L1: Introduction to Environmental Science

TOPIC OVERVIEW

1.1 Environmental Science
1.2 Relevance of Environmental Science
1.3 Learning Environmental Science
1.4 Key Concepts of Environmental Science

Environmental Science

- Aims to understand, analyze, and solve environmental problems using scientific methods and ethical principles.
- Fosters the environmental awareness, literacy, and citizenship among the people, which are essential for environmental action and advocacy.

Relevance Environmental Science

1. John Muir (early 20th century)

- A Naturalist and Writer that helped establish Yosemite National Park.
- Founder of Sierra Club.
- Considered as the "Father of the National Parks" for his advocacy for wilderness preservation.

2. Aldo Leopold (1949)

- Wrote the "A Sand County Almanac" which introduced the "land ethic."
- Land Ethic - A philosophy that argues that humans should view themselves as part of a community that includes the land, not separate from it.

3. Rachel Carson (1962)

- Published the book "Silent Spring", that brought awareness to the dangers of pesticides, especially DDT (dichloro-diphenyl-trichloroethane)
- Her work is often credited with launching the modern environmental movement.

4. Garrett Hardin (1968)

- described the "Tragedy of the Commons", as an economic theory where individuals acting in their own interest deplete a shared resource, even when it's not in the long-term best interest.

Tragedy of the Commons

- → **individuals exploit shared resources such that demand greatly outweighs supply, and the resources become unavailable for the whole.**
- → **External Cost or Externality – all of the benefits but none of the responsibility or cost for the degradation.**
- → **The failure to preserve the natural resource for short term gain and self interest**

5. James Lovelock (1970s)

- ➢ Proposed the "Gaia Hypothesis", which suggests that living organisms and their inorganic surroundings on Earth are part of a single self-regulating system that maintains the conditions for life.

Learning Environmental Science

- ❖ the study of how humans interact with the environment.
- ❖ highly interdisciplinary field, drawing from biology, chemistry, physics, geology, and even social sciences like economics and political science.
- ❖ Focus – concepts and understanding it through an interdisciplinary lens. Analyzing human impact on the issue and how we can provide solutions or innovations.

Key Concepts of Environmental Science

1. Sustainability
   - ➢ The ability to meet the needs of the present without compromising the ability of future generations to meet their own needs.
   - ➢ Example: Water conservation, Green Building, Renewable energy

2. Carrying Capacity
   - ➢ The maximum population size of a biological species that can be sustained by a specific environment.

3. Ecological Footprint
   - ➢ A measure of humanity's demand on nature (global hectares).
   - ➢ Quantifies the amount of land and water area a human population requires to produce the resources it consumes and to absorb its wastes.
   - ➢ Biggest ecological footprint - Americans 9.5
   - ➢ Smallest ecological footprint - africans <1

L2: Principles of Ecology

TOPIC OVERVIEW

1.1 Ecological Levels of Organization
1.2 Energy FLow in the Ecosystem
1.3 Ecological Interactions
1.4 Biochemical Cycles
1.5 Ecological Succession

Ecological Levels of Organization

- **Individual/Organism** - A single, individual living thing.
- **Population** - Group of Individuals of the same species living in the same area.
- **Community** - All the different populations of different species that live and interact in the same area.
- **Ecosystem** - Community of organisms and their non-living (abiotic) environment. Includes things like water, and soil.
- **Biome** - Large-scale area on Earth with a similar climate, plants, and animals.
- **Biosphere** - Sum of all ecosystems on Earth, representing all life and where it exists.

Energy Flow in Ecosystem

Transfer of energy from one organism to another and how much energy is being transferred.

Tropic Levels:

- ★ **Producers (Autotrophs)** - Organisms that create their own food, usually through photosynthesis. (e.g. plants)
- ★ **Consumers (Heterotrophs)** - organisms that get energy by eating other organisms.
  - ❖ **Primary Consumers (Herbivores)** - Eat producers
  - ❖ **Secondary Consumers (Carnivores/Omnivores)** - Eat primary consumers.
  - ❖ **Tertiary Consumers** - Eat secondary consumers.
- ★ **Decomposers** - Break down dead organic materials, returning nutrients to the soil (e.g. fungi, bacteria).

How Energy is Transferred from one tropic level to another

- **Food Chain**- a simple, linear path of energy flow.
- **Food Web**- A complex network of interconnected food chains. Most ecosystems are represented by food webs.
- **The 10% Rule** - only about 10% of the energy from one trophic level to another is transferred to the next. The rest is lost as heat.

Ecological Interactions

Different living things also interact with one another, resulting in different kinds of relationships.

These interactions can be beneficial, harmful, or neutral for each species involved.

This is crucial in maintaining the balance and structure of an Ecosystem.

Species A	Species B	Interaction
+	+	Mutualism
-	-	Competition
+	-	Predation
+	-	Parasitism
+	o	Commensalism
-	o	Amensalism

- **Mutualism** - Interaction where both species benefit. **"Win-win"** relationship. (e.g. pollination, clownfish and sea anemone)
- **Competition** - interaction where both species are negatively affected as they compete for the same limited resources (food, water, or territory). **"Lose-lose"** situation. (e.g lion and cheetah competing for the same prey)
- **Commensalism** - interaction where one species benefits, and the other is neither helped nor harmed. **"Win-neutral"** relationship. (e.g. barnacles on a whale)
- **Parasitism** - interaction where one species (parasite) benefits by living in or in another species (host), causing harm to the host. (e.g. fleas on a dog)
- **Amensalism** - interaction where one species is harmed, and the other is neither helped nor harmed. **"Neutral-lose"** relationship. (e.g. stepping on grass)
- **Predator** - interaction where one species (predator) kills and eats another species (prey). Predation is not always a negative force in an ecosystem; it is a critical part of population control. (e.g. A lian and a zebra)

Biogeochemical Cycles

- Aside from energy, we also need other materials in order to survive. Our overall survival depends on certain materials that are found in the environment.
- The pathways by which chemical substances (like carbon, nitrogen, and phosphorus) cycle between the living (biotic) and non-living (abiotic) components of the earth.
- Essential for life, as they move key nutrients and elements through the environment.

1. Carbon Cycle

- Movement of carbon through the atmosphere, oceans, soil, and living things. Carbon is a building block of all organic molecules.
- **Key Processes**
  - ★ **Photosynthesis** - plants take carbon dioxide (CO_2) from the atmosphere to make food.
  - ★ **Respiration** - Organisms release CO_2 back into the atmosphere when they breathe.
  - ★ **Decomposition** - Decomposers break down dead organisms, releasing carbon.
  - ★ **Combustion** - Burning of fossil fuels and wood releases CO_2 into the atmosphere.

2. Nitrogen Cycle

- Movement of nitrogen (N_2) through the environment and living organisms. Key component of proteins and nucleic acids (DNA and RNA)
- **Key Processes**
  - ★ **Nitrogen Fixation** - Bacteria in the soil or in plant roots convert atmospheric N_2 into

a usable form like ammonia (NH_3).

- ★ **Nitrification** - other bacteria convert ammonia into nitrates (NO_3), which plants can absorb.
- ★ **Denitrification** - bacteria convert nitrates back into atmospheric N_2.

3. Phosphorus Cycle

- ➢ Movement of phosphorus (P) through rock, soil, water, and living organisms. Key components of DNA, RNA, ATP (energy currency of cells), and cell membranes.
- ➢ **Key Processes**
  - ★ **Weathering** - As rocks break down, they release phosphorus into the soil and water.
  - ★ **Uptake** - plants absorb phosphorus from the soil.
  - ★ **Consumption** - Animals get phosphorus by eating plants or other animals.
  - ★ **Decomposition** - Decomposers return phosphorus to the soil.

4. Sulfur Cycle

- ➢ Movement of sulfur (S) through the geosphere, hydrosphere, and atmosphere. Component of several amino acids, essential for proteins.
- ➢ **Key Processes**
  - ★ **Weathering** - sulfur is released from rocks and minerals.
  - ★ **Volcanic Eruptions** - Volcanoes release sulfur dioxide (SO_2) into the atmosphere.
  - ★ **Decomposition**- decomposers release sulfur from decaying matter.
  - ★ **Combustion** - Burning fossil fuels releases sulfur into the atmosphere leading to acid.

5. Water Cycle

- ➢ Continuous movement of water on, above, and below the surface of the Earth. Driving force of all other biogeochemical cycles.
- ➢ **Key Processes**
  - ★ **Evaporation** - Water turns from liquid to gas and rises into the atmosphere.
  - ★ **Condensation** - water vapor cools and turns back into liquid droplets, forming clouds.
  - ★ **Precipitation** - water falls back to earth as rain, snow, or hail.
  - ★ **Transpiration** - water evaporates from the leaves of plants.
  - ★ **Runoff** - water flows over the land surface, often into rivers and oceans.

Ecological Succession

- ➢ Change is the only thing that is constant.
- ➢ Gradual and predictable process of change in the species composition of an ecological community over time.

➢ Series of changes in an ecosystem after a disturbance or when new land is formed.

1. Primary Succession

➢ Start in an area devoid of life and soil

2. Secondary Succession

➢ Area where a previously existing community has been disturbed but the soil remains intact.

L3:Ecosystem and Biomes

TOPIC OVERVIEW

1.1 Ecosystem, Habitat, and Biomes
1.2 List of Biomes
1.3 Aquatic Ecosystem

Ecosystem

➢ A community of living organisms (biotic factors) iterating with the non-living components (abiotic) of the environment.

➢ Smaller than a biome

Biome

➢ Large-scale region of the Earth with a distinct climate, flora, and fauna. It's a collection of many similar ecosystems.

➢ Biome is strongly influenced by its physical factors.

Habitat

➢ Shelter of living organisms.

Types of Biomes

1. Tundra

➢ **Coldest** of all biomes. Specific region

➢ Layer of permafrost (permanently frozen soil)

➢ Vegetarian is limited

➢ Animals adapted to extreme cold (e.g. thick fur, hibernation)

➢ **Limits**: Temperature, Permafrost, Nutrient-Poor Soil

2. Temperate Forest

➢ **Four distinct Seasons**: Summer, Cold winters, moderate spring, and autumn seasons.

➢ Rich, fertile soil. Soil is rich in nutrients due to the decomposition of fallen leaves.

➢ Dominated by deciduous trees. Lose their leaves in the autumn

➢ **Limits**: Seasonal temperature

3. Tropical Rainforest

- ➢ High rainfall and humidity all year around.
- ➢ Most biodiverse biome on Earth
- ➢ **Types of Tropical Rainforest:**

Dipterocarp Forest

- ★ Most common forest type in the Philippines
- ★ Dominated by species from dipterocarpaceae, known for their commercially valuable timber (Yakal and Lauan).
- ★ **Location**: Notably in Mindanao and Palawan.

Molave Forest

- ★ Found in areas with a distinct dry season.
- ★ Dry-type dipterocarp forest
- ★ Trees are typically smaller and have gnarled, crooked appearance (molave and narra)
- ★ **Location**: Central Luzon and parts of Visayas

Pine Forest

- ★ Found in cooler, mountainous regions, with higher elevations (above 100m)
- ★ Dominated by pine trees, have long, needle-like leaves that help them survive in drier, cooler conditions (Benguet Pine)
- ★ **Location**: Cordillera Administrative Region (CAR), Baguio, Benguet, and Mountain Province.

Mossy Forest

- ★ Highest elevations of mountains, shrouded in constraint mist and clouds.
- ★ Trees are stunted and gnarled, with branches, and trunks covered in thick layers of mosses, ferns, and orchids
- ★ Rare and endemic plants and animals, like pitcher plants and specific frogs.
- ★ **Location**: High-altitude peaks, Mount Apo (Davao) and Mount Pulag (Benguet)

- ➢ **Limits**: Light, Nutrients, Space

4. Grassland

- ➢ Dominated by grasses and non-woody plants.
- ➢ Enough rainfall to prevent desert formation but not enough to support a forest.
- ➢ Crafted or maintained by human activities like farming and burning
- ➢ **Limits**: Rainfall, Fire, Grazing

5. Desert

- ➢ Extreme low precipitation
- ➢ Plants have unique adaptations to conserve water
- ➢ **Hot Deserts**: High daytime temperatures, cold nights (e.g. Sahara Desert)
- ➢ **Cold Deserts**: Very cold winters (e.g., Gobi Desert)
- ➢ **Limits**: Water Availability, Extreme temperature, Nutrient-poor soil

Aquatic Ecosystems

- ➢ Ecosystems found in bodies of water.
- ➢ **Freshwater Ecosystems**: Characterized by low salt content. (e.g. rivers, lakes)
- ➢ **Marine Ecosystems**: Characterized by high salt content. (e.g. oceans, coral reefs)
- ➢ **Importance**: Philippines is an Archipelago. Vital for food, livelihoods, and coastal protection.

- Major part of our national identity.

Types of Aquatic Ecosystem

1. Coastal and Marine Ecosystem

- Oceans, seas, and the areas where land meets the sea.
- Light, temperature, and pressure vary greatly with depth.
- **Importance**: Most diverse in the world. Supports our fishing industry and coastal communities.
- **Limits**: Light, Pressure and Temperature

2. Coral Reefs

- Rainforest of the sea due to immense biodiversity.
- Time marine animals called corals which have symbiotic relationships with algae.
- Highly sensitive to pollution, overfishing, and climate change.
- **Importance**: Major source of food and income from fishing and tourism (e.g. Tubbataha Reefs Natural Park)
- **Limits:** Water temperature, Ocean Acidity

3. Mangrove Forest

- Forests that grow in salty coastal water, in intertidal zones.
- Trees have specialized root systems, can filter salt and help them breathe in low-oxygen soil.
- **Ecological Role:** Natural storm barrier, protects coastal communities from typhoons and tsunamis, serves as nursery for many fishes.
- **Location**: Along the coasts of Palawan, Bohol, and other islands
- **Limit:** Salinity, Tidal Action

4. Seagrass Beds

- Underwater meadows of flowering plants.
- Shallow, clear, sheltered coastal waters.
- **Ecological role**: Providing food for endangered marine animals (dugong and sea turtles). Habitat and nursery ground for juvenile fish and invertebrates.
- **Location**: Philippine archipelago, palawan, and mindanao
- **Limits**: Water Clarity, Nutrient levels.

5. Freshwater Ecosystem

- Ecosystems with low salt content. Water comes from groundwater, rainfall or snowmelt in mountains.
- Rivers, lakes, and ponds
- Drinking water, agriculture, and industry.
- **Examples**: Lakes (Laguna de Bay, largest lake), Taal Lake, and Lake Lanao. Rivers (The Cagayan River, the country's longest) and the Pasig River.
- **Limits**: Pollution, Dissolve Oxygen

L4: Biodiversity and Conservation

TOPIC OVERVIEW

1.1 Biodiversity
1.2 Levels of Biodiversity
1.3 Philippine Endemic Species and Flora
1.4 Threats to biodiversity
1.5 Conservation Strategies

Biodiversity

- Variety of life on Earth of all levels, from genes to the entire ecosystem.
- It's not just about the number of species, but also interactions and the complexity of life.

Levels of Biodiversity

1. Genetic Diversity

- The variation of genes within a species.
- Ability to adapt to new diseases or climate change.
- **Example**: different rice grown in the Philippines.

2. Species Diversity

- Number and abundance of different species in a given area.
- Rainforest, and its thousands of plant and animal species, has a higher species diversity than a single-crop farm.
- **Example:** Philippines high number of unique plants and animals (philippine eagle and tamaraw)

3. Ecosystem Diversity

- Variety of habitats, communities, and ecological processes in a specific region.
- Forests, coral reefs, wetlands, grasslands, and deserts.
- **Example:** Diverse ecosystems of Philippines, vast tropical rainforests of Sierra Madre to the vibrant coral reefs of Tubbataha Reefs.

The Philippines: A Megadiverse Country

- The Philippines is one of only 18 megadiverse countries.
- Covers less than 0.5% of the world's land area, containing ⅔ of the Earth's biodiversity.
- Home to over 52,177 described species, with more being discovered.

A Global Biodiversity Hotspots

- Biodiversity Hostspots
- High concentration of endemic species and faces a high rate of habitat loss

Philippine Endemic Species

- Species that are native to and found only in a single geographic area.
- Have a very high number of these, making their loss even more critical as they can't be found anywhere.

1. The Philippine Eagle

- **Name:** Pithecophaga jefferyi
- **Status:** Critically Endangered (IUCN Red List)

- **Why It's Special:** World's largest forest raptor and the country's national bird. "Umbrella species"--protecting habitats also protects many other species.

2. Tamaraw

- **Name:** Bubalus mindorensis
- **Status:** Critically Endangered (IUCN Red List)
- **Why It's Special:** dwarf buffalo found only on the island of Mindoro. Population decimated by hunting and habitat loss.

3. Philippine Tarsier

- **Name:** Carlito Syrichta
- **Status:** Vulnerable (IUCN Red List)
- **Why It's Special:** Small primate is one of the smallest in the world. Has large, fixed eyes, and highly sensitive to noise and human contact.

Endemic Flora of the Philippines

1. Waling-Waling Orchid

- Stunning orchid native to Davao. It is often called the "Queen of Philippine flowers."

2. Jade Vine

- A striking, jade-colored flowering vine endemic to the Philippine rainforests. Its unique color is a rare sight in nature.

Why is biodiversity important?

- **Clean Air** - helps to purify our environment. Plants and trees absorb pollutants from the air and release oxygen, creating cleaner, and healthier air for us.
- **Pollination of crops and plants** - Pollinators (bees, butterflies, birds and bats) ensures that crops and wild plants can reproduce.
- **Pest and disease regulation** - variety of natural predators and competitors helps to keep pest populations in check (e.g. ladybugs eat aphids and birds eat crop-damaging insects).
- **Nutrient cycling** - Decomposers (fungi, bacteria, and insects) break down dead organic matter, returning essential nutrients (like carbon and nitrogen) to the soil.
- **Soil formation** - Tiny organisms (worms, bacteria and fungi) break down rocks and organic material.
- **Economic Value** - Source of food, medicine, and raw materials. Tourism and fisheries.
- **Survival of Life on Earth** - high-biodiversity environments are better for survival, increased resilience and adaptability. Less prone to collapse from threats like disease or climate change. Better to have multiple species to rely on.

Threats to Biodiversity

- The current rate of species extinction is estimated to be 100 to 1,000 times higher than the natural background rate.

- Entering a new mass extinction event, the sixth in Earth's history, driven by human actions.
- Threats due to human activities.
- Understanding effective conservation.

Human-Induced Threats to Biodiversity

1. Habitat Loss and Degradation

- **Description:** Destruction and fragmentation of natural habitat. Single biggest threat to biodiversity in the Philippines.
- **Primary Drivers:** Illegal logging, land conversion for agriculture, mining, and urbanization.
- **Case Study:** Mining in Palawan
- **Issue:** last ecological frontier, facing threats from mining operations.
- **Impact:** Soil erosion and the siltation of rivers and coastal areas. Palawan Forest Turtle.

2. Overexploitation

- **Description:** Unsustainable harvesting of resources.
- **Primary Drivers:** illegal wildlife trade, unsustainable fishing practices, and poaching.
- **Case Study:** The Illegal Wildlife Trade
- **Issue:** Major hub for illegal wildlife trade. species being poached for the exotic pet trade, traditional medicine, and food.
- **Example:** illegal trade of arachnids on social media.
- **Case Study:** Overfishing in the Coral Triangle
- **Issue:** global center of marine biodiversity but is severely threatened by overfishing.
- **Example:** dynamite and cyanide fishing.

3. Pollution

- **Description:** introduction of harmful substances into the environment.
- **Primary Drivers:** Plastic waste, chemical run-off, and oil spills.
- **Case Study:** Plastic Pollution in Manila Bay
- **Issue:** largest contributors to marine pollution.
- **Impact:** travel through rivers where it contaminates marine habitats and ingested by sea turtles.

4. Climate Change

- **Description:** Long-term shifts in temperatures and weather patterns.
- **Primary Drivers:** Greenhouse gas emissions from human activities.
- **Case Study:** Coral bleaching
- **Issue:** Rising sea temperatures, where coral expel the algae living in their tissues causing them to turn white.
- **Impact:** Collapse of the reef ecosystem and a loss of habitat for thousands of fish.

Conservation Strategies: Multi-faceted Approach

1. In-Situ Conservation

- Protecting species in the natural habitats.

- **Protected Areas**
  - **Legal Framework:** National Integrated Protected Areas System (NIPAS) Act of 1992 - legal protection for national parks, wildlife sanctuaries, and other natural monuments.
  - **Case Study:** Tubbataha Reefs Natural Park (Captive Breeding)
  - **Location:** Palawan
  - **Significance:** UNESCO World Heritage Site. Global Benchmark for marine conservation.
  - **Outcome:** Strict enforcement and a dedicated management plant.

2. Ex-Situ Conservation

- Protecting species outside their natural habitats.
- **Captive Breeding**
  - **Description:** Breeding endangered species in controlled environments.
  - **Goal:** eventually reintroduce them back into the wild.
  - **Case Study:** The Philippine Eagle Foundation
  - **Project:** successful captive breeding program for the critically endangered Philippine Eagle.
  - **Outcome:** some individuals being released back into protected forest areas.
- **Gene Banks and Seed Vaults**
  - **Description:** Storing genetic material (seed, tissue, sperm, etc.) in a controlled environment.
  - **Example:** International Rice Research Institution (IRRI) in Los Banos, Laguna, maintains a global gene bank of over 100,000 varieties of rice.

3. Community-Based Conservation

- **Description:** Empowering local and indigenous communities to manage and protect their traditional lands and resources.
- **Goal:** ensure conservation efforts are sustainable and benefit the people living in biodiversity-rich areas.
- **Case Study:** The Palawan Pangolin Project
- **Issue:** Critically endangered due to illegal trade.
- **Problem:** training and hiring former poachers as forest wardens
- **Case Study:** Yellowstone Wolves
- **Location:** Yellowstone National Park, USA
- **Issue:** The extinction of wolves led to an overpopulation of elk
- **Conservation:** Wolves were reintroduced in the 1990s. The trophic cascade restored the ecosystem, bringing back beavers, otters, and other species.

4. International Agreements

- **Convention on Biological Diversity (CBD):** International treat: conservation of biodiversity, sustainable use of its components,

and fair sharing of the benefits from genetic resources.

- International Union for Conservation of Nature (IUCN) Red List, comprehensive inventory of the global conservation status of biological species.

IUCN CONSERVATION CRITERIA OF BIODIVERSITY

IUCN Red List Categories

- **Critically Endangered (CR):** Extremely high risk of extinction in the wild.
- **Endangered (EN):** Very high risk of extinction in the wild.
- **Vulnerable (VU):** High risk of extinction in the wild.

Role of Students

- **Educate Yourself and Other:** Learn about local biodiversity and share your knowledge with friends and families.
- **Support Eco-Tourism:** Choose tourism operators that practice sustainable and ethical tourism.
- **Reduce, Reuse, Recycle:** Practice proper waste management to prevent plastic pollution from reaching our ecosystems.
- **Volunteer:** Join local environmental groups for clean-ups, tree-planting activities, or wildlife monitoring.
- **Advocates:** support policies and laws that protect the environment and hold corporations accountable for their environmental impact.

Conclusion: A Shared Responsibility

- It's a shared responsibility.
- Our actions, big or small, have a direct impact on the survival of our unique and beautiful ecosystems.
- Protecting our own future.