Unit 1: Introduction to Environmental Sustainability, Ecosystem and Biodiversity

Environmental Sustainability — DI02000051

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April 2, 2026

Unit 1 — Syllabus Coverage

Topics (Weightage: 10% | Hours: 4)

1.1 Definition & Scope of Sustainability
Structure and Function of Ecosystems
Food Chain, Food Web, Ecological Pyramids

1.2 Biogeochemical Cycles: Carbon, Nitrogen, Sulphur, Phosphorus

1.3 Importance of Biodiversity
Threats to Biodiversity
Conservation Strategies (in-situ & ex-situ)

GTU PYQ: Su'25, W'25 — MCQs + 4M + 7M descriptive

1.1 Environmental Sustainability

Definition · Scope · Ecosystems

What is Sustainability? (W'25, Su'25 MCQ — 1M)

Brundtland Definition (1987)

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Environmental

Protect natural resources, reduce pollution

Economic

Long-term growth without resource depletion

Social

Equity, health, well-being for all

Three Pillars of Sustainability: Environment + Economy + Society

Scope of Environmental Sustainability (W'25 — 4M)

Area	Scope / Focus
Natural Resources	Conservation of forests, water, soil, minerals
Energy	Shift to renewable; reduce fossil fuel dependence
Waste Management	Reduce, Reuse, Recycle (3R/5R)
Pollution Control	Air, water, soil, noise, e-waste management
Climate Change	Reduce GHG emissions; carbon neutrality
Biodiversity	Protect species, habitats, ecosystems
Policy & Law	Environmental acts, ISO 14000, green building

➥ **Goal**: Balance human development with ecological health for long-term survival.

Sustainable Development Goals (SDGs) (General — 3M)

UN SDGs 2030 — 17 Goals

Adopted by UN in 2015. Key environment-related goals:

SDG 6 — Clean Water & Sanitation
SDG 7 — Affordable Clean Energy
SDG 11 — Sustainable Cities
SDG 12 — Responsible Consumption
SDG 13 — Climate Action
SDG 14 — Life Below Water
SDG 15 — Life on Land

India's Steps:

- ➥ National Solar Mission
- ➥ Swachh Bharat Abhiyan
- ➥ FAME (Electric Vehicles)
- ➥ Namami Gange project
- ➥ National Action Plan on Climate Change (NAPCC)

What is an Ecosystem? (Su'25 MCQ, W'25 — 3M)

Definition

An **ecosystem** is a community of living organisms (*biotic*) interacting with each other and their non-living environment (*abiotic*) as a functional unit.

Biotic Components

- Producers (Plants)
- Consumers (Animals)
- Decomposers (Fungi, Bacteria)

Abiotic Components

- Sunlight, Temperature
- Water, Wind, Soil
- Minerals, Gases (CO_2, O_2)

Largest ecosystem on Earth = Oceans (Su'25 MCQ Answer: B)

Abiotic Components of an Ecosystem (W'25 — 3M)

Category	Components	Role
Climatic	Sunlight, Temperature, Rain	Energy source, habitat
Edaphic	Soil, Minerals, pH	Anchoring, nutrient supply
Aquatic	Water (rivers, lakes, sea)	Medium for life
Atmospheric	O_2, CO_2, N_2	Respiration, photosynthesis
Topographic	Altitude, Slope, Aspect	Microclimate variation

Key Point: Abiotic factors determine which organisms can survive in an ecosystem. They set the **physical limits** (temperature range, water availability, soil type).

Biotic Components: Producers, Consumers, Decomposers (Su'25 MCQ)

Producers

Autotrophs
Make own food via photosynthesis

Examples:
Green plants, Algae, Phytoplankton

Consumers

Heterotrophs
Primary: Herbivores
Secondary: Carnivores
Tertiary: Top predators

Humans = Primary & Secondary (Su'25 MCQ: C)

Decomposers

Saprotrophs
Break down dead organic matter

Examples:
Fungi, Bacteria
(Su'25 MCQ: C — Decomposers)

➥ **Most important element in biotic components = Carbon** (Su'25 MCQ: C)

Structure and Function of Ecosystem (W'25 — 4M)

Two Key Aspects

Structure	The composition of biotic & abiotic components and their arrangement
Function	Energy flow, nutrient cycling and population regulation

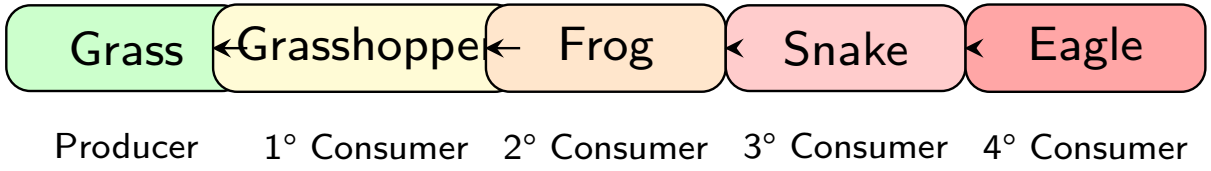
Functions of an Ecosystem

- **Energy Flow** — Sun → Producers → Consumers → Decomposers
- **Nutrient Cycling** — Biogeochemical cycles (C, N, S, P)
- **Productivity** — Primary (plants) & Secondary (animals)
- **Decomposition** — Breakdown of dead matter; nutrient return
- **Regulation** — Population control; disease regulation

Food Chain (Su'25, W'25 — 3M)

Definition

A **food chain** is the linear sequence of organisms through which energy and nutrients pass as one organism eats another.



Types: (1) **Grazing food chain** — starts with green plants. (2) **Detritus food chain** — starts with dead organic matter (detritus) → decomposers.

Food Web (Su'25, W'25 — 3M)

Definition

A **food web** is a network of interconnected food chains in an ecosystem. It shows the complex feeding relationships.

Food Chain vs Food Web

Food Chain	**Food Web**
Linear	Network
Single path	Multiple paths
Unstable	More stable
Few organisms	Many organisms

Significance

➥ Reflects real ecosystem complexity
➥ Removal of one organism affects many
➥ Provides alternative energy pathways
➥ More resilient to disturbance

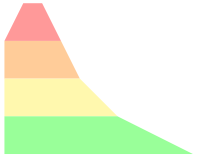
Humans in food web:
Primary AND secondary consumer
(omnivores — eat plants & animals)

Ecological Pyramids (W'25 — 4M)

Definition

A graphical representation of the number, biomass, or energy at each trophic level. Always wider at base (producers) and narrower at top.

Type	Represents	Shape
Pyramid of Numbers	Count of individuals	Usually upright
Pyramid of Biomass	Total dry weight	Usually upright
Pyramid of Energy	Energy (kcal) at each level	Always upright

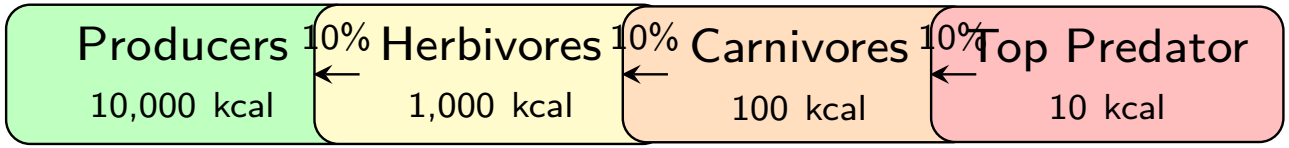


Tertiary (fewest)
Secondary consumers
Primary consumers
Producers (most)

Energy Flow in Ecosystem — 10% Law (W'25, Su'25 — 3M)

Lindeman's 10% Law (1942)

Only **10%** of the energy stored at one trophic level is transferred to the next level. The remaining **90%** is lost as heat (respiration, excretion, etc.).



➥ This is why food chains rarely exceed **4–5 trophic levels**.

➥ Sun provides the initial energy via **photosynthesis** (only ∼1% used by plants).

Types of Ecosystems (W'25, Su'25 — 4M)

Type	Sub-type	Key Feature
Terrestrial	Forest	High biodiversity, dense canopy
	Grassland	Moderate rainfall, grasses dominant
	Desert	Low rainfall, extreme temperature
Aquatic	Freshwater	Rivers, lakes, ponds
	Marine	Oceans — **largest ecosystem on Earth**
	Wetlands	Swamps, marshes; high productivity
Artificial	Cropland, Aquarium	Human-managed systems

Amazon Rainforest releases ≈20% of Earth's total oxygen (Su'25 MCQ: C).
Wetlands = "Kidneys of the Earth" due to natural water filtering.

1.2 Biogeochemical Cycles

Carbon · Nitrogen · Sulphur · Phosphorus

Biogeochemical Cycles — Overview (W'25 MCQ — 1M)

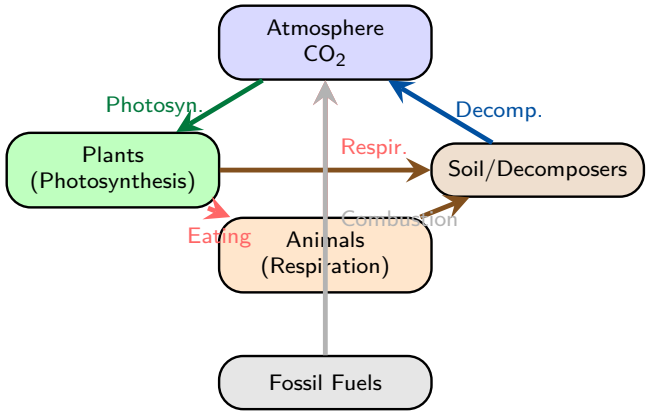
Definition

A **biogeochemical cycle** is the pathway by which a chemical element or molecule moves through both the biotic (biological) and abiotic (geological, hydrological, atmospheric) components of an ecosystem.

Cycle	Reservoir	Key Process
Carbon	Atmosphere, Oceans	Photosynthesis / Respiration
Nitrogen	Atmosphere (78% N_2)	Fixation / Denitrification
Sulphur	Rocks, Ocean sediments	Weathering / Decomposition
Phosphorus	Rocks, Soil, Sediments	Weathering / Uptake by plants

➥ **Nitrogen in atmosphere $\approx$ 78%** (Su'25 MCQ: C)

Carbon Cycle (Su'25, W'25 — 4M)



Key Processes

- **Photosynthesis:** Plants absorb CO_2
- **Respiration:** All organisms release CO_2
- **Decomposition:** Microbes release CO_2 from dead matter
- **Combustion:** Burning fossil fuels adds CO_2
- **Ocean uptake:** Oceans absorb CO_2

Human Impact

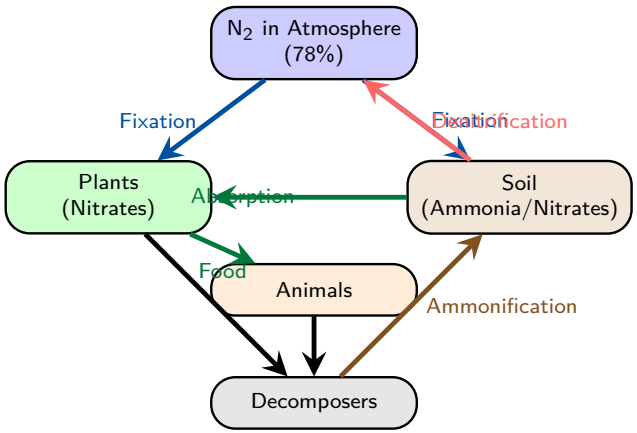
Burning coal/oil raises atmospheric CO_2
$\rightarrow$ Global Warming

Carbon Cycle — Steps & Facts (Exam Guide — 4M)

Step	Process	Description
1	Photosynthesis	$CO_2 + H_2O \xrightarrow{\text{sunlight}} \text{Glucose} + O_2$
2	Respiration	Organisms oxidise glucose $\rightarrow$ release CO_2
3	Decomposition	Bacteria/fungi break down dead matter $\rightarrow$ CO_2
4	Combustion	Fossil fuels burn $\rightarrow$ CO_2 to atmosphere
5	Carbon sequestration	Oceans, forests, soil store carbon
6	Fossilization	Dead organic matter $\rightarrow$ coal, oil (millions of yrs)

Carbon reservoirs: Atmosphere, Biosphere, Hydrosphere (oceans), Lithosphere (rocks/fossil fuels)
Pre-industrial CO_2: 280 ppm **Current:** >420 ppm (2024)

Nitrogen Cycle (Su'25, W'25 — 7M)



Key Steps

1. **Fixation:** $N_2 \rightarrow NH_3$ (Rhizobium bacteria)
2. **Nitrification:** $NH_3 \rightarrow NO_2^- \rightarrow NO_3^-$
3. **Assimilation:** Plants absorb NO_3^-
4. **Ammonification:** Dead matter $\rightarrow NH_3$
5. **Denitrification:** $NO_3^- \rightarrow N_2$ (back to air)

- N_2 = 78% of atmosphere
- Essential for proteins, DNA
- *Rhizobium* fixes N in legumes
- Lightning also fixes N

Nitrogen Cycle — Processes in Detail (W'25, Su'25 — 4M)

Process	Organism	Reaction / Description
Nitrogen Fixation	Rhizobium, Azotobacter	$N_2 \rightarrow NH_3$ (ammonia)
Ammonification	Decomposers	Dead organics $\rightarrow NH_4^+$
Nitrification	Nitrosomonas	$NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$
Assimilation	Green plants	NO_3^- absorbed as nutrients
Denitrification	Pseudomonas	$NO_3^- \rightarrow N_2$ released to air

Exam Quick Points

- **N_2 in atmosphere = 78%** (Su'25 MCQ: C)
- Most plants CANNOT use N_2 directly — needs fixation
- Legumes (beans, peas) have root nodules with *Rhizobium*

Sulphur Cycle (Su'25, W'25 — 4M)

Key Processes

1. **Weathering:** Rocks release SO_4^{2-} into soil
2. **Assimilation:** Plants absorb SO_4^{2-} $\rightarrow$ amino acids (cysteine, methionine)
3. **Decomposition:** Dead matter $\rightarrow$ H_2S (hydrogen sulphide)
4. **Oxidation:** $H_2S + O_2 \rightarrow SO_4^{2-}$ (by bacteria)
5. **Combustion:** Fossil fuels $\rightarrow$ SO_2 (acid rain precursor)
6. **Volcanic:** Volcanoes release SO_2 to atmosphere

Human Impact

➥ Burning coal releases SO_2
➥ $SO_2 + H_2O \rightarrow H_2SO_4$ (Sulphuric Acid Rain)
➥ Acid rain: damages forests, corrodes buildings, acidifies water bodies

Reservoir

Main reservoir: Rocks & sediments (lithosphere)
Atmospheric form: SO_2 gas

Phosphorus Cycle (Su'25, W'25 — 4M)

Key Processes

1. **Weathering:** Rocks → phosphate ions (PO_4^{3-}) in soil
2. **Uptake:** Plant roots absorb PO_4^{3-}
3. **Consumption:** Animals eat plants → phosphorus in bones, DNA, ATP
4. **Decomposition:** Dead matter → phosphate returns to soil
5. **Runoff:** Rain carries phosphates to water bodies
6. **Sedimentation:** Aquatic phosphate settles as rock

Key Facts

➥ **No atmospheric phase** (unlike C, N, S)
➥ Slowest of all biogeochemical cycles
➥ Essential for: DNA, RNA, ATP, bones, teeth
➥ Main reservoir: Rocks (phosphate rock)

Human Impact

Excess fertilizer runoff → **Eutrophication** (algal bloom, O_2 depletion in water)

Comparison of Biogeochemical Cycles (W'25, Su'25 — 7M)

Feature	Carbon	Nitrogen	Sulphur	Phosphorus
Reservoir	Atmosphere/Oceans	Atmosphere	Rocks/Sediments	Rocks
Atmospheric form	CO_2	N_2 (78%)	SO_2	**None**
Key process	Photosynthesis	Fixation	Weathering	Weathering
Key organisms	Plants, Decomposers	*Rhizobium*	Bacteria	Plants, Decomposers
Human impact	Greenhouse effect	Acid rain (NO_x)	Acid rain (SO_2)	Eutrophication
Essential for	Energy (carbohydrates)	Proteins, DNA	Amino acids	DNA, ATP, bones
Cycle speed	Moderate	Fast	Moderate	Very slow

Phosphorus is unique — only cycle with NO atmospheric phase. All others (C, N, S) have gaseous form.

Human Disruption of Biogeochemical Cycles (Exam Guide — 4M)

Cycle	Human Activity	Impact
Carbon	Burning fossil fuels, deforestation	$\uparrow CO_2 \rightarrow$ Global warming
Nitrogen	Synthetic fertilizers, vehicle exhaust	$\uparrow NO_x \rightarrow$ Acid rain, Eutrophicati
Sulphur	Coal burning, smelting	$\uparrow SO_2 \rightarrow$ Acid rain
Phosphorus	Fertilizer runoff, detergents	Eutrophication in water bodies

Mitigation Strategies

- Reduce fossil fuel use, switch to renewables
- Use nitrogen-fixing plants instead of synthetic fertilizers
- Install scrubbers in industries to capture SO_2
- Regulate agricultural runoff to prevent eutrophication

1.3 Biodiversity

Importance · Threats · Conservation

Biodiversity — Definition & Types (W'25, Su'25 — 4M)

Definition (Convention on Biological Diversity, 1992)

Biodiversity is the variety and variability of all life on Earth — including the diversity within species, between species, and of ecosystems.

Genetic Diversity

Variation in genes within a species

E.g. Different rice varieties, dog breeds

Species Diversity

Variety of species in an area

E.g. Tropical forests have thousands of species

Ecosystem Diversity

Variety of habitats & ecosystems

E.g. forests, wetlands, deserts, oceans

Importance of Biodiversity (Su'25, W'25 — 4M)

Category	Importance
Ecological	Maintains ecosystem stability; food webs; pollination; seed dispersal
Economic	Food, medicine, timber, fibre, raw materials worth billions
Medical	25% of medicines derived from plants; wild species = drug sources
Agricultural	Genetic diversity of crops → disease resistance, yield improvement
Cultural	Spiritual, aesthetic, recreational value; ecotourism
Climate	Forests absorb CO_2; regulate rainfall and temperature
Soil	Plants prevent erosion; root microbes fix nutrients

➥ **Ecosystem services** (clean water, clean air, soil formation) depend entirely on biodiversity.

Threats to Biodiversity (Su'25, W'25 — 7M)

Major Threats (Mnemonic: **HIPCC**)

Threat	Cause	Example
Habitat loss	Deforestation, urbanisation	Loss of Amazon, mangroves
Invasive species	Non-native species dominate	Water hyacinth chokes lakes
Pollution	Air, water, soil, noise	Pesticides kill pollinators
Climate change	Global warming, drought	Coral bleaching, species shift
Consumption	Overexploitation, poaching	Tiger, rhino, elephant decline

➥ **85%** of threatened species are affected by habitat destruction
➥ Current extinction rate is **1000×** faster than natural background rate

Causes of Biodiversity Loss (W'25, Su'25 — 4M)

Direct Causes

- Deforestation & land clearing
- Hunting & poaching
- Over-fishing
- Collection of wild plants
- Introduction of invasive species
- Draining of wetlands

Indirect Causes

- Population growth
- Industrialisation & urbanisation
- Agricultural expansion
- Climate change
- Poor environmental policy
- Lack of awareness

Fragmentation: Large habitats split into small patches $\rightarrow$ populations isolated $\rightarrow$ inbreeding $\rightarrow$ extinction.
Edge effect: Fragmented patches expose more species to disturbance at boundaries.

In-situ Conservation Strategies (Su'25, W'25 — 7M)

Definition

In-situ conservation = Protecting species in their **natural habitat**.

Method	Description	India Example
National Parks	Strictly protected; no human activity	Jim Corbett, Gir
Wildlife Sanctuaries	Some human use permitted	Bharatpur, Chilika
Biosphere Reserves	Large area; core + buffer zones	Sundarbans, Nilgiris
Reserved Forests	Protected forests	Across all states
Sacred Groves	Community-protected forest patches	Meghalaya, Kerala

➥ India has **106 National Parks**, **567 Wildlife Sanctuaries**, **18 Biosphere Reserves**.

Ex-situ Conservation Strategies (Su'25, W'25 — 7M)

Definition

Ex-situ conservation = Protecting species **outside their natural habitat**.

Method	Description	Example
Zoos	Captive breeding, public education	Delhi Zoo
Botanical Gardens	Living plant collection	Sanjay Gandhi NP
Seed Banks	Seeds preserved at low temp	Svalbard (Norway)
Gene Banks	Genetic material stored	NBPGR, New Delhi
Tissue Culture	Lab propagation of plants	Orchid conservation
Captive Breeding	Breed & reintroduce to wild	Crocodile, Vulture

In-situ vs Ex-situ: In-situ is preferred (natural conditions); Ex-situ used when in-situ is not possible (critically endangered species).

Biodiversity Hotspots (Su'25, W'25 — 4M)

Definition (Norman Myers, 1988)

A **biodiversity hotspot** is a region with exceptionally high species diversity **AND** facing serious threats (at least 70% original habitat lost).

Hotspot	Location	Key Species
Western Ghats	SW India	Lion-tailed macaque, Nilgiri Tahr
Himalaya	N India	Snow leopard, Red panda
Indo-Burma	NE India, SE Asia	Irrawaddy dolphin, Green peafowl
Sundaland (overlap)	SE Asia	Orangutan, Sumatran tiger

- **India has 4 biodiversity hotspots** out of 36 globally.
- Together cover only 2.5% of Earth's land surface but support **60%** of all species.

India's Biodiversity — Key Facts (General — 3M)

Category	India's Share
Land area	2.4% of world's land
Species share	7–8% of all recorded species
Flowering plants	∼47,000 species (known)
Mammals	∼410 species
Birds	∼1,300 species
Reptiles	∼460 species
Tiger population	∼3,167 (2023 census; world's largest)
Elephants	∼30,000 (60% of world's Asian elephants)

➥ **Project Tiger (1973):** 50+ tiger reserves; population rose from 1,827 to 3,167
➥ **Project Elephant (1992):** 33 elephant reserves in India

Convention on Biological Diversity (CBD) (Su'25 — 4M)

CBD — Earth Summit, Rio de Janeiro (1992)

Three main objectives:

- ➥ Conservation of biological diversity
- ➥ Sustainable use of biological resources
- ➥ Fair and equitable sharing of benefits from genetic resources

Parties: 196 countries (India ratified 1994)

Related Agreements

Nagoya Protocol (2010)	Access & Benefit Sharing (ABS) of genetic resources
Cartagena Protocol (2000)	Safe transfer, handling of GMOs
Kunming-Montreal (2022)	30×30 target: protect 30% land & sea by 2030
CITES	Trade in endangered species regulated

Wildlife Protection Act & Indian Laws (W'25 MCQ — 1M)

Act	Purpose
Wildlife Protection Act, 1972	Protect animals, prevent poaching & trade
Forest Conservation Act, 1980	Regulate diversion of forest land
Environment Protection Act, 1986	Umbrella law for all environmental issues
Biological Diversity Act, 2002	Implement CBD in India; ABS mechanism
Air Prevention Act, 1981	Control air pollution
Water Prevention Act, 1974	Control water pollution

➥ **Wildlife Protection Act 1972** enacted to protect wildlife and prevent poaching and illegal trade (W'25 MCQ: Wildlife Protection Act, 1972).

IUCN Red List — Threat Categories (Exam Guide — 3M)

IUCN = International Union for Conservation of Nature

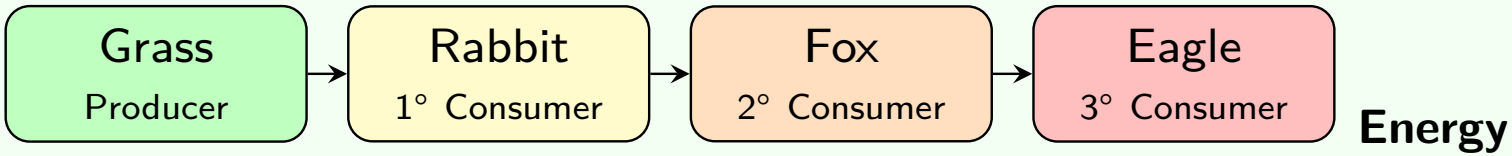
Category	Code	Example (India)
Extinct	EX	Pink-headed duck
Extinct in Wild	EW	Pygmy hog (reintroduced)
Critically Endangered	CR	Great Indian Bustard
Endangered	EN	Bengal Tiger, Asiatic Lion
Vulnerable	VU	Indian Elephant, Gaur
Near Threatened	NT	Clouded Leopard
Least Concern	LC	Common Myna

- **Red Data Book** = IUCN publication listing threatened species.
- India has >900 species on the IUCN threatened list.

Worked: Draw a Food Chain (Su'25, W'25 — 3M)

Question: Draw and label a terrestrial food chain with 4 trophic levels.

Answer



transfer: Only 10% passes to each next level (10% Law).
Types: Grazing food chain (starts with green plant) vs Detritus food chain (starts with dead matter).

Worked: Describe Carbon Cycle (W'25, Su'25 — 7M)

Q: Explain the carbon cycle with a neat diagram.

Answer — 5 key points

1. **Photosynthesis:** $6CO_2 + 6H_2O \xrightarrow{\text{sunlight}} C_6H_{12}O_6 + 6O_2$
2. **Respiration:** $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}$
3. **Decomposition:** Dead organisms $\rightarrow$ CO_2 released by microbes
4. **Combustion:** CH_4 / coal + $O_2 \rightarrow CO_2 + H_2O$ + heat
5. **Ocean absorption:** CO_2 dissolves in sea water $\rightarrow$ carbonic acid (H_2CO_3)

Human impact: Burning fossil fuels has increased atmospheric CO_2 from 280 ppm (pre-industrial) to >420 ppm (2024), driving global warming.

Worked: Explain Nitrogen Cycle (Su'25, W'25 — 7M)

Q: Explain the nitrogen cycle with diagram.

Answer — 5 Steps

Step 1 — Nitrogen Fixation:
N_2 (atmosphere) $\rightarrow$ NH_3 (ammonia) by *Rhizobium*, Azotobacter, lightning

Step 2 — Nitrification:
$NH_3 \xrightarrow{\textit{Nitrosomonas}} NO_2^- \xrightarrow{\textit{Nitrobacter}} NO_3^-$ (nitrate — plant-available form)

Step 3 — Assimilation:
Plants absorb NO_3^- $\rightarrow$ amino acids, proteins; passed to animals via food

Step 4 — Ammonification:
Dead matter decomposed by bacteria/fungi $\rightarrow$ NH_4^+ returned to soil

Step 5 — Denitrification:
Pseudomonas converts NO_3^- $\rightarrow$ N_2 gas, back to atmosphere

Worked: Conservation Strategies (W'25 — 7M)

Q: Explain in-situ and ex-situ conservation with examples.

In-situ (Natural Habitat)

Protects species in own habitat.

- ➥ National Parks: Jim Corbett (Tiger)
- ➥ Sanctuaries: Gir (Asiatic Lion)
- ➥ Biosphere Reserves: Sundarbans
- ➥ Sacred Groves

Advantage: Natural behaviour preserved; self-sustaining

Ex-situ (Outside Habitat)

Protects species outside habitat.

- ➥ Zoos: Captive breeding
- ➥ Botanical Gardens: Plants
- ➥ Seed Banks: Genetic diversity
- ➥ Tissue Culture: Rare plants

Advantage: Useful when natural habitat destroyed

PYQ MCQ Practice — Unit 1 (Su'25) (1M each)

Q	Question	Answer
Q1	Largest ecosystem on Earth	**B) Oceans**
Q2	Role of humans in food web	**C) 1° and 2° consumer**
Q3	% O_2 released by Amazon forest	**C) 20%**
Q4	Primary consumer is	**A) Herbivore**
Q5	Fungi and bacteria are called	**C) Decomposers**
Q6	% Nitrogen in atmosphere	**C) 78%**
Q7	Most important element in biotic components	**C) Carbon**

➥ **Tip:** MCQs test definitions and exact numbers — memorise: Oceans = largest, N_2 = 78%, Amazon = 20% O_2.

PYQ MCQ Practice — Unit 1 (W'25) (1M each)

Q	Question	Answer
Q1	Environmental sustainability means	**C) Maintaining resources f**
Q2	Biogeochemical cycle example	**B) Nitrogen cycle**
Q10	Wildlife Protection Act purpose	**Wildlife Protection Act, 19**

Key Definitions to Memorise

➥ **Sustainability:** Meet present needs without harming future generations
➥ **Ecosystem:** Community of organisms interacting with their environment
➥ **Biodiversity:** Variety of life at genetic, species and ecosystem levels
➥ **Biogeochemical cycle:** Movement of elements through biotic and abiotic spheres

Worked: Ecological Pyramids (W'25 — 4M)

Q: Draw and explain ecological pyramids.

Answer

Type	Unit	Shape	Note
Numbers	Count	Upright	Inverted in parasite chain
Biomass	g/m^2	Upright	Inverted in marine (phyto-plankton)
Energy	kcal/m^2/yr	**Always upright**	Based on 10% law

Key

point: Pyramid of energy is ALWAYS upright and is the most accurate representation of trophic structure.

10% Law (Lindeman): Only 10% of energy at each trophic level is available to the next. If grass has 10,000 kcal $\rightarrow$ rabbit gets 1,000 kcal $\rightarrow$ fox gets 100 kcal $\rightarrow$ eagle gets 10 kcal.

Worked: Short Note on Biodiversity Hotspot (Su'25, W'25 — 4M)

Q: Write a short note on Biodiversity Hotspot.

Answer

Definition: Coined by Norman Myers (1988). A biodiversity hotspot is a biogeographic region that:

➥ Contains at least **1,500 endemic vascular plant species**

➥ Has lost at least **70% of its original habitat**

Global: 36 hotspots worldwide; cover only 2.5% land but hold 60% of all species

India's 4 hotspots:

1. **Western Ghats** & Sri Lanka
2. **Himalayas** (Eastern)
3. **Indo-Burma** (NE India)
4. **Sundaland** (overlaps Andaman)

Significance: Guides conservation funding and international protection efforts.

Ecosystem Services (Exam Guide — 4M)

Definition

Ecosystem services are the benefits that humans receive from ecosystems, free of cost.

Category	Service	Example
Provisioning	Food, water, timber, medicine	Rice, rivers, forests
Regulating	Climate, flood, disease control	Mangroves prevent floods
Supporting	Soil formation, nutrient cycling	Earthworms in soil
Cultural	Recreation, spiritual, tourism	National parks, pilgrimage

➥ Estimated value of global ecosystem services: **$125–145 trillion/year** (Constanza et al., 2014)
➥ Loss of biodiversity directly reduces ecosystem service capacity.

Definition

An **invasive species** is a non-native organism introduced to a new habitat where it spreads rapidly, causing ecological or economic harm.

Species	Origin	Impact in India
Water hyacinth	S. America	Chokes lakes, kills aquatic life
Lantana camara	Americas	Invades forests, reduces native plants
Parthenium	N. America	Causes allergies, kills crops
Common carp	Europe/Asia	Disrupts native fish populations
African catfish	Africa	Threatens native fish in rivers

- Control methods: Manual removal, biological control, chemical treatment

Climate Change Impact on Biodiversity (W'25, Su'25 — 4M)

Direct Impacts

- ➥ Habitat shifts poleward / uphill
- ➥ Coral bleaching (ocean warming)
- ➥ Species phenology mismatch
- ➥ Increased drought → forest die-off
- ➥ Sea level rise destroys coastal habitats
- ➥ Arctic ice loss: polar bear habitat

Key Statistics

- ➥ 1°C rise = 10% species lose habitat
- ➥ 2°C rise = coral reefs effectively gone
- ➥ 50% of species may face extinction risk at 4°C rise
- ➥ Amazon: 3–4°C → savannization
- ➥ India: Himalayan glaciers retreating at 40m/year

Solution link: Protecting biodiversity = protecting carbon sinks (forests absorb CO_2) = slowing climate change.

Reduce, Reuse, Recycle & Restore (Exam Guide — 3M)

4R Strategy for Ecosystem Conservation

R	Meaning	Example
Reduce	Use fewer resources	Drive less, eat less meat
Reuse	Use items again	Cloth bags, refillable bottles
Recycle	Convert waste to resources	Paper, glass, metal recycling
Restore	Rehabilitate damaged ecosystems	Reforestation, wetland revival

Ecological Restoration Examples

- **Project Tiger:** Restored tiger habitats across India
- **Aravalli Greening:** Afforestation in Rajasthan
- **Chilika Lake:** Restored wetland biodiversity
- **Mangrove replanting:** Tamil Nadu, Odisha coastlines

Worked: Importance of Biodiversity (W'25, Su'25 — 7M)

Q: Explain the importance of biodiversity.

Answer — 7 point coverage

1. **Ecological:** Maintains food webs, pollination, seed dispersal, pest control
2. **Economic:** Agriculture (70 crops from 30 plant species), timber, fisheries, tourism
3. **Medical:** 25,000+ plant species used in medicine; quinine, penicillin, aspirin from nature
4. **Genetic:** Wild varieties provide genes for crop improvement (pest/drought resistance)
5. **Cultural:** Sacred groves, eco-tourism, aesthetic value
6. **Climate:** Forests absorb CO_2; regulate rainfall, temperature, humidity
7. **Soil & Water:** Plants prevent erosion; root systems recharge groundwater

Worked: Structure & Function of Ecosystem (W'25 — 4M)

Q: Explain structure and function of an ecosystem.

Structure

Two components:

Abiotic: Soil, water, climate, gases
Biotic:
➥ Producers (autotrophs)
➥ Consumers (heterotrophs)
- Primary (herbivores)
- Secondary (carnivores)
- Tertiary (top predators)

➥ Decomposers (bacteria, fungi)

Function

1. **Energy flow:**
Sun → Plants → Consumers → Decomposers (one-way)
2. **Nutrient cycling:**
C, N, S, P cycle through biotic and abiotic components (circular)
3. **Productivity:**
Primary (GPP) and Net (NPP)
4. **Decomposition:**
Recycling of organic matter

Worked: Short Notes on Sulphur & Phosphorus Cycle

(Su'25 — 4M)

Sulphur Cycle

Reservoir: Rocks, ocean sediments
Atmospheric form: SO_2

Key steps:

1. Rock weathering $\rightarrow SO_4^{2-}$ in soil
2. Plants absorb SO_4^{2-}
3. Dead matter $\rightarrow H_2S$
4. H_2S oxidised $\rightarrow SO_4^{2-}$
5. Combustion releases SO_2

Impact: $SO_2 + H_2O \rightarrow H_2SO_4$ (Acid rain)

Phosphorus Cycle

Reservoir: Rocks (lithosphere)
No atmospheric phase!

Key steps:

1. Rock weathering $\rightarrow PO_4^{3-}$
2. Plants absorb PO_4^{3-}
3. Animals eat plants (bones, ATP, DNA)
4. Dead matter $\rightarrow PO_4^{3-}$ in soil
5. Runoff $\rightarrow$ water bodies $\rightarrow$ sediment

Impact: Fertilizer runoff $\rightarrow$ Eutrophication

Flash Revision — Sustainability & Ecosystems

Term	Key Fact
Sustainability	Meet present needs without harming future generations
Three Pillars	Environment + Economy + Society
Ecosystem	Biotic + Abiotic components interacting
Largest ecosystem	Oceans (marine)
Amazon O_2	20% of Earth's oxygen
Producers	Autotrophs; photosynthesis
Decomposers	Fungi and bacteria
Food chain type	Grazing (plant start) or Detritus (dead matter start)
10% Law	Only 10% energy transferred per trophic level
Pyramid of energy	Always upright

Flash Revision — Biogeochemical Cycles

Cycle	Key Fact	Human Impact
Carbon	CO_2 in atmosphere; photosynthesis/respiration	Fossil fuels → global warn
Nitrogen	$N_2 = 78\%$; Rhizobium fixes N_2	Fertilizers → eutrophicati
Sulphur	Reservoir: rocks; SO_2 from combustion	SO_2 → acid rain
Phosphorus	No atmosphere; slowest cycle	Fertilizer runoff → algal b

Unique facts: Phosphorus = ONLY cycle with NO atmospheric phase.
Carbon current level: >420 ppm CO_2 (was 280 ppm pre-industrial).
Nitrification: $NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$ (by Nitrosomonas & Nitrobacter)

Flash Revision — Biodiversity

Term	Key Fact
Biodiversity types	Genetic, Species, Ecosystem
India's hotspots	4: Western Ghats, Himalayas, Indo-Burma, Sundaland
Global hotspots	36; cover 2.5% land, hold 60% species
In-situ conservation	In natural habitat: National Parks, Sanctuaries, Biosphere Reser
Ex-situ conservation	Outside habitat: Zoos, Seed Banks, Botanical Gardens
India NP count	106 National Parks
Project Tiger	1973; tiger count now 3,167
CBD	Convention on Bio Diversity, Rio 1992
CITES	Regulates trade in endangered species
Wildlife Protection Act	1972 — prevents poaching & illegal trade

Common Mistakes in Unit 1 (Exam Guide)

Mistakes to Avoid

- **Oceans**, NOT forests, are the largest ecosystem
- **Amazon** releases 20% of O_2, NOT 50%
- **Decomposers** are bacteria/fungi, NOT producers
- Pyramid of **energy** is ALWAYS upright — not sometimes
- **Phosphorus cycle** has NO atmospheric phase (unlike C, N, S)
- **In-situ** = protect in natural habitat; **Ex-situ** = outside habitat
- $\mathbf{N_2}$ = 78%, $\mathbf{O_2}$ = 21%, CO_2 = 0.04% of atmosphere
- CBD was at **Rio 1992**, not Kyoto (1997)
- **Wildlife Protection Act** = 1972, Environment Protection Act = 1986

Worked: Define Sustainability & SDGs (W'25 — 4M)

Q: Define environmental sustainability. List 3 SDGs related to environment.

Answer

Definition (Brundtland, 1987):
"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Three Pillars: Environmental + Economic + Social sustainability

Three relevant SDGs:
➥ **SDG 13 — Climate Action:** Reduce GHG emissions; adapt to climate change
➥ **SDG 15 — Life on Land:** Protect forests, combat desertification, halt biodiversity loss
➥ **SDG 14 — Life Below Water:** Protect oceans, prevent marine pollution

India's contribution: National Solar Mission, Namami Gange, FAME scheme.

Worked: Threats to Biodiversity (Su'25 — 7M)

Q: Explain various threats to biodiversity.

Answer — 5 Major Threats (HIPCC)

1. Habitat Loss: Deforestation, urbanisation, agriculture expansion destroy natural habitats. 85% of threatened species affected.

2. Invasive Species: Non-native species outcompete and displace native species (e.g., water hyacinth in Indian lakes).

3. Pollution: Pesticides, industrial effluents, plastic kill organisms across food chains.

4. Climate Change: Rising temperatures shift habitats, cause coral bleaching, increase drought/floods.

5. Over-exploitation: Poaching (tiger, elephant), overfishing, illegal timber trade deplete populations.

Conservation solution: Wildlife Protection Act 1972; Project Tiger; CBD; Protected Areas.

Rapid Revision — Unit 1 Complete (Before Exam)

Ecosystem & Sustainability

Sustainability = 3 pillars (Env+Eco+Social)
Ecosystem = biotic + abiotic
Oceans = largest ecosystem
Amazon = 20% O_2
Producers = autotrophs (plants)
Consumers = herbivore/carnivore
Decomposers = fungi, bacteria
10% law = only 10% energy transferred
Food web = multiple food chains
Pyramid of energy = always upright

Cycles & Biodiversity

C cycle: photo-syn./respir./decomp./combustion
N cycle: fix.$\rightarrow$nitrify$\rightarrow$assimilate$\rightarrow$denitrify
S cycle: rocks$\rightarrow$$SO_4^{2-}$ $\rightarrow$plant$\rightarrow$$H_2S$$\rightarrow$$SO_2$
P cycle: NO atmosphere; eutrophication risk
N_2 = 78%; O_2 = 21% of atmosphere
Biodiversity: genetic/species/ecosystem
India: 4 hotspots, 106 NPs, 567 sanctuaries
In-situ: NP, Biosphere Reserve
Ex-situ: Zoo, seed bank
CBD: Rio 1992; WPA: 1972

Unit 1 — Summary

Sustainability & Ecosystems

- ➥ Sustainability: present needs without harming future
- ➥ 3 pillars: Environmental, Economic, Social
- ➥ Ecosystem: biotic + abiotic interactions
- ➥ Food chain → food web (real ecosystems)
- ➥ 10% energy law (Lindeman, 1942)
- ➥ Types: terrestrial, aquatic, artificial

Cycles & Biodiversity

- ➥ 4 cycles: C, N, S, P (P = no atmosphere)
- ➥ N_2=78%; 10% law governs energy
- ➥ Biodiversity: genetic, species, ecosystem
- ➥ Threats: HIPCC mnemonic
- ➥ In-situ: NP, Sanctuary, BR
- ➥ Ex-situ: Zoo, Seed bank, tissue culture
- ➥ India: 4 hotspots, Project Tiger 1973

Weightage: 10% | Hours: 4 | GTU: 4M + 7M descriptive expected