Environmental Science: Theory into Practice–II

Unit I: Global Environmental Issues and Policies

This unit covers causes and impacts of global environmental issues, international agreements, Sustainable Development Goals, and environmental legislation in India.

Lesson 14: Global Environmental Issues

- **Introduction**: Human population growth significantly increases demand for resources, leading to pressure on natural resources and pollution. The degradation and depletion of resources must be checked without halting development. The current human population exceeds 7.8 billion and is projected to reach over 9 billion by 2040 and 11 billion by 2100, which outpaces the planet's carrying capacity.
- **Climate Change**:
    - **Observations**: Global average surface temperature increased by **0.6° ± 0.2°C** over the last century. There's increased rainfall in mid to high latitudes and increased frequency/intensity of droughts in parts of Asia and Africa. El Niño episodes have been more frequent, persistent, and intense since the mid-1970s.

- **Projections (IPCC)**: Global mean surface temperature is projected to rise by **1.4° to 5.8°C by 2100**, with warming greatest over land and high latitudes. The rate of warming is predicted to be faster than in the last 10,000 years. Increased frequency of weather extremes (floods/droughts), fewer cold spells, more heat waves, and increased El Niño intensity are expected. Global mean sea level is projected to rise by **9 to 88 cm by 2100**.
- **Impacts**: Human societies will be affected by climate extremes. Public health, dependent on safe drinking water, food, shelter, and social conditions, will be impacted. This includes reduced freshwater, increased infectious diseases (e.g., diarrhoeal diseases), reduced food production leading to starvation and malnutrition (especially for children), and potential conflicts. Climate change can lead to **environmental refugees** and spread of vector-borne diseases (e.g., malaria, dengue, yellow fever, Lyme disease) to new areas.

- **Global Warming**:
  - **Mechanism**: Approximately **75% of solar energy** reaching Earth is absorbed, increasing its temperature. Some heat is trapped by **greenhouse gases**, predominantly carbon dioxide. The rapid increase of carbon dioxide from human activities is

causing global warming. The average surface temperature of Earth is about 15°C; without the greenhouse effect, it would be -18°C.

- **Causes**: Industrialisation and population growth have significantly polluted the atmosphere. Carbon dioxide in the atmosphere has increased by **31% since pre-industrial times**, trapping more heat.
- **Solutions**: Many countries have signed conventions (like the United Nations Convention on Climate Change) to reduce greenhouse gases, though current agreements are not fully effective.

- **Acid Rain**:
  - **Formation**: When fossil fuels (coal, oil, natural gas) are burned, **sulfur dioxide and nitrogen oxides** are produced. These chemicals react with water and other atmospheric chemicals to form **sulfuric acid, nitric acid, sulphates, and nitrates**. These acid pollutants return to the ground as **acid rain, fog, or snow (wet deposition)** or as dry particles and gases **(acid deposition)**.
  - **Sources**: Coal burning power plants (about 70% of SO2 in the US), oil refining, metal smelting (61% of SO2 in Canada), and motor vehicle exhaust (main source of nitrogen oxides).

- **Effects**:
  - **Soil**: Dissolves and washes away plant nutrients; frees toxic substances like aluminium and mercury.
  - **Plants/Trees**: Damages waxy coating of leaves, causes brown dead spots, affects photosynthesis, makes trees vulnerable to insects, drought, and cold (e.g., spruce and fir forests).
  - **Aquatic Ecosystems**: Acidifies water, harming plant and animal life (e.g., high mortality for clams and mayflies at pH 6.0) and disrupting food chains.
  - **Infrastructure**: Corrodes buildings, automobiles, and structures made of stone or metal, damaging historic buildings (e.g., Parthenon in Greece, Taj Mahal in India).
  - **Human Health**: Toxic substances leached from soil can pollute water supply, making fish unsafe for consumption. Contributes to urban smog, causing respiratory problems.
- **Solutions**: Reduce emissions of sulfur dioxide and nitrogen oxides by using less fossil fuel energy. Switch to cleaner fuels (natural gas, low-sulfur coal) and develop more efficient vehicles. Use **scrubbers in smokestacks** and **catalytic converters in cars** to prevent pollutants from

entering the atmosphere. **Liming (adding powdered limestone)** can neutralize soil acidity.

- **Ozone Layer Depletion**:
  - **Ozone**: Formed naturally by sunlight on oxygen, creating a layer **20 to 50 km above Earth's surface**. Ground-level ozone is a poisonous gas and a pollutant causing respiratory ailments and damage to materials. However, **ozone in the upper atmosphere is vital for life**, absorbing the sun's harmful ultraviolet (UV) radiations.
  - **Threats**: In the 1970s, **chlorofluorocarbons (CFCs)**, used as refrigerants and aerosol propellants, were identified as a threat. CFC molecules break down in the stratosphere, releasing chlorine atoms that react with and destroy ozone molecules. Ozone thinning has been detected over Antarctica since the early 1980s and in other places like Australia. Other chemicals like bromine, halocarbons, and nitrous oxides also attack the ozone layer.
  - **Effects**: Increased cases of **skin cancer and cataracts**. Damages crops and plankton, disrupting food chains and webs, and increasing carbon dioxide.
  - **Solutions**: The **Montreal Protocol in 1987** led to the banning of CFCs by 2000, with the ozone layer expected to recover slowly over about 50 years after 2000.

- **Nuclear Accidents and Nuclear Holocaust**:
  - **Nuclear Accidents**: A single accident can cause widespread loss of life, long-term illness, and destruction of property. Radioactivity and fall-out lead to cancer, genetic disorders, and death for decades, affecting all life forms for generations.
  - **Nuclear Holocaust**: The use of nuclear energy in war, as seen in **Hiroshima and Nagasaki (1945)** during World War II, caused immediate devastation and long-term health effects (cancer, genetic mutations) in survivors and their children due to radiation.

Unit II: Biodiversity and Conservation

Lesson 11: Biodiversity and its Threat (cont.)

- **Definition**: **Biodiversity** refers to the **variety of living organisms (flora and fauna)**. E.O. Wilson (1988) defined it as the differences in genes among individuals of a species, the variety and richness of all plant and animal species at different scales (local, regional, country-wise, global), and various types of ecosystems (terrestrial and aquatic) within a defined area.
- **Types of Biodiversity**: Biological diversity is observed at three levels:

- **Genetic Diversity**: Variation at the level of individual genes within a species. This variability is responsible for different characteristics and is the raw material for evolution. It is used to breed new crop varieties and disease-resistant crops.
- **Species Diversity**: The number of plant and animal species in a region. Natural, undisturbed tropical forests exhibit greater species richness compared to monoculture timber plantations. Areas rich in species diversity are called **'hotspots'**, and countries with high species richness or many hotspots are known as **'mega diversity nations'**. India is one of the world's 15 mega-diversity nations. Hotspots are defined by two criteria: **rich endemism** (at least 0.5% or 1500 of the world's 300,000 plant species must be endemic) and a **high degree of threat**.
- **Ecosystem Diversity**: The variety of different ecosystems on Earth, each with distinctive interlinked species based on habitat differences. It describes variations in the structure and functions of ecosystems, including the number of niches, trophic levels, and ecological processes that sustain energy flow, food webs, and nutrient recycling. It also focuses on biotic interactions and the role of **keystone species** (e.g., fig, peepal).

- **Methods of Measuring Biodiversity (at community level)**:

    - **Alpha diversity**: Diversity *within* a community or habitat, combining species richness and equitability/evenness.
    - **Beta diversity**: Diversity *between* communities, reflecting differences in species composition along environmental gradients (e.g., altitudinal, moisture). Higher heterogeneity or dissimilarity between communities indicates higher beta diversity.
    - **Gamma diversity**: Diversity of habitats over the total landscape or geographical area, representing the sum of alpha and beta diversities.
- **Biogeographic Classification of India**: India is divided into **ten major regions** based on geography, climate, vegetation, and animal communities. These include the Trans-Himalayan region, Himalayan ranges, Terai, Gangetic and Brahmaputra plains, Thar Desert, Deccan plateau's semi-arid grassland, North Eastern states, Western Ghats, Andaman and Nicobar Islands, and the coastal belt.
- **Values of Biodiversity**: The value of biodiversity is enormous, categorized as:
    - **Consumptive Value**: Direct use for food (animals, fish, plants), medicines (e.g., Penicillin from fungus, Quinine from cinchona tree), and fuel (fossil fuels).
    - **Productive Value**: Commercial utility of products like tusks, musk, silk, wool, fur, and biological pesticides (e.g.,

Pyrethrum from daisy plants, toxic proteins from *Bacillus thuringiensis*).

- **Social Value**: Associated with social life, religion, and spiritual aspects (e.g., sacred plants like Tulasi, Mango leaves; sacred animals like cows, snakes).
- **Ethical Value**: The pleasure derived from knowing that a species exists in nature, even if not directly utilized (e.g., kangaroos, giraffes).
- **Aesthetic Value**: Enjoyment of natural beauty, leading to **eco-tourism**, which generates significant revenue (estimated $12 billion annually). Being in nature is found to relieve stress.

- **Threats to Biodiversity**:
  - **Habitat Loss, Degradation, and Fragmentation**: The single greatest threat, primarily due to human population growth, industrialisation, and changes in land use. This includes conversion of forests/grasslands to agriculture, drainage of wetlands, clearing of mangroves, overgrazing, deforestation for timber (leading to monoculture), excessive firewood collection, encroachment on buffer zones (e.g., Gir National Park), repeated fires, and introduction of exotic weeds (e.g., Lantana bushes, Eupatorium shrubs, 'congress' grass). Over-harvesting of fish stocks (e.g., marine turtles,

whale sharks) is also a significant issue. Scientists estimate human activities may eliminate 10 million species by 2050.

- **Poaching**: Driven by economic benefits from wildlife products such as tiger skins/bones, elephant ivory, rhino horns, musk from deer, gall bladders from bears, corals, shells, and illegal trade in exotic pets and medicinal plants (e.g., Rauwolfia, nux vomica, Datura).
- **Man-Wildlife Conflicts**: Caused by shrinking forest cover, human encroachment, and lack of food for animals, leading to retaliatory killings (e.g., elephants and villagers in Sambhalpur, Odisha).

- **Endangered & Endemic Species in India**:
  - **Endangered Species**: Species whose existence is in danger due to human activities. They are categorized as Vulnerable, Rare, Intermediate, or Threatened (those on the verge of extinction). Many are found in Protected Areas (PAs). Examples include tiger, rhino, elephant, Siberian crane, Great Indian Bustard, and various reptiles, amphibians, and plants like orchids.
  - **Endemic Species**: Species unique to a particular locality or region. Some have very localized distributions within India. Examples: Indian wild ass, angular Kashmiri stag, golden langur, pigmy hog.

Lesson 12: Biodiversity and its Conservation

- **Conservation Needs**: Biodiversity conservation requires different strategies, which can be species-based, habitat-based, or ecosystem-based, and addressed at national or international levels.
- **In-situ Conservation**: **On-site conservation**, which involves protecting endangered species within their natural habitats. This includes protecting the habitat itself or defending the species from predators.
    - **Methods**: Establishing **biosphere reserves, national parks, and wildlife sanctuaries**. India has 589 Protected Areas (PAs), including 89 national parks and 500 wildlife sanctuaries.
    - **Examples in India**: The Great Himalayan National Park (snow leopard), Dachigam Sanctuary (hangul/Kashmiri stag), Kaziranga National Park (elephant, wild boar, swamp deer, birds), Manas Sanctuary (Golden langur, pigmy hog, wild boar).
    - **Project Tiger**: A centrally sponsored scheme launched on **April 1, 1973**, to maintain viable tiger populations and their natural habitats. It uses a **'core-buffer strategy'**: core areas are free of disturbances, while buffer zones are managed for multiple uses, providing habitat supplement and supporting local communities. Initially, it had 9 reserves and 268 tigers;

now it has 27 tiger reserves covering 37,761 sq. km with 2967 tigers.

- **Ex-situ Conservation**: **Off-site conservation**, which involves protecting endangered species populations by removing them from unsafe habitats and caring for them in controlled human environments.
    - **Methods**:
        - **Botanical Gardens**: World's 1500 botanical gardens cultivate an estimated 12,000 to 15,000 threatened plant species.
        - **Zoological Parks**: Modern zoos function as centers for ex-situ wildlife conservation and environmental education, breeding endangered species.
        - **Captive Breeding**: A strategy used by government and NGOs to preserve endangered species (e.g., Madras crocodile trust bank, Guchali zoo for pigmy hog, Delhi zoo for Manipur brow-antlered deer).
        - **Embryo Storage and Transfer Technology**: Techniques (like artificial insemination) developed for laboratory and farm animals, useful for increasing reproductive potential in captive endangered species (e.g., black-footed ferret, elephants, cheetahs).

- **Somatic Cell Cloning**: Propagating from a few survivors of an almost extinct species (e.g., domestic sheep, rare cattle breed).
- **Fostering**: Collecting extra eggs from egg-laying animals and rearing them in captivity with foster parents to supplement wild populations (e.g., peregrine falcon, whooping cranes).
- **Translocations**: Moving individuals from their natural habitat or captivity to another habitat, used for introductions or reintroductions, requiring extreme caution and study.
- **Introduction**: Translocating a species into an area *outside* its historical distribution, making it an "exotic" species.
- **Reintroduction**: Translocating a species into an area *within* its historical distribution to boost or establish new populations.
- **Seed Banks (Gene Banks)**: Preserving plant germplasm. Inexpensive and space-efficient, allowing preservation of large populations with minimal genetic erosion.

- **Conservation of Cultivators and Livestock Breeds**: Important to encourage farmers to grow traditional crop varieties (e.g., India

once had 30,000 rice varieties) and preserve traditional livestock breeds to maintain genetic variability for future disease-resistant varieties.

- **Biological Diversity Act 2002**: This act was the first attempt to legally frame biodiversity conservation in India.
    - **Objectives**: To conserve biological diversity, promote sustainable use of its components, and ensure fair and equitable sharing of benefits arising from the use of biological diversity.
    - **Key Provisions**: Prohibits transfer of Indian genetic material or claiming Intellectual Property Rights (IPR) over biodiversity without government approval. Regulates biodiversity collection/use by Indian nationals (with exemptions for local communities). Mandates benefit-sharing measures (e.g., technology transfer, monetary returns, joint research). Includes measures for habitat and species protection and integrating biodiversity into departmental plans. Empowers local communities to have a say in resource use and charge fees. Protects indigenous/traditional knowledge. Regulates genetically modified organisms. Establishes National, State, and local Biodiversity funds and the **National Biodiversity Authority, State Biodiversity Boards, and Biodiversity Management Committees**.

    - **Functions of the National Biodiversity Authority**: Advise the central government on conservation and sustainable use, coordinate state boards, provide technical assistance, sponsor research, collect/publish data, organize public awareness programs, train personnel, prepare budgets, recommend posts, approve recruitment, build databases, issue directions to state boards/BMCs, report to the central government, sanction grants, and oppose illegal IPR grants on Indian biological resources outside India. It also regulates commercial utilization or biosurvey and bio-utilization by Indians.
- **Need for Conserving Biodiversity**: Biodiversity is important for present and potential future uses. It is essential for maintaining Earth's life support systems that enable human life. It is also ethically important to maintain all existing life forms.

Unit III: Human Communities and the Environment

Lesson 16: Human Communities and the Environment

- **Introduction**: Human population growth is the root cause of most environmental issues, leading to negative environmental, economic, and social impacts. The global population of over 7.8

billion is growing, projected to reach over 9 billion by 2040 and 11 billion by 2100, which outpaces the planet's carrying capacity.

- **Factors Responsible for Human Population Growth**:
  - **Increase in agricultural productivity**: Modern techniques (agrochemicals, machinery) led to a multi-fold increase in yield, supporting a larger population.
  - **Decrease in death rate and infant mortality rate**: Advances in medical facilities, including improved medicines and vaccines.
  - **Advancement in Science and Technology**: Fuelled industrial revolution, providing a surplus of resources.
  - **Lack of awareness**: Illiteracy, poverty, and insufficient knowledge about the negative impacts of a large population, as well as limited awareness and use of family planning methods.
- **Impacts of Human Population Growth on Environment, Human Health, and Welfare**:
  - **Deforestation**: Increased demand for food, space, and energy leads to clearing forests for agriculture, urbanization, infrastructure, and industrialization. This reduces carbon dioxide absorption, contributing to global climate change.

- **Biodiversity Loss**: Decline in forest cover and habitats results in a decrease in floral and faunal biodiversity, ecological imbalance, and loss of biological resources.
- **Urbanisation**: Rapid growth leads to depletion of natural resources in urban areas and inadequate sanitation/drinking water, causing adverse health impacts.
- **Industrialisation**: Establishment of industries (e.g., fertilizers, steel, chemicals) to support population needs causes environmental degradation, land-use change, and pollution, with toxic pollutants affecting respiratory health.
- **Land Degradation**: Intensive farming, excessive agrochemicals, and overexploitation of land/water resources lead to soil erosion, salination, and desertification.
- **Generation of Waste**: Large human populations generate massive amounts of solid and liquid waste, with detrimental environmental and health impacts.
- **Loss of Fresh Water**: Overexploitation of surface and groundwater causes a decline in available freshwater resources and scarcity issues; two-thirds of the world's population is projected to face water shortages by 2025.
- **Climate Change**: Overpopulation and excessive fossil fuel use increase atmospheric gaseous pollutants, including greenhouse gases.

- **Transport Infrastructure**: Development leads to the release of poisonous gases (carbon monoxide, nitrogen oxides) and oil spills from ports/harbors, affecting marine biodiversity.
- **Productivity**: Environmental degradation reduces economic productivity by causing diseases (from polluted air/water) and affecting fisheries/agriculture. Soil degradation leads to siltation of reservoirs and canals.

- **Steps for Population Control (in India)**:
  - **Minimum Age of Marriage**: Effective implementation and public awareness of laws (21 for men, 18 for women).
  - **Better Education**: Changes people's outlook, encouraging delayed marriage and smaller family norms.
  - **More Employment Opportunities**: Improves income and living standards, fostering adoption of small family norms.
  - **Family Planning**: Increasing awareness and easy availability of various family planning methods.
  - **Incentives**: Government can provide monetary incentives, tax benefits, and work-related facilities (leave, promotion) for adopting small family norms.
- **Carbon Footprint**: **The amount of greenhouse gases (mainly carbon dioxide) released into the atmosphere by any human activity**. It is a measure of environmental impact by individuals, organizations, industries, or nations.

- **Reduction Strategies**: Using environment-friendly vehicles (battery-operated), public transportation, energy-efficient appliances, insulating homes, and consuming local/organic food. Carbon offsets (purchasing carbon credits for initiatives like tree planting or renewable energy) can also reduce a footprint.

- **Resettlement and Rehabilitation (R&R) of Developmental Project Affected Persons and Communities**:
  - **Causes of Displacement**: Large-scale developmental projects (mining, dams, industries), political conflicts, natural disasters, or designation of protected areas (National Parks, Sanctuaries, Biosphere Reserves).
  - **Policy**: India implemented a national policy on R&R in 2004, followed by the National Rehabilitation and Resettlement Policy, 2007 (NRRP-2007).
  - **Challenges**: Displacement leads to severe economic, social, and environmental problems, including loss of productive skills, employment, and disruption of social fabric. Regional issues and administrative delays complicate programs.
  - **Aim**: Minimize involuntary resettlement, provide a time-bound plan, and offer compensation for affected land and assets.
- **CNG (Compressed Natural Gas) Vehicles Initiative in Delhi**:

- **Context**: Delhi is one of the most polluted cities globally. Vehicular and industrial pollution, along with Yamuna River pollution, are major concerns.
- **Initiative**: Following a court order (PIL), CNG conversion became mandatory for commercial vehicles (taxis, buses, three-wheelers) from July 1998. Polluting industries were shifted, and the Yamuna River cleaning operation launched. There are plans to introduce hydrogen-enriched CNG buses.
- **Advantages of CNG**: Can be generated and used for bulk storage/pipeline transport of renewable energy; can be mixed with biomethane (from biogas/landfills). This allows mobility without increasing atmospheric carbon and ensures continued use of CNG vehicles even with stricter CO2 emission regulations.
- **Limitations of CNG**: Challenges in fuel storage (requires high-pressure cylinders, taking up more space) and infrastructure for delivery/distribution.

Lesson 17: Environmental Movements in India

- **Introduction**: Environmental and ecological movements are collective actions by social groups focusing on basic survival issues and larger ecological concerns. They reflect an expanded

vision of economics and politics, seeking economic justice, enhanced quality of life, dignity, and participation in decision-making regarding natural resources. These movements gained global attention after the **1972 United Nations Conference on Human Environment in Stockholm**.

- **Bishnoi Movement**:
  - **Year**: 1700s.
  - **Place**: Khejarli, Marwar region, Rajasthan.
  - **Leaders**: **Amrita Devi** and Bishnoi villagers.
  - **Aim**: To save sacred trees from being cut by the king's soldiers for a new palace. Amrita Devi and 363 villagers died hugging trees to protect them. The movement was influenced by Guru Maharaj Jambaji's teachings (1485) forbidding harm to trees and animals.
  - **Outcome**: The king apologized and designated the Bishnoi state as a protected area, a legislation that still exists.
- **Chipko Movement**:
  - **Year**: 1973.
  - **Place**: Chamoli district, and later Tehri-Garhwal district, Uttarakhand.
  - **Leaders**: Noted environmentalist **Sundarlal Bahuguna**, Gaura Devi, Sudesha Devi, Bachni Devi, Chandi Prasad Bhatt, and others.

- **Aim**: To safeguard the rich forests of the Western Himalayan Range from contractors' axes. Bahuguna educated villagers on the importance of trees for soil erosion control, rain, and pure air. Women famously **"hugged the trees"** (Chipko means "to stick").
- **Outcome**: The movement demanded that forest benefits go to local people. It gained momentum in 1978, leading to a committee ruling in favour of the villagers, which became a turning point in eco-development struggles.

- **Save Silent Valley Movement**:
  - **Year**: 1978.
  - **Place**: Silent Valley, an evergreen tropical forest in Palakkad district, Kerala.
  - **Leaders**: The **Kerala Sastra Sahitya Parishad (KSSP)**, an NGO, and poet-activist **Sughathakumari**.
  - **Aim**: To protect the forest from destruction by a proposed hydroelectric dam across the Kunthipuzha River.
  - **Outcome**: Public pressure led Prime Minister Indira Gandhi to declare Silent Valley protected in January 1981. The hydroelectric project was called off in November 1983, and the Silent Valley National Park was formally inaugurated in 1985.
- **Appiko Movement**:

- **Year**: 1983.
- **Place**: Uttara Kannada and Shimoga districts of Karnataka State.
- **Leaders**: Facilitated by **Pandurang Hegde**.
- **Aim**: Against the felling and commercialisation of natural forests and the ruining of ancient livelihoods.
- **Techniques**: Locally known as "Appiko Chaluvali," it was the **southern version of the Chipko movement**, where locals embraced trees. It used various awareness techniques like foot marches, slide shows, folk dances, and street plays. The movement promoted afforestation and later focused on rational use of the ecosphere through alternative energy resources.
- **Outcome**: The movement was successful, and the project was stopped.

- **Narmada Bachao Andolan (NBA)**:
  - **Year**: Begun in the late 1970s, prominent from 1985.
  - **Place**: Narmada River, flowing through Gujarat, Madhya Pradesh, and Maharashtra.
  - **Leaders**: **Medha Patker**, Baba Amte, adivasis, farmers, environmentalists, and human rights activists.
  - **Aim**: A social movement against the construction of a number of large dams (e.g., Sardar Sarovar Dam) across the

Narmada River. Initially focused on the lack of proper rehabilitation and resettlement for displaced people, it later broadened to preserving the environment and ecosystems of the valley.

- **Outcome**: The World Bank withdrew from the project. In October 2000, the Supreme Court approved dam construction but limited the height to 90m (lower than proposed 130m). The project is now largely financed by state governments and market borrowings, expected to be fully completed by 2025.

Lesson 18: Disaster Management

- **Introduction**: India is highly vulnerable to various natural disasters (floods, droughts, cyclones, earthquakes, landslides, forest fires) and human-made disasters (fire, epidemics, chemical leakages). A **disaster** is a severe event that causes widespread human, material, economic, or environmental loss beyond the affected community's coping ability. Disaster management involves effectively preparing for and responding to disasters, coordinating resources, and systematically managing prevention, preparedness, response, and recovery responsibilities.
- **Key Concepts**:

- **Post Disaster Management**: A **reactive mechanism** focused on rebuilding after a disaster. It involves immediate problems like evacuation, warnings, search and rescue, relief, and shelter. Its goals include identifying key issues, establishing partnerships, developing recovery strategies, directing resources, and identifying pre-disaster mitigation projects.
- **Disaster Mitigation**: A **proactive approach** that involves sustained actions to reduce the long-term vulnerability of human life and property to natural hazards. It aims to eliminate or drastically reduce the direct effects of a hazard.
- **Disaster Preparedness**: Focuses on plans to respond to a disaster threat or occurrence, estimating emergency needs, identifying resources, and preparing response plans. It aims to reduce disaster impact, improve the capacity of affected populations, and guide reconstruction to reduce vulnerability.

- **Multi-Disciplinary and Multi-Sectoral Nature**: Disaster management is multidisciplinary (involving forecasting, warning, evacuation, relief, reconstruction) and multi-sectoral (involving administrators, scientists, planners, volunteers, and communities). In India's federal structure, the **State Government primarily handles disaster management**, with the Central Government supplementing efforts for large-scale disasters.

- **Guidelines for Effective Management of Mitigation Programs**:
  - The **National Disaster Management Authority (NDMA)**, headed by the Prime Minister of India, is the apex body.
  - Pre-disaster mitigation is crucial for faster recovery.
  - Mitigation measures must protect natural and cultural assets.
  - Hazard reduction methods should consider community needs and priorities.
  - Effective partnerships between government, scientific community, private sector, NGOs, and the community are essential.
- **Main Elements of a Mitigation Strategy**:
  - **Risk Assessment and Vulnerability Analysis**: Identifying hotspot areas, collecting data on past hazards, population, and infrastructure.
  - **Applied Research and Technology Transfer**: Upgrading observation and warning systems, improving forecasting.
  - **Public Awareness and Training**: Training officials and staff involved in disaster management.
  - **Institutional Mechanisms**: Emphasizing proactive measures and having a permanent administrative structure (e.g., National Disaster Management Centre - NDMC).
  - **Incentives and Resources**: Ensuring stable funding for mitigation programs.

- **Land Use Planning and Regulations**: Restricting development in high-risk areas (e.g., floodplains).
- **Hazard Resistant Design and Construction**: Promoting techniques for building structures that can withstand disasters.
- **Structural and Constructional Reinforcement**: Adapting existing buildings to reduce vulnerability (e.g., inserting walls, designing electrical equipment above flood level).

- **Causes, Effects, and Mitigation Measures of Disasters in India**:
  - **Floods**:
    - **Causes**: Inadequate river capacity, bank erosion, silting, landslides obstructing flow, tidal effects, poor drainage, cyclones, and heavy rainfall. Human activities like deforestation and shifting cultivation also contribute. India is one of the most affected countries.
    - **Effects**: Inundation of houses and properties, damage to crops and livestock, and severe suffering for people in low-lying areas.
    - **Mitigation Measures**:
      - **Structural**: Reservoirs, embankments, flood walls, channel improvement, improved drainage, floodwater diversion.

        - **Non-Structural (Flood-Plain Management)**: Floodplain zoning, flood proofing, maintaining wetlands, flood forecasting and warning, disaster relief, public health measures, and flood insurance.
    - **Post-Flood Management**: Includes rapid restoration of infrastructure (roads, communication, utilities), supply of food/shelter/clothing, assessing losses, assisting property repair, desilting, and agricultural contingency plans. During/after floods, rescue operations, relief camps, basic amenities, air-dropping food, cattle camps, emergency relief, daily reporting, and rehabilitation are crucial.
- **Earthquakes**:
    - **Causes**: Abrupt release of energy from rocks/Earth's crust due to tectonic processes.
    - **Prediction**: No definitive way to predict. However, geophysical/geochemical parameters like land deformation, foreshocks, changes in seismic wave velocity, electrical resistivity, and radon gas increases are observed as precursors.
    - **Mitigation**: Constructing quake-proof houses, ensuring infrastructure withstands earthquakes. NGOs play a

vital role in rescue and rehabilitation due to their manpower, informality, and community reach. Coordination between government, NGOs, and local communities is essential.

- **Cyclones**:
  - **Definition**: Intense depressions forming over oceans, moving towards land.
  - **Prone Regions**: Indian Ocean is one of six major cyclone-prone regions. India's long coastline is exposed, with the eastern coast being more prone. Occur mainly between April-May and October-December in India.
  - **Damage**: Depends on intensity, affecting human life, crops, settlements, and infrastructure.
  - **Mitigation Focus**: Reducing the impact of high-speed winds, storm surges, and floods. This involves understanding cyclone mechanisms, detection, prediction, timely warnings, preparedness measures, relief, rehabilitation, and integrated hazard mitigation policies.
  - **Measures**: Early warning systems, communication infrastructure, shelter belts, permanent houses, and training on land use and settlement planning.

- **Landslides**:
  - **Definition**: Geological process of mass movements (rock falls, slope failures, debris flows).
  - **Causes**: Primarily gravity on oversteepened slopes, exacerbated by erosion, intensive construction, changes in slope composition/structure/hydrology/vegetation, climate/weather, land use changes, and earthquakes.
  - **Mitigation**: Drainage measures, erosion control (bamboo check dams, terracing), rock fall control (grass plantation, masonry walls), preventing deforestation, and improving forestation. Reducing population exposure and physical control are also important.
- **Tsunami**:
  - **Definition**: "Harbor wave" in Japanese. Generated by abrupt seafloor deformation (undersea earthquakes, volcanic eruptions, landslides) vertically displacing water.
  - **Characteristics**: Travel at high speeds (over 800 km/h) across oceans. Near shore, they compress into powerful waves up to 30m high, causing massive destruction.
  - **Case Study (2004 Indian Ocean Tsunami)**: Caused by a 9.0 Richter earthquake off Sumatra. Led to approximately 187,000 deaths and 43,000 missing, with

severe impacts on coastal areas, homes, and schools, especially in Aceh, Indonesia. Lack of effective warning systems meant many did not recognize receding sea as a danger sign.

- **Disaster Management in India (Overall)**: India has shifted from a reactive, relief-based approach to a proactive one emphasizing prevention, mitigation, preparedness, relief, response, reconstruction, and rehabilitation. The nodal ministry for disaster management shifted from Agriculture to Home Affairs in 2002. The **Disaster Management Act 2005** established a joint responsibility for Central and State Governments, creating dedicated institutional mechanisms and funding at national, state, and district levels, including Disaster Management Authorities and specialized response forces. The mission is to build a **Disaster Resilient Community**.

Lesson 19: Practical Understanding of Environmental Science

- **Learning Objectives**: To understand primary concepts of practicals related to basic environment.
- **Visit to a Local Area to Document Environmental Assets (River/Forest/Grasslands/Hill/Mountain)**:

- **Purpose**: To gain a deeper appreciation of an ecosystem's value (natural resources, ecological functions, tourism, aesthetic appeal). Understanding how different cultures and socio-economic groups use ecosystems provides varied perspectives (e.g., tribal vs. urban, men vs. women). Field visits help connect individuals to nature and foster a desire for conservation.
- **Guidelines**:
  - **Two parts**: Document observations and findings from interviews with local user groups.
  - **Key Questions to Answer**: What are the ecosystem's natural resource assets? Who uses them and how? Is the ecosystem degraded, and how? How can it be conserved?.
  - **Methodology**: Observe abiotic and biotic aspects, document what is seen, ask about sustainable vs. unsustainable utilization, look for signs of degradation, and study conservation aspects. Describe the ecosystem's structural nature, quality, geographical features, and plant/animal life. Understand ecosystem function, including linkages and food chains. Interact with local residents to understand utilization patterns, degradation causes, and potential restoration measures.

- **General Features to Document**: Aims, Objectives, Methodology, Observations on the site, Findings from interviews with local people, Results, and Conclusions.
- **Special Resource Features**: Document specific features to create an environmental profile of an area, appreciating its goods and services.

- **Specific Ecosystem Documentation Guidelines**:
  - **River Ecosystem**: Observe local resource use (drinking water, domestic needs, fishing, grazing, irrigation). Map land use around the river, assess water resource importance. Compare clean vs. polluted stretches, identify pollution sources (domestic sewage, agricultural runoff, industrial effluents). Document impact on fish catch. Record flow type, quality, aquatic life, land use patterns. Ask about water potability, pollution extent, efforts to clean, sustainability, historical changes, flood effects, and public awareness.
  - **Forest**: Assess local resource collection (fruits, leaves, roots, fuelwood, timber, honey, medicinal products). Look for signs of forest use (human/animal tracks, lopped branches, cut stumps, overgrazing) and degradation (canopy loss, wasteland formation, soil erosion). Identify forest type (evergreen, deciduous,

thorn), natural vs. plantation, and qualitative aspects (undisturbed, degraded). List natural resources (goods/services) and extent of use. Map the area, provide historical profile, discuss causes of overuse (population, greed), protection, and restoration potential.

- **Grassland**: Discuss local utilization (grazing, fodder, fuelwood). Assess carrying capacity. Map land use patterns (grazing areas, water sources, fuelwood collection). Document degradation by comparing protected/degraded areas and historical changes. Identify grassland type, soil, plant/animal species, and seasonal changes. Estimate extent of grazing, fodder collection, and productivity. Discuss sustainability, burning practices, and rotation grazing.

- **Visit to a Local Polluted Site (Urban/Rural/Industrial/Agricultural)**:
  - **Types of Pollution**: Can affect air (smoke, gases), water (urban sewage, industrial chemicals, agricultural pesticides), soil (chemicals, solid waste), and biodiversity.
  - **General Observations**: Identify site type, geographical characteristics, users, ownership, and map the area. Identify polluted medium (air, water, soil), cause(s), and polluting

agent(s). Assess pollution extent (severe/moderate/slight/nil) and related health aspects.

- **Solid Waste Study**: Observe garbage dumping areas (urban/rural), linking it to population increase and non-biodegradable goods. Analyze waste from households (domestic/municipal), agriculture (biomass, farm residues, fertilizers, pesticides), industries (chemicals, mining waste), and hospitals (pathogen-containing, sharps). Note proper disposal methods like waste separation, autoclaving, or incineration for hospital waste.
- **Water Pollution Study**: Assess pollution level (unpolluted to severely polluted) by visual inspection and water monitoring kits. Document pollution sources (urban garbage, industrial discharge, agricultural runoff) and their characteristics (color, odor). Ask locals (e.g., fishermen) about impacts.
- **Air Pollution Study**: Focus on cities (traffic congestion) and industrial areas (gaseous emissions). Document effects on local residents and discuss ways to reduce pollution and raise public awareness.

- **Study of Common Plants, Insects, Birds**:

- **Approach**: These taxa are chosen as they are widely available for observation. Use a journal, binoculars, and field guides.
- **Plants**: Identify and list common species (e.g., 10 trees, 5 shrubs, 5 herbs) and their abundance. Identify rare species and document characteristic features (leaves, flowers, fruit, seeds). Describe each plant's role in the ecosystem, its use by people, sustainability of collection, commonality/rarity, and whether it's a keystone species.
- **Animals**: Identify and list at least 10 species for each group (insects, birds, mammals if possible). Document field identification features, their role in the ecosystem (producer, herbivore, carnivore, decomposer, pollinator, pest), and abundance. Observe linkages within food chains and the food web. Document species habits (feeding, nesting, breeding, territorial behavior). Research their distribution and current status (e.g., endangered list).

- **Study of Simple Ecosystems (General Guidelines)**:
  - **Key Questions for Ecosystem Field Visits**: Identify ecosystem type, its abiotic/biotic characteristics. Assess misuse/overuse of goods/services and signs of degradation (deforestation, water pollution, soil erosion). Consider how

personal habits (saving water, electricity) can prevent degradation.

- **Observing Cycles**:
  - **Water Cycle**: Observe how vegetation indicates rainfall levels and how rain percolates to recharge groundwater. Note signs of soil erosion (brown water) and its long-term effects.
  - **Carbon Cycle**: Understand plants' role in taking up carbon dioxide and releasing oxygen, and their importance for human survival.
  - **Oxygen Cycle**: Appreciate the role of green plant material in producing oxygen through photosynthesis, driven by sunlight.
  - **Nitrogen Cycle**: Observe decomposition of organic matter (dried leaves) by organisms (ants, beetles, worms, bacteria, fungi) that convert it into nutrients for plants.
  - **Energy Cycle**: Identify different trophic levels (insects, birds) forming food chains, which interlink into a food web. Note the relative abundance of plants, herbivores, and carnivores, forming a food pyramid.
- **Forest Field Visit**: Classify forest type (coniferous, deciduous, evergreen, thorn, mangrove) and interpret

connections between abiotic factors (temperature, rainfall, soil) and biotic aspects (vegetation). Understand food chains and food pyramids by observing species abundance and classifying animals. Identify structural levels (ground, trunk, branches, canopy) and micro-habitats for various species. Reconstruct food chains and the food web based on observations.

- **Grassland Field Visit**: Observe plant/animal life and their food sources. Describe seasonal changes in the grassland and grass conditions. Estimate the abundance of insects (grasshoppers, ants, beetles) versus first-order consumers (birds, mammals) and predators (raptors). Conduct birdwatching and observe the insect world, including spider webs and behavior. Document animal behavior and identify food chains.
- **Desert and Semi-Arid Areas Field Visit**: Observe the sparse but specialized vegetation and limited animal species. Identify birds and insects, noting how they utilize this harsh environment and their food sources. Look for typical species like dung beetles, birds of prey, and rare species like the Great Indian Bustard or wolf.
- **Aquatic Ecosystems Field Visit (Pond/Lake/River/Seacoast)**:

- **Pond Ecology**: Observe seasonal changes in plant and animal life. Identify vegetation zones (grasses, emergent reeds, floating, underwater plants). Document different phases of the pond (early, active, shrinking, dry) and microscopic life (algae, zooplankton) forming food chains.
- **Lake Ecosystem**: Document how water birds use various habitats (shore, water), specializing in food types and feeding depths. Create a checklist of visible aquatic flora and fauna, identify abundant species, and observe food chains.
- **Wetland**: Observe varied vegetation zones, water clarity/turbidity, algal growth, and bed composition. Map vegetation patterns and their relationship to aquatic bird species. Interview local fishermen about fish catch.
- **Beach**: Observe different beach types (sandy, rocky, muddy) and specific species adapted to these niches, such as crabs making holes or shore birds feeding.
- **River**: Document the river as a dynamic system, noting seasonal flow fluctuations and how life depends on its integrity.

- **Hill/Mountains**: Understand how the ecosystem is linked to altitude, slope, soil, vegetation, and animal life. Note different vegetation patterns and seasonal habitat changes. Describe plants, animals, food chains, and biogeochemical cycles (water, nitrogen, energy, detritus). Consider hypothetical scenarios like the impact of removing domestic grazing animals or all vegetation.