures aimed at enhancing water quality.

(II) It authorizes the central government to set environmental standards, including standards for water quality, to prevent and control pollution.

(III) The Act enables the central government to regulate and restrict the handling and disposal of hazardous substances, which could contaminate water bodies and degrade water quality.

(IV) the Environment (Protection) Act authorizes the central and state pollution control boards to take measures for the prevention and control of pollution, including water pollution.

(V) The Act encourages public participation in environmental protection efforts and promotes awareness about environmental issues, including the importance of maintaining and enhancing water quality.

**3. The National Water Policy, 2012:** This policy tells people in India how to handle and protect their water resources. It stresses the importance of managing water resources as a whole, using water in a way that doesn't harm the environment, and making sure that everyone has equal access to water.

The main focus on the policy are:

(I) The policy emphasizes the principle of equitable access to water, aiming to ensure that all sections of society have access to adequate and safe water for drinking, sanitation, livelihoods, and other needs.

(II) It highlights the importance of maintaining and improving water quality to meet various water use requirements, including drinking, agriculture, industry, and ecosystem preservation. The policy advocates for measures to prevent pollution and mitigate the impacts of water contamination.

(III) The policy recognizes the need for rational pricing of water to promote efficient use, encourage conservation, and ensure sustainability. It emphasizes the principle of cost recovery in water management, balancing the need for affordability with the need for financial sustainability.

(IV) Recognizing that many water resources are shared across state boundaries, the policy emphasizes the importance of inter-state cooperation and coordination in water management to address issues of allocation, utilization, and sharing of benefits.

(V) The policy acknowledges the impacts of climate change on water resources and calls for measures to enhance resilience and adaptive capacity in water management practices. It advocates for the integration of climate change considerations into water resource planning and decision-making processes.

(VI) The policy emphasizes the need for effective water governance structures and institutions at various levels to facilitate integrated and participatory water management. It encourages the involvement of stakeholders, including local communities, in decision-making processes related to water resource management.

**4. The National River Conservation Plan (NRCP):** This plan, which began in 1995, aims to clean up India's important rivers that are polluted. Its main goals are to control pollution from both point and non-point sources, treat sewage, and build on the riverbank.

**5. The Clean Ganga Mission (Namami Gange):** This mission, which began in 2014, wants to clean up the Ganges River and its tributaries by reducing pollution, making sewage treatment facilities better, raising public knowledge, and supporting long-term growth along the river basin (Mathur,2020).

**6. The Jal Jeevan Mission (JJM):** This programme began in 2019 and its goal is to give all rural homes in India running water by 2024. Its main goals are decentralised water control, long-term source sustainability, and community involvement.

**7. The Water Cess Act of 1977:** This law says that businesses and local governments must pay a fee for the water they use. The money from the water cess is used to protect water supplies and cut down on pollution.

**8. The Ground Water (Management and Regulation) Act, 2002**: This law is meant to make sure that groundwater supplies are used in a way that doesn't harm the environment. It gives state governments the power to control well drilling, groundwater mining, and encouraging people to save water.

**The key objectives of the Ground Water Act include:**

(I) Regulating and controlling the development and management of groundwater resources to ensure their sustainable use.

(II) Preventing over-exploitation and depletion of groundwater reserves.

(III) Promoting efficient and equitable distribution of groundwater among various users.

(IV) Facilitating the implementation of groundwater recharge and conservation measures.

(V) Establishing regulatory mechanisms to monitor and enforce compliance with groundwater management rules and regulations.

Under this act, the government has the authority to declare certain areas as "notified areas" where groundwater management regulations are stricter. It also provides for the establishment of Ground Water Authorities at the central and state levels to oversee the implementation of the act and to formulate policies and guidelines for groundwater management. The act empowers the authorities to issue permits for drilling boreholes and extracting groundwater, subject to certain conditions and regulations. It also lays down penalties for unauthorized extraction or misuse of groundwater.

These policies and laws set the rules for how India's water supplies should be managed, protected, and controlled. But problems like water pollution, overusing groundwater, water disputes between states, and bad infrastructure still exist. This shows how important it is to effectively implement and enforce these laws, along with ongoing efforts to manage and conserve water resources.

**Environmental policies and laws on Forest:**

In India, environmental policies and laws related to forests are aimed at conservation, sustainable management, and protection of forest ecosystems. Some key policies and laws concerning forests in India include:

**1.The Forest (Conservation) Act, 1980:** This law controls the use of forest land for things other than forests, like farming, mining, industry, and building roads and bridges. This kind of diversion needs to be approved by the central government ahead of time, and the goal is to protect wild resources (Srivastava, 2019).

(I) The act mandates that prior approval from the central government is required for diverting forest land for any non-forest purpose. This ensures that the potential environmental impacts of such diversions are thoroughly assessed and mitigated.

(II) The central government plays a central role in the implementation of the act. It has the authority to grant or reject proposals for diversion of forest land based on the recommendations of the State Forest Department and other concerned agencies.

(III) The act specifies conditions and guidelines for the diversion of forest land, including the requirement for compensatory afforestation to offset the loss of forest cover. Compensatory afforestation involves planting trees on non-forest land to compensate for the loss of trees due to the diversion of forest land.

(IV)The act imposes penalties for contravention of its provisions, including fines and imprisonment for unauthorized diversion of forest land.

**2. The Indian Forest Act, 1927 (Amended in 2017):** This law sets the rules for how woods in India should be managed and protected. It spells out the duties and powers of forest officials, limits how forest resources can be used, and gives punishments for crimes like illegal hunting, encroachment, and cutting (Srivastava,2019). Some principal aim of this forest act:

(I) The act emphasizes the conservation and protection of forests, including measures to prevent unauthorized cutting of trees, encroachment, forest fires, and illegal trade in forest produce.

(II) It regulates various activities related to forests, including felling of trees, grazing of livestock, hunting, collection of forest produce, and use of forest land for non-forest purposes. Permits and licenses may be required for certain activities, and penalties are prescribed for violations.

(III) The act defines the roles and responsibilities of forest authorities, forest officers, and other stakeholders involved in the management and protection of forests. It establishes mechanisms for the administration, supervision, and enforcement of forest laws.

(IV) The amended act includes provisions for the recognition and protection of the rights of forest dwellers and indigenous communities over forest land and resources, in accordance with the Forest Rights Act, 2006.

(V) It encourages sustainable forest management practices, including afforestation, regeneration of degraded forests, and conservation of biodiversity. It may also provide for the establishment of protected areas, wildlife sanctuaries, and national parks to conserve ecologically sensitive areas and endangered species.

(VI) The act regulates the transit of forest produce, including transportation, storage, and trade, to prevent illegal logging and ensure the sustainable utilization of forest resources.

**3. The National Forest Policy, 1988 (Revised in 2018):** This policy tells the government how to protect and handle forests across the country. It talks about how woods help the environment, the economy, and people's lives. It also supports long-term forest management, community involvement, and planting new trees (Joshi,2011).

**4. Joint Forest Management (JFM) Programme:** which was started in the 1980s and pushes forest departments and local communities to work together to manage and protect forest resources. Its goal is to get people involved in protecting forests while also helping them make a living. The Joint Forest Management (JFM) Programme is a collaborative approach to forest management that involves the participation of local communities and the government in the protection, conservation, and sustainable use of forest resources. The concept of JFM emerged as a response to the recognition that traditional top-down forest management approaches often failed to address the needs and aspirations of local communities while also neglecting the importance of their knowledge and involvement in forest conservation. JFM establishes a partnership between forest-dependent communities and government forest departments, recognizing that both have a stake in the sustainable management of forests. It promotes the sharing of responsibilities, resources, and decision-making authority between these stakeholders. One of the central aspects of JFM is the active participation of local communities in all stages of forest management, including planning, implementation, monitoring, and evaluation. By involving communities in decision-making processes, JFM aims to empower them to take ownership of their forest resources and become stewards of their own environment. The success of JFM relies on building the capacity of local communities and forest department personnel in sustainable forest management practices, biodiversity conservation, and alternative livelihoods. Training, education, and skill development initiatives are key components of JFM programmes aimed at enhancing the knowledge and skills of stakeholders involved.It may include the formation of village-level forest committees, user groups, or other community-based institutions tasked with managing forest resources and addressing disputes in a fair and participatory manner.

**5. The Wildlife Protection Act, 1972 (Amended in 2006):** This law protects wildlife and their habitats, like woods, which are very important for wildlife species to stay alive. It controls things like hunting, the trade of wildlife, and the creation of protected places.

Key features of the Wildlife Protection Act:

(I) It prohibits the hunting, poaching, killing, or capturing of specified species of wild animals, including both terrestrial and aquatic species listed in Schedules I to IV of the act. It aims to safeguard endangered and threatened species from exploitation and extinction.

(II) The act regulates the trade and commerce in wildlife and their derivatives, including animal parts, skins, and trophies. It prohibits the sale, purchase, and possession of wildlife products derived from species listed under Schedule I and provides for permits and licenses for trade in certain cases.

(III) The act recognizes the importance of preserving the natural habitats of wildlife species and provides for the declaration of wildlife sanctuaries, national parks, and protected areas to conserve critical habitats and biodiversity hotspots.

(IV) The act establishes central and state wildlife authorities responsible for the implementation and enforcement of wildlife protection laws. These authorities have the power to grant permits, licenses, and exemptions for certain activities, as well as to investigate and prosecute violations of the act.

(V) The act prescribes penalties, including fines and imprisonment, for offenses related to the illegal hunting, poaching, or trafficking of wildlife species. It empowers wildlife officials and law enforcement agencies to take action against offenders and seize contraband wildlife products.

(VI) The act has been amended several times to strengthen its provisions and address emerging conservation challenges. The 2006 amendment introduced significant changes, including stricter penalties for wildlife crimes, enhanced protection for certain species, and provisions for the establishment of wildlife crime control bureaus.

**6. Compensatory Afforestation Fund (CAF) Act, 2016:** This law says how the money that is collected to make up for forest land that is used for things other than forests can be used. The money is used to plant new trees, restore damaged woods, and protect wildlife.

**7. Green India Mission (GIM):** GIM was started as part of India's National Action Plan on Climate Change. Its goals are to grow the amount of trees and forests, improve ecosystem services, and make it easier for people to make a living in forests. It focuses on planting new

trees, replanting old trees, and using sustainable methods to handle forests (Ravindranath, 2010).

These rules and laws are meant to make sure that India's forest resources are used and protected in a way that is good for the environment, the economy, and people. But problems like illegal logging, encroachment, habitat loss, and forest degradation still exist. To protect India's forest ecosystems, policies need to be implemented, enforced, and communities need to be involved.

**Conclusion:** India has made significant strides in formulating environmental policies and laws, there remain challenges in implementation and enforcement, particularly at the state and local levels. Efforts to address these challenges are essential for achieving environmental sustainability and ensuring the well-being of current and future generations.

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## 1.6. Self-assessment Questions

- Briefly discuss the purpose and objectives of environmental management planning
- What are factors affecting urban forestry
- Briefly discuss sustainable development goals
- Explains the various challenges and prospects of eco-tourism in West Bengal Coastal Tract
- What are the advantages of green technology?
- Discuss that guiding principle of green economy
- What is India's status as a green economy?
- Elaborate the various forms of renewable energy