

Environmental Science Study Guide

1. What is Environmental Science?

Definition

Environmental Science is the study of how the environment works and how humans interact with the environment. It examines the interactions of physical, chemical, and biological components of the environment and their relationships with organisms.

Core Goals

1. Learn how natural systems work
2. Understand how humans interact with the environment
3. Determine how we affect the environment and find solutions

Interdisciplinary Nature

Environmental science draws from multiple fields:

- **Natural Sciences:** Biology, chemistry, geology
- **Social Sciences:** Geography, economics, political science
- **Humanities:** Philosophy, ethics

Important Distinction: Environmental Science (objective study) ≠ Environmentalism (social/political movement with subjective values)

2. The Four Spheres of Earth

Earth operates as a **closed system** where matter stays within the system but energy can be exchanged with the outside environment.

The Four Spheres

- **Geosphere (Lithosphere):** The solid Earth, including rocky mountains, sandy beaches, and magma underground
- **Hydrosphere:** All water on Earth in oceans, rivers, clouds, and soil
- **Atmosphere:** The air around us; a unique mixture of gases critical for life
- **Biosphere:** All living organisms from whales to bacteria

Interconnection Example: A river (hydrosphere) is shaped by rocks (geosphere), feeds plants and animals (biosphere), and is affected by gases (atmosphere). All four spheres constantly interact in a delicate balance.

3. Natural Resources

Definition

Natural Resources are substances and energy sources needed for survival that we take from the environment.

Types of Natural Resources

Renewable Resources: Can be replenished over time

- Sunlight, wind, wave energy
- Timber, water, soil (if managed properly)
- Energy ultimately comes from sunlight
- Can be depleted if used faster than they regenerate

Non-Renewable Resources: Available in finite supply

- Oil, coal, minerals
- Once used, cannot be replenished on human timescales
- Will eventually run out

4. Ecosystem Services

Ecosystem Services are services that arise from the normal functioning of natural

systems that benefit humans.

Key Services Include:

- Purifying air and water
- Cycling nutrients through soil and ecosystems
- Regulating climate
- Pollinating plants
- Receiving and recycling waste

Critical Point: Humans depend completely on ecosystem services for survival. We cannot produce our own food through photosynthesis; we must obtain it from ecosystems.

5. Ecosystems

Definition

An **ecosystem** (also called biogeocoenosis) is a self-sustaining unit in which biotic and abiotic components interact with each other.

Components

- **Biotic Components:** Living things (plants, animals, bacteria)
- **Abiotic Components:** Non-living things (air, water, sunlight, temperature, soil)

Types of Ecosystems

Terrestrial Ecosystems:

- Forest ecosystems (large number of trees)
- Grasslands (small shrubs and grasses)
- Desert ecosystems (limited vegetation, high temperatures, low rainfall)

Aquatic Ecosystems:

- Freshwater (ponds, lakes, rivers)
- Saltwater (wetlands, estuaries, marine areas)

Four Major Functions of Ecosystems

1. **Productivity:** Amount of biomass produced by photosynthesizing organisms
2. **Decomposition:** Breaking down dead organic material to maintain soil fertility
3. **Energy Flow:** Movement of energy through food webs from producers to consumers
4. **Nutrient Cycling:** Movement of nutrients (water cycle, carbon cycle, nitrogen cycle) through the biosphere

6. Human Population and Impact

Population Growth

- Current population: Over 8 billion people (as of 2025)
- For most of history: Under 1 million worldwide
- Dramatic increase due to Agricultural and Industrial Revolutions
- Adding approximately 220,000 people per day

Factors Enabling Population Growth

- Stable food supplies from agricultural improvements
- Improved sanitation and medicine
- Pesticides and fertilizers
- Urbanized society powered by fossil fuels

Ecological Footprint

Ecological Footprint is the environmental impact of a person or population, measured in land area needed to supply resources and dispose of waste.

Comparative Footprints:

- If everyone lived like Americans: 5 Earths needed
- If everyone lived like India: 0.7 Earths needed
- Current world average: 1.7 Earths (we're in overshoot!)

7. Environmental Problems

Three Main Categories

1. Resource Depletion

- Using renewable resources 50% faster than they're replenished
- Examples: Deforestation, overfishing, overmining
- Currently using resources equivalent to 1.7 Earths

2. Pollution

- Addition of harmful substances into the environment
- Types: Air pollution, water pollution, light pollution
- Often caused by human activities

3. Loss of Biodiversity

- Variety of living organisms in an area
- Includes species diversity, genetic variety, and community variety
- Once a species goes extinct, it's gone forever
- Some scientists believe we're entering the sixth mass extinction, caused by humans

| 8. Sustainability

Definition

Sustainability is the idea that we must live within our planet's means so Earth and its resources can sustain us and all life for the future.

Key Concepts

Natural Capital: Earth's total wealth of resources (the "principal" in a savings account)

Natural Interest: Earth's replenishable resources (the "interest" we can live off of)

Critical Point: We must live off natural interest, not natural capital. Using resources faster than replenishment is like spending the principal in a savings account—eventually both the principal and interest disappear.

Corporate Sustainability Examples

- **Coca-Cola:** World Without Waste initiative (collect and recycle one bottle/can for each sold by 2030)
- **Levi's:** Reducing water consumption in manufacturing

- **IKEA:** 2030 circular economy target (products can be reused, refurbished, recycled)
- **Lego:** Using sustainable materials by 2030
- **Amazon & Walmart:** Net zero carbon emissions by 2040
- **Apple:** 100% carbon neutral supply chain by 2030

| 9. The Scientific Method in Environmental Science

Definition

Science is a systematic process for learning about the world and testing our understanding through observation, testing, and discovery.

The Scientific Method Steps

1. Make an observation and ask questions
2. Develop a hypothesis (a testable explanation/conjecture)
3. Generate predictions from the hypothesis
4. Conduct experiments or tests
5. Analyze results
6. If supported repeatedly → Scientific Theory
7. If not supported → Revise hypothesis and repeat

Types of Scientific Approaches

Observational/Descriptive Science:

- Used when phenomena cannot be manipulated by experiments
- Examples: Astronomy, paleontology, geology, volcano studies
- Information gathered about organisms, systems, and processes

Hypothesis-Driven Science:

- Targeted research with controlled experiments
- Manipulates variables to see what happens
- Tests specific hypotheses using the scientific method

Important Scientific Terms

- **Variable:** A condition that can change
- **Independent Variable:** Variable that doesn't depend on others (what you control)

- **Dependent Variable:** Variable that depends on the independent variable (what you measure)
- **Control:** Unmanipulated point of comparison
- **Controlled Experiment:** All variables controlled except the one being tested
- **Scientific Theory:** Well-tested and widely accepted explanation
- **Paradigm Shift:** Dramatic upheaval that changes dominant scientific viewpoint

10. Major Environmental Challenges

Planetary Boundaries

Scientists have identified boundaries within which humanity can safely operate. We are currently exceeding several:

- **Climate Change:** Heading toward 3-degree increase
- **Ocean Acidification:** Affecting marine ecosystems
- **Biodiversity Loss:** Potential sixth mass extinction
- **Biogeochemical Cycling:** Excess nitrogen and phosphorus
- **Deforestation:** Loss of forest cover worldwide
- **Fresh Water Use:** Depleting freshwater resources

Historical Examples of Environmental Collapse

Easter Island: Once a lush, forested island, the population cut down all trees (possibly to erect famous statues). Forest ecosystem collapsed, leading to population collapse. Now a barren landscape.

Key Lesson: Civilizations succeed or fail based on how they interact with their environment and respond to environmental problems.

11. Energy and Fossil Fuels

Current Energy Consumption

Modern life depends heavily on fossil fuels for:

- Transportation
- Manufacturing (including steel production)
- Electricity generation
- Chemical production (fertilizers, plastics)
- Consumer products

World Energy Sources (approximate)

- Oil: ~35%
- Natural Gas: ~25%
- Coal: ~30%
- Nuclear: ~5%
- Renewables: ~5%

Challenge: Fossil fuels are a "one-time bonanza"—once depleted, they're gone. The transition to renewable energy is critical for sustainability.

12. Individual Actions for Sustainability

Ways to Promote Environmental Sustainability

1. **Recycle:** Reduces pressure on raw materials and saves landfill space
2. **Grow Your Own Food:** Reduces carbon footprint from transportation and storage
3. **Reduce Waste:** ~50% of food in US is wasted; conserve resources
4. **Monitor Utility Bills:** Conserve energy (close windows when AC/heat running, unplug appliances)
5. **Buy Energy-Efficient Appliances:** Better insulation, lower energy consumption
6. **Use Public Transportation/Carpool:** Reduces carbon emissions

7. **Plant Trees:** Trees absorb CO₂, provide oxygen, offer shade, counter greenhouse effect
8. **Support Sustainability Organizations:** Join nonprofits working on environmental issues

13. Key Terms Review

- **Biotic:** Living components (from Greek "bios" = life)
- **Abiotic:** Non-living components
- **Photosynthesis:** Process by which plants make food using sunlight, CO₂, and water
- **Ecosystem:** Self-sustaining unit of interacting biotic and abiotic components
- **Biodiversity:** Variety of living organisms in an area
- **Overshoot:** Using resources beyond Earth's capacity to replenish them
- **Closed System:** System where matter stays within but energy can be exchanged
- **Wicked Problems:** Complex problems with no simple solution (e.g., environmental challenges)

14. Important Principles to Remember

1. Humans are part of nature and completely dependent on ecosystem services for survival
2. Earth operates as a closed system—we cannot get more matter from outside
3. All four spheres (geo, hydro, atmo, bio) are interconnected and interdependent
4. Once resources (especially species) are gone, they cannot be recovered
5. Affluence increases consumption and ecological footprint
6. Science is incremental—we approach truth through repeated testing
7. Environmental problems are "wicked"—they involve economics, politics, ethics, and science
8. Sustainability requires living off natural interest, not natural capital
9. Historical civilizations have collapsed due to environmental degradation
10. Solutions must be economically viable to drive real change

15. Study Tips

- Focus on understanding interconnections between concepts rather than memorizing isolated facts
- When studying environmental issues, always ask: How does this affect the four spheres?
- Practice applying the scientific method to environmental case studies
- Understand the difference between renewable and non-renewable resources
- Remember that environmental science is interdisciplinary—consider multiple perspectives
- Learn key vocabulary (especially prefixes: bio, geo, hydro, atmo)
- Use real-world examples to contextualize abstract concepts
- Think critically about human impacts and potential solutions

Conclusion

Environmental science is about understanding our planet's systems and our place within them. As the human population grows and resource consumption increases, it becomes increasingly critical to live sustainably within Earth's boundaries. The goal isn't just to "save the planet"—Earth will endure—but to save human society and maintain the ecosystem services we depend on for survival. By understanding how natural systems work, recognizing our impacts, and developing science-based solutions, we can work toward a sustainable future.